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# Book of Abstracts on Agroforestry, Area Enclosure, Participatory Forest Management, Management of Dry Forests and Plantations



**Book of Abstracts  
on  
Agroforestry, Area Exclosure,  
Participatory Forest Management,  
Management of Dry Forests and Plantations**

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## Foreword

This book of abstracts was compiled following the request from federal and regional forestry institutions to help improve access to scientific literature. Most of the technical team members that assembled the abstracts contained in this publication were drawn from our two institutions; the Ethiopian Environment and Forest Research Institute and Wondo Genet College of Forestry and Natural Resources, Hawassa University. Researchers, teaching staff and students will be among the major beneficiaries of this publication. As heads of the respective institutions, we would like to express our gratitude for being part of this important undertaking. We thank all the team members for their contribution. We are also grateful for CIFOR for initiating and implementing this project that played important role in building local capacity and making our two institutions active partners in its planning and implementation.

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## Preface

This publication is an output of a project entitled “Enhancing the Role of Forestry in Ethiopia’s Climate Resilient Green Economy: A Knowledge, Action Research and Innovation Project”. The project was designed and implemented by CIFOR in collaboration with its national partners, mainly the Ministry of Environment and Forest, the Ministry of Agriculture, the Ethiopian Environment and Forest Research Institute, Wondo Genet College of Forestry and Natural Resources and other higher learning institutions and Federal and regional research institutes. Over 25 senior experts from these organizations were engaged in the project. The intended outcome of the project was to identify effective forest management practices for scaling up with emphasis on area ex-closure in Tigray, participatory forest management in Oromia, smallholder plantations in Amhara, agroforestry in Southern Nations, and management of dry forests and woodlands in Benishangul Gumuz National Regional States of Ethiopia. Strategies for scaling up selected practices are being developed for the five regions and a road map to do so for the Ministry of Environment and Forest in order to support national efforts to significantly develop the forestry sector and enhance its contribution to build climate resilient green economy.

This Book of Abstracts that assembled relevant publications, student theses and research reports on area ex-closure, participatory forest management, plantation forests, agroforestry, and management of dry forests and woodlands was compiled in response to the request by our national partners to improve access to literature of policy makers, extension and development planners, researchers and graduate students. The readers need to be informed that the book is simply a compilation of abstracts, key points, and summary note. Some compiled abstracts while others (e.g. the team working on Participatory Forest Management) prepared summaries of the reviewed documents. Despite the errors and omissions there may be, this book of abstracts will improve access to literature to students and experts. The readers are encouraged to access the full content of publications that they are interested in. We hope that this attempt will pave the way for more work on forest management practices by research and higher learning institutions.

The task of compiling abstracts of relevant literature was conducted by five national technical teams established and supported by the project. CIFOR Ethiopia office is grateful to all members of the teams, and their respective institutions. Our thanks also go to the Strengthening Climate Institutions in Ethiopia Program (SCIP) Fund for financing the project. The SCIP Fund is financed by the Governments of the United Kingdom, Norway and Denmark.

### **Habtemariam Kassa (PhD)**

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# 1. AGROFORESTRY



## COMPILED BY

Zebene Asfaw, Tesfaye Abebe, Yigardu Mulatu, Birhanu Assefa, Getachew Mulugeta, Hafte Mebrahten and Habtemariam Kassa

## 1.1. Characterization of Agroforestry Practices

**Abebe Seifu, 2000. Farmers Private Tree Planting and Management Tradition at Wondo Genet, Ethiopia. M. Sc. Thesis, Wageningen University, the Netherlands.**

In the past three decades, forestry extension in Ethiopia was not effective enough to address forestry development needs. Historical negligence of private forestry is one of the essential problem areas that require investigation. Despite the absence of official government encouragement in private forestry, farmers have a tree planting management tradition in some parts of Ethiopia. Yet these practices have hardly been recorded and little is known about the various types of farmers' tree growing practices. This study attempts to explore such practices in Wondo Genet (WG), which is located within the Ethiopian Rift Valley. The survey was conducted in four peasant Associations (PAs): Goto onoma, Shesa kekele, Wosha soyoma and Watera Kechema. These PAs are located in WG and the survey was carried out from July to September 1999. In order to investigate farmers' tree growing tradition, four clusters of villages were selected from the four Pas. Different methods (informal interview and observation, semi-structured interview, structured interview, farm interview, wealth ranking, and literature review) were employed to collect data from the development organisations, Pas and Households. Sixty households, stratified by three wealth categories, were randomly drawn for a structured interview and farm inventory. Quantitative data from the structured interviews and farm inventory were analysed using descriptive statistics. The findings show that farmers' are well informed about the benefits of trees. They are actively engaged in tree management. The number of tree species retained and planted confirms this. Overall, 40 tree species were cultivated in the farms. More than 50% of the sampled households own more than four tree species. The most widely planted and preferred exotic tree species was Eucalyptus. The most commonly retained and preferred indigenous tree species was *Cordia africana*. Farmers plant trees near and around homestead, along external and internal boundaries, to a lesser scale as woodlot. Fruit trees, coffee, and *Cordia africana* in most cases are planted in the home garden together with Enset (false banana). Eucalyptus is often planted in boundaries (border) of the homestead and the cropland. Although tree planting inside the cropland is rare, farmers retain valuable tree species like *C. africana* and *Albizia gummifera*. In addition to these common species, a variety of tree species are retained and planted for fruit, shade, poles income, etc. The relative concentrations of trees in the homestead compared to cropland suggest that veillagisation and land redistribution have promoted a sense of insecurity. The type of farming practices also has a similar effect. The competitions between cash crop, particularly sugar cane, and tree crop for land is posing a constraint in the three PAs. In cereal producing Goto onoma PA, dry season and fallow grazing on cropland is especially destructive to seedlings and young trees. To propagate trees farmers have the necessary skill. More than 50% of the sampled households use natural regeneration direct seeding wildings, and cuttings. This indicates that to propagate trees, nurseries are not always needed. Similar to this finding, about 50% of the source of planting material is farmers themselves. One-fifth of the farmers are already engaged in farm nursery and the remainders are willing to establish their own nurseries, provided the necessary input is made available to them. This willingness makes a good entry point to further intensify farmers' tree growing efforts. Shortage of land and lack of preferred planting material were reported as problems to establish more trees on farms. Other factors, which could affect farmers' decision to add more trees or maintaining, were

considered. However, there was insufficient evidence to support the influence of the socio-economic position of the farmer, access to the forest, and the size of farm on the decision of retaining and planting. WG offers a good opportunity to improve farmers' tree management practices. The sub-humid climate is ideal for growing a variety of trees. Moreover, there is a strong tradition of tree growing among farmers. If the stimulating role of forestry institutions in the study area is well tuned with farmers' tradition of tree planting the resultant effect will be enormous

**Abera Worku, 2009. Status of Traditional Agroforestry and Its Future Potential Development as Buffer Zone Agroforestry for the Natural Forest Conservation in Burkitu Peasant Association, Oromia, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

The roles that buffer zone agroforestry plays in reducing pressures on protected forest resource and improving the living standards of the rural population living around these protected forest areas have been recognized in different parts of the world. However, in Ethiopia the potential role of buffer zone agroforestry in natural forest conservation has been unnoticed in the policy and strategies designed for natural forest conservation. The aims of this study were to characterize the existing traditional agroforestry practices in and around natural forest, to assess the perception of local community on the potential benefits and uses of traditional agroforestry practices and finally to generate information on the potential uses of buffer zone agroforestry practices in the conservation and development of natural forest in Burkitu Peasant Association. Data for the study were collected through key informant interviews, formal questionnaire survey and vegetation assessment. The formal household survey was administered to a total of 75 households that were randomly selected from three villages using random number table. The qualitative information was summarized while quantitative data were analyzed using SPSS version 13. The results showed that traditional agroforestry practices like homestead (in vertical multistrata structural arrangement), farm boundary and multipurpose trees on farm lands (in their spatial structural arrangements) were observed. More than 90% of the respondents practice these agroforestry in their land. Farmers in the study area have accumulated knowledge concerning different tree management practices. They not only have the knowledge of different tree management practices but also which tree species require the different set of management practices. Among the different benefits, 90% of the respondents indicated that, cash income is the most important socio-economic benefit that has been accrued from these traditional agroforestry practices. Beside the benefits they have been obtaining from their agroforestry practices, 88%, 57% and 83% of the respondents (n=75) have been depending on the natural forest for wild coffee production, bee keeping and livestock grazing respectively. 85%, 76%, 75% and 55% of the respondents perceived as expansion of coffee management, improper fire use for bee keeping, tree cut for timber and seasonal grazing in the natural forest caused forest destruction respectively. However, 93% of the respondents perceived positively towards the future potential role of buffer zone agroforestry in natural forest conservation. It was mentioned that future development of buffer zone agroforestry adjacent to protected forest could help in reducing dependency on the forest resource by providing these different uses and services being obtained from natural forest. Since buffer zone agroforestry could play a significant role in natural forest conservation and improve the livelihood of rural community, attention should be given to its development in forest conservation policies.

**Keywords:** Buffer zone, Buffer zone agroforestry, Natural forest, Natural forest conservation

**Agdebe O.O., Adeola A.O. & Oyeboade O.A., 1987. Taungya in Nigeria: Tree Planting Time and Fertilizer Effects on Growth and Crop Yield. *Forest Ecology and Management*, 20: 291-298**

The growth of *Gmelina arborea*, a forest crop tree, and the yields of food crops as affected by tree planting time and fertilizer levels, were investigated in taungya experimental research farms spread over four vegetational zones of southern Nigeria. Yields of food crops were depressed significantly ( $P < 0.05$ ) when both the tree and food crops were planted at the same time or within a period of less than 1 month. Yield reductions of food crops due to planting time of tree crops were 13 %, 25 %, and 31% for maize, yam, and cassava, respectively. Early-planted *Gmelina* seedlings performed markedly well in terms of height and girth increments, probably due to exposure to a longer period of rainfall and soil nutrient availability. Trees planted in May, June and July reached a mean height of 1.97, 1.44 and 0.74 m, respectively, by the following December while the equivalent girths were 17.7, 11.6, and 7.6 cm. Whereas application of 15:15:15 N:P:K fertilizer significantly increased agricultural yields, it tended to depress the girth increment of young *Gmelina* forest tree crops, possibly due to competition for space and light with the food crop.

**Anteneh Fekadu, 2009. Tree Species Diversity and Indigenous Knowledge of Traditional Agroforestry Practices in Katcha-Birra District, Southern Ethiopia. M.Sc. Thesis, Wondo Genet College of forestry and Natural Resources, Hawassa University.**

Indigenous knowledge (IK) plays significant role in managing agroforestry components and its diversity. To enhance our understanding as to how traditional agroforestry practices have been managed at Katcha-Birra district, this study was designed to describe forest and tree cover changes in the study sites, assess the influence of wealth status on tree/shrub species diversity, and record and document farmers' indigenous knowledge in managing components of agroforestry. Multistage sampling approach was employed to select study sites, villages and households. Three villages from each study sites and 90 households were selected randomly. For qualitative data collection from key informants rapid rural appraisal (RRA) and participatory rural appraisal (PRA) techniques were used. Quantitative data analysis was based on questionnaire. This study indicated that natural forest cover decreased over time while on-farm tree cover increased. A total of 41 indigenous and 11 exotic tree/shrub species were recorded. Species richness on farms of poor households' belonging to poor wealth category was significantly lower than on farms of medium and wealthy households. On farms all wealth categories Eucalyptus species were commonly planted. Traditional agroforestry of the district contributed for circa-citum conservation of *Cordia africana* and *Podocarpus falcatus*, which are the two among five endangered species of Ethiopia. In the study site there is rich experience in managing tree/shrub species. *Vernonia amygdalina*, *Cordia africana*, *Erythrina brucei*, *Albizia gummifera* and *Acacia* species are managed to improve soil fertility. Decomposability of these species is well recognized by farmers. Similarly, the latter four species and as well as others (*Persea americana*, *Magnifera indica*, *Millettia ferruginea* and *Grevillea robusta*) were the major shade species for coffee. Unlike the above mentioned species, *Eucalyptus* species, *Cupressus lusitanica*, *Croton macrostachyus*, *P. americana* and *M. indica* were identified as having adverse effects on crops. Farmers developed experience on mother tree/shrub selection and seedling production. Tree/shrub management practices of the farmers include pruning, thinning and coppice management. *Vernonia amygdalina*, *Erythrina brucei*, *C.*

africana and *P. americana* are the most preferred fodder species and mainly used during dry season when feed shortage occur. Because of feed shortage livestock's already started to feed species such as *Eucalyptus*, *Cupressus lusitanica*, *G. rubusta* and *Maeasa lanceolata*, which animals didn't feed in previous time. In general, traditional agroforestry play crucial role for biodiversity conservation and there is also rich experience of farmers in managing tree/shrub resources on farmlands. Therefore, it is imperative that researchers, development agents and policy makers to use and enhance farmers indigenous technical knowledge.

**Keywords:** Coffee shade, On-farm trees, Soil fertility, Tree-crop interaction, Tree management

**Assegid Assefa, 2009. Wild Edible and Medicinal Trees and Shrubs in Benna Tsemay Woreda South Omo Zone, South Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

The study was conducted in Benna Tsemay Woreda south omo Zone, of the South Nations, Nationalities and people of Region (SNNPR) of Ethiopia, with objectives of identifying and documenting wild edible trees and shrubs and assessing their role to household food security. Ethno botanical data were collected using Semi structure questionnaire, key informant interview, group discussion and vegetation inventory. 30 wild edible trees and shrubs were identified and documented of these 15 species (50%) have supplementary role to household food security, 3 species (10%) have used to fill seasonal food shortage and 12 species (40%) have emergency role. In addition to food 4 species were sold at local market to generate income to household. The result of vegetation inventory also showed that the density of wild edible trees and shrubs varied between lower and mid altitude with 6 and 78 wild edible trees and shrubs per ha respectively. The average harvestable materials also varied from site to site and the quantity of harvestable materials was 85 and 382 kg for lowlands and mid altitude respectively. Expansion of agriculture (25%) fire hazards (21.7%) and over grazing (18%) were found as the major threats of wild edible trees and shrubs in the study area. The study indicated that wild edible plants are valuable resource to improve household food security, nutrition and income especially for households living in the dry land areas and thus research should be carried out on the nutritional value of these trees and shrubs.

**Keywords:** Wild edible trees and shrubs, Indigenous knowledge, Benna Tsemay South Omo, Food security

**Assegid Assefa & Tesfaye Abebe, 2011. Wild Edible Trees and Shrubs in the Semi-arid Lowlands of Southern Ethiopia. *Journal of Science & Development*, 1 (1): 5- 17.**

The study was conducted in Benna Tsemay district, South Omo Zone of the Southern Nations', Nationalities' and Peoples' Region (SNNPR) of Ethiopia, to identify and document wild edible trees and shrubs and to assess their role in household food security. Ethno-botanical data were collected using a semi-structured questionnaire, key informant interview, group discussion and vegetation inventory. A total of 30 wild edible trees and shrubs were identified and documented, of which 15 species (50%) have a supplementary role in household food security, three species (10%) are used to fill the seasonal food shortage

and 12 species (40%) have an emergency role. In addition to food, four species are used to generate income for households. The density of wild edible trees and shrubs varied with altitude, the average number being 25 trees or shrubs ha<sup>-1</sup> in the lower altitudinal zones (500–600 m a.s.l.) and 312 in mid-altitudinal zones (1200–1500 m a.s.l.). The harvestable edible materials also varied from site to site, with average quantities of 85 and 382 kg ha<sup>-1</sup> for the lowlands and mid-altitudinal zones, respectively. Expansion of agriculture (25%), fire hazards (21.7%) and overgrazing (18%) were the major threats to the existence of wild edible trees and shrubs in the study area. The study indicated that wild edible plants are valuable resources for improving food and nutritional security and income of households living in dryland areas. Thus, more research is needed to assess their nutritional value and economic as well as ecological contributions.

**Keywords:** Ethno-botany, Food security, Indigenous knowledge, Benna, Tsemay, South Omo

**Assegid Assefa & Tesfaye Abebe, 2014. Ethnobotanical Study of Wild Medicinal Trees and Shrubs in Benna Tsemay District, Southern Ethiopia. *Journal of Science & development*, 2(1): 17-33.**

Medicinal plants and knowledge of their uses provides a vital contribution to human and livestock health care needs throughout Ethiopia. Despite the wide role of medicinal-plant use by local communities, traditional utilization and management practices are not well documented. The objectives of this study were to identify wild medicinal trees and shrubs and document indigenous knowledge about their utilization and management practices. Ethnomedicinal data were collected using semi-structured questionnaires, key informant interviews and vegetation inventories. Ethnomedicinal uses of 23 trees and shrubs were identified and documented, of which 56% were used to treat human disease, 35% to treat livestock disease and 9% to treat both livestock and human disease. Root was the most frequently used plant part used to treat human disease, followed by leaf. Human diseases commonly treated using these substances were malaria, wound, tapeworm and stomachache. Oral applications were widely used, followed, in frequency of prescription, by dermal applications. The most commonly treated animal diseases were external parasites, constipation and anthrax. Expansion of agriculture was found to be a major threat to the existence of wild medicinal trees and shrubs in the study area. The study's results indicated that wild medicinal plants are valuable resources to the local community. Thus, more research needs to be carried out on medicinal efficacies and methods of domestication and propagation of medicinal trees and shrubs.

**Keywords:** Ethno-veterinary medicine, Indigenous knowledge, Semi-arid areas, South Omo, Traditional medicine.

**Cole R.J., 2010. Social and Environmental Impacts of Payments for Environmental Services for Agroforestry on Small-Scale Farms in Southern Costa Rica. *International Journal of Sustainable Development & World Ecology*, 17 (3): 208–216.**

Agroforestry on small-scale farms has potential to provide important ecological services, such as carbon sequestration and maintenance of biological diversity, while also providing on-farm products for domestic use and marketing. Payments for environmental services

(PES) are an increasingly popular mechanism for encouraging production of ecological services on agricultural lands and may also contribute to poverty reduction and sustainable farming practices through adoption of new farming technologies. There is little current information, however, on the degree to which PES increase tree planting relative to a baseline or the effects of program participation on farmer livelihoods. This study examined the initial impacts of a recent PES program for agroforestry in southern Costa Rica by: (1) assessing the efficiency of PES in increasing reforestation relative to baseline tree planting activities; (2) examining farmer perceptions of socioeconomic and environmental impacts of PES; and (3) exploring obstacles to adoption of agroforestry practices. Thirty-six participant and non-participant farmers were given semi-structured interviews. Key informant interviews were conducted with forestry engineers, farmers' associations, NGOs, and government agencies. Farmers reported positive economic benefits in the first 2–3 years of program participation. PES participants also planted substantially more trees and more species than non-participant farmers. The PES program was effective in overcoming initial economic and technical obstacles that made adoption of agroforestry unattractive. Strong local organizations played a key role in facilitating adoption. Additional investment in short- to medium-term technical support will likely be necessary for broad retention of agroforestry practices beyond the life of the PES contracts.

**Egual Tadesse, 2012. Woody Species Management in Agroforestry Practices: The Case of Assosa District, Benishangul Gumuz Region, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

The depletion of natural resources mainly forests is prevalent in the study area. Hence, the objectives of this study were to: identify the agroforestry types, species richness and use diversity of the woody and some non-woody species, record on-farm tree management types, assess the perception and attitude of farmers towards management and management problems and to identify the influence of socio-economic characteristics on species richness. The methods employed were, woody and some and some non-woody species inventory, key informant discussions and questionnaire survey. For the data collection process six villages were selected purposefully based on presence of intensive agroforestry practices (AFPs). A total of 30 KIs, 130 HHs were selected for management related data collection. From the 130 HHs a sample of 54 HHs were selected for woody and some and some non-woody species inventory. The collected data was analyzed using Microsoft Excel 2007 and SPSS ve.16. The results indicated the presence of four AFPs namely; homegardens, parklands, boundary and alleycropping but only homegardens and parklands were dominant. The AF components included cereal and vegetable crops and different livestock in addition to the woody species. From the inventory of woody some non-woody species, a total of 56 and 22 tree/shrub and and some non-woody species were recorded in homegardens and parkland AF respectively. Both high species richness and stems per AFP was recorded in homegardens than parkland agroforestry. The respondents identified different uses of tree/shrubs importantly provision of food, fodder, shade, fuel wood, income and increasing soil organic matter. The HH respondents had also given ranks in use to the different species. Socio-economic characteristics such as sex, age, family size, and educational level showed some influence on the mean species richness and stems per agroforestry practice. The farmers' knowledge in managing agroforestry practices was immense. The tree/shrub management types identified in the study area included watering, fencing, coppicing,

pollarding, pruning, cultural insect pest/disease control and others. Of the management types, making a slant cut on mango stem to make it productive was observed only at Amba-8 village. Among the management problems mentioned by the HH respondents and key informants land tenure insecurity, prevalence of termite and other insect pests/diseases, scarcity of water, and less survival of seedlings were the major ones. Despite the presence of problems, the perception and attitude of farmers towards tree/shrub management was positive. The farmers in all the villages have strong desire to have more tree/shrubs in their homegardens and on their farm plots. Their greatest interest to practice more agroforestry and to conserve natural resources expressed in having opportunities for these activities like supports by government and NGOs and preparedness of the farmers themselves. Based on the findings of the study, land certification, waterresource development, integrated pest management(IPM), training of farmers and further research on the cultural management practices by integrated approach of responsible bodies is recommended for further development of agroforestry in the study area.

**Keywords:** Agroforestry practices, Local knowledge, Management, Slant cutting, Species richness, Use diversity

**Ermias Lulekal, Zemed Asfaw, Ensermu Kelbessa & Patrick Van Damme, 2011. Wild Edible Plants in Ethiopia: A Review on Their Potential to Combat Food Insecurity. *Afrika Focus*, 24 (2): 71-121.**

This work reviews literature on ethnobotanical knowledge of wild edible plants and their potential role in combating food insecurity in Ethiopia. Information on a total of 413 wild edible plants belonging to 224 genera and 77 families was compiled in this review. Shrubs represented 31% of species followed by trees (30%), herbs (29%) and climbers (9%). Families Fabaceae (35 species), Tiliaceae (20) and Capparidaceae (19) were found to be represented by the highest number of edible species. About 56% (233) of species have edibility reports from more than one community in Ethiopia. Fruits were reported as the commonly utilized edible part in 51% of species. It was found that studies on wild edible plants of Ethiopia cover only about 5% of the country's districts which indicates the need for more ethnobotanical research addressing all districts. Although there have been some attempts to conduct nutritional analyses of wild edible plants, available results were found to be insignificant when compared to the wild edible plant wealth of the country. Results also show that wild edible plants of Ethiopia are used as supplementary, seasonal or survival food sources in many cultural groups, and hence play a role in combating food insecurity. The presence of anthropogenic and environmental factors affecting the wild plant wealth of the country calls for immediate action so as to effectively document, produce a development plan and utilize the plants.

**Keywords:** Ethnobotany, Cultural diversity, Food insecurity, Indigenous knowledge, Nutritional analysis

**Gatluak Gatkoth, 2009. Agroforestry Potentials of Under-Exploited Multipurpose Trees and Shrubs in Lare Woreda of Gambella Region, Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

A study was conducted in Lare woreda of Gambella region with the aim of assessing the



type and role of under-exploited multipurpose trees and shrubs. The study was specifically to identify under-exploited multipurpose tree and shrub species in different land use systems in the study area, determine the production and services role of the species and assess the local trees management practices. Key informants, formal survey with structured questionnaires and vegetation inventory were used to collect data on household's resources, local uses of MPTS, management practices and biomass of trees and shrubs. SPSS version 13 was employed to analyze the results and mean values were used to compare vegetation biomass between the two ethnic groups (Anuak and Nuer). The species richness or diversity was higher in the woodland (Nuer survey households) than the river bank (Anuak survey kebeles) but the standing volume was higher in the river bank. A total of 19 and 7 trees and shrubs were locally used for food and medicine in the study area, respectively. It was also found that multipurpose trees and shrubs play various traditional roles to local community. They are used for fuel, construction, food, local medicine, folder, tools, religious function, shade, windbreak, soil conservation and fertility improvement, bee forage, local boat and other uses.

**Keywords:** Under-exploited MPTS, Species diversity, Woodland, River bank, Anuak, Nuer, Gambella

**Getachew Urga & Kelbessa Dikasso, 2005. Ethnobotanical Study of Edible Wild Plants in Some Selected Districts of Ethiopia. *Human Ecology: an Interdisciplinary Journal*, 33: 83-118**

The ethnobotanical study on edible wild plants was carried out from May to December, 2001, in four districts of Ethiopia. The study areas included the rural and semiurban settings of Alamata, Cheha, Goma, and Yilmana Densa districts of Tigray, Southern Peoples, Oromiya, and Amhara regional states, respectively. Voucher plant specimens were collected along with ethnobotanical information, and scientific names were determined. One hundred and fifty two plant parts from 130 species were recognized and consumed in these districts. Children consumed more wild plants during seasons of food availability (sufficient crop stock) than adults. There was marked increase in quantity and number of wild plant species consumed during food shortage and famine. A few of the reportedly edible species caused health problems that sometimes lead to fatality. Research into the safety and nutritional composition of edible wild plants and fungi is warranted. Selected edible wild plant species should be promoted as supplements to dietary variety and/or bridging the hungry periods of food shortage.

**Keywords:** Drought, Edible wild plants, Ethiopia, Food shortage, Poisoning.

**Gezahegn Kassa, 2011. Tree Species Diversity and Determinants of Tree Growing in Agroforestry Practices of Yem Special District, Southern Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

Conserving tree species diversity cannot be restricted in forest areas because of increasing encroachment to remnant forests. Agricultural landscapes that have good tree cover can maintain tree species diversity while providing complementary products and services. The present study was therefore conducted in Yem Special district, Southern Ethiopia,

to determine the diversity of tree species, and assess the factors that influence farmers' decision making in tree growing. The data used for this research were collected through two consecutive field surveys involving structured household questionnaires and woody species inventory administered to 126 households. Data were analyzed using one way ANOVA, Chisquared, Kruskal-Wallis test, Mann-Whitney test and t-test, and logistic and multiple regression models. The status of tree species richness and diversity were quantified for different agroforestry practices. Within the 98 individual household farms surveyed, a total of 100 tree and shrub species belonging to 57 families and 83 genera were recorded in the different agroforestry practices, of which 11 (or 11%) were exotic and 89 (or 89%) native species. The mean number of tree species per household for the overall agroforestry practices was 14.04 and it was found to be significantly different among study sites, reflecting differences in site conditions. Tree species richness was influenced by distance to major roads, wealth, farm size and family size. Boundary plantings and live fences were occurring in 50% and 70.41% of the total household farms, with mean effective length of 0.21 km ha<sup>-1</sup> (ranging from 0.01 to 1.48 km) and 0.22 km ha<sup>-1</sup> (ranging from 0.019 to 0.963 km) per household, respectively. The present study revealed that the existing agroforestry practices contribute to the conservation of biodiversity in agroecosystems. Results of the logistic regression model showed that three variables were significant in explaining farmers' decisions to tree growing. Among the variables considered, age of household head, farm size, and livestock size were found to positively and significantly influence farmers' tree growing decisions. On the other hand, Ordinary least squares (OLS) indicated that only family size was positively and significantly influenced extent of tree growing. The findings imply that it is appropriate to distinguish farmers' household- and farm-specific characteristics in order to better intensify tree growing activities/agroforestry practices.

**Keywords:** Human-dominated landscapes, Species richness, Biodiversity, Household- and farm-specific, Tree growers.

**Gonfa Kewessa, 2012. Ethnobotanical Study of Native Edible and Medicinal Trees and Shrubs in Dale District, Sidama Zone, Southern Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

There is rich knowledge and experience in the utilization of native trees and shrubs among the rural population of the region, but the knowledge is not systematically documented and is gradually disappearing among the communities. The purpose of this study was to document native tree and shrub species of edible and medicinal value, and the associated indigenous knowledge on utilization, threats and conservation of them. A total of 60 informants aged 20 and above were involved. Data were collected using semistructured interviews, field observations and farm inventory. A total of 61 native edible and medicinal species were documented; 36 (59%) trees and 25 (41%) shrubs. Of these, 19 (31.2%) are edible, 34 (55.7%) are medicinal and the remaining 8 (13.1%) are both edible and medicinal. Of the total species, 42 medicinal species were used for treating 49 different diseases (34 human and 15 livestock diseases). The most frequently used parts of those edible species were fruits. The most frequently used medicinal species parts were leaves (41%) for human and (50%) for livestock. The most widely used method of remedy preparation was crushing (30%) and (50%) for human and livestock, respectively. The common route of administration was oral about (84%) for both human and livestock. The most commonly used application of remedies was via drinking (55%) and (83.33%) for human and livestock, respectively.

Trees like *Cordia africana*, *Podocarpus falcatus*, *Syzygium guineense* and *Ficus sycomorus* have high informant consensus. Preference ranking and direct matrix ranking showed that people of the area have preference for *C. africana* and it is the most utilized species by the community. Population pressure, agricultural land expansion, construction, timber production, and firewood collection are the major threats to those species. Due to limited conservation efforts, the participation of the local people, and awareness raising through training on wise utilization and conservation of these species should be encouraged. Further nutritional and biological studies should also be conducted on the reported species to generate information that could be used in future food and drug development.

**Keywords:** Conservation, Disease, Indigenous knowledge, Informants, Utilization

**Gerhardt K. & Nemarundwe N., 2006. Participatory Planting and Management of Indigenous Trees: Lessons from Chivi District, Zimbabwe. *Agriculture and Human Values*, 23: 231–243.**

This paper reports on action research that evaluated local perceptions and knowledge of indigenous tree planting and management in the Romwe catchment, Chivi District, southern Zimbabwe. The species tested were the overexploited *Azelia quanzensis*, important for timber and carvings of sculptures and utensils; *Sclerocarya birrea*, the marula tree used for wood, bark, and fruit; and *Brachystegia glaucescens*, the dominant miombo tree species, used for firewood, fiber, and fodder. Participants volunteered to plant and manage the test seeds, while a research team monitored their activities and results for 26 months. For *Azelia quanzensis*, the germination rate was 81%, and 69% of the seedlings were still alive after one year. In the case of *Sclerocarya birrea*, the germination rate was 69%, and the one-year survival rate was 50%. For *Brachystegia glaucescens*, the germination rate was only 30%, and the survival rate was 31%. The main reasons for planting were to provide shade, to serve as a windbreak, and to conserve and gain individual control over dwindling natural resources, particularly *Azelia quanzensis*. Women were generally more active and innovative than men. For instance, they searched for their own seeds or seedlings in the bush when there weren't sufficient plants. Some participants tried out various indigenous methods of pest and disease control, water conservation, and moisture retention. Group feedback sessions and informal interactions provided the opportunity to share experiences. The participants learned that indigenous trees can be purposefully planted and were not simply a gift from God. Despite the droughts and political instability of recent years, a growing number of people became involved in tree planting during 2002–2003. As a result, there is now greater awareness among the local population of dwindling resources and their future potential.

**Gordon J.E., Hawthorne W.D., Sandoval G. & Barrance A.J., 2003. Trees and Farming in the Dry Zone of Southern Honduras II: The Potential for Tree Diversity Conservation. *Agroforestry Systems*, 59: 107–117.**

The potential of the dry zone agro-ecosystem of southern Honduras to contribute to the conservation of Mesoamerican dry forest tree diversity is evaluated. Four rural communities containing eight land uses were surveyed using rapid botanical sampling resulting in the identification of 241 tree and shrub species. As a result of ordination analysis, it is concluded

that the land uses are relatively similar in their species composition, particularly maize fields, *milpas*), fallows, pastures and woodlots, because of the predominance of natural regeneration. Therefore all land uses might contribute to local tree diversity conservation. Those land uses in which planting also contributes to diversity, home gardens, *solares*) and orchards, are more distinct; however the tree species found there are widespread and often exotics and thus not the usual focus of conservation measures. Across the landscape the total complement of species considered a global priority for biodiversity conservation is very low and therefore this agro-ecosystem does not represent a good place in which to implement dry forest tree diversity conservation programmes. Instead its value is likely to be in the contribution that tree diversity makes to rural livelihoods. Particular consideration is given to *Swietenia humilis* Zucc, small leaved mahogany, and its status as a threatened species is questioned because of its abundance within this landscape and its wide distribution.

**Guillermo S. Kumar B. M., Menon A., Hinnewinkel C., Maire E. & Santhoshkumar A. V., 2011. Impacts of Public Policies and Farmer Preferences on Agroforestry Practices in Kerala, India. *Environmental Management*, 48:351–364.**

Agroforestry systems are fundamental features of the rural landscape of the Indian state of Kerala. Yet these mixed species systems are increasingly being replaced by monocultures. This paper explores how public policies on land tenure, agriculture, forestry and tree growing on private lands have interacted with farmer preferences in shaping land use dynamics and agroforestry practices. It argues that not only is there no specific policy for agroforestry in Kerala, but also that the existing sectoral policies of land tenure, agriculture, and forestry contributed to promoting plantation crops, even among marginal farmers. Forest policies, which impose restrictions on timber extraction from farmers' fields under the garb of protecting natural forests, have often acted as a disincentive to maintaining tree-based mixed production systems on farmlands. The paper argues that public policies interact with farmers' preferences in determining land use practices.

**Iniobong A. A. & Inemesit P. I., 2009. Agroforestry Practices among Male and Female Farmers in South–South, Nigeria. *Small-scale Forestry*, 8:63–76.**

Perceptions of the benefits of agroforestry practices (AFPs) and the level of utilization of these practices by male and female participants were examined in the agroforestry programs of the Akwa Ibom and Cross River State Governments of the South–South region of Nigeria. Responses were derived from 250 randomly selected respondents. Overall, respondents perceived the major benefit of agroforestry practices as enhancement of environmental conservation. Female respondents however perceived increased income as the major benefit of agroforestry practices. A composite perception index revealed that women farmers were more favourably disposed than male respondents to the utilization of agroforestry practices. The farmers were favourably disposed to the utilization of only five of the 16 identified AFPs in the study area, including 'leaving of isolated woody trees on farmlands', 'utilizing woody trees as windbreaks' and to 'demarcate farm boundaries', 'planting of woody trees in combination with fruit trees', and 'planting of woody trees in combination with vegetable crops'. Male and female responses were generally similar although a major difference was observed with regard to 'planting of trees for fuel wood'. The composite index, however, revealed a general low level of utilization of AFPs, although female farmers were relatively

more disposed to the utilization of AFPs. The key policy implication of the study is the necessity to embark on sustained education and environmental awareness campaign, with a focus on presenting AFPs as livelihood sustaining and risk mitigation activities, against its present misperception as simply a government strategy to increase the stock of woody trees in the environment. This policy should endeavour to target landless women farmers who have been found to be more interested in the adoption of AFPs into their farming system.

**Lill V., Kruger W.S. & Van Wyk D.B., 1980. The Effect of Afforestation with *Eucalyptus grandis* and *Pinus patula* on Stream Flow from Experimental Catchments at Mokobulaan, Transvaal. *Journal of Hydrology*, 48: 107--118.**

This paper reports results of a catchment experiment on the Eastern Transvaal escarpment, South Africa. Gauging of flow from the catchments under natural grass cover began in 1956. One of the catchments was planted to *Eucalyptus grandis* in 1969 after 12 years of calibration, a second was planted to *Pinus patula* in 1971, and the third was maintained in the natural condition. Simple regression analysis procedures were used and showed that afforestation with *Eucalyptus grandis* exerted an observable influence from the third year after planting, with a maximum apparent reduction in flow, expressed as rainfall equivalent, of between 300 and 380 mm yr.<sup>-1</sup>, and with maximum reductions in seasonal flow of about 200--260 mm yr.<sup>-1</sup> in summer and 100--130 mm yr.<sup>-1</sup> in winter. Conclusions from the *Pinus patula* treatment are very tentative, but the effect of afforestation is apparently delayed by one year relative to that of *Eucalyptus grandis*, and apparent streamflow reductions are smaller.

**Mehari Alebachew, 2012. Agroforestry Practices, Opportunities, Threats and Research Needs in the Highlands of Oromia, Central Ethiopia. *International Research Journal of Agricultural Science and Soil Science*, 2(5): 194-206.**

Informal and formal surveys were conducted at Jeldu and Guder district in two peasant associations (PA) of western Shewa zones of Oromia region in 2006/2007. The study were conducted with the objectives to describe and understand indigenous agroforestry practices and identify constraints for natural resources management and propose research agenda in the context of farming system. Informal surveys were implemented through discussion, key informant interview, and physical observation. And formal survey was conducted using structured questionnaires from one hundred households (50 per district). The common agroforestry practices recorded at both study sites were scattered trees on farmlands, trees on gullies, rivers, home gardens, live fence, grazing lands, farm boundaries and around fences. *Hagenea abyssinica*, *Dombeya torrida*, *Maytenus ugaliensis*, *Eucalyptus globulus* and *Buddleja polystacha* are abundant at Jeldu where as *Acacia abyssinica*, *Cordia africana*, *Croton macrostachys*, *Olea africana*, *Eucalyptus camaldulensis*, *Cupressus lusitanica*, *Podocarpus glaciali*, *Entada abyssinica*, *Ficus vasta*, *Sesbania sesban*, *Albizia scimperiana*, *Vernonia amygdalina*, *Acacia decurrens*, *Celtis africana*, *Croton macrostachys* and *Myrica salicifolia* are familiar at Guder. Free livestock movement, land shortage, poor access of tree seedlings and termite hazard are the major bottlenecks recorded outside homesteads. Soil erosion, feed shortage, wood shortage and depletion of soil fertility are the critical problems in the study areas. Investigation of feed value and soil improving characteristics are some of the potential indigenous trees and shrubs need a priority research attention.

Hence this paper discussed the causes of the aforementioned problems and forwarded relevant recommendation research intervention to be conducted.

**Keywords:** Traditional farm forestry, Farming system, Multipurpose trees.

**Mekuanent Tebkew, Zebene Asfaw & Solomon Zewudie, 2014. Underutilized Wild Edible Plants in the Chilga District, Northwestern Ethiopia: Focus on Wild Woody Plants. *Agriculture & Food Security*, 3:12**

Ethiopia encompasses an extraordinary number of ecological zones and plant diversity. However, the diversity of plants is highly threatened due to lack of institutional capacity, population pressure, land degradation and deforestation. An adequate documentation of these plants also has not been conducted. The farmers in Ethiopia face serious and growing food insecurity caused by drought, land degradation and climate change. Thus rural communities are dependent on underutilized wild edible plants to meet their food and nutritional needs. Hence, this study was conducted to examine the distribution, diversity, role, management condition and associated traditional knowledge of underutilized wild edible plants with a focus on woody plants in the Chilga District, northwestern Ethiopia. A questionnaire survey, semi-structured interviews, preference and direct matrix rankings, a market survey and focused group discussion methods were employed for data collection. Data were collected from 96 respondents. A plant inventory was also conducted on 144 quadrates in two agroecologies and in three uses. Both quantitative and qualitative data analysis methods were used. Statistical Analysis System (SAS) version 9.0 was used for statistical analysis. Analysis of Variance ( $P < 0.05$ ) was used to compare diversity indices and species richness between agroecologies and among kebeles were trees. Fruits (76%) were the most frequently used plant parts. More than half of the respondents (56.3% in the midland and 66.7% in the lowland area) consumed underutilized wild edible plants for supplementing staple food. Underutilized wild edible plant citation of the poor was significantly higher ( $P < 0.05$ ) than medium and rich classes. Underutilized wild edible plants in the study area were threatened by agricultural expansion, overharvesting for fuel wood and construction, and by overgrazing. However, these plants have been given minimum conservation attention. Thirty-three underutilized wild edible plants were recorded in the study area. The community consumes underutilized wild edible plants for supplementing staple food, filling food gaps and for recreation. The local community applies only some management practices to some wild edible plants. Therefore, special management is needed to sustain the benefits of these plants.

**Keywords:** Farmlands, Herbaceous species, Natural forest, Riverine forests, Woody species

**Melkamu Alebachew, 2009. Assessment of Traditional Agroforestry Practices and Associated Local Knowledge in Banja District, Awi-zone, Amhara region, Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University, Ethiopia.**

The farmers' local knowledge (LK), woody species management and their contribution in traditional agroforestry practices have been there through centuries in Ethiopia. Nevertheless, very little of this knowledge has been recorded in the country even none in Banja district. The objectives of this research were to: assess multipurpose trees/shrubs

distribution at various agroforestry practices; identify the contributions of trees/shrubs to HH income with various wealth categories; record and describe LK in use and gender roles to manage woody species. In this study, both informal (54 key informants) and formal (108 HHs) surveys were conducted. For tree/shrub inventory, 54 sample farms were involved. The result of this study indicated that farmers have a great deal of LK that helped them to manage agroforestry components. Household (HH) respondents have various types of trees/shrubs at existing agroforestry practices. For example, 15, 13, 11 and 4 woody species in boundaries, parklands, live fences and woodlots respectively were recorded. A mean of 1349 and 6546 stems per HH and per ha respectively were recorded. The mean proportion of both stem number and species types was highest at boundaries and less in other agroforestry practices. The studied species distributions were variable with wealth classes too for HHs do have variable land size. In general, a total of 26 woody species were inventoried at 54 farms for the three wealth categories. Of these, *Arundinaria alpina*, *Justicia schemperiana* and *Erythrina burcei* were found most abundant. Farmers' LK about trees/shrubs selection, propagation, thinning, coppicing, pollarding and pruning was practiced. For example, *Arundinaria alpina*, *Erythrina burcei*, *Dombeya torrida* *Prunus africana*, e.t.c., were found and managed accordingly. HHs deliberately retained woody species on their farms for an immense and multiple contributions such as cash-income from various products and to optimize production of crops and livestock. Gender decision making role in the HH to tree management, product use and disposing was differing and usually location specific. It was concluded that woody species distributions and their contributions for wood, food, medicine, and cash-income for the livelihood of HHs in agroforestry practices were profound in the area. The farmers' LK to tree management was also remarkable. Generally, traditional agroforestry practices of Banja district are sources of farmers' LK, woody species types with their contributions. Further inventory on woody species types, their distributions at agroforestry practices and their contribution is required in order to more fully understand farmer's LK in woody species management as well as for documentation of these and this need be necessary.

**Keywords:** Boundary, Parkland, Woodlots, Use diversity, Cash-income, Gender role

**Mesele Negash, 2007. Trees Management and Livelihoods on Gedeo's Agroforests, Ethiopia. *Forests, Trees and Livelihoods*, 17: 157–168.**

Ethiopian farmers' indigenous knowledge on the management of trees and their contribution to improving the farmers' livelihoods has no extensive literature. The object of this study is to record indigenous knowledge of tree management and the role of trees in the farmers' livelihoods. Farmers use tree seedlings from natural regenerations, cuttings and coppice and practise tree pollarding and lopping. Trees supply fuelwood, timber, poles, fodder and human and veterinary medicines, play a part in honey production and are a source of income, as well as having cultural value. Farmers have a fund of indigenous knowledge of managing trees in the farming systems and trees provide invaluable support to their livelihoods.

**Keywords:** Honey, Lopping, Medicinal plants, Pollarding, Regenerations

**Mesele Negash, Abdu Abdlekdir & Sten Hagberg, 2005. Farmers' Planting Practices of Eucalyptus Spp. in Enset-Coffee Based Agroforestry System of Sidama, Ethiopia. *Ethiopian Journal of Natural Resources*, 7(2):239-251.**

Past studies conducted on Eucalyptus spp. have mainly focussed on the financial and ecological implications as well as on adaptation and provenance selection of the species. Little attention has been given to the socioeconomic factors that influence planting and expansion of Eucalyptus spp. in Ethiopia. This study was conducted to evaluate the significance of socioeconomic factors in relation to Eucalyptus spp. planting and expansion. A stratified random sampling based on wealth was used for selection of households. Sixty households were included in the socioeconomic survey. In addition, key informant interview was carried out to collect historical information on eucalyptus planting. Rich farmers who held farm sizes greater than one hectare allocated larger proportion of land for Eucalyptus spp. planting than the poor. Most farmers considered Eucalyptus spp. as one of their major sources of income and risk aversion. Farmers have been expanding eucalyptus planting with little support from extension agents. Eucalyptus spp. is most commonly planted in the form of woodlots, live fence, boundaries and front yards. Farmers were reluctant to plant Eucalyptus spp. in croplands. It is concluded that socioeconomic factors considered in the study had a far-reaching impact on the introduction and expansion of Eucalyptus spp. in the farming system of Sidama, Ethiopia.

**Keywords:** Eucalyptus spp., Extension, Family Size, Farm Size

**Mesele Negash & Negussie Achalu, 2008. History of Indigenous Agro-Forestry in Gedeo, Southern Ethiopia, Based on Local Community Interviews: Vegetation Diversity and Structure in the Land-Use Systems. *Ethiopian Journal of Natural Resources*, 10 (1): 31-52.**

In spite of the immense socio-economic, cultural and ecological benefits of multistrata agroforestry land-uses, the effort exerted to document and improve the practice in Ethiopia has been limited. Thus, much of the accumulated indigenous knowledge on evolutionary developmental stages and management practices of each component in the system has remained a blurr to outsiders. This study was conducted to investigate the evolution and prevailing spatial arrangements and species composition of agroforestry systems in Gedeo zone in southern Ethiopia. Interviews with key informants, focus groups, surveys on randomly selected households and ethnobotanical inventory were carried out. Historical development of agroforestry land-use system on the study sites has shown that the area was originally dominated by naturally grown species such as *Syzygium guineense*, *Podocarpus falcatus*, *Millettia ferruginea*, *Cordia africana*, *Croton macrostachyus*, *Aningeria adolfi-friederici* and *Erythrina* spp. Introduction of *Ensete ventricosum* and *Coffea arabica* into the farming system intensified the agroforestry system in the study area. A total of 50 crops comprising 35 plant families were recorded in the system. These constituted 90% naturally grown species; the rest being imported species. Among these, 16 species (32%) occurred across all altitude ranges and the remaining species represented either one or two of the altitudes. Breakdown of the species showed that cash crops accounted for 54%, food crops for 40%, firewood for 28%, timber/pole construction for 26% and soil fertility improvements for 20%. Soil fertility improvements' implies farmers' practices to maintain the soil organic matter, and ensure sustainable production in indigenous agroforestry system. Various plant



species in the system occupied upper, middle, lower and under-storey vertical strata that accounted for 38, 14, 12 and 26 percent of the species, respectively. It was revealed that farmers' gradual intensification of land-use systems developed well-composed architectural arrangements and plant diversity in the agroforestry system. This resulted in diversifying the use values and thus contributes to sustainable use of the natural resource base.

**Keywords:** Enset, Farming system, Indigenous knowledge, Spatial arrangements

**Mulugeta Sisay & Kindu Mekonnen, 2013. Tree and Shrub Species Integration in the Crop-livestock Farming System. *African Crop Science Journal*, 21(3): 647 – 656.**

Tree and shrub integration has been promoted as a means of enhancing rural livelihoods through sustaining watershed provision of services and products, especially in Ethiopia. However, research to support this effort has been limited. This study was conducted in Borodo watershed in central Ethiopia, to identify constraints to the process of tree and shrub integration in the watersheds. A household survey was conducted, supplemented with focus group discussions (FGDs), key informant interview and field observations. A total of 31 tree and 11 shrub species were identified in different niches in the watershed. The key constraints to tree and shrub species integration included shortage of arable land, soil cracking, free grazing, lack of seedlings of desired species and water-logging. The main catalysts to the integration were availability of information on improved integration and cash for investment in the required activities, easy land certification and market opportunity for tree and shrub products. The tree and shrub growing niches preferred by farmers were homesteads (95.5%), gully sides (67.4%), stream sides (61.8%) road sides (60.7%), and crop land (12.4%). It is essential to address the factors that hinder tree and shrub species integration at various growing niche so as to improve the availability of tree products and services. Moreover, the capacity of farmers should be upgraded through training and demonstration of best tree planting, management and utilisation practices.

**Keywords:** Household, Landscape, Niche, Watershed

**Munyanziza E. & Sarwatt S.V., 2003. Evaluation of *Moringa oleifera* for Food Security and Environmental Rehabilitation in Tanzanian Rural Areas. *Journal of Tropical Forest Science*, 15 (3):450-456.**

Evaluation of *Moringa oleifera* for its potential in food security and environmental rehabilitation has been carried out in Morogoro, Tanzania. For this purpose, three-month-old potted nursery seedlings were transplanted in the field at a spacing of 3 X 3 in where they were left to the prevailing weather conditions. Seven months after field planting, plant total height, branching pattern and root architecture were assessed. The number of pods was also counted. Linear regression analysis was computed to relate pod yield with key growth parameters, namely, total height and stem branching rate. Within a period shorter than a year, the average tree height has reached 4.13 in (SD = 0.86). *Moringa oleifera* yielded enormous amount of edible green beans within the first year. These green beans were borne throughout the long dry season when other sources of vegetables died or became unaffordable for the common people. Owing to its modified roots and probably to other mechanism, this species is drought-resistant. There was a positive correlation between the number of pods and the total number of branches ( $p < 0.001$ ). The relationship between

height growth and amount of pods or number of branches was very weak ( $p > 0.10$ ). Any kind of shoot treatment able to stimulate the branching rate will most likely increase pod yield.

**Neef, A and Heidhues, E. 1994. The Role of Land Tenure in Agroforestry: Lessons from Benin. *Agroforestry Systems*, 27: 145-161.**

In this article the relationship between land tenure and agroforestry is analysed drawing on a case study from Benin. It is argued that tenants, the landless and the majority of women are disadvantaged compared with landowners in terms of their ability to adopt agroforestry systems. This is due to a lack of land resources, tenure insecurity and restrictions in planting perennial crops. State interventions and conflicts between farmers and pastoralists further limit land tenure security of the rural population and thus reduce the willingness of peasants to invest on a long-term basis and to protect natural resources. The article concludes with some implications for policy and project interventions in the field of land tenure systems.

**Oumer Ejero, 2009. Community Perception and Status of on Farm Trees and Adjacent Natural Forest Under Participatory Management: Dodola District, West Arsi Zone, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

This study attempts to investigate the local community perception with temporal changes of on- farm trees and adjacent natural forest at present under participatory management, and its contribution to livelihoods. The study was conducted in Dodola district, Ethiopia. From the district two representative PAs namely Bura chale and Barisa were randomly selected by stratified purposive sampling based on presence of on farm trees and their access to natural forest since these factors were believed to affect the contribution of on- farm trees and PFM to livelihoods. From each PAs two villages of WAJIB and Non-WAJIB were selected. A household was then selected using random sampling from the study population using WAJIB member and PAs lists. Formal survey was conducted on 120 households that makeup 6% of households under the total population of study areas. Forest inventory was made at Sokora and Mararo-Urgo WAJIB forest applying systematic sampling design using transects lines. Nine plots were laid in each sites and inventory data from the two sites were integrated and computed for number of stems per hectare, basal area ( $m^2/ha$ ), forest structure and regeneration status. Based on the wealth categories data were collected from a total of 72 plots of 0.5ha sizes which were laid out in the crop fields and homegarden of WAJIB and Non-WAJIB. SPSS and excel were used for data analysis, the result showed that the studied community have positive perception for the WAJIB forest management and on-farm trees as well as its contributions to livelihood. WAJIB promote forest awareness among the local people, enable them to regulate forest access, empower locals for decision making. Forest and on-farm trees contribute about 21% and 6% for WAJIB and Non-WAJIB livelihoods respectively. With regard to forest conservation, better woody species diversity as well as seedling and sapling densities were observed in the forest under PFM, while, declining on-farm trees were observed for the time scale. According to respondents, the reasons for

retaining woody species in on-farm were provision of construction wood, shade, fuelwood and income generation in their order of importance.

**Keywords:** Perception, PFM, WAJIB, On-farm trees, Livelihoods and Woody species diversity

**Temesgen Lintamo, 2012. Farmers' Traditional Knowledge on the Management of Agroforestry Practices in Soro District, Hadiya Zone, SNNPRS, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Assessment of farmers' traditional knowledge on the management of agroforestry practices were studied in Soro district, Hadiya Zone, SNNPRS, Ethiopia. In order to assess the effectiveness of agroforestry practices, it is necessary to recognize farmer's knowledge and learn more about the complex and diverse nature of indigenous resource use and management practices. The main objective of this study, therefore, is to characterize and document the traditional agroforestry practices and related farmers knowledge and outlook on the management of practices. Six villages from three peasant associations were selected for in-depth study of the traditional knowledge of farmers concerning the management of agroforestry practices. Survey (questionnaires), key informant interview and observation were the major data collection methods used. A total of 24 key informants and 90 samples households were conducted in the study area. Homegardens, windbreaks, live fences and woodlot are the main agroforestry practices identified in the area. Among them, homegarden is the best preferred practice followed by live fences and windbreaks. Farmers' knowledge on the dynamics of vegetation cover change, tree management, the management of tree-crop interaction and tree-animal interaction were found to be appreciable. Local farmers have accumulated knowledge on tree species and preferences are based mainly on their compatibility and adverse effects to agricultural crops. The major tree species preferred for crop yield improvement are *Dodonea angustifolia*, *Allophylus abyssinica*, *Acacia abyssinica*, *Croton macrostachyus*, *Olea africana*, *Grewia ferruginea*, *Grewia mollis*, *Dombia torrid* and *Bersama abyssinica*. *Eucalyptus globulus* and *Eucalyptus camaldulensis* were the tree species considered to have adverse effects to crops in all surveyed villages and avoided from crop fields due to their perceived negative effect to crops, owing to cause competition for nutrients and water. The attitude of the farmers to practicing agroforestry practices was remarkable. However, lack of capital, seedling shortage, drought, free grazing and labor shortage were mentioned as the major constraints to the practice of agroforestry in the area. Local knowledge, seedling, native tree species, market, good price and construction of water harvesting structures are the opportunities for the development of agroforestry practices, which in turn indicates farmers have an interest to incorporate trees in their land use systems.

**Keywords:** Local knowledge, Agroforestry, Farmer's attitude, Tree-crop interaction, Tree-animal interaction, Vegetation dynamic

**Tesfaye Abebe, 1997. Land Husbandry Education in Agricultural Colleges of Eastern Africa. RSCU Working Paper no. 16. Regional Soil Conservation Unit (RSCU)-Sida and International Centre for Research In Agroforestry (ICRAF), Nairobi.Kenya.**

Agricultural colleges produce middle level manpower who works as frontline extension staff engaged in the dissemination of agricultural knowledge and skills, including soil conservation and agroforestry, to small-scale farmers. To ensure the supply of graduates that are competent in soil conservation and agroforestry principles and practices it is necessary to include recent aspects of these subjects in the syllabus. This study was therefore conducted to make inventory and analysis of the curricula and teaching aspects of agroforestry and soil conservation subjects at sample agricultural colleges in Eastern Africa and make recommendations for improvement. Five sample colleges, one from each RSCU member countries, namely Egerton University (Kenya), Jimma College of Agriculture (Ethiopia), MoA Training Institute-Ukiriguru (Tanzania), Bukalasa Agricultural College (Uganda) and Natural Resources Development College (Zambia) were visited during the months of April and March, 1994. After collection of data from the sample colleges, a preliminary report was produced and this was discussed in a workshop composed of participants from the sample and other colleges, as well as the Extension departments of the Ministries of Agriculture in the respective countries. The main findings regarding the curricula and delivery of the subjects were: (i) Agroforestry: Agroforestry education is gaining firm ground in the curricula due to the interest shown by the colleges and also the support provided by the African Network for Agroforestry Education (ANAFE) and ICRAF. The content of this subject in most of the colleges is based on ICRAF's Agroforestry model course and most of the teaching staff participated in ICRAF's training courses. However, ANAFE has not reached all institutions in the region and attempts should be made to introduce Agroforestry education in the curricula of institutions that have not yet started teaching the subject, such as Jimma college of Agriculture. (ii) Land Husbandry: Soil and water conservation education in the sample colleges emphasizes on physical conservation methods and there is a clear lack of attention to biological and socio-economic aspects. It was recommended that soil and water conservation should be approached from a broad perspective taking into account the whole agricultural enterprise, soil and water conservation being an integrated part of the entire farming activity and farmers' agricultural practices. The term, "Land Husbandry" was considered an appropriate title for such an approach. A model curriculum, for a Land Husbandry course, was developed to serve for diploma level education in agricultural colleges. This curriculum may be used to replace or to complement the existing conventional soil and water conservation curricula. In most of the colleges the introduction of a new course into the existing curriculum is a cumbersome business. The change has to be approved at a high level, in a curriculum review, which takes place only every second year. New resources have to be set aside for the course, etc. So rather than introducing a new "Land Husbandry" course it would, at least initially, be appropriate to include parts of its suggested content in Soil and Water conservation courses. Training of the teaching staff on the principles and practices of Agroforestry and Land husbandry is a crucial element that needs to be given attention. Teaching materials, for use in extension, are available in most of the countries visited. They are produced by ICRAF, RSCU, national ministries, donor supported projects, etc. Thus emphasis should be given to the distribution of such materials to the colleges. Field practical should be a major part of the training at technical level. Due to lack of resources and large class size, practical education is weak in most of the colleges. In this respect, the colleges can be supported, if possible through increased resources, but also by

assisting lecturers to develop practicals more adapted to the new situation. (iii) Institutional Links: The field study as well as the recommendations from the workshop emphasized the importance of institutional linkage at all levels, for the continuous development of land husbandry courses. Linkages between colleges and international or regional organizations, such as ICRAF and RSCU, are important sources of technical backstopping and additional resources, teaching materials etc. The links with the national soil and water conservation programmers is essential to provide contact with farmers and to make sure the syllabi tally with national policies. Linkages between the colleges are important at national level to foster an multidisciplinary exchange, and at an international level to facilitate exchange of staff and information. A joint land husbandry committee at national level was suggested as a means to strengthen the contact within the countries. To facilitate exchange between colleges at an international level a database of staff and resources would be useful. ICRAF has developed a similar database for agroforestry teaching that could easily be expanded to include land husbandry. International and regional organizations such as RSCU and ICRAF have a responsibility to include teaching staff from the technical institutions in their training activities.

**Tesfaye Abebe, 1997. Land Husbandry Education, Research and Extension at the Awassa College of Agriculture. In: Ewnetu et al., 1997 (eds). Land Husbandry in the Highlands of Ethiopia. Proceedings of a Workshop Held at Mekelle, Ethiopia, 10-14 Nov. 1997, ICRAF, Nairobi. pp 101-105.**

Awassa College of Agriculture (ACA), located in the city of Awassa, 275 kms south of Addis Ababa, is one of the leading centres of agricultural education and research in Ethiopia. The three major objectives of the college are 1) to produce middle-and high-level personnel in agricultural sciences, 2) to advance basic, applied and adaptive research in the areas of agriculture and natural resources, and 3) to promote extension and consultancy services. As regards to the first objective, the college runs five diploma and three degree programs in five different areas of specializations. Since its establishment in 1976, the college has produced more than 5000 agricultural professionals at diploma and BSc degree levels. The college also offers various training courses to government and non-government organizations. ACA staff have been active in undertaking problem-solving research that can contribute to the development of sustainable agriculture in the country. Most of the research projects have produced useful outcomes that can be extended to users. At present, the college runs 36 research projects in the areas of agriculture, home science and natural resources. Recently established was the extension unit to strengthen research and extension linkage and to promote extension services to farmers and other users. ACA collaborates with various educational, research and development organizations at national and international levels. Land husbandry, which refers to the care, management and improvement of land resources, is a new approach in the college, superseding the term 'soil conservation'. It recognizes that achieving food security and alleviating land degradation can be realized through proper land management that aims at improved and sustainable production. The term, therefore, encompasses different land management practices, which in the traditional sense have other names. ACA has been offering courses in soil and water conservation, soil fertility and management, soils and water management, agroforestry, and rangeland management, all of which reflect contents and principles of Land husbandry. The courses are offered in the different departments. Similarly, land husbandry related researches have been undertaken in the college. Currently, there are four agroforestry and agronomic research projects that

aim at land management/husbandry. ACA has, therefore, been involved in land husbandry education and research, although the term has not been stated explicitly. Since the problems of food and wood production and environmental degradation can be tackled only in holistic manner, it is necessary to link and coordinate the teaching and research efforts of the different departments under the theme of Land husbandry. Coordinating such efforts at regional and national levels is also of paramount importance to facilitate exchange of information and expertise, for effective use of resources, and to avoid duplication of efforts.

**Tesfaye Abebe, 2000. Indigenous Management and Utilization of Tree Resources in Sidama Zone, Southern Ethiopia. Research Center for Human Environment, Addis Ababa, Ethiopia.**

The Sidama people of Southern Ethiopia manage trees intensively in their farming systems, but little attempt is made to systematically describe and analyse the various characteristics of these indigenous tree management and utilization methods. This study was carried out to understand and analyse the ways in which the Sidama people manage and utilize tree resources. The survey was carried out on 60 randomly selected households, from four Kebeles in Dale and Aleta Wondo districts of Sidama zone. Data were collected using structured interviews, measurements and focus group discussions. The study revealed that farmers in Sidama grow diverse species of trees in different planting arrangements, namely sparsely scattered in farm fields, multistorey homegardens, farm boundaries, live fences and woodlots. The average density of trees was 1500 individuals' ha<sup>-1</sup>, but it varied widely with planting locations: Trees scattered in crop fields have low density of 40-60 trees ha<sup>-1</sup>, while woodlots and boundary plantings have high density of 2,000 to 20,000 individual's ha<sup>-1</sup>. Scattered trees are deliberately kept in low density and managed intensively to minimize their negative effects on associated crops. On the other hand, the eucalypts-dominated woodlots and boundary plantings are aimed at maximizing biomass production. Among the trees, the native species *Cordia africana* and *Milletia ferruginea* are found in all sample farms being grown inside crop fields. They are complimentary to crop production since they serve as shade to understorey crops and improve soil fertility. The other most common species include, *Afrocarpus falcatus*, *Persea americana* and *Eucalyptus spp.* The latter is increasingly becoming a popular cash crop among farmers in the region. Farmers use different tree management practices to promote growth of trees. These practices include propagation, protection and maintenance, interface management and utilization. Tree propagation is often done by means of natural regeneration and the planting of wildlings. This is particularly true to the indigenous species that are mostly difficult to raise from seedlings. Trees such as *Erythrina abyssinica*, *Euphorbia candelabrum* and *Arundinaria alpina* are reproduced from cuttings. On the other hand, most of the exotic species are reproduced from seedlings. Many farmers produce seedlings of eucalyptus for planting and for sale. Farmers also protect and maintain trees during their growing period: Weeding and pruning of dry branches are the commonest practices in this regard. However, practices of fencing around seedlings and saplings are also carried out for more valuable species such as *A.falcatus* and avocado. Depending on the nature of the species, they also apply common tree management practices such as coppicing, pollarding, lopping and pruning. These practices often have multiple purposes. These include reduction of competition from neighboring crops, and provision of wood and fodder. The farmers use different tree parts: the root and bark are often used for medical purposes leaves are used for fodder and medical

purposes. The wood is used for housing construction, fencing, making of farm implements and tools, household utensils, etc. The trees used for such purposes are selected on the basis of their quality (such as durability, density, termite resistance, and luster) to meet the qualities required for the end product. High value native trees are often pollarded or lopped and not wholly harvested. They are felled only when farmers are in need of some cash, or when they need wood for construction purposes. This demonstrates that the farmers have a rational way of utilizing the trees and tree products. Sidama farmers also have a profound understanding of the ecological benefits of trees. Most of the trees that are dispersed in their farms are kept for their contribution to agriculture. They clearly identify the species that contribute to soil and water conservation, provision of shade, and soil fertility improvement, and maintain them in the appropriate niches in the farms. The increasing shortage of wood in urban areas is motivating the farmers to grow trees as cash crop. Many farmers grow eucalyptus for the purpose of income generation. Its adaptation to the locality, low labor requirement, profitability as well as the presence of road infrastructure for transportation has made it the most preferred species by the farmers. Generally, there are well-founded tree management and utilization practices in Sidama which are both ecologically sustainable and acceptable within the existing socio-economic context. External intervention in tree planting and management activities is low, and wherever such attempts were made, they didn't aim at enhancing the traditional tree management strategies and they focused on exotic species. It is therefore advisable that, any intervening organization should devise strategies on how to strengthen these local tree management initiatives. This might give us a wider scope for intensifying tree growing in the area to meet the demands of the future generation.

## 1.2. Diversity in Homegarden Agroforestry Systems

**Ashebir Kebede, 2011. Woody Species Diversity and Management in Traditional Agroforestry Practices in Yeki Woreda, Sheka Zone, Southwestern Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

Agroforestry contributes to agricultural biodiversity as it incorporates species such as trees, shrubs, various crops, and livestock. This study attempts to characterize the major agroforestry practices and woody species diversity and the type, local technical knowledge in use for managing and utilizing agroforestry components. It also identified major socio-economic factors influencing woody species preference and management in Yeki woreda, Southwest Ethiopia. From the woreda, two PAs with traditional agroforestry practices (namely Addisberehan and Ermich PAs) were selected by purposive sampling approach. Selection of villages was also based on two major variables (access to local market and to natural forest) that are believed to affect farm level woody species diversity management. A total of 60 households were selected randomly, from different wealth categories (30 households from poor, 18 households from medium, and 12 households from wealthy). Woody species inventory also carried out from farms of these sampled households. Data for the socio-economic survey were collected through key informant interviews and formal household interview. The qualitative information was summarized while quantitative data were analyzed using SPSS version 17. The results showed that major agroforestry practices of the study site were homegarden, coffee shade, woodlot, and parkland. A total of 80 woody species belonging to 39 families were identified, of which 19% species were recorded as exotic and 71% were indigenous. *Dracaena afromontana*, *Cordia africana*,

*Millettia ferruginea*, and *Albizia gummifera* are the most ecologically important species in the study area. In addition, *Coffea arabica*, *Eucalyptus camaldulensis*, *Mangifera indica*, *Persia americana*, and *Carica papaya* are economically important species. An average of five species, from HG, CFS, and PL and only one species, from WL agroforestry practices were recorded. With increasing wealth status of the households, the tree and shrub species richness increased. The Pearson correlation test showed that family size, farm size, number of livestock, year of possession of the land, and age of head of household are significantly ( $p < 0.05$ ) correlated with woody species diversity. Farmers have accumulated knowledge concerning different tree management practices, such as pruning, thinning, pollarding, coppicing, weeding etc. Farmers managed a considerable number of woody species that contribute to the livelihoods and play a great role for conservation of biodiversity. About 20 different uses of trees and shrubs are identified.

**Key words:** Addisberehan, Coffee shade, Ermich, Homegarden, Local technical knowledge, Parkland, Woodlot.

**Biruk Birhan, 2012. Diversity and Composition of Cultivated Species in Homegardens of Sub-humid Zones in Wadera District of Oromia, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Homegarden agroforestry is widely practiced in the Wadera district of Guji zone, Oromia region, but no study has been made to understand their management as well as species diversity and composition. A total of 60 homegardens were surveyed with an objective of investigating management of homegardens, factors that affect diversity and composition of cultivated plant species and utilization of homegarden products in the study area. Variations in occurrence of homegardens, size of homegardens were observed. The variations observed were best attributed to the difference in; geographic location of homegardens, farm size, distance from market and family size conditions. An average size of homegarden was 0.51ha. The gardens studied could be grouped in to backyards (21.78%), front yards (4.44%), side yards (8.89%), combination yards like side and back yards (50.22%), side and front yards (7.56%) and enclosed yards (7.11%). A total of 36 homegardens were inspected further with an objective of determining diversity and composition of cultivated species in homegardens of the study area. A total, 65 cultivated plant species belonging to 36 families were recorded with an average of 27.5 plant species per homegarden. Rutaceae was the dominant family with 6 species followed by Lamiaceae and Solanaceae 5 species each. Diversity indices ( $H'$ ) of 1.63, 1.99 and 2.06 were recorded for Wadera 01, Chelo Segida and Handoya Keno homegardens respectively. Underlining main use of species, a total of 13 use categories were recognized. Among the recorded species, Maize (*Zea mays* L.) and Potato (*Solanum tuberosum* L.) were major food crops and Khat (*Catha edulis* (Vahl) Forssk. ex Endl.) and Coffee (*Coffea arabica* L.) were major cash crops which were the most frequent specie in the homegardens of the study area.

**Keywords:** Agroforestry, Cash crops, Diversity and composition, Food crops, Guji zone, Homegarden, Wadera.



**Demel Teketay & Assefa Tegineh, 1991. Shade Trees of Coffee in Harerge, Eastern Ethiopia. *International Tree Crops Journal*, 7: 17-27.**

Seven coffee (*C. arabica*) producing provinces (awrajas) in the Harerge administrative region were surveyed to identify shade trees used by farmers in coffee plantations. Fourteen permanent shade species and three temporary shade species were recorded. They represented seven families of flowering plants, with 69% of the species belonging to two families: Fabaceae (Leguminosae) and Moraceae. A new record of a leguminous tree is reported for the region. The habitat/ecology, means of propagation, uses and geographical distribution of the species 'are presented. Recommendations for future studies are made.

**Desta Hamore, 2012. Traditional Agroforestry Homegarden Component Management and its Contribution to Household Livelihood in Tembaro District, Southern Ethiopia. M.Sc. Thesis, Wondo Genet College of forestry and Natural Resources, Hawassa University.**

Homegarden is believed to be more diverse and provide multiple contributions for household than other agroforestry practices due to the intimate association between a multitude of crops, trees and livestock. The objective of this study was to record and describe technical management practices in use, identify the contribution of homegarden towards household livelihood, assess main component types and their arrangement as well as factors that affect species diversity of homegarden agroforestry at Sigezo and Debub ambukuna KAs, Tembaro district, SNNPR, Ethiopia. For this study socio-economic data were collected from 120 households by using semi-structured questionnaires. Both vertical and horizontal structure data were collected during field survey. For species diversity, woody species inventory on garden level was carried out on 120 households randomly selected from three wealth categories. A total of 29 woody species categorized under 22 families were recorded in homegarden agroforestry of the study area. Woody species richness and abundance was significantly higher ( $P < 0.05$ ) both in Debub ambukuna and rich HHs than Sigezo and the rest two wealth categories, respectively. *Coffea arabica*, *Cordia africana*, *Persea americana* and *Mangifera indica* are the most frequently recorded woody species in both site. In order to get better picture on extent of woody species diversity, several diversity indices were employed. The highest Shannon, Simpson and Evenness diversity indices were recorded at Debub ambukuna than Sigezo due to differences in agro-climatic factors, proximity to market place and road access. Planting or retaining of woody species in homegardens depends on farmers' preference. Accordingly, farmers' preference for woody species in the order of: *Coffea arabica* > *Cordia africana* > *Persea americana* > *Mangifera indica* > *Grevillea robusta* > *Albizia gummifera* > *Casimiroa edulis*, etc. based on the benefits they provide. Current study has identified three different vertical arrangements and 4-6 horizontal compartments in both study sites. Homegarden contribute multiple benefits for households. The proportions of HHs benefiting were: Food crops (100%), fuel wood (100%), animal feed (100%), cash crops (100%) and as well as income for improving household economy and construction materials (98%). To sustain all these contributions, farmers carried out management practices such as pruning, thinning, coppicing, pollarding, composting, weeding and hoeing mainly to reduce resource competition, enhance growth, obtain fuel wood and fencing materials and facilitate water infiltration. All members of household have been participating in homegarden management activities. However, women have

been involved in more responsibilities than other members in each of the sites. Farm size, altitude, wealth status, age of household head and accessibility to market/road were the factors associated with species diversity management of homegarden.

**Keywords:** Horizontal and vertical arrangement, Species richness, Woody species, Wealth class

**Desta Mulu, 2013. The Role of Women in Homegarden Management: The Case of Dale district, Southern Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

A study was conducted in three districts of Dale, southern part of Ethiopia, namely: Tula, Debub Mesenkela and Debub Kega, to describe and analyze the different roles of women in home garden management and utilization in Dale District. A multi-stage sampling technique was adopted to select sample households and the methods that were employed for the study were questionnaire and field observation. Ninety (90) households were interviewed and data were analyzed in descriptive manner by using statistics by SPSS version 16. In study area the average size of land holding male headed household was higher than female headed households. The home gardens have provided for surveyed households a lot of economically and ecological services. In study area product of homegarden that is area in percent for male headed household and female headed household was differing in type of crop that cultivated. The study findings have explicitly shown in Land preparation, seed preservation for major crops, planting activities (sowing), application of organic fertilizer, Watering, Harvesting participation of households from these men was higher contribution than his wives. The wives do the planting activity basically for fruit seedling, manuring, harvesting selected crops, storage, transportation, marketing of homegarden products except for cash crops. Women alone was deciding in (72 %) in vegetable (41%); in root crop (75%); in fruit production. There is shared decision making in (15%) in vegetable; (35%) in root crops; in cereal and pulse (15%); in cash crop (21%); in Fodder & forage (8%); in Livestock (30%) and (7%) in fruit tree. Men alone decided on 85% in cereal and pulse, 62% in cash crops, 92% in fodder and forage, and 60% in livestock particularly in large animals. Therefore, In order to improve their decision making, benefit, accesses and control for homegarden products training should be given to DA to grass root level, encourages them to participate in different activities.

**Keywords:** Agroforestry, Gender, Homegarden, Management, Sidama zone, Southern Nation Nationality People's Region

**Ebisa Likassa, 2011. Diversity of Shade Tree Species in Smallholder Coffee Farms of Manasibu District, Western Oromia, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Shade grown coffee has been promoted as means of preserving biodiversity in the tropics even though expansion of coffee cultivation has been seen as contributing factor to deforestation and erosion of biodiversity. In the current study, diversity of shade tree species in selected smallholder coffee farms in Manasibu district, western Oromia was assessed. The aim of the study was to (i) assess tree species diversity and structural parameters in smallholder coffee farms, (ii) evaluate the species diversity and similarity between the coffee farms and the adjacent natural forests, and (iii) assess the effect of species richness,

shade tree structural parameters, and household wealth status on coffee shrub density. The study was conducted in three PAs and six villages purposively selected from the district by selecting HHs following stratified random sampling method in equal proportion from each wealth class. Vegetation data were collected from 74 rectangular plots laid out both in coffee farms (54) and forests (20) with plot area of 35m\*35m and 20m\*20m, respectively. The vegetation data was analyzed for tree diversity, IVI, similarity coefficient, density, BA, shade cover and other structural parameters. One way ANOVA was used to test the significance of the results. A total of 53 tree species were recorded from the coffee farms and the adjacent forests, but 49 and 36 species from the adjacent forests and coffee farms, respectively with 32 species common to both land uses. Species richness was significantly higher in the adjacent natural forest than the coffee farms. Tree species similarity between the land uses as well as among the PAs was high. The highest species richness, diversity, and coffee density were recorded from Mana village of Qorke 01 PA. Furthermore, coffee shrub density was significantly correlated with wealth but not with tree species richness, tree density, and shade cover. The highest mean tree density, BA, shade cover, and coffee shrub density were recorded from rich HHs coffee farms. Tree management practices in the study area coffee farms were more or less the same among the PAs. It was observed that tree species diversity and HH dependency on coffee production increased with the closeness of the PAs and the villages to the adjacent natural forest. It was concluded that traditional coffee production system (growing coffee under the shade of trees) is an important land use system in slowing down loss of biodiversity and should therefore be encouraged.

**Keywords:** Diversity, Manasibu district, Shade trees, Smallholder coffee farms, Western (Oromia) Ethiopia

**Essayas Abebe, 2013. Woody Species Diversity, Management and Uses in Agroforests of Yirga- Cheffe Wereda, Gedeo Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources. Hawassa University.**

This study was designed with the objective of understanding the extent of woody species diversity, composition, managements and uses. Data for the study were collected through 40 key informant's discussion and they *categorized the villagers into wealth status* based on local wealth indicators. Both socio-economic and vegetation inventory data was gathered by formal questionnaire survey from 120 respondents and 120 sample plots. Over all 45 woody species representing 27 families were recorded of which 56.5% and 43.5% were trees and shrubs respectively, whereas 80% of the species were indigenous and 20% were exotic to the area. The mean numbers of woody species richness were 5 per household and 12.7 per study sites. Regarding gardens *the mean numbers of woody species richness were 4.4 in homegarden and 5.6 in village forest gardens. The mean numbers of woody species richness in rich, medium and poor farmers were 4.6, 5.0 and 5.6 respectively. Finally there was no significant difference in woody species richness were observed among the wealth status, between two gardens and study sites. The horizontal structure of agroforest was assessed considering basal area, volume and stem density.* Overall mean basal area of the woody species were 12.3 m<sup>2</sup> per ha while 15m<sup>2</sup> per ha was recorded *in village forest gardens and 10m<sup>2</sup> per ha in homegardens. The highest basal area of woody species were recorded at wealthier gardens and followed by medium and poor. The mean trees volume was 149 m<sup>3</sup> per ha, while 175m<sup>3</sup> was recorded in village forest gardens and 123m<sup>3</sup> at homegardens.* There was significant difference observed in mean basal area and volume

between two gardens and between rich and poor wealth status. The mean stems density of woody species in the study sites were 5095 per ha, while 5380 and 4810 stems per ha were recorded at village-forest gardens and homegarden agroforest respectively. The highest stems density per ha were recorded at poor HHs and followed by medium and rich. The vertical structure of agroforests was assessed in terms of top height woody abundance and show inverted" u" shape. Farmers obtained multiple benefits from woody species such as soil fertility improvement, shade, timber, fuel wood, cash source, fodder, food and bee forage. The communities have indigenous knowledge in woody species management practices such as pruning, thinning, composting, planting, weeding and cultivation. Disease and pest of woody and non woody plants were common phenomena. The cultural measures that adopted by HHs were planting disease and pest *protector species such as Millettia ferruginea close to Enset plants, Plumeria alba in side enset farms, Croton macrostachyus in side coffee farms and Euphorbia abyssinica surrounding enset and coffee farms. In addition to this keeping sanitation of the farms uses separate farm tools, planting in aerated pits and adding compost before and after planting were implemented.* Agroforest is characterized by having more diverse species, structures and contributions for households and known for being sustainable land use.

**Keywords:** Homegarden, Village-forest garden, Coffee, Enset, Indigenous knowledge, Income

**Ewuketu Linger, Zebene Asfaw & Solomon Zewdie, 2014. Plant Species Diversity of Homegarden Agroforestry in Jabithenan District North West Ethiopia. *International Journal of Biodiversity and Conservation*, 6 (4) : 301-307.**

Homegarden agroforestry is believed to be more diverse due to the combination of crops, trees and livestock. The main aim if this study was to assess plant composition and diversity Homegarden agroforestry in Jabithenan district North West Ethiopia. Two site purposefully and two villages randomly selected. Plant species diversity inventories were carried out for 48 homegardens. All woody and herbaceous species were counted and recorded 10m x 10m and 2m X 2m plots, respectively. A total of 69 plant species (44 wood and 25 hebaceous) belonging to 40 families were recorded in the study homegardens. About 6-8 different species of plants were recorded. Plant species such as *Musa paradisiaca* and *Brassica integrifolia* among herbs and *Coffea arabica* and *Cordia Africana* were among the most frequently recorded species in the study Kebeles. Of all woody species, *C. arabica* and *C. Africana* showed the highest important value index. Generally according to calculated diversity, the studied homegarden was found be diverse.

**Keyword:** Composition, Diversity, Important value index

**Galfato Gabiso, 2011. The Role of Women in the Management and Utilization of Homegarden Agroforestry System: The Case of Boricha & Wondo Genet Woredas of Sidama, SNNPR, Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

Ethiopian rural women make significant contribution to agriculture sector and are the mainstay of the farm labor. Despite, their active engagement in agriculture, women are neglected from control of resource because of socio-cultural barriers. The study was conducted in Boricha and Wondo Genet woredas of sidama zone southern Ethiopia with the

major objective of assessing the role of women in agroforestry homegarden management and acquisition of benefits for themselves and communities. Data were collected from 90 households using different methods that include interviews, vegetation inventory and questionnaire survey. The finding revealed that (1) farmers manage homegarden for ecological and economic benefit according to availability of natural resources in the surrounding (2) women are mostly involved in homegarden management-related activities and interested in conserving homegardens biodiversity to obtain benefits as food security, income, and environmental benefits. (3) Women contribute about 50% of the labour and control 33% of income of household. (4) The plant species richness was studied and 108 plant species are recorded. The distance to market, wealth states and number of cattle are significant at ( $P < 5\%$ ) Homegarden contribute 83% of total annual income for the household at all and women control 24-40% of income share. The number of species and farm size are significant at ( $P < 5\%$ ) and off farm income is significant at ( $P < 0.01$ ) for income of household income in the study areas. The findings also suggest that increased involvement of women in a broad range of homegarden management activities is not only beneficial for their own socio-economic well-being, but also for community and for preserving the agro-biodiversity in homegardens

**Getahun Yakob, 2011. Diversity and Management of Woody Species in Homegardens Agroforestry in Gimbo Woreda, South West Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Homegardens agroforestry in southern Ethiopia are traditional management practices with relatively high species diversity, complex structure and multiple functions but not well studied. To contribute to understanding of the current status, the study was conducted to assess the diversity of woody species in homegardens and farmers' strategy of managing woody species diversity at Gimbo district, South West Ethiopia. A systematic sampling strategy was used to collect vegetation data from homegardens and natural forest, while simple random sampling was used to select sample households within wealth categories. A total of 120 households were selected for interview. A questionnaire was developed to gather information on farmers' strategy of managing woody species diversity. The data on species diversity in homegardens and natural forest was collected from 120 and 60 plots respectively. A total of 73 woody species were recorded from homegardens and natural forest in the study area. The number of woody species in the homegardens was 57, of which, 76% were indigenous while the remaining 24% were exotic. Diversity of woody species in the homegardens was variable. Lower diversity indices were recorded at the villages that were relatively closest to the market. The diversity indices of woody species were also higher for the adjacent natural forests than homegardens. Of all the recorded species from homegardens, *Persea americana* is the most important woody species. The abundance of *Persea americana* and *Millettia ferruginea* was highest in the  $< 5$  cm DBH range and least in 51-60 cm DBH ranges. Wealth status of the household influenced the species diversity of homegardens. At Shera and Shuba villages, the wealthier households were found to own more number of woody species. At all studied villages, the the largest number of stems per garden was recorded on gardens of wealthy households. In general, the rationales for retaining woody species in the homegardens were fuelwood, provision of shade and construction wood, in increasing importance order. Whereas the

reasons for planting woody species were income generation, shade and fruit, in increasing importance order. The study showed that homegardens play a remarkably high role in conserving biodiversity.

Keywords: Species, Composition, Use, Wood production, Wealth class, Natural forest, Species rich-ness

**Getahun Yakob, Zebene Asfaw & Solomon Zewdie, 2014. Wood Production and Management of Woody Species in Homegardens Agroforestry: The Case of Smallholder Farmers in Gimbo District, South West Ethiopia. International Journal of Natural Sciences Research, 2 (10): 165-175.**

Homegardens are defined as a system of production of diverse plant species, which can be adjacent to household or slightly further away and is easily accessible. Wood production and management systems of Kaffa homegardens are poorly known. The study was conducted to assess the wood production and farmers' strategy of managing woody species in Gimbo district, South West Ethiopia. A complete homegarden woody species inventory was carried out to collect vegetation data, while simple random sampling was used to select sample households within wealth categories. From two purposely selected sites, a total of 120 households were selected for interview and vegetation data collection. Semi-structured interviews, direct observation and focus group discussions were employed to gather information on farmers' strategy of managing woody species. The DBH of all trees and shrubs  $\geq 5\text{cm}$  was measured. The mean number of stems per garden was 34, ranging between 6 to 99. Wealth status of the household influenced the wood production of homegardens. At all studied villages, the largest number of stems per garden was recorded on gardens of wealthy households. Various trees and shrubs are managed on the same piece of land. About 92% of the respondents have retained different woody species in their homegardens while converting the original forest to settlement areas. Some woody species like *Millettia ferruginea*, *Vernonia amygdalina*, *Ficus sur*, *Croton macrostachyus* and *Sapium ellipticum* were more frequently retained than others. In general, the reasons for planting woody species were income generation, shade and fruit, in increasing importance order. About 96 % of the respondents did practice different types of management activities for the woody species they owned. The common management practices carried out in the homegardens were thinning, pruning, fertilizing, watering, protection, coppicing and lopping. However, only 2% of the respondents did practice compost preparation. Diseases of coffee and fruit trees were the major problem faced by the farmers in woody species management. Therefore, it is recommended that appropriate intervention either through research or extension has to take place in order to reduce the impacts

**Hintsa Muruts, 2012. Diversity and Management of Plant Species in Homegardens Agroforestry in Hintalo Wajerat district, Tigray, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Homegardens are intensive land-use systems involving the management of woody species grown in deliberate association with herbaceous species, with or without livestock, managed within the compounds of individual homes. Most studies on homegardens have been carried out in humid or subhumid regions of Ethiopia, thereby overlooking homegardens in arid and

semi-arid regions. To contribute to understanding on the current status, a study was conducted in the homegardens of rural villages in the semi-arid of Hintalo Wajerat district, Tigray, Ethiopia, from December to February 2012 to assess the diversity of plant species in homegardens and farmers' strategy of managing plant species. Questionnaire was developed to gather information on farmers' strategy of managing plant species diversity. For species diversity and related parameters, plant species inventory were carried out in homegarden agroforestry practices of 60 households randomly selected from three wealth categories. A systematic sampling strategy was used to collect herbaceous species. Woody species > 5cm DBH (1.30cm height) were measured and recorded, and all woody species < 5 cm DBH were counted and recorded in 10m x 10m (100m<sup>2</sup>) laid twice in a garden. The result showed highest species richness (for both woody and herbaceous) was recorded at Melebe village. The mean value of woody species abundance per plot was significantly ( $P < 0.05$ ) different among the study villages. Lowest diversity indices for woody species were recorded at Ade-kolo village while at Ade-abyeto for herbaceous species. Differences exist in the diversity and composition of plant species in the homegarden among the households and villages. Homegarden size, source of water and wealth status were particularly responsible for the variation. Four woody species namely, *Rhamnus prinoides*, *Psidium guajava*, *Eucalyptus camaldulensis* and *Catha edulis* showed the highest importance value index. Species with multiple uses as well as high commercial value lead to high IVI values. The study identified four main plant use categories, namely food, medicinal, wood and structurally functional species. To sustain all these uses, farmers carried out management practices such as pruning, fertilizing, weeding, hoeing and watering. The study showed that homegardens play a remarkably high role in conserving biodiversity.

**Keywords:** Diversity indices, Herbaceous species, Households, Species richness, Woody species.

**Kitessa Hunder, Raf Aerts, Alexandre Fontaine, Maarten Van Mechelen Pieter Gijbels, Olivier Honnay, Bart Muys 2013. Effects of Coffee Management Intensity on Composition, Structure, and Regeneration Status of Ethiopian Moist Evergreen Afromontane Forests. Environmental Management, 51(3):801- 809.**

The effect of arabica coffee management intensity on composition, structure, and regeneration of moist evergreen Afromontane forests was studied in three traditional coffee-management systems of southwest Ethiopia: semiplantation coffee, semiforest coffee, and forest coffee. Vegetation and environmental data were collected in 84 plots from forests varying in intensity of coffee management. After controlling for environmental variation (altitude, aspect, slope, soil nutrient availability, and soil depth), differences in woody species composition, forest structure, and regeneration potential among management systems were compared using one way analysis of variance. The study showed that intensification of forest coffee cultivation to maximize coffee production negatively affects diversity and structure of Ethiopian moist evergreen Afromontane forests. Intensification of coffee productivity starts with the conversion of forest coffee to semiforest coffee, which has significant negative effects on tree seedling abundance. Further intensification leads to the conversion of semiforest to semiplantation coffee, causing significant diversity losses and the collapse of forest structure (decrease of stem density, basal area, crown closure, crown

cover, and dominant tree height). Our study underlines the need for shade certification schemes to include variables other than canopy cover and that the loss of species diversity in intensively managed coffee systems may jeopardize the sustainability of coffee production itself through the decrease of ecosystem resilience and disruption of ecosystem services related to coffee yield, such as pollination and pest control.

**Keywords:** Afromontane forest, *Coffea arabica*, Coffee certification, Ecosystem services, Extinction debt, Traditional coffee management, Wild coffee

**McNeely J.A. & Schroth G., 2006. Agroforestry and Biodiversity Conservation-Traditional Practices, Present Dynamics, and Lessons for the Future. *Biodiversity and Conservation*, 15:549–554.**

The environmental services that agroforestry practices can provide, and especially their potential contribution to the conservation of biodiversity, have only recently attracted wider attention among agroforestry and conservation scientists. This new view is consistent with the ecosystem approach to natural resource management advocated by the Convention on Biological Diversity. This collection of six papers, which is based on a Workshop held in June–July 2004, brings together studies of biodiversity impacts of traditional agroforestry practices from Central and South America, Africa and Asia. The contributions highlight the considerable potential of traditional agroforestry practices to support biodiversity conservation, but also show their limits. These include the importance of sufficient areas of natural habitat and of appropriate hunting regulations for maintaining high levels of biodiversity in agroforestry land use mosaics, as well as the critical role of markets for tree products and of a favourable policy environment for agroforestry land uses. In combination the case studies suggest that maintaining diversity in approaches to management of agroforestry systems, along with a pragmatic, undogmatic view on natural resource management, will provide the widest range of options for adapting to changing land use conditions.

**Mengistu Teshome, 2014. Comparative Analysis of Woody Species Diversity in Agricultural Landscape and Adjacent Natural Forest of Mount Duro, Arsi Negele, South central Rift valley, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Crop fields have a role to contribute native woody species conservation. Understanding plant species diversity and spatial distribution along environmental gradients is crucial in the long-term management of the remnant natural forest. This study aimed i) to analyze population structure of native woody species on agricultural landscape and natural forest as well as diversity along altitudinal ranges in natural forest; ii) to compare native woody plant species diversity and richness of crop fields and Mount Duro natural forest; iii) to identify plant community type of Mount Duro natural forest; iv) to characterize the relationships between some selected environmental variables and plant communities. Systematic sampling design was used to collect all native woody species (Tree/shrub) with a total of forty two plots in crop field (sizes = 50x100m) and in natural forest (size=20x20m) were arranged along three transect line. In natural forest within main plots at four corners four sub-plots and in the center one sub-plot of 1m x 1m was laid for herbaceous plants assessment and also environmental variables such as altitude, aspect and slope were



recorded for main quadrat. Shannon diversity index, Evenness and species richness were employed to detect diversity between crop field and natural forest. A total, 48 native woody species recorded from crop field and natural forest. The highest number of native woody species (41) was recorded in natural forest than crop field (27). Despite the low species number, crop fields showed higher evenness. This was due to uniform distribution of individual species in crop fields. Population pattern of native woody species in natural forest shows inverted J-shape whereas in crop field revealed J-shape. In natural forest four community types were identified using TWINSpan analysis. *Vernonia myriantha*, *Vangueria adagascariensis*, *Bersama abyssinica* (community II) exhibit highest Shannon diversity. The canonical correspondence analysis (CCA) revealed that the association of species explained by altitude, slope and aspect. The finding generally suggested that crop field in study area has a role to contribute large native woody species conservation. Environmental variables such as altitude, slope and aspect explain the distribution of plant diversity through regulating soil moisture, temperature and water run off at mountain area. Therefore, the large native woody species which have J-shape pattern in crop field needs to be regenerate. Moreover, any intervention should take into account these four discrete community types and their environmental settings to make the intervention more successful.

**Keywords:** Native woody species, Diversity, Crop field, Population structure, Plant community, Environmental variables

**Mesele Negash, Eshetu Yirdaw & Olavi Luukkanen, 2012. Potential of Indigenous Multistrata Agroforests for Maintaining Native Floristic Diversity in the South-Eastern Rift Valley Escarpment, Ethiopia. *Agroforestry Systems*, 85:9–28.**

Most studies undertaken in the field of agroforestry have focussed on system design, soil fertility management, and system interactions. Less emphasis has been placed on biodiversity aspects. The aim of this study is to investigate the potential of indigenous, multistrata agroforests for maintaining native woody species diversity in the south-eastern Rift Valley escarpment, Ethiopia. A total of 60 farms, representing three agroforest types (enset-AF, enset-coffee-AF and fruit-coffee-AF), were randomly selected along altitudinal gradients. Enset (*Ensete ventricosum*) is a perennial, herbaceous monocarpic banana-like plant which serves as a food plant in Ethiopia. The three agroforests are results of the domestication of natural forests and intensification of the land use systems centuries ago. Sample-based assessment protocols were employed to place sample quadrats and to measure all individuals in the quadrats. A total of 58 woody species, belonging to 49 genera and 30 families, was recorded. Of all woody species identified, 86% were native. The highest proportion of native woody species was recorded in enset-AF (92%), followed by enset-coffee-AF (89%) and fruit-coffee-AF (82%). Among native tree species, *Millettia ferruginea* and *Cordia africana* were the most widespread. In all, 22 native woody species were recorded as of interest for conservation, according to IUCN Red lists and local criteria. Among them, *Pygeum africanum* and *Rhus glutinosa* were categorised as vulnerable in the wild, and in need of conservation priority. The introduction of non-native fruit trees in agroforests can be a threat to maintenance of native woody species. Management strategies favouring enset and coffee will also put other native tree species at risk. A smaller number of native woody species was recorded in fruit coffee-AF, but a higher mean basal area and stem number. The mean basal area and stem number ranged from  $5.4 \pm 0.5$  to  $11.7 \pm 1.0$

m<sup>2</sup> ha<sup>-1</sup> and 625 ± 84 to 1,505 ± 142 stems ha<sup>-1</sup>, respectively. Altitude explained 68 and 71% of the variation in species richness and abundance, respectively. Finally, it is concluded that recognition of the indigenous agroforestry system as an option for maintaining native woody species should be given more attention, to counteract the local threat of these species from the wild.

**Keywords:** Biodiversity, Enset, Fruit trees, Gedeo, Native species

**Motuma Tolera, Zebene Asfaw, Mulugeta Lemenih & Erik Karlun, 2008. Woody Species Diversity in a Changing Landscape in the South-Central Highlands of Ethiopia. *Agriculture, Ecosystems & Environment*, 128 (1-2): 52-58.**

Ethiopia hosts one of the richest flora and fauna resources in tropical Africa. However, this rich bioresource is decreasing due to extensive deforestation. The objectives of this study were to (i) investigate woody species diversity on smallholder cultivated land (crop fields and homegardens) and its implication for biodiversity changes over time; (ii) assess the dynamics of woody species diversity, density and structure with age of crop fields since conversion from natural forest using a chronosequence of farm fields; and (iii) assess the effects of some household and homegarden characteristics on woody species diversity around homegardens in the south-central highlands of Ethiopia. Woody species diversity in the adjacent natural forest was used as a reference. Systematic sampling was used to collect vegetation data from crop fields and natural forest, while simple random sampling within wealth categories was used to select sample households and their homegardens. In total, 70 woody species were recorded. The highest number of woody species (64) was recorded in homegardens, followed by crop fields (32) and the lowest number (31) in remnant natural forest. Despite the low species number, natural forest showed higher Shannon and Simpson diversity indices and Shannon evenness than crop fields and homegardens. This was due to the uniform distribution of species in natural forest compared with homegardens or crop fields. The diversity and density of woody species declined with increasing age of crop fields, while diversity of woody species increased with increasing age and size of homegardens. Wealth status of the households also affected species diversity in homegardens. Rich households kept a greater number of woody species, probably due to their larger-sized homegardens. Generally, the study showed that conversion of natural forest into cultivated land (mosaics of homegardens and crop fields) typical of the smallholder system in the highlands of Ethiopia does not result in a dramatic loss of species but that the spatial distribution, density and species composition may be altered.

**Osemeobo G.J., 1987. Smallholder Farmers and Forestry Development: A Study of Rural Land Use in Bendel, Nigeria. *Agricultural Systems*, 24: 31-51.**

The supply of forest products has lagged behind the demand in Bendel State, Nigeria. This derives from unplanned growth of wood-based industries and low capital input in afforestation programmes. Another reason has to do with the general misconception that the supply of timber to wood-based industries is solely a government venture. In the face of these problems, forest regeneration efforts within the reserves could not keep pace with the rate of timber exploitation. It is on the basis of the foregoing deficiencies of wood supply that the land outside reserve boundaries forms an alternative source of timber production. The

study described in this paper explored ways of integrating tree planting into the traditional farming system. Data were collected through a questionnaire survey. A sampled population of 300 rural farmers was randomly selected from 32 settlements in Bendel State. Available data indicate high prospects for wood production by the smallholder farmers. This form of land use is favoured by the land tenure system, willingness of farmers to plant trees and the long fallow periods of between 6 and 12 years. However, successful adoption of tree planting relies heavily on cost-sharing devices between government and rural farmers, virile extension services and the possibility of tree crops to generate cash flow.

**Raf Aerts, Gezahegn Berecha, Pieter Gijbels, Kitessa Hundera, Sabine Van Glabeke, Katrien Vandepitte, Bart Muys, Isabel Roldán-Ruiz & Olivier Honnay, 2012. Genetic Variation and Risks of Introgression in the Wild *Coffea arabica* Gene Pool in South-Western Ethiopian Montane Rainforests. *Evolutionary Applications*, 6(2): 243–252.**

The montane rainforests of SW Ethiopia are the primary centre of diversity of *Coffea arabica* and the origin of all Arabica coffee cultivated worldwide. This wild gene pool is potentially threatened by forest fragmentation and degradation, and by introgressive hybridization with locally improved coffee varieties. We genotyped 703 coffee shrubs from unmanaged and managed coffee populations, using 24 microsatellite loci. Additionally, we genotyped 90 individuals representing 23 Ethiopian cultivars resistant to coffee berry disease (CBD). We determined population genetic diversity, genetic structure, and admixture of cultivar alleles in the in situ gene pool. We found strong genetic differentiation between managed and unmanaged coffee populations, but without significant differences in within-population genetic diversity. The widespread planting of coffee seedlings including CBD-resistant cultivars most likely offsets losses of genetic variation attributable to genetic drift and inbreeding. Mixing cultivars with original coffee genotypes, however, leaves ample opportunity for hybridization and replacement of the original coffee gene pool, which already shows signs of admixture. In situ conservation of the wild gene pool of *C. arabica* must therefore focus on limiting coffee production in the remaining wild populations, as intensification threatens the genetic integrity of the gene pool by exposing wild genotypes to cultivars.

**Raf Aerts, Kitessa Hundera, Gezahegn Berecha, Pieter Gijbels, Marieke Baeten, Maarten Van Mechelen, Martin Hermy, Bart Muys & Olivier Honnay, 2011. Semi-forest Coffee Cultivation and the Conservation of Ethiopian Afromontane Rainforest Fragments. *Forest Ecology and Management*, 6 (15):1034–1041.**

*Coffea arabica* shrubs are indigenous to the understory of the moist evergreen montane rainforest of Ethiopia. Semi-forest coffee is harvested from semi-wild plants in forest fragments where farmers thin the upper canopy and annually slash the undergrowth. This traditional method of coffee cultivation is a driver for preservation of indigenous forest cover, differing from other forms of agriculture and land use which tend to reduce forest cover. Because coffee farmers are primarily interested in optimizing coffee productivity, understanding how coffee yield is maximized is necessary to evaluate how, and to what extent, coffee production can be compatible with forest conservation. Abiotic variables and biotic variables of the canopy were recorded in 26 plots within 20 forest fragments managed as semi-forest coffee systems near Jimma, SW Ethiopia. In each plot, coffee shrub characteristics and coffee yield were recorded for four coffee shrubs. Cluster and indicator

species analyses were used to differentiate plant communities of shade trees. A multilevel linear mixed model approach was then used to evaluate the effect of abiotic soil variables, shade tree plant community, canopy and stand variables, coffee density and coffee shrub size variables on coffee yield. Climax species of the rainforest were underrepresented in the canopy. There were three impoverished shade tree communities, which differed in tree species composition but did not exhibit significant differences in abiotic soil variables, and did not directly influence coffee yield. Coffee yield was primarily determined by coffee shrub branchiness and basal diameter. At the stand level a reduced crown closure increased coffee yield. Yield was highest for coffee shrubs in stands with crown closure less than median ( $49\pm 1\%$ ). All stands showed a reduced number of stems and a lower canopy compared to values reported for undisturbed moist evergreen montane rainforests. Traditional coffee cultivation is associated to low tree species diversity and simplified forest structure: few stems, low canopy height and low crown closure. Despite intensive human interference some of the climax species are still present and may escape local extinction if they are tolerated and allowed to regenerate. The restoration of healthy populations of climax species is critical to preserve the biodiversity, regeneration capacity, vitality and ecosystem functions of the Ethiopian coffee forests.

**Rudel T.K., 2009. Tree farms: Driving forces and regional patterns in the global expansion of forest plantations. *Land Use Policy*, 26: 545–550.**

People have planted trees in rural places with increasing frequency during the past two decades, but the circumstances in which they plant and the social forces inducing them to plant remain unclear. While forests that produce wood for industrial uses comprise an increasing number of the plantations, most of the growth has occurred in Asia where plantations that produce wood for local consumption remain important. Explanations for these trends take economic, political, and human ecological forms. Growth in urban and global markets for forest products, coupled with rural to urban migration, may spur the conversion of fields into tree farms. Government programs also stimulate tree planting. These programs occur frequently in nations with high population densities. Quantitative, cross-national analyses suggest that these forces combine in regionally distinctive ways to promote the expansion of forest plantations. In Africa and Asia plantations have expanded most rapidly in nations with densely populated rural districts, rural to urban migration, and government policies that promote tree planting. In the Americas and Oceania plantations have expanded rapidly in countries with relatively stable rural populations, low densities, and extensive tracts of land in pasture. If, as anticipated, the growing concern with global warming spurs further expansion in forest plantations in an effort to sequester carbon, questions about their social and ecological effects should become more pressing.

**Scott D.F & Lesch W., 1997. Stream Flow Responses to Afforestation with *Eucalyptus* and *Pinus* and to Felling in the Mokobulaan Experimental Catchments, South Africa. *Journal of Hydrology*, 199 (3-4): 360-377.**

The reductions in stream flow following the afforestation of grassland with *Eucalyptus grandis* and *Pinus* pun & in the Mokobulaan research catchments on the Mpumalanga escarpment, and the subsequent response in stream flow to clear-felling of the eucalypts are presented. Afforestation with eucalypts of an entire catchment with a virgin annual runoff

of 236 mm, caused a statistically significant decrease in stream flow in the third year after planting and the stream dried up completely in the ninth year after planting. The eucalypts were clear felled when 16 years old but full perennial stream flow did not return until five years later. Afforestation with pines of an entire catchment with a virgin annual runoff of 217 mm, produced a significant decrease in stream flow in the fourth year after planting and caused the stream to dry up completely in the twelfth year after planting. The drying up of the streams was not altogether surprising as the annual runoff was lower than the expected reductions owing to complete afforestation. The delayed return of stream flow in the clear felled catchment is surprising though, and is attributed to the desiccation of deep, soil-water stores by the eucalypts. These stores had to be replenished before the streams could return to normal behaviour.

**Keywords:** Afforestation, *Eucalyptus grandis*, *Pinus patula*, Streamflow, Clearfelled catchment

**Salam M.A., Noguchi T. & Koike M., 2000. Understanding why Farmers Plant Trees in the Homestead Agroforestry in Bangladesh. *Agroforestry Systems*, 50: 77–93.**

Because trees cover only 6.4% of the total land area of Bangladesh, while agricultural expansion continues to massively deplete the natural forests, a well-managed homestead forestry practice is vital for reversing the existing trend and promoting the ecological balance of the country. An understanding of the decision-making process of the farmers who practice homestead forestry is important in expanding and improving the practice. This paper seeks to characterize and analyze factors influencing farmers' decisions about tree planting. Logistic and multiple regression analyses were applied to determine the factors that influence the farmers' tree-planting decisions. The analyses demonstrate a number of important conclusions: (i) tree planting increases with the amount of homestead land owned; (ii) farmers whose main source of income is non-agricultural are more likely to decide to plant trees in the homestead; (iii) purchasing cost of fuelwood has a positive influence on tree-planting decisions; (iv) number of male family member has a positive influence on farmers' tree-planting decisions; and (v) knowledge of the activities of the forestry extension programs has a positive influence on tree-planting decisions. The results of the study demonstrate that, in recent years, farmers' decisions of whether or not to plant trees have been based primarily on economic rather than ecological concerns. It is concluded that there is substantial potential for the improvement of homestead forestry, and that properly managed homestead forestry can alleviate the poverty of rural people by increasing overall household income. To this end, it is suggested that forestry extension workers work more closely with the local people in order to implement homestead forestry.

**Teklehaimanot Z., Jones M., Sinclair F. L., 2002. Tree and Livestock Productivity in Relation to Tree Planting Configuration in a Silvopastoral System in North Wales, UK. *Agroforestry Systems*, 56 (1): 47-55.**

Silvopastoral systems in Europe offer the potential of introducing environmental benefits while at the same time increasing the diversity of farm outputs. The establishment of new silvopastoral systems by planting young trees into existing pasture was investigated at a site in North Wales, UK. Two tree species, sycamore (*Acer pseudoplatanus* L.) and red

alder (*Alnus rubra* Bong.), were planted into pasture at a range of densities and planting arrangements. Growth of trees planted in farm woodland blocks (2500 stems ha<sup>-1</sup>) was compared with the growth of trees planted at 400 stems ha<sup>-1</sup> in clumps and dispersed throughout the plot and at 100 stems ha<sup>-1</sup> (dispersed). Over the first six years after planting, alder trees were significantly taller and larger in diameter than sycamore. Sycamore trees planted at close spacing in farm woodland or clumped arrangements were significantly larger in diameter than widely spaced sycamore at 100 and 400 stems ha<sup>-1</sup>. Livestock productivity was unaffected by the presence of trees during the six-year establishment phase of the system. The planting of trees in a clumped pattern appears to combine silvicultural benefits to tree growth with agricultural benefits of maintaining livestock production while trees are established.

**Taye Kufa & Mand J. Burkhardt, 2011. Plant Composition and Growth of Wild *Coffea arabica*: Implications for Management and Conservation of Natural Forest Resources. *International Journal of Biodiversity and Conservation*, 3 (4): 131-141.**

The montane rainforests of Ethiopia are the only places of origin and genetic diversity for *Coffea arabica* species. These natural forest areas with the occurrence of wild coffee gene pools are however under constant threats, largely due to anthropogenic activities. The study aims to determine the variability in plant compositions and growth of wild *Coffea arabica* trees in the natural forests of southeastern and Southwestern Ethiopia. The data were collected at twelve study sites. The dominant plants were broadly classified into three forest canopy strata with varying vegetation coverage among and within the study forests. The average abundance of large shade trees, wild coffee plants and shrubs was highest at Berhane-Kontir, Yaju and Bonga natural forests, respectively. The frequency of the respective plant forms was highest at Birhane-Kontir (61%), Harena (53%) and Bonga (68%). The occurrence of the semi-domesticated spices crops was higher in the Bonga and Berhane-Kontir forests. The average plant density followed the descending order of Bonga>Yaju>Birhane-Kontir>Harena forest, largely reflecting anthropogenic impacts. There was negative association between the growth of the coffee trees and the undergrowth shrubs. In contrast, the upper canopy large trees and coffee plants had direct relationships. However, the vegetative and reproductive growth responses of wild coffee plants were impaired, partly due to the multiple stresses in the dense forest ecology. Consequently, more than 70% of the total surface area of coffee trees did not bear crops and altogether coffee yield was low. The highest and lowest reproductive efficiencies were obtained from the Harena and Yaju wild coffee populations, demonstrating the levels of coffee forest management practices. Overall, our findings indicated great variations in the patterns of plant co-existences and growth natures of wild coffee trees and underlines in multiple benefits of coffee forest environments, among others, as natural coffee gene pools. This depicts the need for multi-site in situ conservation and environmental management planning for sustaining biodiversity conservation and maintaining ecosystem goods and services in Ethiopia and worldwide.

**Keywords:** Biodiversity, Ethiopian wild coffee, Genetic conservation, Natural coffee forest, Plant composition

**Tefera Jegora, 2011. Woody Species Diversity and Management in Homegarden Agroforestry in Shashemene District, Oromia, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Homegarden is believed to be more diverse and provide multiple contributions for household than other agroforestry practices due to the intimate association between a multitude of crops, trees and livestock. The present study was carried out in Shasha I and Shasha II villages (Ilala Korke KA) and Wotara and Bake villages (Wotara Shagule KA), Shashemene district, Ethiopia. Management related data were collected by using both informal and formal surveys. For species diversity and related parameters, woody species inventory were carried out in homegarden agroforestry practices of 60 households. The HHs was randomly selected from three wealth categories. Woody species  $\geq 5\text{cm}$  dbh at breast height were measured and recorded. All woody species with dbh  $< 5\text{cm}$  were counted and recorded in  $10\text{m} \times 10\text{m}$  homegarden size. Accordingly, a total of 36 woody species were recorded, of which 58% were indigenous to the area. The overall mean number of woody species per plot was 3.13. Shasha I and Shasha II villages showed higher woody species richness and abundance than Wotara and Bake villages due to proximity to market place and road access. Four woody species namely, *Cordia africana*, *Croton macrostachyus*, *Persea americana* and *Catha edulis* showed the highest importance value index. However, farmers' preference for selected woody species in homegarden agroforestry was in the order of *Cordia africana* > *Eucalyptus camaldulensis* > *Croton macrostachyus* > *Cupressus lusitanica*. The similarity in woody species composition between the study villages ranged from 0.46 to 0.60. Five woody species were common to all study villages. Higher basal area per plot and per hectare was recorded in Ilala Korke. To sustain the management of all woody species, farmers carried out management practices such as pruning, thinning, composting, weeding, digging and watering. Farmers in the study area encountered with problems such as lack of enough garden size, market and road access for diversifying woody species in homegarden agroforestry. The aim of the study was to assess woody species diversity, local farmers' management practices of woody species as well as factors that influence the diversity and management techniques of these woody species in homegarden agroforestry.

**Temesgen Addise, 2012. Plant Diversity in Traditional Homegardens and Their Socioeconomic Contributions in Lemo District, Hadiya Zone, SNNPRS, Ethiopia. M.Sc. Thesis, Wondo Genet College of forestry and Natural Resources, Hawassa University.**

The practice of traditional agroforestry homegardens encompasses wealth of plant diversity, which provides socio-economic and ecological benefits for the local people of the study area. The present study was carried out to assess plant diversity in traditional homegardens and their socioeconomic contributions in Lemo District, Hadiya Zone, SNNPRS, Ethiopia. Two representative Kebeles from each agroecological zones (highland and midland) were selected purposively based on proximity to market and access to road. A total of 120 sampling households (30 from each of the four Kebeles) were selected with stratified random sampling procedures to administer formal survey. Inventory of plant diversity was conducted in 36 household homegardens. All woody plants with  $\geq 5\text{cm}$  DBH (at 1.3m height) were measured and recorded from randomly laid plot size of  $10\text{m} \times 10\text{m}$  while woody plants with  $< 5\text{cm}$  DBH, were also listed and counted. All herbaceous plants were inventoried from  $2\text{m} \times 2\text{m}$  plots. A total of 103 plants, 56 woody and 47 herbaceous species were recorded in

overall studied Kebeles. Specifically, in the highland, 47 woody and 39 herbaceous species were recorded while 48 woody and 40 herbaceous were documented in the midland. The findings show that species composition and diversity indices value were slightly higher in the midland as compared to the highland agroecological zone. In the study, it also evident that Fabaceae was the most diverse plant family (for both woody and herb plants) in the study area and it is represented by seven species. *Catha edulis*, *Cordia africana* and *Coffea arabica* were the most significant socio-economic plant species of the study area. It was also evident that household's wealth status influenced plant diversity in traditional homegardens. That's, the mean Shannon diversity index and species richness showed significant variations ( $P < 0.05$ ) among household's wealth classes of the study area. Markets, access to road and homegarden size were other important factors that affect plant species diversity in homegardens. Homegarden sizes are statistically significant ( $P < 0.05$ ) between household's wealth classes, which indicates high variation in land holding among wealth classes. From the study it is possible to conclude that plant diversity in the homegardens provides mainly food and cash income for farm households.

**Keywords:** Woody species, Herbaceous species, Indigenous knowledge

**Tesfaye Abebe, 2005. Diversity in Homegarden Agroforestry Systems in Southern Ethiopia. Ph.D. Thesis. Wageningen University, Wageningen.**

In the highlands of Southern Ethiopia extensive areas of agroforestry homegardens occur. These systems are characterised by a unique combination and dominance of two native perennial crops, enset and coffee. Enset (*Enset ventricosum* (Welw.) Cheesman) is the major staple food while coffee (*Coffea arabica* L.) is the principal cash crop. In addition a large variety of staple food crops, vegetables and tree crops are present. Unlike most homegardens which are small and supplementary food production units, these homegardens are extended farm fields around houses and they form the principal means of livelihood for the farming households. Homegardens are important agricultural systems and occur everywhere in the tropical world. These traditional small-holder farming systems are changing rapidly due to increasing population pressure on the land, the introduction of new agricultural technologies, new opportunities for agricultural markets and an increasing need for cash earnings. In several places this traditional subsistence agriculture, generally based on diversity of crops, is changing into a market-oriented agriculture based on few crops only. The present study aims at characterizing the diversity and the composition of the species in these enset-coffee agroforestry homegardens and at identifying the factors that affect the dynamics in their composition. It attempts to assess the implications of the changes in these homegardens for agricultural sustainability. The study was conducted in Sidama, southern Ethiopia. This area is considered representative for the enset-coffee agroforestry homegardens. In order to get a good representation of the area and their systems in total 4 districts (woredas) with 12 peasant associations (administrative villages) and 144 farms were selected (12 farms, representing households with different resources, per association). At district and association level, information was gathered on environmental factors (climate, soil, altitude) and on socio-economic factors (population density, market structure) through interviews, reconnaissance surveys and literature studies. At farm level information was gathered for the whole farm and for individual plots, using measurements, interviews and observations. Information was collected on crop composition, abundance and yield, tree composition and abundance, altitude and slope, and on socio-economic situation (distance



to markets and major roads, household characteristics) per farm. Overall a total of 78 cultivated crop species have been recorded in these systems among which 13 occur in 50% of the farms. Each homegarden had an average of 16 crop species. Enset, coffee and maize are frequent and abundant across all homegardens, but their area share varies across sites and among households. Enset and coffee together cover about 63% of the crop area, maize covers 16% and the remaining 75 crop species together cover only 21%. This uneven distribution in abundance of the species has resulted in a low uniformity (evenness) in their composition. Crop diversity is not evenly distributed across the different plots (units) observed in the homegardens. Plots of coffee and enset were found to be associated with a high number of crop species and thus contributing to high species richness of the gardens. The number of crop species grown in a farm is an indicator of diversity. However, from the utility point of view the heterogeneity in functional groups of crops is important in order to fulfil the dietary and cash requirements of the households. In this respect, a total of 10 functional groups of crops were recognized each represented by 3 to 15 species of crops, and an average of 8.1 groups were found in each farm. The basic food crops, enset and maize, which are rich in carbohydrates are supplemented by pulses, vegetables, fruits and animal products that provide proteins, fats and vitamins. Based on the share of the major crops of the farms, four homegarden prototypes were distinguished: Enset-Coffee-Maize (84 farms), Enset-Coffee-Maize-Sweet potato (12), Enset-Coffee-Maize-Chat (24) and Enset-Coffee-Maize-Chat-Pineapple (24 farms). Variation among sites (peasant associations) in both prototypes and crop species is large and is largely explained by geographical location and altitudinal differences. At some sites the share of the basic crops, enset and coffee has decreased significantly over the last years, because these crops have been replaced by new cash crops like chat and pineapple, or food crops like maize and sweet potato. The recent changes in land use have been triggered by improved marketing opportunities (cash crops) and shrinking land holdings (food crops). Productivity per unit area of crops was higher for the prototypes where the share of enset and coffee is high. Monetary output per unit area of land, however, was higher for prototypes with introduced new cash crops. Access of farms to market and major roads had a significant effect on most farm composition and structure indices used. Crop species richness increased with distance of farms to markets, but evenness (uniformity in abundance) decreased. Homegardens close to markets grow fewer crop species because they give priority to marketable products. Close to markets, the share of coffee decreased while that of chat and maize increased. Access to major roads (highways) has linked the farms with external markets and thus in homegardens close to the roads farmers produced more new cash crops, and less enset and coffee, while the production of maize has increased. These land use developments have also changed the structure of the systems: the expanded crops (chat, pineapple, maize and sweet potato) are largely grown in monoculture plots. The characteristically integrated multistorey systems thus are gradually changing to a mosaic of patches of monoculture plots that have only one or two storeys. The expansion of cash crops in the systems is economically attractive in the short term, but the disintegration of these multistorey, perennial-crop-based systems into monoculture plots could negatively affect the stability and resilience associated with their complexity. Attempts should therefore be made to integrate the new crops into the existing systems without changing its multistorey structure. A total of 120 tree and shrub species were recorded, and an average of 21 species in each farm. The species *Cordia africana*, *Eucalyptus camaldulensis*, *Milletia ferruginea* and *Euphorbia candelabrum* occurred in more than 88% of the farms. The first two species together with *Podocarpus falcatus* are the most

abundant trees (61% of the tree population). The total population of trees per farm averaged 855 (475 per ha). The high tree density is due to presence of closely spaced eucalyptus trees which, because of their highly competitive effects, are planted on farm boundaries and in separate woodlots. Trees scattered inside the farms are mainly native species such as *C. africana* and *M. ferruginea*, which farmers regard to be complimentary to crop production. Tree diversity was not evenly distributed across the different plots in the farms. Coffee plots have the highest number of associated tree species followed by enset plots and woodlots. Plots of the newly expanding crops such as chat, pineapple, sweet potato and maize have few associated tree species, since shade trees are deliberately reduced or avoided.

The four homegarden prototypes differed clearly in the composition of tree species, which reflects the light requirements of the dominant crops and the prevailing physical and socioeconomical conditions. Farm size, woodlot area and road access affected both diversity and density of trees. Tree species richness of farms increased with size and remoteness of farms. Density of trees increased with woodlot area but evenness (uniformity in abundance) of tree species decreased because woodlots are dominated by densely stocked eucalyptus. Access of farms to major roads was associated with few tree species and a low tree density but a higher evenness because farms closer to the roads focused on commercial crops. The average wood standing volume per homegarden was 24 m<sup>3</sup> ha<sup>-1</sup>, with a large variation across sites and individual farms. At boundaries and in woodlots, trees are densely stocked, but inside crop fields and grazing lands they are sparse. These sparse trees have much wood, however: some 31% of the standing wood volume occurred in scattered trees while 69% was grown on boundaries and woodlots. Wood volume varied widely among sites and households due to ecological and socioeconomic factors, particularly altitude, access to road and farm size. The major findings of the study are synthesized in the last chapter. A total of 198 cultivated plant species and 7 livestock species were recorded in these systems. The diversity of crops, the perennial nature of the systems, the high diversity and standing stock of trees, the presence of livestock, and the interaction between the components are suggested to be the most important reasons for their sustainability and stability. The presence of different functional groups of crops in these systems fulfils the nutritional and monetary needs of the households. Among the crops, enset and coffee have the most significant economic and ecological roles. Enset is a high yielding food crop and provider of various products and is thus a suitable crop for low-input sustainable agriculture. Coffee provides the principal source of income and its processing and marketing creates employment for a large number of people, thereby making a significant contribution to regional and national economies. The combination of these two native perennial crops and their dominance in the systems therefore contributes to socio-economic and ecological sustainability. Trees provide households with wood, food, fodder and cash. Moreover, they play important ecological roles (provision of shade and mulch, nutrient recycling, soil and water conservation and improvement of microclimate) which contribute towards the stability of the systems. Livestock provide protein and cash but they also generate manure that is vital for maintenance of soil fertility. Recent trends in land use changes that result from increasing commercialization and land pressure have led to the decline in the areas of enset, coffee and trees. The decline in the share of these perennial components and their replacement particularly with annual crops could adversely affect the ecological benefits derived from these integrated and complex systems and threaten their longterm sustainability. Therefore, attempts to improve these homegardens should not affect their integrated nature. In this respect, research and development efforts

should aim at developing techniques on how to integrate high value crops into the systems without affecting their integrity.

**Tesfaye Abebe, 2013. Determinants of Crop Diversity and Composition in Enset-Coffee Agroforestry Homegardens of Southern Ethiopia. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 114 (1): 29-38.**

Households in much of the tropics depend for their livelihoods on the variety and continued production of food and other products that are provided by their own farms. In such systems, maintenance of agrobiodiversity and ensuring food security are important for the well being of the population. The enset-coffee agroforestry homegardens of Southern Ethiopia that are dominated by two native perennial crops, Coffee (*Coffea arabica* L.) and Enset (*Enset ventricosum* Welw. Cheesman), are examples of such agricultural systems. This study was conducted in Sidama administrative zone of Southern Ethiopia to determine the factors that influence the diversity and composition of crops in the systems. Data were collected from 144 sample homegardens selected from four districts. Stepwise multiple regression analysis was used to relate indices of crop diversity and area share of major crops with the physical and socioeconomic factors. The study revealed that socioeconomic factors, mainly proximity to markets, affected negatively crop species richness. The production area of the main crops enset and coffee decreased with increasing proximity to market and road while that of maize and khat increased. At household level, farm size had a significant effect on area share of enset and coffee. As farm size increased the share of the cash crop, coffee increased but that of the staple, enset declined. Enset, which is the backbone of the system in terms of food security, is declining on small farms and the share of monoculture maize system is increasing. The trend towards declining agrobiodiversity, and reduction in the production area of the main perennial crops and their gradual replacement with monoculture fields could make the systems liable to instability and collapse. As these sites are high potential agricultural areas, intensification can be achieved by integrating high-value and more productive crops, such as fruits, spices and vegetables, while maintaining the integrated and complex nature of the systems.

**Keywords:** Agroforestry systems, Coffee, Crop diversity, Enset, Homegardens, Sidama

**Tesfaye Abebe & Frans Bongers, 2012. Land-use Dynamics in Enset-based Agroforestry Homegardens in Ethiopia, pp. 69-85: In Arts B. et al. (eds.), *Forest-people Interfaces: Understanding Community Forestry and Biocultural Diversity*. Wageningen Academic Publishers, The Netherlands.**

In many tropical countries homegardens sustain large numbers of people. Households depend for their livelihoods on the variety and continued production of food and other products that are provided by their own gardens. Such homegardens combine production with the maintenance of biodiversity. Long-term sustainability of the system is crucial for the long-term wellbeing of the population, including food security. The enset-coffee system of Southern Ethiopia is an example of such agroforestry homegardens. Enset is the main food crop and coffee is the main cash crop. We analysed the homegardens of 144 households covering a range of geographical conditions. Household wealth status was the main determinant of homegarden size. In total, 198 species of cultivated crops (78) and trees

(120) were found. Enset and crops were represented by 42 and 24 cultivars respectively. The homegardens were covered by around one-third of enset and one-third of coffee. Enset provides the backbone of the system as it provides food security. Our results show that the stability of the system depends both on its diversity and on the specific characteristics of the two main crops, enset and coffee. The enset-coffee homegardens are changing as farmers increasingly make individual choices and respond to emerging challenges and opportunities. The dynamics of the agroforestry homegarden of Southern Ethiopia can be considered as a productive bricolage process on the micro scale.

**Keywords:** Coffee, *Enset ventricosum*, Ethiopia, Livelihood, Agricultural intensification

**Tesfaye Abebe, Sterck F. J., Wiersum K.F. & Bongers F., 2013. Diversity, Composition and Density of Trees and Shrubs in Agroforestry Homegardens in Southern Ethiopia. *Agroforestry Systems* , 87: 1283-1293.**

Diversity of trees and shrubs in agricultural systems contributes to provision of wood and non-wood products, and protects the environment, thereby, enhancing socioeconomic and ecological sustainability of the systems. This study characterizes the diversity, density and composition of trees in the agroforestry homegardens of Sidama Zone, Southern Ethiopia, and analyses physical and socioeconomic factors influencing diversity and composition of trees in the systems. A total of 144 homegardens were surveyed from 12 sites. In total, 120 species of trees and shrubs were recorded of which, 74.2 % were native to the area. The mean number of tree species per farm was 21. Density of trees varied between sites with mean values ranging from 86 to 1,082, and the overall average was 475 trees ha<sup>-1</sup>. Four different crop-based enset (*Enset ventricosum* (Welw.) Cheesman) coffee homegarden types were recognized and they differed not only in the composition of major crops but also in the diversity, density and composition of trees. The composition, diversity and density of trees is influenced by physical and socioeconomic factors. The major physical factors were geographical distance between sites and differences in altitude of farms. The most important socioeconomic factors were farm size and access to roads. Tree species richness and density increased with farm size. Increased road access facilitated marketing opportunities to agricultural products including trees, and lead to a decline in the basic components of the system, enset, coffee and trees. In the road-access sites, the native trees have also been largely replaced with fast growing exotic species, mainly eucalypts. The decrease in diversity of trees and perennial components of the system, and its gradual replacement with new cash and annual food crops could jeopardize the integrity and complexity of the system, which has been responsible for its sustenance.

**Keywords:** Determinants of on-farm tree diversity, Enset-coffee homegardens, On-farm density of trees, Landuse changes, Sidama Zone

**Tesfaye Abebe, Wiersum K. F. & Bongers F., 2010. Spatial and Temporal Variation in Crop Diversity in Agroforestry Homegardens of Southern Ethiopia. *Agroforestry Systems*, 78:309–322.**

A key assumption in many homegarden studies is that homegardens are ecologically and socio-economically sustainable due to their species diversity. The precise relation between diversity and sustainability is still heavily debated, however. A basic question is how

diversity in homegardens can best be characterized in view of the various dimensions of species diversity and their variation in time and space. This paper assesses different types of species diversity in the homegardens of Sidama region of southern Ethiopia. In a survey of crop species in 144 homegardens a total of 78 cultivated crop species (excluding trees) belonging to 10 functional groups were recorded; there were on average 16 crop species and 8 functional groups per farm. Within homegardens, plots differ in species composition and crop diversity. Four types of homegarden systems are distinguished differing in both type and area-share of dominant species, relative orientation at subsistence or cash production and overall crop diversity. The gradual replacement of enset by maize and of coffee by more financially attractive cash crops khat and pineapple causes a decrease in overall crop diversity. Our data demonstrate that it is incorrect to consider homegardens as generic systems with a uniform distribution of species diversity: important within and between homegarden variation exists. Ecological and socio-economic sustainability is not just related to species diversity per se, but rather to more specific features such as presence of keystone species and diversity in functional species groups. Socioeconomic sustainability in terms of adjustment to socio-economic change implies dynamics in species diversity.

**Keywords:** Homegarden dynamics, Functional groups, Keystone species, Enset/coffee gardens, Species diversity

**Tesfaye Abebe, Wiersum K.F, Bongers F. & Sterck F., 2006. Diversity and Dynamics in Homegardens of Southern Ethiopia, In: Kumar B.M. & Nair P.K.R. (Eds), Tropical Homegardens: A Time-Tested Example of Sustainable Agroforestry, Pp. 87-103. Springer Science, Dordrecht, The Netherlands.**

Most homegarden studies have focused on Asia, where homegardens constitute a component of a spatially separated farming system consisting of cultivated fields with staple and/or commercial crops away from homes complemented by the homegardens with supplementary crops such as fruits and vegetables surrounding residential houses. In the highlands of East and Central Africa, another type of homegarden is found in the form of an integrated farming system within itself and without additional cultivated fields. In these 'integral' homegardens, not only supplemental crops such as fruits and vegetables, but also staple food crops and cash crops are grown. The enset (*Enset ventricosum*) and coffee (*Coffea arabica*) homegarden system in Southern Ethiopia is a typical example of such integral homegardens. An assessment of 144 of these homegardens was made to gain insights into their structure and vegetation composition and the relation between composition and geographic and socioeconomic factors. Four specific garden types are identified, which vary in commercial crop composition and diversity. These variations are related to farm size, access to roads and markets, and illustrate the dynamic character of homegardens. Overall, the diversity of the integral homegarden systems seems to be lower than that of the 'complementary' homegarden systems in Asia, probably due to the inclusion of light demanding staple food crops and relatively large number of commercial crops. The dynamic pathways of the integral homegarden systems because of commercialization appear similar to reported trends in the 'complementary' homegarden systems in Asia. Although the composition of the homegardens is influenced by socioeconomic dynamics, overall the Ethiopian homegardens can be characterized as being ecologically and socioeconomically sustainable. This can be attributed not only to species diversity but also to the presence of two keystone species-enset and coffee.

**Tilahun Teklehaymanot & Mirutse Giday, 2010. Ethnobotanical Study of Wild Edible Plants of Kara and Kwegu Semi-Pastoralist People in Lower Omo River Valley, Debub Omo Zone, SNNPR, Ethiopia. *Journal of Ethnobiology and Ethnomedicine*, 6:23**

The rural populations in Ethiopia have a rich knowledge of wild edible plants and consumption of wild edible plants is still an integral part of the different cultures in the country. In the southern part of the country, wild edible plants are used as dietary supplements and a means of survival during times of food shortage. Therefore, the aim of this study is to document the wild edible plants gathered and consumed by Kara and Kwegu people, and to analyze patterns of use between the two people. A cross sectional ethnobotanical study of wild edible plant species was conducted from January 2005 to March 2007. About 10% of each people: 150 Kara and 56 Kwegu were randomly selected to serve as informants. Data were collected using semi-structured questionnaire and group discussions. Analysis of variance ( $\alpha = 0.05$ ) was used to test the similarity of species richness of wild edible plants reported by Kara and Kwegu people; Pearson's Chi-square test ( $\alpha = 0.05$ ) was used to test similarity of growth forms and plant parts of wild edible plants used between the two people. Thirty-eight wild plant species were reported as food sources that were gathered and consumed both at times of plenty and scarcity; three were unique to Kara, five to Kwegu and 14 had similar local names. The plant species were distributed among 23 families and 33 genera. The species richness: families, genera and species ( $p > 0.05$ ) were not significantly different between Kara and Kwegu. Nineteen (50%) of the reported wild edible plants were trees, 11 (29%) were shrubs, six (16%) were herbs and two (5%) were climbers. Forty plant parts were indicated as edible: 23 (58.97%) fruits, 13 (33.33%) leaves, 3 (7.69%) roots and one (2.56%) seed. There was no difference between wild edible plants growth forms reported (Pearson's Chi-square test  $(d.f. = 3) = 0.872$ ) and plant parts used (Pearson's Chi-square test  $(d.f. = 3) = 0.994$ ) by Kara and Kwegu people. The majority of wild edible plants were gathered and consumed from 'Duka' (March) to 'Halet' (May) and from 'Meko' (August) to 'Tejo' (November). Sixteen (41%) of the plant parts were used as a substitute for cultivated vegetables during times of scarcity. The vegetables were chopped and boiled to make 'Belesha' (sauce) or as a relish to 'Adano' (porridge). The ripe fruits were gathered and consumed fresh and some were made into juices. The seeds and underground parts were only consumed in times of famine. Thirty-seven percent of the wild edible plants were used as medicine and 23.6% were used for other functions. The wild edible plants were used as supplements to the cultivated crops and as famine foods between harvesting seasons. But information on the nutritional values and possible toxic effects of most of the wild edible plants reported by Kara and Kwegu, and others in different part of Ethiopia is not available. Therefore, the documented information on the wild edible plants may serve as baseline data for future studies on nutritional values and possible side effects, and to identify plants that may improve nutrition and increase dietary diversity. Some of these wild edible plants may have the potential to be valuable food sources (if cultivated) and could be part of a strategy in tackling food insecurity.

**Keywords:** Adaptability, Socioeconomic change, Species composition, Sustainability.

**Tsegahun Tesfaye, 2010. The Link Between Agroforestry and Food Security: Analysis of Determinants of Food Security in the Homegardens of Halaba Special Woreda, Southern Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

Food availability and reliable access to food are both critical to household food security. Access to food is determined by the available resources for food acquisitions (food production, and gathering, buying of food) and the social and buffer mechanisms. While food might be available on markets, many households can hardly afford to buy sufficient food (vegetables in particular) with the limited cash available. Thus home gardening has a major role in household food security and self sufficiency. The role of home gardens for food security and genetic diversity of vegetable crops attracts increasing attention in the development debates. Home gardening combined with awareness campaigns on nutrition can be a viable strategy for improving household food security for at-risk populations. In terms of genetic diversity, home gardens have a high potential to compensate the loss of diversity through mono cropping in the fields. So far, little is done on exploring the linkage between food security and Agro forestry home garden. Thus, the present study was envisaged with objectives of exploring the linkages between food security and agro forestry and identifying determinants of food security and coping strategies at household level in Halaba special woreda. A two- stage sampling procedure was employed to select 90 sample households from two sample kebeles. The basic data used for this study were collected from sample households, focus group participants and key informants through structured questionnaire and semi-structured checklist, respectively. The survey result revealed that out of the total of 90 sample households, 32 households (35.6%) were found food insecure while the remaining 58 households (64.4%) were food secure. Results of the study also identified various socio-economic and bio-physical factors that influence the food security status of households. The binary logit model results disclosed that among 7 explanatory variables included in the model, 4 were found to have significant effect on household food security status. These significant variables include age of household head, total amount of calorie from home garden, total livestock ownership and size of home garden. At last, the study recommended that policy makers and development agents must give attention and high priority in improving the agro-forestry home garden practices of the resource poor small scale farm households, which enable them to maintain diversity and thus improve food security status. Moreover, due attention and policy consideration has to be given by the government to those significant variables which have a potential impact in determining household food security status in the study area.

**Keywords:** Homegardening, Household food security, Agroforestry, Determinants of food security

**Tsegazeabe H. Haileselasie, Mekonen T. G/hiwot, Gebru E. Gebremichael & Solomon A. Hiluf, 2012. Agroforestry Practices and Biodiversity Management in Backyards in Hiwane, Hintalo Wejerat of Tigray, Northern Ethiopia. *Asian Journal of Agricultural Sciences*, 4(2): 110-116.**

In Ethiopia more than 85% of the population is involved in agriculture based profession. Farmers in Ethiopia have been practicing different agroforestry models since time immemorial. What is more, backyard (home garden) agroforestry practice is most popular in the northern part of the country. This backyard agroforestry (home garden) is practiced as a

mixture of crops (vegetables, herbs) and trees (fruits and fodder trees) to provide diversified products to the cultivators. This study found over 40 species of plants maintained in home garden of the study area. Furthermore, agroforestry practice in backyard has a crucial role in the improvement of livelihoods to small scale farmers in the study area through direct subsistence production, indirect subsistence production (such as foods, fuel wood, fodder and shade to the cultivators) and income generation. Furthermore, it has helped to conserve many species of plants in a small areas with providing diversify needs to the farmers. We found that trees to have multiple roles in the study area where they provide significant economic and ecological benefits. Planting trees provide rural households with wood products for own consumption as well for sale and play role in decreasing soil degradation. Our findings also suggest that households consider a number of attributes in making decision to backyard agroforestry practice. These results can be used by policy makers to promote home garden agroforestry practice in the study area by creating conducive water supply and considering households' backyard size and roofing system.

**Keywords:** Agroforestry, Backyard, Ethiopia, Home garden, Tigray

**Tsegazebe H. Haileselasie & Mekonen T. G. Hiwot, 2012. Agroforestry Practices and Flora Composition in Backyards in Hiwane, Hintalo Wejerat of Tigray, Northern Ethiopia. *International Journal of Biodiversity and Conservation*, 4(7) : 294-303.**

Backyard (home garden) agroforestry practice is most popular in the northern part of the country. This backyard agroforestry is practiced as a mixture of crops (vegetables, herbs) and trees (fruits and fodder trees) to provide diversified products to the cultivators. This study found over 40 species of plants maintained in home garden of the study area. Furthermore, agroforestry practice in backyard has a crucial role in the improvement of livelihoods to small scale farmers in the study area through direct subsistence production, indirect subsistence production (such as foods, fuel wood, fodder and shade to the cultivators) and income generation. Furthermore, it has helped to conserve many species of plants in a small areas with providing diversify needs to the farmers. However, we found that availability of water has significantly affected the home garden plant species diversity (t-test,  $n = 13$ ,  $p < 0.05$ ). Additionally, there is a high correlation between the diversity of vegetables (leafy, fruit and root and tuber crops, spice and herbs in combination) kept in backyards and availability of water (Number of plant species =  $6.11767 (\pm 0.14790) - 0.27023 (\pm 0.01349)$  distance from the river  $r^2 = 0.9733$ ,  $F_{1, 11} = 401.1$  ( $P < 0.001$ ) planting trees provide rural households with wood products for own consumption as well for sale and play role in decreasing soil degradation. Furthermore, our findings also suggest that households consider a number of attributes in making decision to backyard agroforestry practice. These results can be used by policy makers to promote home garden agroforestry practice in the study area by creating conducive water supply and considering households' backyard size and roofing system.

**Keywords:** Agroforestry, Home garden, Backyard, Ethiopia, Tigray.



**Zebene Asfaw, 2008. Perennial Species Diversity and Rehabilitated Ecosystem in Sidama Zone, South Ethiopia: A Paper Presented in a Conference on Forest Landscape Restoration in North East Africa, Organized by Viikki Tropical Resources Institute University of Helsinki. Wondo Genet, Ethiopia.**

The study was initiated to characterize historical development of agroforestry in rehabilitating agroecosystem in the Awassa and Shebedino districts. Those districts are very much known for their highly developed and complex traditional agroforestry systems. The first part of this paper reports historical account of original forest degradation to grazing land and rehabilitation approach by local community. For this part of the study, extended participatory rural appraisal techniques was applied by involving 28 key informants, at four villages within two peasant associations. By using information collected at this level checklists and questionnaires were developed for further investigation on 74 household farms (poor, medium and wealthy). To identify spatial arrangement of varies tree/shrubs species individual farm was divided in to fields (8-11 fields). Status soil fertility was also assessed for major fields identified. The results of this study shows that original forest which was *Podocarpus-Cordia* dominated was destroyed to get grazing field. According to the key informants the grazing fields were used communally mainly during the main rainy season. The practices have been there for more than a century. The trends, however, have been changed during the last three decades mainly due to population pressure. As population size increased settlement area increased too. With increasing settlement sites, on farm tree planting of indigenous, in some cases exotics, have also been increased substantially during the last three decades. As a result, forest looking landscape has been developed and can be reached with an hour drive from Wondo Genet College. Mean value of woody species richness at study site, *ca.* 16 species per sampled farms. Higher species diversity was recorded at Enset fields and boundaries. Higher land allocation to woodlots was strategies of wealthier households. There were significant variations in the analyzed soil nutrients between the tree species grown on various fields. Soils under tree canopy were superior to soils from open agricultural crop fields. At all study sites, significantly higher concentration of P was observed under *Millettia* and *Cordia* than under Red gum. At one site, concentrations of available P under *Cordia* were nearly two-fold, and four and half-fold greater than under *Millettia* and Red gum, respectively. Total N under Red gum was 14% and 24% lower than under *Cordia* and *Millettia*, respectively. In contrast, organic C content under Red gum was 11.6% greater than under *Millettia* and 23.8% greater than under *Cordia*. The pH under *Millettia* and *Cordia* were significantly higher than concentrations under Red gum at one site. Topsoil under *Millettia* and *Cordia* also had significantly higher levels of exchangeable Ca and Mg than Red gum.

**Keywords:** Traditional agroforestry, Grazing, *Cordia*, *Millettia*, Red gum, Enset, Maize, Field

**Zebene Asfaw & Håkan Hultén, 2003. Tree Diversity Management in the Traditional Agroforestry Land Use of Sidama, Southern Ethiopia. Acta Universitatis Agriculturae, SLU. *SLVETRIA*, 263 (1): 1-28.**

Sidama farmers cultivate trees to meet their food, wood, fodder and other service needs. This study indicated that tree cultivation intensity has increased during the last three decades. Farm size ranged from 0.05 to 3.7 ha and there was a significant ( $P < 0.05$ ) positive correlation

between farm sizes and number of species, and number of stems per farm. Within farms, up to ten different field types with specific management practice were identified. These fields contributed to conserve four of the first five officially declared priority endangered trees, not allowed to be harvested in the forest in Ethiopia, namely *Cordia africana*, *Podocarpus falcatus*, *Juniperus excelsa* and *Olea africana*. A total of 87 trees and shrubs species were recorded. Of these the exotic species *Eucalyptus*, *Persea* and *Cupressus* ranked 1<sup>st</sup>, 3<sup>rd</sup> and 4<sup>th</sup> in abundance, respectively. Of natives, the most important species are *Cordia africana* and *Millettia ferruginea* ranked 2<sup>nd</sup> and 5<sup>th</sup> in abundance, respectively. The Important Value Index of those five species accounted 63 % of the total index value 110. The number of tree species per farm averaged 16 and ranged from 4 to 28. However, wealthy households have got more of tree species than poor households. The largest number of species per farm was recorded at Hara site with relatively less access to market. Surprisingly, the highest diversity index for trees was recorded on the farms of poor households at Enta site, 2.2, 0.7 and 0.9 for Shannon-Wiener, Simpson and Shannon Equitability index, respectively, despite having the lowest species richness and number of trees (231 ha<sup>-1</sup>).

In general, the largest numbers of tree species per farm, number of stem ha<sup>-1</sup> and basal area ha<sup>-1</sup> were recorded on farms of wealthy households.

**Keywords:** Market, Enset, Field, Households, Shannon-Wiener index, Species, Wealth categories.

**Zemed Asfaw & Ayele Nigatu, 1994. Home–Gardens in Ethiopia: Characteristics and Plant Diversity. *Ethiopian Journal of Science*, 18(2): 235-266.**

A study was conducted on 111 home-gardens located in 58 sites in central, eastern, western and southern Ethiopia. The study area covered urban, peri-urban and rural settings of Dega (highland), Weyna-dega (middle land) and Kolla (low land) agroecological zones. Variations in home-garden frequency, position, size, shape, crop composition, planting pattern and level of development were observed. The gardens studied could be grouped in to backyards (48%), front-yards (26%), side-yards (13%) and enclosing yards (13%). On the average, many homes located in peri-urban towns of the Weyna-dega zone have gardens. The variations observed can best be accounted for by agroclimatic and socio-cultural factors. High diversity of species (162), of which 78% were food crops, was observed in home-gardens. Typical garden crops (52%), conventional field crops (22%) and those cultivated in both setups (27%) were recorded during the survey. On the whole, maize (*Zea mays* L.) and Enset (*Ensete ventricosum* (Wells.) cheesm.) were the most frequent crops in home-gardens. Fruit and vegetable crops constituted 41% of the species recorded, while other economically useful species occurred in gardens that produced cash and staple crops. Many multipurpose tree and shrub species were used as live fences. Rural farming families frequently use both home-gardens and fields to produce most of their crops. The home-garden complex is viewed as reminiscent of traditional agroforestry systems. It is a place where evolution and diversification of many crops of indigenous taxa have occurred. Also, crops introduced in the primal stage of agricultural innovations and species planted at experimental levels are found in home-gardens. It is concluded that the potential of home gardening in Ethiopia is quite significant.

### 1.3. Park Agroforestry and Agroforestry for Soil Fertility

**Abebe Yadessa & Diriba Bekere, 2002. Influence of Scattered *Cordia africana* Trees on Maize Yield in Western Oromia, Ethiopia. Proceeding of the Fourth Conference of the Forestry Society of Ethiopia. Pp 91-98.**

A study on scattered *Cordia africana* Lam. trees was conducted around Bako, western Oromia, Ethiopia. The objective of the study was to assess the influence of scattered *C. africana* trees on the growth and yield of maize, and get baseline information for the implications to introduce more and/or maintain the existing *Cordia* trees in cropland agroecosystem which serve as one means of conserving this endangered tree species. Eight individual scattered *C. africana* trees (four pollarded and four unpollarded) were selected for the study. For each tree, data on tree height, diameter and crown spread were recorded, and they were used as covariates to represent variation that has not been controlled. Data on height and grain yield of maize were collected from a quadrant of 2m<sup>2</sup> placed at different distances (3, 6, 9, 12 and 15 m) and four directions (north, south, east and west) and analyzed using SPSS statistical software. Results showed that maize height and grain yield were not significantly affected by direction, but they were significantly affected by distance ( $p = 0.001$ ). Maize grain yield was also not significantly influenced by tree management (pollarding). But the interaction between pollarding and direction was significant ( $p = 0.000$ ). The impact of *Cordia* trees on maize yield was noticed up to 3 m distance and there was little, if any, impact up to 6 m and almost no impact at 9 and 12 m distances, but this was not noticed on grain size. There was differential response of direction to tree management on maize yield; pollarding branches seriously affected maize yield on the western side, whereas not pollarding highly favored maize yield on the same direction. Maize grain yield was lower under the tree canopy as compared to the adjacent open area, even though a previous study on horizontal soil gradient showed that some soil chemical properties were higher under the tree canopy than in the open area. This finding indicates that the problem may be more related to light than soil nutrient, suggesting the need for systematically pollarding *C. africana* branches to reduce shading on the crop especially on the eastern orientation and increase the litter fall that could possibly add nutrients to the soil.

**Abebe Yadessa, Diriba Bekere, Worku Burayu, Tamirat Arficho & Dechasa Jiru, 2005. Agroforestry-based Maize Production: Another Option for Sustaining Maize Yield. Proceeding of the 2<sup>nd</sup> National Maize Workshop of Ethiopia.**

This paper is a summary of agroforestry research results related to maize production conducted by different institutions /organizations in Ethiopia. Its objective is to bring together scattered information and make it available for users, analyze gaps and indicate research needs for the future. The paper highlights major research findings on biomass transfer, alley cropping, and taungya and scattered tree systems where maize was used as intercrop. According to works reported so far, biomass transfer seems a promising agroforestry option for boosting maize production. But most agroforestry research works are at start and hence further investigations to strengthen the information base are of paramount importance in the future

**Alemayehu Beyene, 2012. The Influence of *Acacia senegal* (L.) Wild of Selected Soil Properties, Microclimate and Sorghum Yield In Mieso District, Oromia, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

*Acacia senegal* is a multipurpose dry land species that produces diverse socio-economic and ecological benefits. The tree is grown with sorghum in Mieso area but scientific information is lacking about its effect on soil physicochemical properties, microclimates, and sorghum yield. Thus, this study was initiated to investigate the influence of this species on some selected soil properties, microclimate and sorghum yield in Mieso District, Oromia, Ethiopia. For the study of soil physico-chemical properties, two factors: 1) distance from tree trunk (at 0.5m of crown, mid of crown, edge of crown radius and open field), and 2) depth from ground level (surface; 0 – 15cm and subsurface; 15 – 30cm soil layers) with factorial arrangement in RCBD replicated five times were employed. For microclimates and sorghum yield only one factor; distance from tree trunk with two levels for microclimates and four levels for sorghum yield arranged in CRD replicated five times were used. The result showed that, soil texture was not influenced significantly ( $P > 0.05$ ) by *Acacia senegal* tree; whereas soil bulk density was significantly ( $p < 0.05$ ) lower under canopy than outside canopy, and in surface soil than in subsurface soil layer. Results of soil chemical properties (SOC, total soil N, available soil P, available soil K and soil CEC) were significantly ( $p < 0.05$ ) higher in the canopy zone than open field and in surface soil layer than subsurface soil layer. On the other hand, soil pH and EC were not significantly ( $p > 0.05$ ) influenced by *A. senegal*. Relative illumination, air temperature, soil temperature were significantly ( $p < 0.05$ ) higher at open field than canopy zone while soil moisture was significantly ( $p < 0.05$ ) higher under canopy than open field. Though not significant, sorghum yield was slightly higher under canopy than open field. Thus, *A. senegal* tree has the potential to improve soil fertility beneath its canopy, and retaining of this tree on crop land with proper management in drought prone area could enhance productivity of companion crops or the land.

**Keywords:** Air temperature, Open field, Relative illumination, Soil fertility, Soil moisture, Soil Temperature and under canopy

**Amanuel Beyene, 2013. Traditional Management Practices and Woody Species Diversity Of Parkland Agroforestry In Gombora District, Hadiya Zone, SNNPRS, M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources. Hawassa University.**

A study was conducted to assess i) the woody species diversity in parkland agroforestry. ii) Farmers' traditional knowledge in management practices and contributions of woody species and iii) Socio-economic factors that influence managements of woody species. A total of 32 key informants (KI), 4 from each village (8) were selected by snowball method and were used to categorize the village households (HH) in to three wealth categories. Moreover, simple random sampling within wealth categories was used to select a total of 85 samples HHs for interview. A line transect survey method was used to collect woody species diversity data from 240 plots (100m x 50m) in parkland agroforestry and a questionnaire was developed to gather information on farmers' strategy of managing woody species diversity. A total of 27 woody species belonging to 19 families were recorded. Of these, 27 woody species recorded in lowland and 23 woody species in midland altitude.

Important value index of individual trees/shrub species at farm-level was assessed and *Croton macrostachyus* was ranked first at lowland and midland altitude sites with mean IVI of 120.27 and 118.91 respectively. Woody species richness per plots in lowland altitude ( $3.51 \pm 0.23$ ) was significantly ( $P < 0.05$ ) higher than midland altitude ( $2.71 \pm 0.21$ ). Generally the study exposed that the woody species Shannon, Simpson and Evenness diversity indices were higher at lowland than midland altitude. At the study sites, farmers retain and/or plant woody species in their parklands for the purpose of improving soil fertility, fodder, fuel wood, timber, shade, construction, etc. They also developed experiences in identifying their woody species preferences and manage them for different reasons. The management practices employed at both study altitude sites includes branch pruning, pollarding, lopping, protection and coppicing. The socio-economic factors that influence management of woody species in parkland agroforestry across the study agro-ecologies were found to be farm size, educational background, wealth status and distance of market from parklands.

**Keywords:** Frequency, Importance value index, Lowland and midland altitude sites, Sampling design and transect layout.

**Bekele Lemma, Dan Berggren Kleja, Ingvar Nilsson & Mats Olsson, 2006. Soil Carbon Sequestration Under Different Exotic Tree Species in the Southwestern Highlands of Ethiopia. *Geoderma*, 136: 886 – 898.**

At Belete forest in southwestern Ethiopia ( $7^{\circ} 33' N$ ,  $36^{\circ} 35' E$ ), tree plantations were established on abandoned farmland, which was previously mainly used for maize cultivation. Total carbon and  $^{13}C$  analyses were used to evaluate the changes in soil organic carbon (SOC) pools associated with land use changes using a comparative approach. Forest clearing followed by continuous cultivation of crops caused a loss of 43% ( $75.4 \text{ Mg ha}^{-1}$ ) total SOC and 73% ( $128.4 \text{ Mg ha}^{-1}$ ) forest derived SOC after nearly 75 years. The net loss of SOC was lower because of addition of  $53.0 \text{ Mg ha}^{-1}$  of SOC of  $C_4$  crop origin (mainly maize) to the farmland. On the other hand, afforestation of farmland led to a net accretion of SOC of  $69.6$  and  $29.3 \text{ Mg ha}^{-1}$  after 20 years under *Cupressus lusitanica* and *Pinus patula* stands, respectively. The SOC accretion of plantation origin amounted to  $63.3 \text{ Mg ha}^{-1}$  under *C. lusitanica* and  $24.2 \text{ Mg ha}^{-1}$  under *P. patula*. Contrary to the results obtained in some other studies, the SOC of  $C_4$  origin did not decline in these stands. This could be attributed to pasture grasses of  $C_4$  origin that took over after land abandonment and continued to grow under the tree canopies. The grasses could thus have compensated for the SOC loss. SOC might also have been close to a steady state under the pre-plantation period. Based on the SOC amount found in a reference stand of native forest, afforestation with *Eucalyptus grandis* during 20 years, preceded by 20 years of cultivation and 35 years of pasture, returned the total SOC to nearly pre-deforestation levels. SOC accumulation rates of  $1 - 3.2 \text{ Mg ha}^{-1} \text{ year}^{-1}$  are apparently possible 20 years after afforestation of an abandoned farmland but the accumulation rate is species dependent.

**Keywords:** Afforestation, Land use changes, Soil organic carbon accretion, Natural  $^{13}C$  abundance

**Belay Manjur, Tesfaye Abebe & Abdu Abdulkadir, 2014. Effects of Scattered *F. Albida* (Del) and *C. macrostachyus* (Lam) Tree Species on Key Soil Physicochemical Properties and Grain Yield Of Maize (*Zea mays*): A Case Study at Umbulo Wacho Watershed, Southern Ethiopia. *Wudpecker Journal of Agricultural Research* , 3(3): 63 –73.**

Information regarding the effects of multipurpose tree species on soil conditions in Ethiopia is very scarce to be of use for improved agricultural productivity. The study was conducted on farmers' fields at Umbulo Wacho watershed, which is located in the Hawassa Zuria woreda Sidama Zone of the Southern Ethiopia. The aims of the study were to identify the effects of scattered *F. albida* and *C. macrostachyus* tree species on the physico-chemical properties of soil fertility parameters and grain yield of maize within and outside the canopy of the tree and at varying soil depths. Soil samples were collected under the canopy of the two tree species and in the open cultivated land from three radiuses of 1.5m, 3.5m and 25m out of the trees within the 0-20cm and 20 to 40cm soil depths. The results of the study indicated that except for pH and C/N ratio the amount of soil nutrients under *F. albida* tree species were significantly ( $P \leq 0.05$ ) higher than the *C. macrostachyus* tree species and that of the open cultivated land. Generally, comparisons between under the canopy and outside the canopy of the two tree species indicated a highly significant difference on major soil fertility parameters. The effect of the two tree species on soil fertility parameters as well as grain yield of maize was significantly ( $P < 0.05$ ) higher within the canopy of the tree than outside of the canopy. The findings suggest that the maintenance of soil fertility and improvement in grain yield of maize by small-holder farmers can be attained by incorporation of the two tree species in agricultural landscapes of similar agro-ecological conditions.

**Keywords:** Parkland agroforestry, Productivity and soil fertility management, Hawassa Zuria, Sidama zone

**Dargo Kebede, Abdu Abdelkadir & Zebene Asfaw, 2014. Effect of *Leucaena leucocephala* Leaf Biomass and Fertilizer Application on Sorghum Growth and Striga Control in Pawe District, Benishangul Gumuz Region, Ethiopia. *East African Journal of Sciences*, 6(2):147-156**

Field experiment was conducted during the 2010 cropping season to investigate the effect of leucaena leaf biomass and fertilizer application on sorghum growth and striga control. Two levels of leucaena leaf biomass (2.5 and 5 t ha<sup>-1</sup>) was applied with 50% recommended dose of urea (RDU) with or without 50% recommended dose of DAP. The experiment also included a standard treatment of growing sorghum with 100% recommended dose of fertilizer (RDF) (100 kg urea + 100 kg DAP) and farmers' practice of growing sorghum without any input as a control. The experiment was laid out in a RCBD in three replications. Data on soil fertility parameters, sorghum foliar macro-nutrient content, sorghum plant height, and stalk diameter, number of tillers, grain yield and aboveground biomass were collected. Striga count at 65 and 95 days after sowing (DAS) of sorghum and striga aboveground biomass at 95 DAS were collected. Results revealed that plots treated with 5 t ha<sup>-1</sup> + 50% RDF and 5 t ha<sup>-1</sup> + 50%RDU recorded significantly ( $P < 0.05$ ) higher SOC, CEC and total N where as significantly highest available P was recorded in the 5 t ha<sup>-1</sup> + 50%RDF treated plots. Significantly higher ( $P < 0.05$ ) foliar N and P content was also recorded in plots treated with 5 t ha<sup>-1</sup> + 50%RDF and 5 t ha<sup>-1</sup> + 50%RDU while significantly higher ( $P < 0.05$ ) foliar P content

was recorded in the 5 t ha<sup>-1</sup> + 50%RDF treated plots. Sorghum grain yield and aboveground biomass were increased by 133 and 123%, and 368 and 385% in the 5 t ha<sup>-1</sup> + 50%RDF and 5 t ha<sup>-1</sup> + 50%RDU treated plots, respectively over the control plots. Number of striga at 65 DAS was also reduced by 82.33% and 96.33% in the 5 t ha<sup>-1</sup>+50%RDF and 5 t ha<sup>-1</sup>+ 50%RDU treated plots respectively over the control plots. Aboveground biomass of striga at 95 DAS also decreased by 41.6 and 39.32 % in the 5 t ha<sup>-1</sup> + 50%RDF and 100%RDF treated plots respectively over the control plots. Therefore, it was concluded that application of leucaena leaf biomass at 2.5 t ha<sup>-1</sup> + 50% RDF, 5 t ha<sup>-1</sup> + 50% RDF and 5 t ha<sup>-1</sup> + 50% RDU can be used to improve sorghum productivity and control striga in the study area.

**Keywords:** Aboveground biomass, Sorghum foliar nutrient content, Grain yield, Soil, fertility, Striga infestation

**Dawit Kebede, 2012. Woody Species Diversity, Selected Soil Properties, and Community Attitude in Reforested Degraded Land Around Lake Hawassa Sub-Watershed, southern Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Land rehabilitation through planting multipurpose trees (MTPs) on degraded lands in Udo-Mekibassa sites was studied for changes in vegetation and soils. This study was conducted in Hawassa Zuria district with the main focus on investigating whether the reforestation can bring better impact on richness, regeneration status of woody species and soil improvement with than non-reforested or closed area. Totally, 36 plots of 20X20m area were taken by means of transect sampling for collection of vegetation data and composite soil samples. A total of 60 households were interviewed purposively using semi-structured questionnaires to understand their attitude. Local people also expressed a strongly positive attitude towards the rehabilitation efforts by the project. About 87% of the respondents confirmed that they had benefited from the rehabilitation work in their surroundings in the form of harvesting of grass for their livestock and reduction of flooding risks. The results demonstrated that a total of 36 species of both indigenous and exotics were identified in all of the reforested project area and the adjacent non-reforested area. Woody species richness and natural regeneration in reforested area were higher than non-reforested area. The soil analysis also revealed that there is a significant difference in their physical and chemical attributes between the two intervention types. Soil bulk density (g cm<sup>-3</sup>) decreases for the reforested project area, which revealed improvement of soil structure. Unlike the reforested project area, the soil organic carbon of the non-reforested project area was significantly lower. This study suggested that reforestation with MTPs on the degraded land can rehabilitate the area and can restore both tree species and soil of degraded area.

**Keywords:** Land rehabilitation, Multipurpose trees, Regeneration, Soil physicochemical characteristics, Farmers' participation

**Endalkachew Mekonnen, 2012. Influence of *Cordia africana* and *Albizia Gummifera* Parkland Trees on Some Physico-Chemical Properties of Soil and Wheat Yield at Tambaro District SNNPR, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

The focus of this research was influence of *Cordia africana* and *Albizia gummifera* parkland trees on some soil physico-chemical properties and wheat yield at Tambaro district SNNPR, Ethiopia. Soil under the tree canopies was compared with soil in the open field. For soil physico-chemical property study, two factors (distance from the tree trunk and depth from the ground level) arranged in RCBD with five replications was involved. The distance factor had three levels at 0.5m and 2.5m from tree trunk under the tree, and at 10m away from the tree trunk outside the canopy. The depth factor had two levels surface (0 – 15 cm) and subsurface (15 – 30 cm) soil layers. Data were collected on soil physico-chemical properties and wheat grain yield. All data collected were subjected to ANOVA using the general linear model of SAS. Results of soil physical and chemicals properties revealed that except for soil sand, silt, clay, EC and Na the studied soil physical and chemical properties (BD, pH, CEC, TN, ava. P, OC, C/N, K, Ca and Mg) for *Cordia africana* and except sand, silt, clay, soil bulk density, pH and EC the studied soil physical and chemical properties (CEC, OC, TN, ava. P, K, Ca and Mg) for *Albizia gummifera* were enhanced under canopy as compared to open field, mainly due to the effects of litter accumulation and root activities under the tree canopies. Highest wheat yield (4900.50kg/ha) and (4800.60 kg/ha) was obtained under canopy of *C.africana* and *A.gummifera*, respectively. Wheat yield and soil fertility increased under canopy of the trees. This study suggests that presence of trees (*C.africana* and *A.gummifera*) can increase crop yield and soil fertility significantly when grown within farm fields.

**Keywords:** Agroforestry parkland, Soil fertility, Tree canopy, Tree litter

**Etefa Guyassa & Antony Joseph, 2013. Assessment of Biodiversity in Cropland Agroforestry and Its Role in Livelihood Development in Dryland Areas: A Case Study from Tigray Region, Ethiopia. *Journal of Agricultural Technology*, 9(4): 829-844.**

The assessment of species diversity is crucial since it represents a fundamental property of ecological communities and provides a tool to compare assemblages in time and space, independently from species identities. This research investigation was carried out to assess biodiversity of woody plants in agroecosystem and their significance in dryland agroforestry for livelihood development in Abreha we Atsebeha, Tigray region, Ethiopia. The biodiversity was assessed in three types of agro-ecosystems (homegarden, cropland and grazing land) and adjacent forest land (exclosure). The following biodiversity indices were used for comparison between different land uses: Shannon diversity index (H), species richness (S), species evenness or equitability index (E), Sorensen coefficient of similarity (Ss) and importance value index (IVI). The results revealed high woody species richness in agricultural landscapes than exclosure which indicates that human-managed agricultural landscapes can play a vital role in preserving woody species diversity. In the present study, 39 woody species were recorded in the different agro-ecosystems as only 23 woody species were recorded in exclosures indicating highest species richness on agricultural lands than exclosures. A focused questionnaire survey indicated that about 98% of the respondents have maintained different woody species in their homegardens, croplands



and grazing lands. Although the number and type of species retained differed, *Faidherbia albida* and *Acacia etbaica* were more frequently retained than others and were also ranked the top preference of the local people. Farmers retain or plant trees intentionally to derive different socio-economic benefits as a source of their livelihood. The major benefits obtained from trees in the order of their applications were fuelwood, conservation, shade, fencing, construction, farm tools, fodder, fruit and medicine.

**Keywords:** Biodiversity, Cropland agroforestry, Shannon diversity index, Species richness, Equitability index, Sorensen coefficient of similarity, Importance value index.

**Gizachew Zeleke, 2013. Assessment of the Effect of *Ficus vasta* on Soil Physicochemical Properties of Galo Argissa Kebele, Hawassa Zuria District, Southern Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

This study was conducted to evaluate the effect of *Ficus vasta* on selected soil physicochemical properties on farmers' fields of parkland agroforestry practice and to identify tree and shrub species along with their uses and management practices in Hawassa Zuria district, southern Ethiopia. Transect walk and PRA method of interview was made to identify trees and shrubs and their uses. To determine the effect of *Ficus vasta* on soil, four isolated nearly similar trees were selected under similar site and management conditions. Composite soil samples from top 20cm were collected in tree transects method from distances of 3 and 6m away from the tree base under the tree canopy and 25m outside the tree canopy. Results showed that there were 15 tree and shrub species belonging to 10 families and the major uses derived were fuel wood (14.8%), soil conservation (13.6%), fodder and shade (12.5%), farm tool (11.4%), and soil fertility maintenance (10.5%). Pruning, pollarding and lopping are the management practice applied and most farmers (53%) believed that *Ficus vasta* played a positive role in soil fertility in general, though there were farmers (47%) who reasonably stated its negative side, such as yield reduction at most near of tree trunk. In order to reduce competition with agricultural crops trees are kept scattered and had low density (8.9 ha<sup>-1</sup>). Among the biophysical factors that hinder them from growing more number of trees in their cultivated land, land-holding size and the increased demand for fuel wood in general and farmers' underestimation on its role in soil fertility maintenance of *Ficus vasta* in particular were the major ones. On the other hand, the result of the analyses on the soil physicochemical properties revealed that with the exception of soil texture and bulk density, all the selected soil properties increased significantly under the canopy than in the open area, showing a decreasing trend with increasing distance from the base of the tree. The present study demonstrates that *Ficus vasta* improves soil properties under its canopy considerably and this makes its integration into parkland agroforestry practice worthwhile and promising in the area.

**Keywords:** Cation exchange capacity, Soil macronutrients, Soil pH, Soil texture, Soil organic matter

**Gosaye Degu, 2011. Status of Some Soil Properties and Wheat Production Under Agroforestry Trees at Beressa Watershed in Gurage Zone, Central Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

This study was conducted in Gurage administrative Zone of Central Ethiopia and it was

intended to assess and document the dimensional effect of trees (*Faidherbia albida*, *Cordia africana*, *Croton macrostachyus*, *Persea americana*) on soil fertility and wheat crop. In the selection of appropriate trees, uniformity in topography and history of cropping practice was considered. The sampling procedure for agronomy, soil physical and chemical properties under the agroforestry tree species at different radii from tree trunk (0.5m, 1m, 2m and 10m) and soil layer (0-20cm & 20-40cm) was followed accordingly. After collection of the soil data it was submitted to laboratory for the analysis of different physical and chemical properties. Significant differences were observed between 0-20cm and 20-40cm depths for bulk density under *C. mycrostachus* compared to the control. Variation was observed for texture among the different tree species and radii. Comparisons of organic carbon, total nitrogen, available phosphorous, and carbon to nitrogen ratio among radii have shown no significant difference. However, it has shown decreasing trend for the above parameters down the depth. Soil pH and electrical conductivity were significantly different at 0-20cm and 20-40cm depths for soil sample taken from *P. americana*. Exchangeable potassium also showed significant difference between the two depths at one and two meter from all agroforestry tree species. There were significant differences among different radii from *Faidherbia albida*, *Croton mycrostachyus*, *Cordia africana* and *Persea americana* trunks for wheat grain yield. Different trees have different impact on the crop and soil under neath. In this study the wheat grain yield has shown positive relation for *F. albida* as compared with the control. It has increased the yield more than 111%.

However for the rest tree species (*Cordia africana*, *Croton macrostachyus*, *Persea americana*) the highest yield was obtained at the control. As a general recommendation pruning for this tree species is advised, except for *P. americana*. In addition to the above recommendation planting *P. americana* should be planted around homestead than in the farmland.

**Keywords:** Agroforestry tree, Surface, Sub-surface, Gurage, *Faidherbia albida*, *Cordia africana*, *Croton mycrostachus*, *Persea americana*.

**Haile Ketema, 2012. Soil Physico-Chemical Properties Under Agroforestry Based Conservation Tillage and Maize Based Conventional Tillage: The Case of Chichu and Haroresa Kebele, Dilla Zuria Woreda, Gedeo Zone. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Since the last few decades, there has been a growing interest in quantifying changes in soil properties resulting from different tillage systems. With the objectives of assessing variations in soil physical and chemical properties, two land uses: Agroforestry based Conservation Tillage (AFCST) and Maize (*Zea mays*) based Conventional Tillage (MCVT) under three age categories ( 5,10 and 15-years) were selected in Chichu and Haroresa Kebels, Dilla Zuria Woreda, Gedeo Zone. A total of 48 composite soil samples (4 replication \* 2 land uses \* 3 age categories \* 2 soil depth layers: 0-10cm and 10-20 cm) were collected for the analysis of Soil Organic Carbon (SOC%), Soil Moisture Content (SMC%) and soil textural fractions. Undisturbed soil samples were collected for determination of soil bulk density ( $g\ cm^{-3}$ ). Water infiltration capacity was also measured separately in the field using double ring infiltrometer. The result showed that clay and sand textural fractions significantly varied ( $P<0.001$ ,  $P=0.002$  respectively) with age of land management. Clay fraction decreased while sand tended to increase with age due to selective removal of fine fractions either

through leaching or water erosion leaving behind the sand fraction. Soil bulk density, SMC and SOC varied significantly with land use types ( $P < 0.001$ ) and soil depth ( $P < 0.001$ ). The overall mean soil bulk density was lower in AFCST ( $1.09 \text{ g cm}^{-3}$ ) than in MCVT ( $1.15 \text{ g cm}^{-3}$ ). SMC was higher in AFCST (17.86%) than in MCVT (11.11%). SOC was higher (16.43%, 52.63% and 88.35%) in AFCST than in MCVT with respect to age of land management, respectively. Lower soil bulk density (5.4%) and higher SOC (45.86%) and SMC (60.5%) were observed at 0-10 cm soil depth in AFCST than in MCVT. Soil bulk density and SMC increased while SOC has decreased with soil depth in both land use types. Water infiltration (rate and cumulative) significantly varied ( $P < 0.001$ ) with respect to land use types and was higher in AFCST than in the MCVT. Improvement in soil properties under AFCST was due to higher soil organic matter (SOM) input and less soil disturbance. Besides, the presence of continuous pores, live/dead root channels and soil fauna might have been other factors for better water infiltration in AFCST. Thus, reducing the frequency of soil disturbance through application of conservation tillage would help to improve the soil quality.

**Keywords:** Agroforestry Based Conservation tillage, Maize (*Zea mays*) based Conventional tillage, Soil physico-chemical properties, Ages of land management

**Hassen Nasro, 2010. The Role of Coffee Shade Trees in Soil Fertility Maintenance in Coffee Based Agroforestry System of Darolabu Woreda, West Hararge Zone, Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

This study was conducted on farmers' field; to assess the role of coffee shade trees in soil fertility maintenance in coffee-based agroforestry systems of Darolabu woreda, west Hararge. Key informants and household interviews were used. Analysis of physicochemical properties of soil samples collected from the farms were also carried out. The result showed that, farmers deliberately retained/planted and managed different tree and shrub species on their coffee fields except in few cases. Tree-coffee-Maize system is the most widely distributed agroforestry practice in the Woreda. Under this practice the most widely planted tree species as coffee shade trees by farmers are *Erythrina* spp. and *Acacia* spp. under which coffee (*Coffea arabica* L.), Maize (*Zea mays* L.) and Haricot bean (*Phaseolus vulgaris*) are the most dominantly intercropped crops. Most of the farmers (94%) believed that shade trees played a positive role on the survival of coffee seedling. They have expressed interest in incorporating more shade trees into their farms and they also need to adopt better shade trees than the ones which are locally available. Generally trees are dispersed in the farm and had low number in order to reduce competition with agricultural crops. Among the biophysical factors which hinder them from growing more coffee shade trees in their coffee fields, farmers' ranking was in the order of, 1) difficulty created by shade trees for intercropping crops (83%), 2) competition for resources specially nutrients (78%), 3) moisture stress in the area (75%). From the socioeconomic factors, land holding size of the HH was given the first rank (68%); followed by labour shortage for the trees and field management (43%); misunderstanding on the role of coffee shade trees given the third rank (27%). On the other hand two of the widely grown indigenous coffee shade tree species in the area namely, *Erythrina abyssinica* and *Faidherbia albida*, were used to assess their influence on the soil physicochemical properties. The result of soil analysis revealed that with the exception of soil texture and bulk density, all soil properties increased significantly under the tree canopy than in the open area in both kebeles showing a decreasing trend with increasing distance from the tree base. An increase of about 11.3 and 21.7% for organic carbon; 34.1

and 19.1% for total nitrogen; 30.3 and 39.9% for available phosphorus; 19.9 and 39.9% for CEC; 16.2 and 15.3% for exchangeable potassium; 26.1 and 21% for moisture content; 8.9 and 4.6% for soil pH, and a decline by 7.9 and 11%, in bulk density values were detected under the canopies of *Erythrina abyssinica* and *Faidherbia albida*, respectively. The present study demonstrated that *E. abyssinica* and *F. albida* trees that were planted or maintained as coffee shade trees inside coffee farms of Darolabu woreda, improve soil properties under their canopy very considerably and this makes their integration into the farming system worthy and promising in the area.

**Keywords:** Coffee-based agroforestry system, Coffee shading practice, Darolabu

**Haymanot Dibekulu, 2011. Investigation of the Biodiesel Potential of *Jatropha curcas* in Dry Land Areas; The Case of Adami Tulu-Jiddo Kombolcha, Eastern Erewa Zone, Central Rift Valley, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Biomass use as the main source of energy in most developing countries coupled with gradual depletion of fossil oil needs special attention to find out alternative fuel sources. *Jatropha curcas* L. is considered as a potential source of non-edible oil that is used for biodiesel along with its fencing uses and grows well in the tropical and subtropical countries. However, there is little field experience and documented information about the biodiesel content of *Jatropha* in Ethiopia. The present investigation has been undertaken to assess the available energy sources at household level in the study area. Farmers' perceptions towards *Jatropha curcas* was investigated for its potential of fuel production to the local condition in Eastern Shewa zone, Adami Tulu-Jiddo Kombolcha Woreda. Informal discussion, structured and semi structured interviews were used and a total of 103 households who have planted *Jatropha* were interviewed. The *Jatropha* seeds were collected from different live trees randomly. The oil was extracted from the selected live tree seeds using Soxhlet extraction with hexane and analyzed for their fatty methyl esters composition using the gas chromatography (GC) equipment. The result of the study revealed that most of the farmers at study area planted *Jatropha* through their initiative for fencing and home garden purpose. The farmers were never interested in the seeds because of the lack of knowledge, how it could be used except for few women who used powdered seed to polish the flat hot clay to bake 'injera'. The study also showed that firewood, charcoal, crop residues and dung are the leading sources of energy for cooking and used kerosene for lighting. The study revealed that households are consuming about 51.17 Ethiopian Birr per week for fuel. The mean oil content of *Jatropha* at the study site was 35%. The Gas Chromatographic (GC) analysis showed that *Jatropha* oil methyl ester (JOMEs) mainly comprised of five fatty acids methyl esters (FAMES) with high levels of unsaturated FAMES, especially oleate (47.1 to 52.8%) and linolate (29.81 to 31.5%) and Palmitolate (2.3 %). The dominant saturated FAMES were palmitate (13.32 to 9.1%) and Stearate (3.9 to 5.29%). Taking this result into account, *Jatropha curcas* has potential of biodiesel production in the study area.

**Keywords:** *Jatropha curcas*, Household energy, Farmers' perception, Oil yield and Biodiesel potential.

**Jiregna Gindaba, Andrey Rozanov & Legesse Negash, 2005. Photosynthetic Gas Exchange, Growth and Biomass Allocation of Two Eucalyptus and Three Indigenous Tree Species of Ethiopia Under Moisture Deficit. *Forest Ecology and Management*, 205: 127–138.**

The effects of water deficit on growth, biomass allocation and gas exchange of *Cordia Africana* Lam., *Croton macrostachyus* Del., *Eucalyptus camaldulensis* Dehnh, *Eucalyptus globulus* Labill. and *Millettia ferruginea* (Hochst.) Baker seedlings were studied under glasshouse conditions for 104 days. Plants were subjected to four watering regimes, viz. control (well-watered), mild-, moderate- or severe-water-deficit conditions corresponding to 25, 50, or 75% of the control moisture level, respectively. Well-watered plants produced about 4–6 times higher biomass compared to severely water deficient plants. All species had comparable biomass production under sufficient water or mild water deficit. However, the eucalypts produced more biomass than the deciduous species under severe water deficit. *C. africana* and *C. macrostachyus* invested more biomass to root unlike the other species. Increased water supply increased biomass allocation to leaves in *M. ferruginea* and the eucalypts whereas it increased biomass allocation to roots in *C. macrostachyus*. Water deficit reduced predawn and midday leaf water potentials in all the studied species with large decline at the midday in the eucalypts. Water deficit had marked effect on leaf relative water content (RWC) in *C. macrostachyus* and *C. africana* in which severely stressed plants had greatly reduced RWC than the controls during both predawn and midday. *M. ferruginea* maintained high predawn and midday RWC under all treatment conditions. Both stomatal conductances and photosynthetic rates declined in response to increasing water stress, however, the reductions followed different patterns for the different species. Water losses from *C. macrostachyus* and *C. africana* leaves were about 2–3 times those of *E. camaldulensis* and *E. globulus* across all the treatments. Water stress reduced whole plant water use efficiencies (WUEWL) from 50.9 to 20.6 g dry mass kg<sup>-1</sup> water depending on the species. WUEWL of *C. africana* and *C. macrostachyus* were lower compared to the other species in all treatments. *M. ferruginea* showed superior water stress avoidance as evidenced by its high tissue water potential, RWC and photosynthetic rate under severe water deficit.

**Keywords:** Relative water content, Stomatal conductance, Transpiration, Water potential, Water use efficiency

**Jiregna Gindaba, Andrey Rozanov & Legesse Negash, 2005. Trees on Farms and Their Contribution to Soil Fertility Parameters in Badessa, Eastern Ethiopia. *Biology and Fertility of Soils*, 42: 66–71.**

Surface (0–15 cm) and subsurface (30–45 cm) soil samples from under canopy, edge of canopy and away from canopy of isolated *Cordia africana* Lam. and *Croton macrostachyus* Del. trees and their leaves were examined to investigate leaf nutrient content, root biomass and the contribution of trees on farms to soil fertility parameters in Badessa area, eastern Ethiopia. Leaves of *C. macrostachyus* had 20% higher P and 25% lower K contents than those of *C. Africana*. The studied species had comparable leaf N content. Both species produced shallow lateral roots that extended beyond the canopy zone. Typically, higher fine root biomass was observed in the surface soils than the sub-surface soils. Both species did not affect soil organic C, pH and cation exchange capacity. Surface and subsurface soils

under tree canopies had 22–26 and 12–17% higher N, re-spectively, than the corresponding soils away from tree canopies. Surface soil available P under tree canopies was 34–50% higher than the corresponding soil away from canopies. Available P content of subsurface soil was improved only under *C. africana* canopy. The available P of surface soil under *C. macrostachyus* canopy was more than double that for *C. africana*. Trees of both species increased underneath surface and subsurface exchangeable K by 18–46% compared with the corresponding controls.

In conclusion, *C. macrostachyus* and *C. africana* trees on farms keep soil nutrient high via protection against leaching, translocation of nutrients from deeper to the surface layer and accumulation of litter, which create a temporary nutrient pool in the surface soils under their canopies.

**Keywords:** *Cordia Africana*, *Croton macrostachyus*, Litter, Nutrients, Root density

**Jiregna Gindaba, Mats Olsson & Fisseha Itanna, 2004. Nutrient Composition and Short-Term Release from *Croton macrostachyus* Del. and *Millettia ferruginea* (Hochst.) Baker Leaves. *Biology and Fertility of Soils*, 40: 393–397.**

A field study was conducted to investigate the nutrient content of green and abscised leaves of *Croton macrostachyus* Del. and *Millettia ferruginea* (Hochst.) Baker and their decomposition to return these nutrients to the soil in the short-term. Green and abscised leaves were collected from trees of comparable size in Wondo Genet, Ethiopia, and were incorporated into litterbags to decompose for a period of 12 weeks. Green leaves of *C. macrostachyus* had significantly higher nutrient concentrations than those of *M. ferruginea*. In both species, green leaves had significantly higher ( $P < 0.05$ ) C, N and P and significantly lower ( $P < 0.05$ ) lignin and polyphenol concentrations than abscised leaves. Fifty percent of the biomass applied was lost during the first 7 weeks in *C. macrostachyus*, which was about 3 times faster than that of *M. ferruginea*. The half-lives of N and P were 5–8 weeks and 4–6 weeks, respectively, in *C. macrostachyus*; the corresponding values for *M. ferruginea* were 6–8 and about 22 weeks, respectively. Only 15.7% and 26.8% of green and abscised leaves of *C. macrostachyus*, respectively, were recovered after the 12 weeks of decomposition. The corresponding values were about 3.5-fold and 2.5-fold higher for *M. ferruginea*. Generally, leaves with higher initial lignin, polyphenol, lignin: N and C:N ratios had lower decomposition and mineralization rates. In both species, removal of leaf biomass before abscission (e.g. by pruning) could enhance both the quantity and rate of nutrient return to the soil.

**Keywords:** Agroforestry, Ethiopia, Green leaves, Leaf abscission, Litter decomposition

**Kahsu Gerbru, 2012. Status of Soil Properties Under Agroforestry and Cropland in Kara Sodity Kebele, Wenago Woreda Southern Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Land use and management practices influence soil properties; good management enhances soil fertility while improper management degrades soil fertility. This study was undertaken in Kara Sodity Kebele, Southern Ethiopia, with the objective of assessing the variability in physico-chemical properties of soil and the types of woody and other perennial species under agroforestry and annual monocropping land uses. For both land uses, three slope

positions: 0-10%, 10-20% and 20-30%, were indentified and sample plots of 10 m\*10 m were placed horizontally for species inventory at 50 m distance interval in each slope position. A total of sixty soil samples (2 land uses\*3 slope positions\*5 sample plots\*2 soil depth) were collected and composited for individual depth. At the center of each sample plot infiltration rate was measured using double ring infiltrometer and the antecedent soil moisture content was also measured using Time Domain Reflectrometer (TDR). Soil dry bulk density was determined taking separate undisturbed samples from the specified depths from each land uses. The agroforestry in the study area was an assemblage of different plants occupying different horizontal and vertical arrangements. A total of 13 woody and other perennial species were recorded in agroforestry land use. Farmers in the study area manage woody species for various purposes mainly food, fodder, timber/construction, income generation, tools, medicine and soil fertility management. According to farmers the most preferred woody species for soil fertility improvement were in the order of: *Millettia ferruginea* > *Cordia africana* > *Erithrina brucei* > *Vernonia amygdalina* > *Croton macrostachyus*. Results showed that the soil textural fractions of sand and silt varied significantly ( $\alpha=0.004$  and  $\alpha=0.030$ , respectively) with respect to land uses. Sand fraction was higher and silt was lower in soil under the annual cropland than in the agroforestry. Soil dry bulk density was significantly higher in the lower than the top surface and in the annual cropland than the agroforestry. Soil moisture content and water infiltration showed significant differences with land uses ( $\alpha=0.003$ ) and soil depths ( $\alpha<0.000$ ). Soil organic carbon, total nitrogen, available P and K, and pH under agroforestry were significantly higher than soil under annual monocropping land use. Exchangeable Mg and Na also, significantly varied with land uses and depth; higher in soil under the annual cropland than in the agroforestry and higher in the lower than in the upper soil depth, respectively. Farmers' knowledge of selecting tree species for soil fertility improvement under agroforestry was in line with the result of soil fertility indicators in this study.

**Keywords:** Species richness, Coffee-enset based agroforestry, Land uses, Soil quality

**Kindu Mekonnen, Gerhard Glatzel & Monika Sieghardt, 2009. Diversity of Farm Forestry Tree and Shrub Species, and Their Socio-economic and Soil Fertility Improving Roles in the Central Highlands of Ethiopia. *Forests, Trees and Livelihoods*, 19 (2): 167-184.**

Research work was carried out in Galessa-Jeldu areas from 2004 to 2006 to; identify traditional farm forestry practices in different farm niches; rank the tree and shrub species found in some farm forest practices in terms of their fodder value and soil improvement potential; evaluate the nutrient content and fodder nutritional value of the foliage of selected tree and shrub species, and assess the socio-economic importance of the species in some of the farm forest practices traditional farm forest practices and the tree composition of some of the practices were identified through participatory rural appraisal techniques (PRA). Fodder lots, woodlots, contour hedges, scattered trees on croplands, live fences and home garden were the traditional farm forest practices in the study areas. Local farmers also helped to rank the fodder and soil improving tree and shrub species. Soil samples were collected under the farmers' top ranked indigenous species and analyzed for various soil attributes, and plant samples were collected to determine their macronutrient contents, fodder nutritional parameters and other green biomass quality indicators. *Hagenia abyssinica*, followed by *Dombeya torrida* and *Buddleja polystachya* were the three top ranked tree species for animal fodder. Farmers selected *Senecio gigas* followed by H.

abyssinica and *D. torrida* for soil fertility improvement. The green biomass of *S. gigas* was rich in important plant nutrients. *Chamaecytisus palmensis*, *D. torrida* and *B. polystachya* had a significantly higher N content than *H. abyssinica*. The foliage from *H. abyssinica* and *D. torrida* had a relatively low content of chemicals that lower palatability and dry matter digestibility. All these species can play an important role in soil management in high altitude areas where soil erosion and nutrient depletion are critical problems.

**Keywords:** Indigenous species, Soil fertility, Fodder, Green biomass, Plant and soil nutrients

**Kindu Mekonnen, Tadesse Yohannes, Gerhard Glatzel & Yosef Amha. 2006. Performance of Eight Tree Species in the Highland Vertisols of Central Ethiopia: Growth, Foliage Nutrient Concentration and Effect on Soil Chemical Properties. *New Forests*, 32 (3): 285-298.**

The coverage of trees in the highland Vertisol areas of Ethiopia is very scarce. A tree screening trial was conducted from 1997 to 2002 in Ginchi (central Ethiopia) to select fast growing and high biomass producing tree species; evaluate foliage macronutrient concentration of different tree species; and assess effects of trees on soil chemical properties beneath their canopies. *Acacia decurrens* Willd, *A. mearnsii* De Wild and *Eucalyptus globulus* Labill attained the highest height growth at 64 months as compared to other indigenous and exotic species. *E. globulus* provided better height increment from 24 to 36 and 36 to 64 months than other tree and shrub species. *Acacia mearnsii* and *A. saligna* Labill Wendl produced high biomass at 40 and 64 months. Differences between the highest and lowest dry biomass at 12, 40 and 64 months were 1.13, 29.19 and 38.89 kg tree<sup>-1</sup>, respectively. None of the tree species resulted in a foliage to stem biomass ratio of >0.98 at 40 and 64 months. *Sesbania sesban* (L.) Merr had high N and P concentrations in its foliages and stems at 12 and 40 months. Total N under *Acacia abyssinica* Hochst. Ex Benth, *saligna* and *S. sesban* was slightly greater at 40 months than 12 months.

**Keywords:** Available P, Biomass, Foliage to stem ratio, Foliage and soil N, Height

**Kiros M. Hadgu, Lammert Kooistra, Walter A. H. Rossing & Ariena H. C. van Bruggen, 2009. Assessing the Effect of *Faidherbia albida* Based Land Use Systems on Barley Yield at Field and Regional Scale in the Highlands of Tigray, Northern Ethiopia. *Food Security*, 1:337 –350**

Abstract Implications of changes in traditional *Faidherbia albida* based land use systems on productivity were investigated in Tigray, northern Ethiopia. The relation between *F. albida* based land use systems and crop productivity was explored in 77 fields and 81 farms at field and regional scales, respectively. Barley yield and soil fertility increased when field locations were closer to a *F. albida* trunk in the *F. albida* alone (AA) and *F. albida* +livestock (AL) land use systems. However, the *F. albida* +*Eucalyptus camaldulensis* (AE) land use system showed a decreasing trend in barley yield and soil fertility as distance from a *F. albida* trunk decreased. At regional scales, higher *F. albida* tree density per farm and sparsely cultivated land use types were associated with increased potential ecosystem services (barley yield). This study suggests that local biodiversity components (e.g. *F. albida* trees) can increase crop yield and soil fertility significantly when grown within and around farm lands. This study contributes to the knowledge on agricultural productivity



enhancement by developing an approach to scaling up from farm to regional level.

**Keywords:** *Faidherbia albida*, Ecosystem service, Land use, Scaling, Barley productivity

**Mekoya A., Simon J., Oosting S.J., Fernandez-Rivera S. & Van der Zijpp A.K., 2008. Farmers' Perceptions about Exotic Multipurpose Fodder Trees and Constraints to Their Adoption. *Agroforestry Systems*, 73:141–153.**

Many organizations in Ethiopia have for many years promoted exotic multipurpose fodder trees (EMPFT) for livestock feed and soil improvement. Despite the apparent benefits, the number of farmers planting these trees was low. The objectives were to elucidate farmers' perceptions about their use value, management practices and constraints to adoption in three districts representing annual (one wheat-based and one teff-based) and perennial (coffee-based) crop-livestock systems in the Ethiopian highlands. Data were collected from 235 farm households. Most farmers (95.3%) had awareness of EMPFTs and the principal information sources were development agents (75.3%). Over half of the farmers were motivated to plant EMPFTs for feed value. Motivation for other purposes depended on cropping system, vegetation cover and availability of alternative local fodder trees in the area. Farmers had positive perceptions about EMPFTs for their feed value and contribution to soil conservation. Current adopters had a mean number of 587 (SE ± 84) EMPFTs per farm. Major constraints to adoption of EMPFTs were agronomic problems, low multipurpose value, and land shortage. Majority of farmers (89.8%) were interested to either continue or begin fodder tree development. Of the interested respondents, 44.5% preferred local fodder trees whereas 55.5% preferred EMPFTs. We conclude that farmers are aware of use values of EMPFTs while perceived constraints suggest that introduction of EMPFTs need consideration of farmers multiple criteria, but also awareness of feeding fodder trees and resource availability. Moreover, current development approaches have to recognize the importance of involving the end-users at all stages through participatory approaches to enhance adoption.

**Muir K. & Casey J., 1989. Institutional Responsibility for Social Forestry in Africa: Lessons from Zimbabwe. *Journal of Social Development in Africa*, 4 (2): 27-37.**

Social forestry has failed in many countries in Africa because the projects have been conceived, designed and implemented by agencies with a commercial forestry orientation. Social forestry must address the needs of farmers and be incorporated in the peasant farm system, using and expanding the existing institutions which service rural development. The lack of appropriate technologies is a major constraint to the success of social forestry. Foresters should play a major role in developing appropriate species and technologies and in the management of indigenous woodlands. Existing agricultural extension agencies are better placed to implement social forestry programmes. An integrated approach to development and land use is essential to maximise growth and ensure the sustainable utilisation of natural resources. Agriculturalists should consider trees, and other indigenous flora and fauna, essential components of the farming systems they are developing.

**Mengsteab Hailemariam, Emiru Birhane, Zebene Asfaw & Solomon Zewdie, 2013. Arbuscular Mycorrhizal Association of Indigenous Agroforestry Tree Species and Their Infective Potential With Maize in the Rift Valley, Ethiopia. *Agroforestry Systems*, 87 (6): 1261- 1272.**

Tree species in agroforestry are important source of inoculum for companion agricultural crops. Agroforestry trees can serve as a source of Arbuscular mycorrhiza (AM) inoculants to intercropped annuals. We studied spore abundance, root colonization of *Albizia gummifera* (J.F. Gmel.) and *Croton macrostachyus* (Hochst Ex Del.) trees and their effect on colonization of maize. Soil and root samples were collected from field standing trees from under and outside the canopy of trees and maize crops in the main rainy season. The number of spore count was significantly higher under the canopy of *A. gummifera* (791/100 g of dry soil) and *C. macrostachyus* (877/100 g of dry soil) trees than outside the canopy (547 and 588/100 g of dry soil, respectively). The level of root colonization of *C. macrostachyus* (45%) was higher than *A. gummifera* (41%). Root colonization of maize crops grown under the canopy of *A. gummifera* and *C. macrostachyus* trees was significantly higher than outside the canopy ( $P < 0.001$ ). Maize seedlings grown on non-sterilized soils collected under and outside the canopy of *A. gummifera* and *C. macrostachyus* trees recorded higher root colonization, plant height, shoot and root dry weight than grown on sterilized soils ( $P < 0.001$ ). The percentage of AM colonized roots of *Zea mays* seedlings was significantly positively correlated with the number of spore counts for field soils. The rhizospheres of indigenous agroforestry perennial species are important source of inoculum for annuals. The integration of perennials and annuals in an agroforestry system enhances the maintenance of soil quality in the tropics.

**Mesfin Kassa, 2009. On-Farm Management of *Persea americana* and Its Influence on Some Soil Physicochemical Properties and Maize Yield: A Case Of Damot Gale, South Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

On-farm trees are known to contribute to biophysical and economical sustainability at farm and landscape levels. This study assessed the contribution of on-farm avocado tree on some selected soil fertility parameters and maize yield, and explored farmers' local knowledge the influence of avocado on maize production and soil fertility at Aro-Wagera, Damot Gale, Southern. Soil samples were collected from under the canopies of four avocado trees at four radial distances (0.5-1, 2-2.5, 4.5-5 and 16m) away from the trunk and at two depths (0 – 15cm and 15 – 40cm) for each radial distance. The soil samples were analysed for physical and chemical properties. The local knowledge was gathered by involving seven KI, 35% of HHs from the total of 206 HHs over the studied area. Random sampling technique was used to selected the HHs from each of the three wealth categories. Both informal and formal surveys were employed. Households with different wealth categories have different strategies in managing avocado tree grown at different niches. The interviewed farmers indicated that avocado tree have negative influence on maize production. The farmers view is supported by quantitative analysis. Tree-maize interaction showed reduction of maize yield under the tree canopy compared with open area. On the hand, the farmers' perception that avocado tree depletes soil nutrient was not supported by soil analyses. The soil textural class of the soil was sandy loam at both depths and all radial distances. There was no significant difference between samples taken from open field and under the canopy. The bulk density showed increasing trend with increasing depths and positively and highly

significantly correlated with distances from the tree trunk to open area. Chemical properties including, available P, total N, organic carbon, soil pH, and CEC had decreasing tendency with increasing depths and four radial distances from the tree trunk. In conclusion, on-farm avocado tree influence soil nutrients grown on Eutric Nitosols (which is equivalent to Ultisols) in research site do not influence fertility of soil under their canopy. Indeed, the tree can be regarded as parkland agroforestry trees to integrate them with maize production to enhance the sustainability of soil fertility.

**Keywords:** Local knowledge, Income, Parkland, Soil fertility

**Mesfin Tsegaye, 2012. Comparative Analysis on the Quality of Organic Wastes and Their Effect on the Growth Performance of Potted Seedlings at Alage, Ethiopia. M.Sc. Thesis, Wondo Genet College of, Forestry and Natural Resources, Hawassa University.**

The reliability of synthetic fertilizers to positively influence long term soil physical, chemical and biological properties has been questioned. This inevitably has led to a search for options like the recycling of organic by-products as a nursery soil media amendment. This greenhouse experiment focused on a comparative analysis of organic wastes, namely: sericulture, poultry and dairy applied as components of potting medium, and their effects on the growth performance of *Leucaena leucocephala* and *Moringa stenopetala* seedlings. The three organic wastes amendments were generated using a proportion of 3:1:1 ratio: 3 parts local soil, 1 part sand and 1 part organic waste (60, 20 and 20) % soil filled into poly bags, replicated four times, and arranged in a completely randomized design (CRD). The nutritional analysis results revealed that there was significant difference ( $P < 0.001$ ) in the nutrient contents of nitrogen. Consequently, nitrogen (N) content was highest in poultry wastes followed by dairy and sericulture wastes. The highest phosphorous value was similarly recorded in poultry waste followed by dairy and sericulture wastes. The organic wastes also significantly ( $p = 0.001$ ) in the contents of potassium (K). The results demonstrated that these organic wastes significantly ( $P < 0.05$ ) influenced growth parameters including plant height, root length, shoot and root dry mass, and shoot to root ratio. The effects of the organic wastes on height growth of *M. stenopetala* seedlings were significant ( $p = 0.0138$ ). The mean height was highest for sericulture waste treatments (27.94 cm) followed by poultry (25.96 cm) and dairy waste (20.32 cm). The effects of organic waste on height growth of *L. leucocephala* also showed similar results. Accordingly, mean height of *L. leucocephala* was highest for sericulture wastes (26.89 cm) followed by poultry (18.38 cm) and dairy waste (12.3 cm). In general; application of sericulture waste was the best in enhancing the growth performances of both species of seedlings followed by poultry and dairy wastes. Finally, it could be concluded that the effects of the organic wastes were remarkably significant for most of the measured parameters except on root collar diameter. The reason might be attributed to the nutritional quality of the organic wastes used as amendments as well as their effects on the improvements of the various soil properties.

**Keywords:** Dairy waste, Sericulture waste, Poultry waste, *Moringa stenopetala*, *Leucaena leucocephala*

**Minyishaw Ergetew, 2010. Diversity, Structure and Management Practices of Woody Species in Parkland Agroforestry in Shashemene and Arsi Negelle Weredas of Central Rift Valley, Ethiopia. M.Sc. Thesis, Wondogenet College of Forestry and Natural Resources, Hawassa University.**

Diversification of products and services from diverse woody species and other agricultural crops allowed the traditional agroforestry systems of central rift valley of Ethiopia to be considered as sustainable farming systems over decades. But their sustainability has been threatened in recent years, owing to the increasing pressure from a rapidly growing population. The present study was carried out in the parkland agroforestry in Shashemene and Arsi Negelle weredas, Ethiopia with the intention to assess (i) the woody species diversity (composition, population structure, frequency, wood resources); (ii) farmers' management practices and uses of woody species. A systematic sampling method was used to collect woody species data from 90 quadrates (100m $\times$ 50m). A total of 90 households were selected for interview when the sample quadrates fell on their field. A questionnaire was used to gather information on farmers' woody species management practices and uses. The woody species data was then analyzed for diversity, similarity index, density, basal area, and importance value index. Based on the analysis of the woody species data, a total of 33 woody species belonging to 21 families were recorded. Of these, 26 woody species were recorded in Shashemene site and 20 woody species in Arsi Negelle site. The Shannon and Simpson diversity indices were higher at Shashemene than Arsi Negelle and the reverse is true for evenness. The density of woody species in Shashemene site ( $8.58 \pm 4.51$ ) was significantly ( $p < 0.05$ ) higher than Arsi Negelle site ( $6.62 \pm 4.35$ ). However, the mean basal area of woody species at Shashemene was lower ( $2.48 \pm 3.13 \text{ ha}^{-1}$ ) than at Arsi Negele ( $4.34 \pm 5.54$ ). *Ficus vasta* is the dominant tree species at both study sites. At the study sites, farmers retain woody species in their parklands for the purpose of improving soil fertility, fodder, fuel wood, timber shade, construction, etc. They also developed experiences in identifying their woody species preferences and manage them for different reasons. The management practices employed at both study sites includes pruning, lopping, protection and coppicing. Generally the study revealed that the woody species diversity and density higher at parklands of Shashemene than Arsi Negelle. However, the basal area of woody species in parklands of Shashemene is higher than that of Arsi Negelle.

**Keywords:** Diversity indices, Frequency, Importance value index, Wood resources, Woody species

**Nath T.K., Inoue M., Myant H., 2005. Small-scale Agroforestry for Upland Community Development: A Case Study from Chittagong Hill Tracts, Bangladesh. *Journal of Forest Research*, 10:443–452.**

The potentialities of agroforestry are generally investigated through their biophysiological phenomena, cost–benefit analysis, and possible impact upon poverty reduction. There have been inadequate studies on the actual impacts of agroforestry intervention on small landholders and of farmers' attitudes toward these agroforestry programs. Drawing upon the findings of an empirical study, this article explores the effects of small-scale agroforestry on upland community development in the Chittagong Hill Tracts, Bangladesh. More specifically, the study clarifies the merits and demerits of different agroforestry systems as perceived by farmers, their impacts on the rural economy and the environment, farmers' attitudes toward

the adoption of agroforestry, and impacts of various government policies. Field data were collected by administering questions to 90 randomly selected smallholders of the Upland Settlement Project (USP), as well as from project staff. The research tools employed were semi-structured interviews, group discussions, and uncontrolled observations. The results indicated that the agroforestry interventions have in fact increased farmers' income through employment and the selling of farm products, as well as by improving the ecological conditions of these areas through reduction of soil erosion, increasing tree coverage, and maintaining soil fertility. The adoption of different agroforestry systems was governed mainly by the farmers' interests in following these techniques, their ability to cultivate the land in the pre-scribed manner, and the market demand for their products. The major obstacles that prevented increased agroforestry improvements included lack of confidence in new land-use systems, inappropriate project design (e.g., top-down innovation approach), and policy issues regarding land tenure. Recommendations are proposed to strengthen social capital in local organizations to enhance the livelihoods of the upland communities.

**Ong C. K., Black C. R. & Muthuri C. W., 2006. Modifying Forestry and Agroforestry to Increase Water Productivity in the Semi-Arid Tropics. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, 1:065.**

The need to increase water productivity is a growing global concern as the World Commission on Water has estimated that demand for water will increase by c. 50% over the next 30 years and approximately half of the world's population will experience conditions of severe water stress by 2025. Three-quarters of African countries are expected to experience unstable water supplies, whereby small decreases in rainfall induce much larger reductions in stream flow. Vital water catchments have been lost or are being degraded, creating concerns about the loss of hydrological functions and increasing competition for scarce water resources between agriculture, urban centres, industry and wildlife. The challenge is to improve water productivity at the landscape or river basin level, especially for the rapidly growing populations in many developing countries. Water productivity is defined as the value or benefit derived from the use of water. In this review, we describe recent findings regarding the hydrology of forests and agroforestry systems and indicate how modifications to tree-based systems may increase water productivity in the semi-arid tropics. Throughout the tropics, reforestation using eucalyptus has been the most significant approach for modifying the water productivity of forestry and agroforestry systems. Fortunately, the 'eucalyptus dilemma' of providing local benefit at the expense of decreased stream flow for downstream users has been well articulated in many countries where evidence-based research has changed water policy and discouraged further planting of eucalyptus on water catchments. In East Africa, the most popular replacement for eucalyptus has been another exotic from Australia, *Grevillea robusta*, which has become the species of choice for farmers in the sub-humid highlands. However, attempts to introduce this species to semi-arid areas have been disappointing due to its evergreen canopy and consequently high demand for water. Current attempts to use deciduous species such as *Melia volkensii* and *Paulownia fortunei* in such areas are much more encouraging, although the long-term implications are still unknown. Agroforestry has the potential to improve water productivity in two ways. Trees can increase the quantity of water used on-farm for tree or crop transpiration and may also improve the productivity of the water that is used by increasing the biomass of trees or crops produced per unit of water used. Plot-level evidence shows that improvements in

water productivity resulting from modifications to the microclimate experienced by crops may be limited. Instead, evidence from semi-arid areas of India and Kenya has shown that the greater productivity of agroforestry systems is primarily due to the greater quantity of water used. Further research is needed to examine the impact of the increased water use on drainage and base flow at the landscape level. Finally, we describe some of the technical approaches, which may be used to improve water productivity based on differences in tree phenology and the challenges facing smallholders in areas of growing water scarcity.

**Peter Poschen, 1987. An Evaluation of the *Acacia albida* Based Agroforestry Practices in the Hararghe Highlands of Eastern Ethiopia. *Agroforestry Systems*, 4: 129-143.**

Growing *Acacia albida* as a permanent tree crop, on farmlands with cereals, vegetables and coffee underneath or in between, is an indigenous agroforestry system in the Harrarghe highlands of Eastern Ethiopia. However, there is practically no systematic record or data on the merits and benefits of this practice. The paper presents the results of an investigation in to the effects of the presence of *A. albida* on farmlands on the yield of maize (*Zea mays* L.) and sorghum (*Sorghum bicolor* L.Moench). Twenty seven plot pairs each consisting of one plot underneath the *A. albida* foliage cover and the other in the open, away from the tree- on farmers' fields, in a 40 km radius around the Alemaya College of Agriculture, were sampled and the yield components analysed. A statistically significant increase in crops yields by 56% on average was found for the crops under the tree canopies compared to those away from the trees. This increase was caused by the improvement in 1000grain weight and number of grains of plants under the tree, indicating that the trees enhanced the fertility status of the soil and improved its physical conditions in terms of crop growth. Additional benefits from the *A. albida* trees include supply of fuelwood and fodder. Quantitative estimates of these outputs as well as their monetary values are presented in the paper. However, in order to realize these benefits to a discernible extent, higher stand densities of the tree than at present are required. Based on an enquiry about the farmer's attitude towards *A. albida*, the prospects for an extension of this promising agroforestry technique are discussed against the background of the state and trends of development of agriculture in the area. It is surmised that despite some shortcomings like the relatively slow and highly variable growth of *A. albida* and a conflict with the spreading cultivation of Ch'at (*Catha edulis* Forsk.), the prospects of extension of this technique are good. It is recommended that its propagation should be incorporated in to the programmes of the extension agencies of the various governmental agencies concerned with land use.

**Sturmheit, P. 1990. Agroforestry and Soil Conservation Needs of Smallholders in Southern Zambia. *Agroforestry Systems*, 10: 265-289.**

An agroforestry and soil conservation needs assessment survey conducted in southern Zambia revealed valuable insight into needs, constraints and development options as perceived by smallholders themselves. Inadequate efforts to conserve soil are due to technical and socio-economic factors, they do not result from a lack of awareness of the widespread erosion threat. Fruit tree planting, windbreak establishment as well as the protection of the natural *Faidherbia albida* regeneration in cropland are popular agroforestry interventions whose positive effects are widely acknowledged. Forty-two perennial species were found to directly contribute to people's diet. Although local fuelwood and fodder shortages as well as

the need for fencing are recognized only few respondents envisage agroforestry solutions such as fuelwood and fodder tree planting or live fencing. Most smallholders are interested in tree planting but have so far only planted few trees. Those planted are usually exotic fruit trees. Drought hardy, termite and browse resistant perennials adapted to smallholder tree planting must be provided by the extension services. The widespread exclusion of women from decision making and the lack of tenure security hampers female participation in agroforestry development and consequently threatens sustainable development altogether.

**Solomon Mengesha, 2010. The Role of *Erythrina abyssinica* in the Traditional Agroforestry System of Angacha Woreda, Kemebata Timbaro Zone, Southern Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

Traditional Agroforestry systems can provide valuable information for design of ecologically sustainable and socially acceptable systems. One of such traditional system is the growing of *Erythrina abyssinica* Lam. Ex. trees along farm boundaries and in homegardens of small holders in Angacha Woreda, SNNRS. The objective of the study was to document the local knowledge of farmers' in utilization and management of *E. abyssinica* in the existing Agroforestry system and evaluate its contribution to soil fertility and grain yield of wheat. Information regarding establishment and socioeconomic importance of this tree species was collected through structured questionnaire survey in two peasant associations by interviewing 60 households. The influence of *E. abyssinica* on soil properties was assessed by analyzing of soil samples The result of the socio-economic survey indicated that about 66.6% of the sample households prefer to grow this tree species on farm boundaries as well as in homegardens because they believe that the decomposed litter- fall and young branches of the tree can improves the fertility of soil. The majority of the sampled households 96.67% use the tree for livestock feed. The density of the tree was found to be 38 and 3960 trees per hectare in home gardens and on farm boundaries, respectively. In crop land, the average density of *E. abyssinica* is very limited (6 trees /ha) although it cover large proportion (63.4%) of the total average area of the farms. The average wheat yield under the tree canopy of *E. abyssinica* significantly decreased as compared to the open crop field by 12.46%. The results from soil analysis indicated that most of the physical and chemical properties of the soil under the canopy of *E. abyssinica* trees have shown significant difference compared to the soil in the open crop field. The content of organic carbon, nitrogen, available phosphorus and potassium under the tree canopy were higher than in the open crop field. This study suggested that the farmers should be advised to use the required management practices such as pruning in which grain yield reduction under this traditional Agroforestry practice could be minimized and the branches can be used for livestock feed, as fencing and planting material, and for fuel. More detailed investigations on its social, economic and cultural attributes are needed to improve this traditional system.

**Keywords:** Traditional Agroforestry system, *E. abyssinica*, Soil fertility, Wheat grain yield

**Tadesse Hailu, Legess Negash & Olsson M., 2000. *Millettia ferruginea* from Southern Ethiopia: Impacts on Soil Fertility and Growth of Maize. *Agroforestry Systems*, 48: 9-24.**

Growing agricultural crops under *Millettia ferruginea* (Hochst.) Baker, a tree that is endemic to Ethiopia, is an age-old practice in the country, but the beneficial effects of the tree on crops have not been scientifically quantified. To achieve this, four isolated and nearly identical *Millettia* trees growing on similar site conditions were selected and canopy coverage of each tree was divided into four radial transects. Four plots of 0.5x0.5m were established on each radial transect at 0.5 to 1, 2.5 to 3, 4.5 to 5, and 6.5 to 7m away from the tree bases. The control plot was established at 29.5 to 30m. Composite soil samples from each of the four plots located at a comparable distance and at two soil depths, 0 to 10 and 20 to 30 cm, were collected and analysed. The level of surface soil P, organic C, exchangeable base-forming cations and cation exchange capacity were all significantly higher ( $P < 0.000$  to  $P < 0.015$ ) under the trees than in the open field. Nutrient levels declined with depth and increasing distances from the tree trunk. Soil PH values did not show significant horizontal or vertical variations in all the soil samples analysed. Maize plants grown on soils collected from underneath *Millettia* trees resulted in significantly better growth responses and higher dry matter yield as compared to the control ( $P < 0.0001$ ). Socio-economic studies indicated that *Millettia* trees have a good standing in the region both because of their desirable biological characteristics and because of their economic benefits.

**Teklu Erkossa, Ebrahim Ahmed, Selamyihun Kidanu & Tekalegn Mamo, 1998. *Erythrina brucei*: A Potential Indigenous Species for Gully Stabilisation on a Vertisol. *Ethiopian Journal of Natural Resources*, 1(1): 77-85.**

An experiment was conducted at Ginchi watershed in 1995/96 cropping season to study the survival rate and use of *E. brucei* seedlings and cutting materials for gully stabilization. A split plot design, where two gullies with different slope gradient were in the main plots, and the seedlings and cutting materials of *E. brucei* were in sub-plots was employed. The sub-plots seedlings have shown a greater survival rate compared to the cutting materials; but this did not significantly affect sediment deposition, which was rather affected by the gully slope. The survival of both the seedlings and cutting materials were constrained by high rate of sediment deposition, insects and rodent attack as well as livestock grazing.

**Yadessa Beto, 2010. Management of Scattered *Faidherbia albida* and its Effects on Soil Physico-chemical Properties and Chickpea Grain Yield in the Parkland Agroforestry System of Adama District, Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

A field study on scattered trees of *Faidherbia albida* (Del.) commonly grown on farmers' chickpea farmlands was conducted at Adama district, Oromia region, Ethiopia. The Objective was to evaluate the effect of scattered *Faidherbia albida* trees on soil physical and chemical properties of chickpea field and grain yield production. Four isolated nearly similar *F. albida* sample trees on chickpea fields were selected under similar soil type, and topography. Soil samples were collected in tree transect method at different distance (1m and 3.5m) under the tree canopy and at two soil depths (0-15 cm and 30-45cm) and compared with samples



collected from the adjacent open areas (25m far from tree trunk). Results revealed that trees of *F.albida* significantly improved the overall soil physical and chemical properties under their canopies as compared to that of the adjacent open area. The mean values of the measured soil variables (OC, TN, available P, Ca, Mg, K, Na, pH, CEC, % BS and MC) gradually decreased with distance away from the tree trunk, except bulk density, C: N ratio and EC increased. The soil parameters were higher in the topsoil than in the subsoil layer at all soil sampling distances except bulk density, C: N ratio and EC. Data on chickpea grain yields were collected also in tree transect method from *F.albida* tree trunk at different distance ranges of 0.5–1.5m, and 3-4 m under the canopy and compared to the adjacent open area of 24.5-25.5m. The obtained result indicates the grain yield under the tree canopy zone was higher than that of in the adjacent open area by 32%. The results of this study indicated that *F.albida* trees on chickpea fields have contributed to the maintenance and improvement of soil physical and chemical properties resulting in an increase in grain yield of chickpea per unit area.

**Keywords:** *Faidherbia albida*, Parkland agroforestry, Chickpea, Soil fertility, Adama district

**Yeshanew Ashagrie, Tekalign Mamo & Mats Olsson, 1999. Changes in Some Soil Chemical Properties under Scattered *Croton macrostachyus* Trees in the Traditional Agroforestry System in North-Western Ethiopia. *Ethiopian Journal of Natural Resources*, 1 (2): 215-233.**

Changes in soil chemical properties under scattered *Croton macrostachyus* trees were studied in the traditional agroforestry system in northwestern Ethiopia. Two cultivated farmers' fields were selected on the basis of their uniformity and possession of several *Croton* trees. In each field, three adjacent *Croton* trees having approximately the same size and age, and growing side by side were selected. Soil samples were taken from under the three trees at 50, 150, 300 and 800cm (control) away from the tree base at the depths of 0-15 and 15-30 cm in four directions. Mean soil  $C_{org}$  content was low at both sites. The contents of CEC ( $P \leq 0.05$ ),  $Mg^{++}$  ( $P \leq 0.001$ ) and  $Ca^{++}$  ( $P \leq 0.01$ ) were significantly influenced by distance at both soil depths. Differences in  $C_{org}$  ( $P \leq 0.001$ ) and K ( $P \leq 0.001$ ) contents were significant only in the topsoil. A decreasing trend was found for mean values of all parameters except nitrogen with increasing distance from the tree base at both depths. The decline in topsoil chemical properties was evident up to 300cm away from the tree base, indicating the potential influence area of the tree. According to this study, some nutrient-conserving mechanism has been postulated for this particular system against the high rates of organic matter decomposition, leaching and erosion losses. The living biomass of the system (i.e., the tree) acts as a buffer or a major storage for essential nutrients and releases them slowly to increase the nutrient efficiency of the system. However, in light of the findings of this study many of the above conclusions are subject to further verification.

**Zebene Asfaw, 2008. Growth of *Millettia ferruginea* and Its Impact on Soil Properties at three Coffee Plantations of South Ethiopia. *Ethiopian Journal of Natural Resources*, 10(2): 147-160.**

Shade trees in the coffee production systems have established role of providing quality coffee, timber and environmental services. The objective the study was to investigate

growth of *Millettia ferruginea* Hochst (*Millettia*) grown in coffee plantations at Korate Kumate and Morocho sites and assess the impact of *Millettia* on topsoil properties mainly on soil texture, pH, total nitrogen, organic carbon, CEC, available phosphorus, and exchangeable base. The result showed that at 15 years of age significant differences were noticed across the sites in total height, diameter at breast height (DBH) and crown width *Millettia* trees. At Kumate site trees were higher by 25 and 48% in height, 18 and 17% in DBH and 28 and 9% in crown diameter than trees grown at Korate and Morocho, respectively. Estimation of annual wood production increment was equivalent to 2.32, 4.48 and 2.08 m<sup>3</sup> ha<sup>-1</sup> at Korate, Kumate and Morocho sites respectively. Soil textural fractions, mainly sands generally slightly decreased under tree canopies compared to open fields. Organic carbon (OC) and total nitrogen contents (TN) and available P of soils were significantly higher ( $p < 0.05$ ) under tree canopies compared to the contents in open gaps. Topsoil under canopy of *Millettia* trees, compared with open fields, had higher ( $P < 0.04$  at Korate,  $P < 0.03$  at Morocho) K but had no significant effect on some exchangeable bases.

**Keywords:** Coffee shade, Wood production, Soil properties, Legume, *Millettia*

**Zewdie Afework, 2007. The Contribution of some Agroforestry Systems to Soil Fertility Maintenance: A Case Study in Guraghe Zone, Southern Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

A study was conducted in Guraghe zone (Southern Ethiopia) to evaluate the contribution of some traditional agroforestry systems to soil fertility maintenance. Traditional home garden and farmland agroforestry systems, developed under similar soil type, topography, and time were selected. Field soil morphological descriptions and laboratory analysis were made to examine soil chemical and physical properties. Soil organic matter (SOM) was selected as the main parameter because trees and shrubs improve SOM through the provision of litter and continuous root biomass. The result of analysis indicated a decline of SOM by 36.93 and 14.6 % in continuous mono cropping and farmland agroforestry systems, respectively, as compared to the home garden, and the mean value of the home garden was significantly different ( $P \leq 0.05$ ). Similarly, moderate total nitrogen (TN) and higher available phosphorus (P) values were obtained in the two-agroforestry systems, whereas both TN and P values were low in the continuous mono-cropping field. It could be inferred that SOM might act as source or temporary sink of plant nutrients. The cropping systems had significantly ( $P \leq 0.05$ ) influenced the total nitrogen content. Estimates of the stability of the aggregates for the three cropping systems revealed that continuous mono-cropping system was at great risk of structural degradation while the two agroforestry systems have sufficient amount of SOM to maintain stable structure. In general, the results of this study justified that the traditional agroforestry systems performed better than the continuous cropping system in maintaining soil fertility. However, this study did not relate nutrient content with crop demand, and hence there might be a need for improving existing systems and/or introduce new technologies. As a result, detailed study is inevitable to make recommendations pertinent to the given biophysical and socioeconomic conditions.

**Zebene Asfaw & Ågren G. I., 2003. Top Soil Conditions and Enset Growth Beneath Scattered *Cordia africana* and *Millettia ferruginea* Trees and Topsoil Properties in Sidama, Southern Ethiopia. Acta Universitatis Agriculturae, SLU. *SLVESTRIA*, 263 (2): 1-18.**

The influence of scattered, *Cordia africana* Lam.(Cordia) and *Millettia ferruginea* Hochst. (Millettia) trees on topsoil properties and growth of *Enset ventricosum* (Welw.) Cheesman (enset) was studied and described in relation to farmers' perceptions. 110 farmers were interviewed to assess why they maintained those species on maize and enset fields and their strategies to manage them. Households with different wealth categories have different strategies in managing these tree species. Crown cover was in the order of wealthy > medium > poor. Most farmers were well aware about the role of these native tree species in improving/maintaining soil fertility, provision of protection for maize and enset crop against storm, and other ecological benefits. To evaluate farmers' perception, soil and enset plants were sampled at laterally increasing distances from the tree trunks and outside the canopy on enset and maize fields. Height growth of enset under the canopy of Millettia, but not under Cordia, was significantly ( $P < 0.05$ ) higher than on open fields. Under canopies of both Cordia and Millettia trees, the diameter of the pseudostem of enset was significantly ( $P < 0.05$ ) greater than an enset plant grown in open fields. Sand particles decline while silt particles increase laterally as a function of distance from the tree trunk. With Cordia grown on maize fields at the Enta site, however, the opposite trend was observed. In all cases, the proportion of clay was almost similar. This study also showed that topsoil under canopies of scattered Cordia and Millettia trees, compared with open fields, generally had higher pH, CEC, total N, organic C and available P, but had no effect on some exchangeable bases.

**Keywords:** Corm, Crown diameter, Enset fields, Farm trees, Farmers' knowledge, Households, Pseudostem diameter.

**Zebene Asfaw & Goran I. Agren, 2007. Farmers' Local Knowledge and Topsoil Properties of Agroforestry Practices in Sidama, Southern Ethiopia. *Agroforestry systems*, 71:35-48.**

Based on the farmers' knowledge and laboratory studies, the nutrient accumulation in the top soil (0-20cm) under *Cordia Africana* Lam (Cordia) *Millettia ferruginea* Hoschst (Millettia) *Eucalyptus camaldulensis* Dehnhardt (red gum) managed under two agroforestry practices on different farmers at three sites was evaluated. The number of trees on individual farms has increased during the last two decades. The number of stems ha<sup>-1</sup> of red gum was higher on farms of wealthier households than on farms of poor and medium households at two of the sites but at one site the number of stems ha<sup>-1</sup> on farms of poor households was higher than on farms of wealthier households. Apart from the concentration of Na in the topsoil, there were significant variations in the analyzed soil nutrients between the tree species. At all study sites, significantly higher concentration of P was observed under Millettia and Cordia than under Red gum. At one site, the concentrations of available P under Cordia were nearly two-fold, and four and half-fold greater than under Millettia and Red gum, respectively. At one site, the total N under Red gum was 14% and 24% lower than under Cordia and Millettia, respectively. In contrast, organic C content under Red gum was 11.6% greater than under Cordia and 23.8% greater under Millettia. The pH under Millettia and Cordia was significantly higher than concentrations under Red gum at one site. Topsoil

under *Millettia* and *Cordia* also had significantly higher levels of exchangeable Ca and Mg than Red gum.

**Keywords:** *Cordia africana*, *Millettia ferruginea*, *Eucalyptus camaldulensis*, Enset fields, Households, Traditional agroforestry

**Zebene Asfaw & Håkan Hultén, 2003. Arbuscular Mycorrhizal Colonisation of *Cordia africana* and *Millettia ferruginea* Trees in Traditional Agroforestry Land Use Systems of Sidama, Southern Ethiopia. Acta Universitatis Agriculturae, SLU. SLVESTRIA, 263: (4) 1-20.**

Six tree-crop combinations and two open-maize plots in enset and maize fields, in the Sidama traditional agroforestry systems were studied, assuming that such practice could affect the level of indigenous arbuscular mycorrhizal (AM) number of spores and levels of root colonization. At field level, the study was conducted beneath the canopy of *Cordia africana* and *Millettia ferruginea* trees at different plots. To assess the relationship, root colonization and spore counts of field soils sampled from varying *Cordia* and *Millettia* trees at enset and maize plots, maize and *Millettia* plants were grown in the nursery. Tree-crop combinations induced higher number of spores and higher level of colonization than in open-maize field. Significantly lower numbers of spores were observed in soils under *Cordia* and *Millettia* trees grown on maize plots than under trees grown in enset-coffee and enset plots. Levels of root colonization were relatively high for both *Cordia* (25-57%) and *Millettia* (33–62%), reflecting the mycotrophic nature of the two tree species. The proportions of colonized roots were in the following order: tree-enset-coffee > tree-enset > tree-maize for *Cordia* trees and tree-enset > tree-enset-coffee > tree-maize for *Millettia* trees. Beneath both *Cordia* and *Millettia* trees scattered on maize fields, the proportion of colonized root decreased with increasing distances laterally from the tree trunks. At nursery level, significantly higher levels of root colonization were observed for maize plants grown on soil from beneath tree enset-coffee and enset plots than those grown on soil from tree-maize and open-maize plots. Although not significant, root colonization of *Millettia* plants tended to be higher on soils from under *Cordia* trees at enset-coffee plots. The percentage of AM colonized roots of maize was significantly positively correlated with the number of spore counts for field soils. A similar trend was noticed for *Millettia* seedlings, but not significant. Both maize and *Millettia* plants with high levels of root colonization attained higher fresh weight.

**Keywords:** Fresh weight, Number of spores, Open-maize plot, Root colonization, Tree trunks, Tree-enset, Tree-maize,

## 1.4. Multipurpose Trees and Shrubs

**Alemayehu Solbamo, 2011. Management and Utilization of *M. stenopetala* and Its Role in Livelihood of Low Land Communities. M.Sc. Thesis, College of Agriculture, Hawassa University.**

The study site was at Kutcha Woreda, Gamo-Gafa zone, SNNPRS. *M. Stenopetala* is among 14 species of Moringaceae family which is endemic to Africa, specially South Ethiopia and North Kenya. It is familiar in its importance as contingency food source in times of food

deficit for low land communities where drought is main problem. However, no attention has been accrued to distribute to new areas in the national wide, even not intensified on most household's farm of adapted areas and still not get institutional extension support were the constraints of the *M.stenopetala* cultivation. The Major and specific objectives of the study was to assess and describe locally adopted management practices for better production and sustainable utilization of the species in livelihood of communities. Among 28 *M.stenopetala* growing rural Kebeles in the study Woreda 3(10.71%), 2 villages from each and total of 6 were selected in purposive method of selection. Primary data were gathered by using PRA components such as SSI (with Key informant's discussion, households and group interview), wealth ranking and scoring, and trend analysis. Key informants (26) were selected by using snowball selection technique and interview households (n=70) were selected by simple random method. Semi-structured questionnaire was implemented to collect quantitative and qualitative data from selected households. Secondary data was gathered from WoA &RD and from various online sources. Data was analyzed by using SPSS 13.0 software. The study results showed that owning of Moringa trees is positively and has significant relationship with most of households characteristics in bivariate correlation analysis at  $p<0.05$  and  $p<0.01$  significant level. Wealth categories also indicated similar correlation and significant mean difference at  $p<0.05$  level. The major means of livelihood of households identified were crop production, animal husbandry and off-farm activities, however *M.stenopetala* held the first score among other perennials in crop production. 90% interviewed HHs were Moringa growers and 51.43% planted only on backyard and 25% both on backyard and on on-farms. *M.stenopetala* planted for food, shading inter-crops, enclosing residence areas and income source. Weighted mean of planting space found was 3.6m x 3.6m and abundance of *M.stenopetala* tree computed per/ ha was 772 stems, however owning of Moringa trees on both (backyard and on-farm) locations found was 19 per/HH. 50.59% of interviewed HHs undertaken tending activities (pollarding and pruning, cultivating, mulching and pinching) and growing in inter-cropping system. In months of food unavailability (April to June) and in slight situations from January to March Moringa leaf is used as major vegetarian food for human and sold in farm gates, village and central markets. Therefore, the distribution to new areas, intensifying on previously adapted localities, creating meaningful awareness about socio-cultural, economic and ecological values of the species through incorporating with agricultural extension programs and lobbying to get policy support are pivotal to sustain this multi-usage species in recurrent drought affected low land areas.

**Keywords:** Livelihood, Wealth status, Socio-cultural, Management and utilization.

**Current D., Lutz E. & Scherr S.J., 1995. The Costs and Benefits of Agroforestry to Farmers. *The World Bank Research Observer*, 10 (2): 151-180.**

Deforestation, growing scarcity of tree products, and environmental degradation have created serious problems for rural land use in many developing countries. Agroforestry, a system in which woody perennials are grown on the same land as agricultural crops or livestock, has been increasingly en-listed in the campaign to meet these threats to the rural economy. Case studies of twenty-one agroforestry projects in six Central American and two Caribbean countries formed the empirical basis for the study de-scribed in this article. A focal point of analysis was the profitability of agroforestry for farmers as a crucial incentive to adoption. The findings indicate that many agroforestry practices are profitable un-der a broad range of conditions and are therefore likely to be widely applicable. Successful projects have worked

with local communities, responding to local needs and preferences and offering farmers a broad basket of species and systems from which to choose. Demonstration plots and the use of para technicians have been low-cost and effective means of technology transfer, and applied research has been important in identifying techniques and practices suited to the region. Other findings have identified government regulation of tree harvesting and insecurity of tenure-though not lack of title in itself-as disincentives to adoption.

**Demel Teketay, 1993. Germination Ecology of *Vernonia galamensis* (Cass.) Less. Var *ethiopica* M. G. Gilbert, a New Industrial Oilseed Crop. *Tropical Ecology*, 34(1): 67-74.**

*Vernonia galamensis* var. *ethiopica* has unique properties, which make it a promising plant to be developed as a new industrial oilseed crop in semi-arid area. However, seeds have high degree of dormancy, which may hamper its development as a crop. Four experiments were undertaken to find out the cause of dormancy and requirements for germination of the seeds. Germination in untreated seeds was highest at 25 °C (32%).

**Demel Teketay, 1996. The Effect of Different Pre-Sowing Seed Treatments, Temperature and Light on the Germination of Five Senna Species from Ethiopia. *New Forests*, 11 (2):155-171.**

The germination requirements of five Senna species: *S. bicapsularis*, *S. Didymobotrya*, *S. Multiglandulosa*, *S. occidentalis* and *S. septemtrionalis* have been investigated. Seeds possess dormancy, which is caused by their hard seed coats hampering maximum, uniform and rapid germination. To overcome this dormancy, seeds of the five species were pre-treated with (a) mechanical scarification, (b) concentrated sulphuric acid for 15,30,45 and 60 minutes and (c) boiling water for 15,30,45 and 60 seconds. To determine the effects of temperature on the germination of seeds, pre-treated seeds from each species were incubated at 10, 15, 20, 25 and 30 °C. Germination was also tested in the dark. Both acid treatment and mechanical scarification resulted in fast and uniform germination. The highest germination (95-100%) for all species was obtained from seeds treated with sulphuric acid for 60 minutes. Mechanical scarification resulted in 100% germination in all the species except *S. septemtrionalis* (59%). Boiling water improved germination significantly in *S. didymobotrya* (98%), *S. occidentalis* (82%) and *S. septemtrionalis* (97%), but had very little effect on *S. multiglandulosa* and reduced germination in *S. bicapsularis*. Senna seeds germinated over a wide range of temperatures with the optimum temperatures for germination falling around 20-25 °C. Germination was either completely inhibited or very low at 10°C. Seeds of all species germinated both in light and dark conditions. Application For maximum, uniform and rapid germination of Senna species with hard seed coat imposed dormancy; use pre-sowing treatments involving mechanical scarification, acid or boiling water treatments. Once dormancy is broken, seeds can be sown in nurseries with the temperatures ranging between 15-30 °C.

**Demel Teketay, 1995. The Effect of Temperature on the Germination of *Moringa stenopetala*, a Multipurpose Tree. *Tropical Ecology*, 36 (1): 49-57.**

*Moringa stenopetala* is a potential multipurpose tree used in traditional agroforestry practices in southern Ethiopia. Its leaves and fruits are eaten as vegetables and are also

used as fodder; the wood is used for fuel and construction; many parts of the plant have different traditional medical applications. One of the most promising potential applications of the species, however, is to purify turbid water since its seeds have flocculating and anti microbial properties. Powder from seeds is being used as a natural coagulant for low-cost water purification. Despite its promising potentials as a multipurpose tree, it has attracted little attention compared with *Moringa oleifera*, which is widely cultivated throughout the tropics. The most common method of propagation of the species in southern Ethiopia is direct sowing, without pretreatment of seeds. However, very little is known about the temperature requirements of the seeds for germination. To assess the effect of temperature on germination and to find out the optimum germination temperature, seeds were placed in a thermo gradient set at 10°C, 15°C, 20°C, 25°C, and 30°C. Germination values were 0 % (10°C), 6% (15 °C), 85% (20°C), 94% (25°C), and 76% (30°C). Germination increased with increase in temperature until 25°C, but started to decline thereafter suggesting that the optimum temperature for the germination of seeds is about 25°C. Speed of germination was higher at 25°C, and 30°C. Germination was almost inhibited at 15°C and completely inhibited at 10°C. It is concluded that areas with appropriate temperature (30°C) be selected in future agroforestry designs involving the species or development of the tree.

**Demel Teketay & Assefa Tigineh, 1991. Traditional Tree Crops Based Agroforestry in Coffee Producing Areas of Harerge, Eastern Ethiopia. *Agroforestry Systems*, 16: 257-267.**

Seven coffee (*C. arabica*) producing provinces (awrajas) in the Harerge administrative region were surveyed to identify shade trees used by farmers in coffee plantations. Fourteen permanent shade species and three temporary shade species were recorded. They represented seven families of flowering plants, with 69% of the species belonging to two families: Fabaceae (Leguminosae) and Moraceae. A new record of a leguminous tree is reported for the region. The habitat/ecology, means of propagation, uses and geographical distribution of the species 'are presented. Recommendations for future studies are made.

**Fabe A. & Grote U., 2013. The Economic Relevance of Sustainable Agroforestry Practices: An Empirical Analysis from Tanzania. *Ecological Economics*, 94: 86–96.**

This paper investigates the economic relevance of sustainable behavior of agroforestry practices for smallholders using the example of firewood exploitation in rural Tanzania. Three questions are addressed: (1) To what extent do households behave sustainably regarding firewood extraction from agroforestry? (2) Which factors determine the likelihood of households practicing sustainable agroforestry? (3) Are sustainably behaving households better off in terms of income compared to households practicing unsustainable agroforestry? The analysis is based on cross-sectional data of 314 households. A sustainability indicator shows that the share of sustainable households varies between 14 and 41% depending on the underlying wood growth rate. The results of the logistic regression indicate that property rights regarding the ownership of agricultural land and environmental awareness increase the likelihood of sustainable firewood extraction. Empirical evidence from the quantile regression reveals that poorest households generate higher income if they extract firewood unsustainably. The opposite is true for households of upper income percentiles. Thus, the poor are likely to increase environmental degradation to generate more income causing a 'downward spiral' of the poverty–environment trap resulting in income losses in

the long run. Households with a per capita income of 524 TZS or more manage their tree stocks sustainably.

**Fortmann L., 1988. Great Planting Disasters: Pitfalls in Technical Assistance in Forestry. *Agriculture and Human Values*, 5 (1-2):49-60.**

Social forestry, in contrast to traditional forestry, is intended to meet biological or environmental, procedural and equity goals. Social forestry projects may not fulfill this multiplicity of goals either because priority is given to a single goal or because various factors including the structure and norms of implementing institutions and the distribution of local power overwhelm procedural and distributive intentions. Thus, despite participatory and equitable project designs, social forestry projects may result in the distribution of benefits to the rich and costs to the poor and products that either have little local value or lose their value over time. Factors leading to these outcomes are explored and countervailing measures considered.

**Franzel S., 1999. Socioeconomic Factors Affecting the Adoption Potential of Improved Tree Fallows in Africa. *Agroforestry Systems*, 47: 305–321.**

In many parts of Africa, farmers periodically fallow their land, which is allowing land to lie idle for one or more seasons primarily to restore its fertility. This paper assesses the feasibility, profitability, and acceptability of improved tree fallows, which are the deliberate planting of trees or shrubs in rotation with crops to improve soil fertility. Improved tree fallows are assessed at different stages of intensification, drawing on farmers' experiences in three different settings. In extensive systems where land is plentiful and existing fallows with natural regeneration of vegetation restore soil fertility (southern Cameroon), farmers have little incentive to invest labor in establishing improved fallows. Where population density is higher and fallow periods are decreasing and farmers perceive a decline in soil fertility (eastern Zambia), improved fallows have great potential. In intensive systems where land is unavailable and cropping is often continuous (western Kenya), many farmers find it difficult to fallow land. Even here, there is scope for introducing improved fallows, especially among farmers who have off-farm income. Labor constraints and institutional support were found to greatly influence the feasibility of improved fallows. In intensive systems, low returns to cropping, low base yields, and a high opportunity cost of labor increase the returns to improved fallows. Principal factors associated with acceptability include past perception of soil fertility problems, past use of measures for improving soil fertility, current fallowing, economic importance of annual cropping, and wealth level. Adoption potential may be increased by reducing fallow periods, intercropping trees and crops during the first season, reducing establishment costs, producing higher value by-products, and by encouraging farmers to test improved fallows on high-value crops.

**Fikirte Asrat, 2011. Integration of Fruit Trees in the Farmland: Production and Contribution to Household Income in Mota District, Amhara Region, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Field trial was conducted in Mota district, East Gojam zone, Amhara region of Ethiopia during the cropping season of 2011. The main purpose of this research is to evaluate the



contribution of fruit tree-based agroforestry on diversification of products, improvement of household income and soil property changes. The study consisted of seven treatments in four replications laid down in randomized complete block design. Three of the treatments involved intercropping of onion (*Allium cepa* L.), tomato (*Lycopersicon esculentum* Mill.) and cabbage (*Brassica oleracea* L.) with papaya tree (*Carica papaya* L.); the other three sole annual crops and one represented papaya tree alone. Data were recorded on growth and yield performance of papaya tree; soil physical and chemical properties at two soil layers (0 – 15 cm and 15 – 30 cm) under intercropping and monoculture systems; input costs and returns from selling of products; and on land equivalent ratio (LER). Results from the study showed that all the measured tree growth parameters of papaya such as tree height, trunk circumference, crown diameter and number of fruits per tree were found non-significant under different treatments. Nonetheless, fruit weight per papaya tree was significantly influenced by the intercropping. The highest yield of fruits per tree (41.27 kg) was achieved under papaya monocropping. All soil parameters (% soil MC, BD, pH, EC and %OC) showed significant difference among treatments. In both soil layers, except bulk density the rest soil parameters revealed higher values under the agri-horticulture systems. All the treatments yielded positive net revenues with benefit cost ratio (BCR) of more than one. Moreover, the intercrops revealed 12.21 – 32.96 % revenue augmentation from their respective monocrops. In all treatments LER exceeded unity. The highest LER value (1.74) was obtained when tomato was intercropped with papaya, while the lowest LER (1.53) was revealed in the papaya + cabbage intercropping. Based on the findings it was concluded that fruit tree integration into agricultural mono cropping system can improve soil properties, provide higher total outputs as well as financial returns and can prove to be remunerative business.

**Keywords:** Agri-horticulture, Intercropping, Soil properties, Mota, Land equivalent ratio

**Gebreslassie Hadish, 2011. Assessment of Morphological Characteristics, Natural Regeneration, Leaf Biomass and Seed Germination of *Senna alexandrina* mill in Somali and Afar Regional States. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

*Senna alexandrina* Mill belongs to the plant Family Fabaceae, sub family Caesalpinioideae. It is overexploited and collected for market for its medicinal uses. Despite its useful little is known about its morphology population status in Ethiopia. The species also suffer from seed germination. The objective of the current study was to characterize morphology, natural regeneration; abundance and the effect of pre-sowing seed treatments on its germination. Study was conducted on morphology, abundance and natural regeneration status of the species in Shinille and Dubti districts following systematic random sampling. In each of the study sites, 15 plots of 25x25m were laid down at intervals of 100m, following a transect line. Four sets of laboratory experiments were conducted at Addis Ababa University to investigate the effect of pre-sowing seed treatments. The seed pre-treatments comprised of acid scarification, hot water treatments and mechanical scarification. The acid scarification experiments involved the use of H<sub>2</sub>SO<sub>4</sub> (95%, 50% and 25%), 35% HCl, and 70% NHO<sub>3</sub> for soaking seeds for a range of time intervals. Hot water treatment was applied at 90 °C, 70 °C and 50 °C for different time intervals. Mechanical scarification was done by nicking the seed coat with scalpel blade. Most of the morphological characters did not show significant variation between the two study sites; however, the mean number of leaflets, pod length,

pod length- pod width ratio, internode length, with the values 4.05287, 2.96333, 1.99335, 1.50486, 3.19339, 2.70159, respectively were significantly higher in Dubti than in Shinille. Fresh leaf biomass (kg/ha) was also significantly higher in Dubti (45.77) than in Shinille (27.24). Natural regeneration and abundance was numerically higher in Dubti than in Shinille. Among the seed treatments, the highest germination percentage was obtained from the 95% H<sub>2</sub>SO<sub>4</sub> (100%), followed by mechanical scarification (92%). However, 50% and 25% H<sub>2</sub>SO<sub>4</sub> pre-treatments also resulted in 76% and 80% MGP respectively. Hot water treatment resulted in the MGP of 46%, which was smaller than both the H<sub>2</sub>SO<sub>4</sub> and mechanical scarification. It was thus concluded that the natural populations of *S. alexandrina* did vary in some of the morphological characteristics but it was not possible to conclude that the two populations were different since many other characters were nearly similar. Furthermore, seed pre-treatment with sulphuric acid and mechanical scarification could be used to raise seedlings and establish man-made stands whenever the need arises.

**Keywords:** *S. alexandrina*, morphology, Natural regeneration, Abundance, Leaf biomass, Seed pre-treatment

**Genet Negash, 2011. Effect of Pre-sowing Treatments and Incubation Temperatures on Germination Characteristics of *Acacia senegal* (L.) Willd seeds. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University**

*Acacia senegal* population in the dry lands has been subjected to increasing anthropogenic pressures. Attempts to rehabilitate the degraded wood lands with reforestation programs of the species are constrained with lack of a procedure for large-scale production of *Acacia senegal* seedlings. It produce seeds with hard, impermeable seed coat which prevents the simultaneous germination of an entire stock of seed and often necessitates a range of pre-sowing treatments for a faster and more uniform seed germination. Three set of laboratory experiments were conducted at Wondo Genet College of Forestry and Natural resources to investigate the effect of a range of pre-sowing treatments, incubation temperatures and their interaction on the germination characteristics of *A. senegal* seeds. Seeds were nicked, soaked in cold water for 12 or 24 hours, hot water for 10 or 15 minutes, acid for 5 or 10 minutes or left untreated and incubated either at room temperature, 15OC, 23OC, or 30OC in laboratory incubators for 10 days. Data on cumulative and final germination percent, mean daily germination, peak value, germination value, and germination energy were computed. The results revealed that clean daily germination reached a peak (31-35.6%) on the 2 and day for seeds soaked in cold water (12 and 24hours) and in acid for 5 minutes. In contrast, for control and hot water treated for 10 minutes reached a peak (16.3 -19%) on the 4 th day which was significantly lower than the mean daily germination (29-30%) for the same day within seeds subjected to cold water, acid for 5 minutes and nicking. Seeds treated with hot water (10 and 15) yielded significantly lower final germination percent (27 and 73%) than the rest pre-treatments. Moreover, seeds treated with hot water had significantly lower germination value (0.14-1.24) and germination energy (0.39-2.15) than the other pre-sowing treatments. Final germination percent, germination value and germination energy of untreated seeds incubated at 15O C was significantly lower than seeds incubated at room temperature, 23 O C and 30OC. There was no significant difference in final germination percent of untreated seeds incubated at different temperatures. However, final germination percent of seeds incubated at 15OC was 32-35% lower than seeds in the rest of the incubation

temperatures. Across all pre-sowing treatments (except hot water 15 minutes) and sampling days, percent seed germination generally increased with increasing incubation temperature. Nicking seeds or soaking seeds in cold water and subsequent incubation at 15OC yield 73-90% seed germination 3 days after sowing, which was 72-78% higher than that in the control (20%). Generally, increase in incubation temperature (15OC → 23 OC → 30OC) had no significant effect on final germination percent, germination value and germination energy of nicked seeds and seeds soaked in cold water (12 and 24hours). Soaking *A. senegal* seeds in cold water for 12 and 24 hours is a cheaper and easier-to-administer pre-sowing treatment that yielded well above 73-90% seed germination at room temperature in the first 2 days after sowing and more than 90% seed germination at 23OC in the first 3 days after sowing.

**Keywords:** *Acacia senegal*, Dormancy, Pre-treatments, Incubation temperature, Germination

**Getachew Mulugeta, 2014. Moringa Germplasm Collection and Screening. Journal of Natural Sciences Research, 4 (3): 2224-3186.**

*Moringa stenopetala* and *Moringa oleifera* germplasm collection & screening trial was conducted in three locations at Konso, Arbaminch and Awassa in SNNPR, Ethiopia. The study was carried out for three consecutive years during, with the following objectives: to assess natural variability of agronomic yield and to generate germplasm pool for subsequent genetic improvement. In the experiment 33 Moringa accessions were in comprised among which 28 accessions belong to indigenous specie of *Moringa stenopetala* and 5 accessions to exotic *Moringa oleifera* species also included and were compared by using Randomized Complete Block Design with four replications. The results three years after establishment revealed that there was a significant variation in accession Konso Nagayle with mean values of survival rate (98.88 %), height growth (4.53 m), collar diameter (28.56 cm), number of branches (96.99 branches per tree) and dry leaf biomass (47.62 kg per tree) at three tested sites. This could be due to the environmental factors and natural genetic variability of the Moringa accessions, which generally expressed in terms of tree growth and yield. Therefore, the native Moringa accession Konso Nagayle could be recommended for further genetic pool improvement and leaf production at Konso, Arbaminch, Awassa areas and places with similar agroecologies.

**Keywords:** *Moringa stenopetala*, *Moringa oleifera*, Locations/sites, Accession, Natural variability, Growth, Yield

**Getachew Mulugeta & Anteneh Fekadu, 2014. Industrial and Agricultural Potentials of Moringa. Journal of Natural Sciences Research, 4 (14):2224 - 3186.**

Moringa is called the “miracle tree” because the plant can provide as a food supplement for fortification, energy drinks, specialty creams (cosmetics, shampoos, etc.) and oil and especially in the current oil crisis, can be blended with diesel to form as “biofuel”. The leaves can be used as food and oil can be extracted from the seeds as vegetable oil or as biofuel feedstock. According to published Report “Moringa Oil” (Jesus Benavides, et. al., 01.17.2008) the demand in the United States and European Union could only be filled by 3.8% and 7.3%, respectively, and there was a growing demand for biofuel production from 12B liters to 37B liters by 2010. As biofuel feedstock, Moringa seeds can produce up to 40

percent oil. This means that a kilo of seeds from the pods would yield 400 milliliters of oil, which can be used either for cooking or as substitute for diesel. *Jatropha* was the toast in biofuel oil industry until *Moringa* was discovered as better source. More recently the ben oil has also been shown to be particularly effective in the manufacture of soap producing a stable lather with high washing efficiency suitable for some African countries. The seed oil is used in arts and for lubricating watches and other delicate machinery, and useful in the manufacture of perfumes and hairdressings. The pressed cake obtained after oil extraction may be used as a fertilizer. The industrial uses of the *Moringa* tree include the use of its wood in paper and textile industries, bark in the tanning industry, and the seeds in water purification. The dried leaves appear to be much more effective animal feed. One agriculturist fed his cows with just 2 kg of dry matter of *Moringa* per day in addition to the normal food he had been feeding them with and the milk production increased by 58 percent. Then he increased it to 3 kg per day, and the milk production increased by 65 percent. The extract obtained from the leaves of *Moringa* in 80 % ethanol contains growth enhancing principles (i.e. hormones of the cytokinine type). The extract can be used in the form of a foliar spray to accelerate the growth of young plants. Study on *moringa* and global warming revealed that 1 person emits 320kg of CO<sub>2</sub>/yr; it takes 23 Japanese Cedar trees 50 years to absorb this amount of CO<sub>2</sub>; it takes 2 *Moringa* trees 2 years to absorb this amount and 1 family car emits 2300kg of CO<sub>2</sub>/yr; it takes 160 Japanese Cedar trees 50 years to absorb this amount of CO<sub>2</sub>; it takes 10 *Moringa* trees 2 years etc (Muriel, 2010). Therefore, this review article tries to depict the industrial and agricultural potentials of *Moringa*.

**Keywords:** Industry, Biofuel, Carbon emission and absorption, *Moringa*

**Hyde W.F. & Köhlin G., 2000. Social Forestry Reconsidered. *Silva Fennica*, 34(3): 285–314.**

This paper reviews the expectations for forestry's contribution to rural development – and for its special contributions to the most disadvantaged, to women and the landless users of the forest commons. A growing literature challenges some of these expectations; in particular, certain expectations about cultural differences and physical stocks as explanatory factors for patterns of household behavior. This literature could also be used to support a call for sharper definitions of deforestation, improved indicators of the effects of forest resources on the rural poor, and improved design of forest policy interventions. Our paper reviews the literature, suggests some unifying themes, and identifies the critical issues that remain unanswered. The primary contention arising from this literature is that households follow systematic patterns of economic behavior in their consumption and production of forest resources, and that policy interventions in social forestry should be analyzed with regard to markets, policies, and institutions. Markets for forest resources generally exist in some form – although they may be thin. Successful forestry projects and policies require careful identification of the target populations and careful estimation of market and market-related effects on the household behavior of these populations. Institutional structures that assure secure rights for scarce forest resources are uniquely important in a forest environment often characterized by open access resources and weak government administration. Social and community forestry, improved stoves, improved strains of multi-purpose trees, and even private commercial forest operations can all improve local welfare, but only where scarcity is correctly identified and the appropriate institutions are in place. An increasing number of observations of afforestation from developing countries around the world is evidence that

forestry activities do satisfy these conditions in selective important cases. The critical point for policy is to identify the characteristics of these successful cases that are predictive of other cases where new forestry activities can be welfare enhancing.

**Ingwe R., Ushie M., Ojong F.E. & Okeme I., 2009. Pursuing Sustainable Development through Agroforestry in Nigeria: Geodemographic and Spatial Analyses of Agroforestry Implementation in 36 States and Capital Territories. *Journal of Sustainable Development in Africa*, 11:101-103.**

The presence of 10 of the world's most rapidly deforesting nations in Africa adds to threats to sustainable development on the continent. Although Agro forestry is increasingly promoted for restoring forest, degraded environment, reducing green house gases, and gaining other co-benefits, its implementation in parts of Nigeria is poorly understood. Using geodemographic and spatial analysis, we show patterns of agro forestry implementation in Nigeria's 36 states and capital territory. We found that per capita implementation of agro forestry (populations of farmers and totals by states) have been low nationally and varies among constituent states/territory. We argue that Israel's reversal of about 400- year old desertification and Niger (Nigeria's northern neighbour)'s re-vegetation and environmental improvement through agro forestry present good practices and innovations in agro forestry for reversing Nigeria's 50-year old desertification. The implication of this paper for policy includes the adoption of agro-forestry for achieving multiple MDGs in Nigeria as urgent and imperative.

**Keywords:** Agroforestry, Nigeria, Deforestation, Desertification, Environmental Degradation, Poverty

**Iniobong A., Inemesit A. & Ibok P., 2009. Agroforestry Practices among Male and Female Farmers in South–South, Nigeria. *Small-scale Forestry*, 8:63–76.**

Perceptions of the benefits of agroforestry practices (AFPs) and the level of utilization of these practices by male and female participants were examined in the agroforestry programs of the Akwa Ibom and Cross River State Governments of the South–South region of Nigeria. Responses were derived from 250 randomly selected respondents. Overall, respondents perceived the major benefit of agroforestry practices as enhancement of environmental conservation. Female respondents however perceived increased income as the major benefit of agroforestry practices. A composite perception index revealed that women farmers were more favourably disposed than male respondents to the utilization of agroforestry practices. The farmers were favourably disposed to the utilization of only five of the 16 identified AFPs in the study area, including 'leaving of isolated woody trees on farmlands', 'utilizing woody trees as windbreaks' and to 'demarcate farm boundaries', 'planting of woody trees in combination with fruit trees', and 'planting of woody trees in combination with vegetable crops'. Male and female responses were generally similar although a major difference was observed with regard to 'planting of trees for fuel wood'. The composite index, however, revealed a general low level of utilization of AFPs, although female farmers were relatively more disposed to the utilization of AFPs. The key policy implication of the study is the necessity to embark on sustained education and environmental awareness campaign, with a focus on presenting AFPs as livelihood sustaining and risk mitigation activities, against its present misperception as simply a government strategy to increase the stock of woody trees

in the environment. This policy should endeavour to target landless women farmers who have been found to be more interested in the adoption of AFPs into their farming system.

**Kahurananga J., Alemayehu Y., Tadesse S. & Bekele T., 1993. Informal Surveys to Assess Social Forestry at Dibandiba and Aleta Wendo, Ethiopia. *Agroforestry Systems*,24: 57-80.**

Two surveys were carried out at Dibandiba, a semi-arid site in central Ethiopia, and Aleta Wendo, a sub-humid site in southern Ethiopia, to assess farmers' attitudes toward and perceptions of tree planting, levels of social forestry and uses of tree products. At Dibandiba, farmers planted mostly *Eucalyptus camaldulensis* trees, exclusively on homesteads and *Acacia albida* was left on farmland. Trees were planted mainly for construction (32%), fuelwood (29%), shade (11%) and cash (11%). Major (85%) uses were fencing, fuelwood, construction and plough handles. Dung was the major source of fuel (56%). At Aleta Wendo, planting consisted of *Eucalyptus globulus* mostly on private woodlots and homesteads, of *Milletia ferruginea* and *Cordia abyssinica* on farms, and of *Euphorbia abyssinica* on fences and boundaries. Avocado and pears were also planted. The uses were the same as at Dibandiba. Major constraints were lack of seedlings and shortage of land at both sites, plus shortage of water at Dibandiba. Also, a review of information obtained from previous surveys on household composition and income, farm holding, cropping pattern, livestock composition and the use of labour was made.

**Keith A. B., Bonongwe C.S.L. & Carroll M.S., 2000. Adopting Agroforestry: Evidence from Central and Northern Malawi. *Journal of Sustainable Forestry*, 11 (3): 41-69.**

This study was conducted in rural central and northern Malawi to (1) identify factors limiting/enhancing agroforestry adoption and (2) assess the impact of cultural differences on the adoption and use of agroforestry systems. The study involved interviewing representatives of a large number households concentrated in four separate study areas. The study used the grounded theory method of sociology, which relies on largely qualitative data and inductive reasoning. Nine-tenths of the farmers in the study were resource poor with little or no formal education. Two-thirds of the farmers in the study were not familiar with agroforestry systems such as alley cropping. The level of interest in adopting agroforestry systems, which did not include the application of inorganic fertilizer, was quite high because of anticipated improved crop yields. An overriding theme emerging from the study was the importance of considering micro-level economic conditions and cultural dynamics in the design of successful agroforestry programs. The results also suggest the utility of local level social analysis prior to efforts designed to further promote the adoption of agroforestry. Clearly, biological sustainability is essential, but not sufficient in the design of such programs.

**Kindu M., Glatzel G., Tadesse Y., Yosef A., 2006. Tree Species Screened on Nitosols of Central Ethiopia: Biomass Production, Nutrient Contents and Effect on Soil Nitrogen. *Journal of Tropical Forest Science*, 18(3): 173–180.**

Shortage of tree biomass is a severe problem in the highlands of Ethiopia. A screening trial was conducted from 1997 till 2002 to select fast growing and high biomass producing tree species, evaluate foliage and wood macronutrient contents of different tree species, and

assess effect of tree species on soil nitrogen beneath their canopies. Seven treespecies: (i) *Acacia decurrens*, (ii) *Chamaecytisus palmensis*, (iii) *C. proliferus*, (iv) *Eucalyptus globulus*, (v) *E.camaldulensis* (vi) *Grevillea robusta* and (vii) *Hagenia abyssinica* were evaluated in a randomized completeblock design with three replications. All species were exotic except *H. abyssinica*. *Grevillea robusta* exhibited slow height growth and wood production as compared with the five exotic species. *Acacia decurrens* provided the highest mean dry biomass at 64 months. Foliar N levels in *A. decurrens*, *C. palmensis* and *C. ploriferu* were significantly higher than those in the other four tree species. *Acacia decurrens*, *C. palmensis* and *C. ploriferus* are N-fixing tree species. *Hagenia abyssinica* had higher K levels in the foliage and wood. *Eucalyptus* species tended to deplete soil fertility whereas *C. palmensis* and *C. ploriferus* improved soil fertility. *Chamaecytisus* species and *A. decurrens* can be short-term options for soil fertility improvement and a source of fuelwood respectively.

**Keywords:** Aboveground biomass, Exotic, Indigenous, Nitrogen, Phosphorus

**Masresha Fetene & Solomon Habtemariam, 1995. Investigation on Allelopathic Properties of Coffee (*Coffea arabica* L.) Leaves, Pulp and Tree-canopy soil. *Ethiopian Journal of Science*, 18 (1): 51-65.**

The presence and intensity of allelopathic properties in coffee (*Coffea arabica* L.) leaves, pulp and under-canopy soil was investigated using aqueous extracts of the same on germination and radicle growth of lettuce (*Lactuca sativa* L.) and on the growth of barley (*Hordium vulgare* L.).Germination of lettuce was inhibited by both coffee leaf and pulp extracts. The degree of inhibition ranged from about 10% over the control for the lowest concentration (0.5%) to 100% inhibition for the highest concentration (20%). Only 10 to 20% of the inhibitions by the highest extract concentration cold be attributed to osmotic effects of the extracts. In both seed germination and radicle elongation, more inhibition was observed for leaf extracts than for pulp extracts of similar concentration. Growth of barley was significantly reduced by pulp extracts, and the reduction in shoot growth was more pronounced than that of root growth. Effect of canopy soil extract on germination and radicle elongation of lettuce decreased with distance of sample from the tree trunk within the canopy. These results indicated the accumulation of allelopathic substances within under-canopy soils of coffee trees. Implications of the findings for the management of coffee trees in agroforestry systems are discussed.

**Mohammed Abdalle, 2010. Local Management and Diversity of Trees in Land Use Systems of Dollo Ado District, Liban Zone of Somali Regional State. M.Sc. Thesis, College of Agriculture, Hawassa University.**

The study on local tree management practices was carried out in Dollo-Ado district of Somali Regional State (S.R.S), to assess local knowledge and practices with respect to management and utilization of trees, on which sustainable use of tree resource could be based. The study was conducted in eight Kebeles which were selected on the basis of the presence of two different land uses; Agro-pastoralism and pure pastoralism. Vegetation data were collected from 48 sample quadrats that were laid on 16 transects. Each quadrat had a size 20mx20m = 400 m<sup>2</sup>. To assess the land use system, local tree management and utilization, indigenous knowledge of tree/shrubs management and traditional rules, norms

and customs governing tree management and access to common property resources, forty-eight households were randomly selected from the eight-villages and questionnaire survey were undertaken. Analysis of the vegetation data revealed that a total of 80 woody species, 44 at Pastoralists land use and 36 at Agro-pastoralists land use, distributed in 22 families and 30 genera were encountered. Mimosaceae and Burseraceae were found to be the predominant species comprising 26.3% and 25% of the species composition, respectively, while Acacia and Commiphora were found to be the predominant genus comprising 18.75% and 16.25% of the species composition, respectively. Among the eighty-recorded woody species, trees were the dominant growth forms accounting for about 78% of the total species composition while shrubs contributed to 22%. The result showed the existence of high diversity and evenness values for both land uses. Variation existed in vegetation diversity and density between the pastoralist and agropastoralist land use, with the former showing higher values for both variables. The trees and shrubs play very important economic and ecological roles in the study area that include a critical support to the livestock sector, which is the mainstay of the regions economy. Extraction of gum and incense could play significant role to the local economy, but they are under exploited due to poor marketing and infrastructure development. The household survey also disclosed that the pastoralist and agro-pastoralist communities have a wealth of traditional knowledge about their environment and it's management. However, they are being prevented from using it due to the weakening of traditional institutions for decision making and resource control and its replacement by alternative power structures that do not have sufficient knowledge base about the rangeland environment. Over the last decade, the increasing human and livestock population is exerting too much pressure on the woodlands leading to degradation in some areas. To overcome degradation of the vegetation, there could be a process of enabling customary and local institutions that best use the traditional knowledge in natural resources management. Policy options that improve conservation and sustainable utilization of the natural resources should also be developed. Moreover the economy of the pastoral communities should be strengthened by reducing their susceptibility to volatile terms of trade, and increasing market opportunity for their products. This could reduce their heavy dependence on the natural vegetation.

**Keywords:** Diversity of trees & shrubs, Agropastoralism, Pastoralism, Indigenous woodland

**Mussa Yusuf, Zewge Teklehaimanot & Deribe Gurmu, 2013. The Decline of the vulnerable Yeheb *Cordeauxia edulis*, an Economically Important Dryland Shrub of Ethiopia. *Oryx*, 47 (1):54-58.**

*Cordeauxia edulis* (Leguminosae: Caesalpinioideae), commonly called yeheb, is a small tree/shrub species endemic to Ethiopia and Somalia. The tree produces nuts that are consumed as a staple food by pastoralists and are sold in local markets. Recent reports indicate that *C. edulis* has vanished from many locations where it was noted by earlier travellers and, as a result, it is currently categorized as Vulnerable on the IUCN Red List. To assess the current status of the species we studied it around 10 villages in Boh district in the Somali Regional State of Ethiopia, where the only known remnant stands of *C. edulis* in Ethiopia are found. The results show that these populations of *C. edulis* are declining and natural regeneration is negligible. We recommend that yeheb should be categorized as Endangered on the IUCN Red List, based on criteria A1d, because we estimate that there has been at least a 70% reduction in population size from overexploitation. The



major constraints to natural regeneration and imbalance in the population structure are over-harvesting of immature nuts, excessive browsing of shoots and leaves by livestock and excessive cutting of wood for fuel and construction. We recommend that conservation measures for the species focus on sustainable harvesting of mature nuts, raising awareness among local people, preservation and monitoring of remnant populations and introduction of the species in ecologically suitable sites.

**Keywords:** Caesalpinioideae, *Cordeauxia edulis*, Ethiopia, Nuts, Population density, Regeneration, Size class distribution

**Nardos Philipos, 2013. The Role of *Cordia africana* (Lam) in the Farming Systems of Baja Fabrica and Abaye Kebeles of Wondo Genet Woreda, Southern Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

This study was conducted with the objectives of identifying socio-economic roles of *C. africana* at household and community level, to document farmers' perceptions on its environmental roles and to assess its on-farm management and utilization practices at Wondo Genet area. Informal survey was conducted before the actual assessment was done. Then, two Kebeles (Baja Fabrica and Abaye) were purposively selected based on the availability of *C. africana* tree. From each Kebele the numbers of respondents were determined using random sampling method, and the data were collected using structured questionnaire. The data were analyzed using Statistical Package for Social Sciences (SPSS). Descriptive statistics were used to summarize the data. The average number of *C. africana* owned by individual farmer was 3.32 trees. The various purposes for which *C. africana* has been promoted and initially planted are not the same as the primary or most important benefit derived by the farmers. About 73% of the farmers planted *C. africana* mainly for timber production, 12.4% to improve soil fertility, 9.5 % as a live-fence and 5.3% to increase crop productivity. Those who responded that the most important benefit derived from *C. africana* was timber production reported that soil fertility improvement and as live-fence were other main benefits. The most common management practice done for *C. africana* was pruning. Most farmers have experienced positive economic, social and environmental benefits from *C. africana*, but very few farmers reported negative experiences. The majority (97%) had not experienced any negative effects of *C. africana* on agricultural crops.

**Keywords:** Agroforestry, Soil fertility management, Timber production, Tree management, Utilization of trees.

**Oukula Obsa, 2010. Management and Utilization of Bamboo Based Agroforestry Systems Around Teticha, Hula Woreda, Sidama Zone. M.Sc. Thesis, College of Agriculture, Hawassa University.**

Bamboos are grasses belonging to the subfamily Bambusoideae. Over 1250 different species grow world-wide. Ethiopia has over one million hectares of highland and lowland bamboo resources. Although bamboo is not an integral part of the economy of Ethiopia, it plays a very important role socially, economically and ecologically in areas where it occurs naturally and where it is planted. However, the use of this abundant resource is largely restricted to the household level, where people consider bamboo as their second-most important source of livelihood after agriculture. The overall aim of this research proposal

is to assess and explore the impact of bamboo for improving food security and income generation of farmers through enhancing productivity while conserving the resource base. This resource has great contribution in improving the livelihood, tackling food insecurity problem, decreasing pressure on natural forest, reduce erosion hazard and great social values. However, lack of awareness about their multiple use, lack of technical information particularly on the local bamboo resource, Network and information gaps between various stakeholders of the sector and over exploitation of the resources are the main challenges of the bamboo resources faced in the proposed study area, Arsi Negelle district. Data will be collected at district, PA and household levels. In the house hold levels, interview, group and individual discussions with a local peoples and personal observation will be conducted. Within each PA 10% of households will be selected on the basis of their economic status and involvement in bamboo resources production. Data will be entered in a SPSS 17.0 version spreadsheet. Descriptive statistics will be computed from the entered variables. Chisquare and t-significance tests will be used to find the significance of dependence and homogeneity, and difference, respectively, between some of the variables. To conduct research activates 41,820.90 birr will be needed.

**Temima Ibrahim, 2012. Avocado (*Persea americana* m.) Management Practice and Its Role for Household Consumption and Income Generation in Farming System of Wondo Genet. M.Sc. Thesis, College of Agriculture, Hawassa University.**

This study was conducted with the objective of assessing status of avocado fruit production at household level, to determine the contributions of avocado to household income and food security and to assess farmers' management practices of avocado tree at Wondo Genet, Ethiopia. Informal survey was conducted before the actual assessment was done. After this, two kebeles (Baja Fabrica and Abaye) were purposively selected based on the availability of avocado tree. From each kebele the number of respondents were determined using proportional sampling method and the data were collected using structured questionnaire. The data was analyzed using statistical package for social science (SPSS). Descriptive statistics such as percentage, frequency, mean and standard deviations were used to summarize the information. The results show that the average number of fruit bearing trees in a farm was 3.25. This gives an average of 250.8 kg per tree (815.1 kg per farm) and it helps to obtain an average income of 3623.35 birr per year. About 8.3% of the total avocado production is used for household consumption. The production and marketing of avocado is constrained by different factors including fluctuation of market price (54.3%), harvesting (51.4%), disease (14.3%), blowing of flowers (14.3%), low productivity (11.4%), transportation (10%) and lack of good variety (5.7%). Therefore, further investigation should be made to find solution to these major constraints so as to increase the production and productivity of avocado.

**Tesfahun Aberaham, 2010. The Contribution of Lowland Bamboo (*Oxytenanthera abyssinica*), to the Community's Livelihood; The case of Assosa Woreda, Benishangul-Gumuz Region, Western Ethiopia.**

Lowland bamboo (*Oxytenanthera abyssinica*) is among Ethiopia's dry land vegetation resources offer diverse socio-cultural, economic and environmental benefits. Assosa woreda possesses about 77, 947 ha of this resource. Bamboo is the basic natural

asset available for the livelihoods of people living in the area with multiple uses, and the local communities are benefiting in various ways, especially for the poor. Intensive anthropogenic pressures, absence of economic diversification, meager development efforts, past state farm and resettlement schemes, current ill-implemented investment activities are major problems for its degradation. The dependence of rural households on it hasn't been recognized by decision makers. Its contribution to the economy and to society in general, is neglected; studies to estimate these contributions are insufficient. Its potentialities for development have never been fully recognized. The objective of this study was to examine the contribution of *Oxytenanthera abyssinica* for the livelihoods of households in the study area. Also it attempts to capture the impact of existing bamboo management practices by conducting bamboo resource inventory for comparison. Data for the study were collected through field inventory, key informant interviews, formal questionnaire survey and focus group discussion. Bamboo resource inventory has conducted in four selected sample PAs, two from each social classes; and eight sample plots of 500 m<sup>2</sup> areas from each PA. The formal survey was administered to a total of 89 households that were randomly selected from two society and proximity classes and three wealth strata. The qualitative information was summarized and the quantitative data were analyzed using Excel version 13. Enumeration data were computed and used for comparisons. Comparison of the inventory and informal discussion result revealed that stock density and area cover show a decreasing trend, respectively. Livelihood survey results showed that people depend on agricultural crop production contributes the highest (66.80%) followed by forest (22.06%) and non-farm activities (9.97%), and livestock production (1.17%) the least. The share of bamboo is 67.86% that of forests and 15.53% of total income- as second most important asset, next to Crop production in the area. Due to its long socio-cultural tie the indigenous inhabitants feed on bamboo shoot and more dependent on it than the resettlers. Although bamboo is important for all rural households, its contribution varied with variations in proximity to it and the wealth status of households. Households found near to the bamboo extracted more than did distant households. Proximity also has positive impact of productivity of other sectors; increase crop and animal production. Contribution of bamboo for livelihoods was more important to the poor (26.72 %) than medium (15.16%) and rich (9%) households. Furthermore, it was a prominent stream of fuel wood and construction material for the nearby town Assosa. Since bamboo plays significant role in the rural household's livelihood, attention should be given for it in conservation and development of the area as its cultivation and products obtained leads to livelihood improvement without compromising the socio- economic setting and environmental resources. Access to these basic components of livelihood taken for granted by much of the humankind can dramatically improve levels of well-being in Assosa.

**Keywords:** *Oxytenanthera abyssinica*, livelihood, Ethiopia, Assosa, rural households, lowland bamboo

**Tesfaye Abebe, 1992. Early Growth Performance of *Grevillea Robusta* in Southern Ethiopia. in, Harwood, CE (ed), *Grevillea robusta* in agroforestry and forestry, pp111-116. ICRAF, Nairobi.**

*Grevillea robusta* and other multipurpose tree species were planted at five locations representative of different agro-ecological zones of southern Ethiopia. Growth rates of the different species were studied for 48-57 months. Best height and diameter growth of *G. robusta* (1.88 m year<sup>-1</sup>, 2.05 cm year<sup>-1</sup>) was attained in the semi-arid lowlands (1200 m

elevation) while the lowest (0.62 m year<sup>-1</sup>, 0.69 cm year<sup>-1</sup>) was in the cool highlands (2450 m elevation). Survival rates of *G. robusta* have been greater than the overall average survival rates of the different species at all sites.

**Tesfaye Abebe, 1994. Growth Performance of Some Multipurpose Trees and Shrubs in the Semi-Arid Areas of Southern Ethiopia. *Agroforestry Systems*, 26: 237-248.**

Growth performances of some multipurpose trees and shrubs have been studied for five years at two locations in the semi-arid areas of southern Ethiopia. The best performance in terms of rates of survival and growth rates (height and diameter growth) has been attained by *Acacia nilotica*, *A. cyanophylla*, *A.seyal*, *Cassia siamea* and *Prosopis juliflora*. Given the ecological limitations of semi-arid areas, growth rates of these species is promising and this indicates that sustainable production system can be realized using proper agroforestry technologies in the semi-arid areas of Southern Ethiopia and similar area types elsewhere.

**Keywords:** Agroforestry, Growth rates, Multipurpose trees and shrubs, Semi-arid areas, Southern Ethiopia

**Zebene Asfaw, 1990. Silvicultural Management of *Cupressus lusitanica* and *Grevillea robusta* in Southern Ethiopia. Thesis, Bangor University, UK.**

From 1988-90, a study of *Grevillea robusta* A. CUNN. and *Cupressus lusitanica* MILL. Was carried out. A monographic account of each species was prepared as relevant background for interpretation of the results of silvicultural studies at wondo genet, south shewa, an intercropping experiment involving wheat, teff and horse bean with *Grevillea* was carried out. Intercropping crops with *Grevillea* significantly improved early growth compared with trees grown as a monoculture. In the second growing season crop yield was depressed by the shade effect from the trees and in the third after no crops could be harvested. The highest returns were from the wheat and trees intercrop. In a second experiment, the initial spacing appropriate for *Cupressus* stand establishment was examined. Spacings involved were 1.5 m\*1.5 m, 2 m\*2 m, 2.5 m\*2.5 m and 3 m \* 3 m. By 6.5 years of age, there were no significant effects of spacing on survival and height but there were marked influences on other growth parameters. Increasing spacing increased diameter at breast height, bark thickness, crown diameter, branch diameter, branch length and branch angle. Trees at close spacings attained significant longer bole height than trees at wide spacing. Suggestions are made for further initiatives to improve the yields of both species through silvicultural management by increasing spacing for intercropping of crops with *Grevillea* and through the introduction of provenances from a wider genetic base for both species. The need for pathological study on the currently serious but so far unidentified canker disease of *Cupressus* is indicated and the need for research on the silvicultural systems with *Grevillea* is stressed.

## 1.5. Trees and Shrubs for Fodder Production

**Bonsi M.L.K, Osuji P.O, Tuah A.K. & Umunna N.N., 1985. Intake, Digestibility, Nitrogen Balance and Certain Rumen Characteristics of Ethiopian Menz Sheep Fed Teff Straw Supplemented With Cotton Seed Cake, Dry Sesbania, Dry Leucaena or Fresh Leucaena: *Agroforestry Systems*, 31 (3): 243 – 256.**

Twenty five rumen fistulated Ethiopian Menz sheep were used in a completely randomized block design to determine roughage utilization when different types of supplements (sesbania, leucaena, cotton seed cake (CSC) and forms (fresh or dry leucaena) were fed. The chemical composition, intake, digestibility, nitrogen balance and rumen degradability coefficients were determined. Rumen pH and ammonia-nitrogen ( $\text{NH}_3\text{-N}$ ) levels were estimated in samples taken at 1, 2, 3, and 6 h after feeding. There was substitution of teff straw dry matter by the supplements. Fresh leucaena effected the highest substitution. Supplementation enhanced ( $p < 0.05$ ) the dry matter degradation (DO) of teff straw at 6 and 12 hours of incubation but not ( $p > 0.05$ ) for the other incubation times. There were no significant differences ( $p > 0.05$ ) between treatments in the degradation constants: readily soluble component (a) slowly degradable fraction, (b) potential degradability ( $\text{PD} = a + b$ ) and rate of degradation (C) and for rumen  $\text{NH}_3\text{-N}$  concentration, the ranking was  $\text{CSC} > \text{sesbania} > \text{dry leucaena} > \text{fresh leucaena} > \text{teff straw alone}$  ( $p < 0.05$ ). The particularly high substitution rate observed with fresh leucaena might suggest that bulkiness may be a limiting factor in the intake of low quality roughages supplemented with tree leaves. The lower DM and OM digestibilities of the supplemented diets were attributed to substrate preference by rumen cellulolytic bacteria. Excessively high levels of rumen  $\text{NH}_3\text{-N}$  (328 mg/l) in the CSC diet resulted in high urinary nitrogen losses ( $r^2 = 0.32$ ;  $p < 0.001$ ) leading to low N balance. This may suggest that for the utilization of poor quality tropical roughages, moderate levels of rumen  $\text{NH}_3\text{-N}$  sustained over a longer period may be needed.

**Bonsi M.L.K, Osuji P.O, Tuah A.K. & Umunna N.N., 1995. Vernonia amygdalina as a Supplement to Teff straw (*Eragrostis tef*) Fed to Ethiopian Menz Sheep. *Agroforestry Systems*, 31(3):229-241.**

Sixteen rumen fistulated Ethiopian Menz type sheep were used in a completely randomised block design (CRBO) in experiment 1. Unchopped teff straw was fed alone or supplemented with either 100, 150 or 200 g/d of sun-dried vernonia leaves. The chemical compositions of fresh, boiled, water-soaked and sun-dried vernonia and soluble carbohydrate (SC) loss by boiling were determined. In experiment 2, 25 growing Ethiopian Menz type sheep, were fed teff straw alone or supplemented with 120 g (OM) of either boiled (B) or soaked (S) fresh vernonia with or without molasses (M) (50 g). SC lost by boiling fresh vernonia for 15, 30, 45 or 60 min was determined. In experiment 1, boiling increased the nitrogen (N) concentration in vernonia but sun-drying reduced it. N bound to fibre (NOF-N) was reduced by boiling but not by soaking. SC loss increased with boiling time. Supplementation did not affect the degradation constants (a, b, PO, c) of teff straw, but OM disappearance was increased ( $p < 0.05$ ) at 76 and 120 h of incubation. Intake of sun-dried vernonia was poor but increased with quantity offered. Intakes and digestibilities of OM, OM and the fibre fractions were marginally higher ( $p > 0.05$ ) in the supplemented diets. Nitrogen balance in the supplemented diets was low due to increased faecal and urinary excretion. In experiment 2, rumen  $\text{NH}_3\text{-N}$  was

higher for the boiled treatments compared to the soaked treatments. Acceptability at both 2 and 4 h was highest for BM, followed by SM, Band S. Boiling for 30 min, but not soaking, enhanced the acceptability of vernonia, suggesting that a pre-treatment may enhance the feed value of vernonia.

**Coppock D.L., 1993. Grass Hay and Acacia Fruits: A Local Feeding System for Improved Calf Performance in Semi-Arid Ethiopia. *Tropical Animal Health and Production*, 25 (1):41-49.**

A 90-day growth trial was designed to compare the performance of calves on 3 dry-season diets composed of local resources from the Borana pastoral system. The control group received the traditional diet-and-carry, standing-brown grass while the other diets consisted of grass hay stored since the previous wet season with or without *Acacia tortilis* fruits as a protein supplement. All calves had access to water once every 3 days as traditional. The objective was to see whether modest changes in traditional feeding management could enhance nutrient intake and growth of calves under conditions of restricted water access. The hay had a higher nitrogen content and in vitro digestibility than the standing grass, and the Acacia fruits had higher nutrient concentrations than the hay (both at  $P \leq 0.05$ ). Calves on hay plus Acacia fruits had higher nitrogen intakes than those on standing grass (both at  $P \leq 0.05$ ). Calves on standing grass lost weight and condition, those on hay only maintained weight but lost condition, and those on hay plus Acacia fruits gained weight and maintained condition (all at  $P \leq 0.05$ ). Calves consumed the most feed on day 2 of the watering cycle, regardless of treatment. Water intake increased 27% for animals on both hay diets compared to those on standing grass ( $P \leq 0.01$ ). Feeding packages based on hay making and collection of browse legumes are appropriate options for extension to these semi-settled pastor lists.

**Getnet Assefa, 1998. Biomass Yield, Botanical Fractions and Quality of Tagasaste, (*Chamaecytis Palmensis*) as Affected by Harvesting Interval in the Highlands of Ethiopia. *Agroforestry Systems*, 42 (1): 13-23.**

Tagasaste, a hardy leguminous shrub has potential for wide utilization in the highlands of East Africa. Establishment and productivity of tagasaste at two, three, four, and six months harvesting intervals were evaluated from the first to the fourth years of age (1991/1992-1994/1995) in the highlands of Ethiopia. Biomass yield, botanical fractions (Leaf, Edible branch and stem) and quality were assessed. Annual biomass production was sustainably greater for six months interval than for the more frequent harvests in a range of 4.7 to 10.2 t/ha/hacter. Average biomass yield also increased, as the plant got older. Leaf proportion of the biomass yield consistently decreased from 71.7 to 45.3% and the stem increased from 0.4 to 25.5% as the harvesting interval was prolonged from two to six months, respectively. However, the longest harvesting intervals were still the most productive of leaf DM from the increased biomass yield. The average crude protein (CP) content and in vitro dry organic matter digestibility (DOMD) of leaf were not significantly affected by harvesting interval. They ranged from 18.0-21.2% and 65.3-70.5%, respectively. Allowing tagasaste to grow during the wet season for four to six months and harvesting during the early dry season could improve the yield of high quality herbage, fuel wood and increase persistence in the highlands of Ethiopia. Tagasaste could be the best browse tree for the highlands of

East Africa. It could alleviate problems of feed shortage, soil degradation, low soil fertility through mulching and nitrogen fixing ability, and fuel wood scarcity, which are predominantly prevalent in these areas.

**Kahsay Berhe & Tothill J.C., 1995. Performance, Feed Quality and P Response of *Leucaena* and *Calliandra* Species Grown as Hedgerows on an Acidic Nitisol at Soddo, Ethiopia. *Tropical Grasslands*, 29:1-8.**

Eleven accessions taken from *Leucaena leucocephala*, *L. revolute*, *L. pallida*, *L. diversifolia* and *L. trichandra* hybrids (*leucaena*), together with 3 accessions of *Calliandra calothyrsus* (*calliandra*), were evaluated on an acidic, nitisol in the tropical highland region of Soddo in southern Ethiopia for dry matter production, feed quality, soil fertility and responses to phosphorus fertilisation. At the first harvest (11 months after transplanting), over all accessions and for individual accessions, plant height, spread, basal stem diameter and dry matter yield showed significant responses to the application of phosphorus (P). There was also a significant interaction between accessions and P treatments for most of these growth parameters. Two regrowth harvests showed a significant response in dry matter production of both leaf + soft stem and hard-stem fractions to the application of phosphorus (P). *L. leucocephala* accessions had higher invitro dry matter digestibility (IVDMD) values than the other *Leucaena* spp. Two of the 3 *C. calothyrsus* accessions had significantly higher values for ash, NDF and ADF, lower IVDMD and slightly lower protein than all *leucaena* accessions. The clearly superior growth performance of the *calliandra*s and the *leucaena*s, other than *L. leucocephala*, over that of cv. Peru (control), emphasises the need to evaluate their feed value in vivo and at the farm level. While already being used quite widely as a multi-purpose tree, *calliandra* has not been collected and researched much around the world as a forage species. There seems to be considerable scope for the selection of productive and useful lines of *calliandra* and *L. diversifolia*, *L. pallida*, *L. revolute* and some of their hybrids for the cooler tropical highlands, for acidic soils and for potential psyllid resistance.

**Kahsay Berhe & Tothill, 1997. Dry Matter Yield, P Response and Nutritive Value of Selected Accessions of *Chamaecytisus palmensis* (tagasaste) and *Teline monspessulana* (Montpellier broom) in the Ethiopian Highlands. *Tropical Grass Lands*, 31: 49-57.**

Four accessions of the multi-purpose fodder tree, tagasaste (*Chamaecytisus pabnensis*) and one of Montpellier broom (*Teline monspessulana*) were evaluated for dry matter yield, response to P fertilizer and nutritive value for livestock feeding, at 2 contrasting sites in the highlands of Ethiopia, one on a neutral pH Alfisol, and the other on an acid Nitisol. Montpellier broom was considerably lower yielding than tagasaste. There were substantial differences in dry matter yield between tagasaste accessions at both sites, but superior accessions were not consistent across sites. All accessions responded considerably to P fertilizer at first harvest at Soddo, where the soil is known to be P deficient and to have a high ability to fix P. Responses were inexplicably negligible at subsequent harvests. Some variation was evident in the parameters reflecting feed quality, but values were generally consistent with the exceptions for leguminous feeds. Mortalities from fusarium wilt were relatively high at the Soddo site, probably exacerbated by the seasonal water logging. This study underlines the need for research on how tagasaste fits into farming systems, taking

into account establishment, management and utilization of the plant, and to identify suitable well-drained habitats for its successful growth.

**Kindu Mekonnen, Gerhard Glatzel & Monika Sieghardt, 2009. Assessments of Fodder Values of 3 Indigenous and 1 Exotic Woody Plant Species in the Highlands of Central Ethiopia. *Mountain Research and Development*, 29(2):135-142.**

Leaves and twigs of indigenous woody plant species are used as a source of supplemental animal feed in the mountainous landscapes of central Ethiopia. A study was carried out from 2004 to 2006 to assess the nutritional value of 3 indigenous and 1 exotic species, based on the chemical composition, tannin contents, in vitro dry matter digestibility, and digestible energy. The species studied were *Hagenia abyssinica* (Bruce) J.F. Gmel., *Dombeya torrida* (J.F. Gmel.) P. Bamps, *Buddleja polystachya* Fres. and *Chamaecytisus palmensis* (Christ) Bisby & K. Nicholls. The first three are indigenous, and the last one is an exotic species. The Na content of the foliage and flower bud in the 4 species was much lower than the minimum requirement for ruminants, while other micro- and macronutrients were within the recommended range of nutrient concentrations in animal feeds. On the other hand, the crude protein content of the foliage and flower bud in the 4 fodder species was higher than the minimum required level. The foliage and flower bud in vitro dry matter digestibility of *H. abyssinica* and *C. palmensis* was 70% and 71%, respectively. The digestible energy of the foliage of *H. abyssinica* and *C. palmensis* was significantly higher than the digestible energy of *D. torrida* and *B. polystachya*. Therefore, the foliage and flower bud of most of those species can be used as sources of supplemental fodder with a proper feeding management scheme.

**Keywords:** Fodder tree, Condensed tannin, Crude protein, Dry matter digestibility, Lignin, Mineral nutrients, Ethiopia.

**Mengistu S., Keftasa D. & Yami A., 2002. Productivity of Four *Sesbania* Species on Two Soil Types in Ethiopia. *Agroforestry Systems*, 54:235-244.**

In Ethiopia, lack of quality forage in adequate quantities is a major constraint to livestock productivity. Fast growing N<sub>2</sub> fixing *Sesbania* have shown great promise both as high quality fodder and green manure. The objective of this study was to evaluate and select among the species *S. macrantha*, *S. rostrata*, *S. quadrata* and *S. sesban* for fodder yield, quality and green manure potential. The field experiment was conducted on a light soil (loam, Alfisol) and a heavy soil (cracking type clay, Vertisol) at Debre Zeit (9° N and 39 °E, 45 kms SE of Addis Ababa). There were two cutting treatments: cutting once at ground level or cutting twice at 50cm (first, 65 days after sowing; second, 40 days later). A two-factor factorial in randomised block design was used. *S. macrantha* performed better on the light soil producing the highest dry matter (DM) yields of leaf (2.8t/ha), stem (6.3 t/ha) and total nitrogen (151 kg/ha) in 105 days than the rest of the species. Most species performed poorly on the heavy soil. *S. quadrata*, however, showed better adaptability to the heavy soil (5.5t/ha DM) than any of the other species. The lowest DM yield was recorded for *S. rostrat*, which could be due to poor nodulation. Cutting twice over the 105 days growth period caused a drastic reduction in DM yield, but resulted in higher leaf-to-stem ratio and total N yield. The nutritional composition of all the species was with in an acceptable range



for livestock requirements. N content (4%) and IVDMD (over 70%) were high. *S. macrantha* had superior overall performance and seems promising both as high quality fodder and green manure crop. Under rain-fed conditions, cutting once was better than cutting twice particularly for *S. macrantha*.

## 1.6. Agro forestry, Carbon Sequestration and Climate Change

**Abiot Mola, 2013. Woody Species Diversity and Carbon Stock under Patch Natural Forests and Adjacent Enset-Coffee Based Agroforestry in Midland Of Sidama Zone, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

The major impacts of humans on forest ecosystems include; loss of forest area, habitat fragmentation, soil degradation, depletion of biomass and associated carbon stocks leads to climate change through the increasing of CO<sub>2</sub> and biodiversity losses. These problems can be addressed through increasing of forest biomass, managing the existing forest, integrated of agriculture with forests, and increasing the connectivity of communities and ecological processes in fragmented landscapes (patch forests). This paper examines the potential of woody species and selected perennial plants in carbon sequestration as well as diversity of woody species and connectivity potential in the patch natural forest and adjacent enset-coffee based agroforestry systems in the midland of Sidama zone, Ethiopia. 98 square plots (48 in each systems), having 400 m<sup>2</sup> area each were systematically sampled using the four transect lines at different distance for vegetation data collection and woody biomass estimation. Soil organic carbon was sampled by using "X" design with a depth of 0-30cm at each patch natural forest, enset-coffee based agroforestry and annual crop agricultural land uses with total of 90 composite soil samples. The diversity of woody species was analyzed by using different diversity indices. To analyze the woody species and the selected perennial plant biomass carbon stock, appropriate allometry equations were used after measuring parameters such as height and diameter of trees (diameter ≥5 cm) at DBH in each land use systems, and coffee and enset diameter at 15cm and 10cm height were measured respectively. In this study a total of 75 different woody species categorized under 31 families were found and identified, of which 43 species were from the patch natural forests under 30 families and the remaining 32 species were under 21 from adjacent enset-coffee based agroforestry. The 22 species under 15 families were common both the patch natural forests and adjacent enset-coffee based agroforestry which makes 58.67% of similarity in woody species composition, 48.67% average woody species similarity in between the patch forest. The results in total biomass and SOC carbon stock showed that there was significantly (p<0.05) varied with land use types. The total biomass carbon stock in the patch natural forests was 258.67±41.1 Mg ha<sup>-1</sup>, 175.3±9.77 Mg ha<sup>-1</sup> in the adjacent enset-coffee based agroforestry. On the other hand, the SOC in the patch natural forests were 76.18±3.58 Mg ha<sup>-1</sup>; 66.79±2.73Mg ha<sup>-1</sup> was in soil under adjacent enset-coffee based agroforestry, while 38.93 ± 2.75 Mg ha<sup>-1</sup> was in the annual crop agricultural land. In terms of CO<sub>2</sub> assimilation, the highest potential was found from the patch natural forests which was sequestered 58.04% of CO<sub>2</sub> over its lifetime with compare to the enset-coffee based agroforestry (41.96%), in the total carbon stock density. The results of the present study confirm that the patch natural forests and adjacent enset-coffee based agroforestry play a major role in the conservation of native woody species and climate change mitigation.

**Keywords:** Biodiversity, Biomass, Carbon sequestration, CO<sub>2</sub>, SOC and carbon stock density

**Badege Bishaw, Henry Neufeldt, Jeremias Mowo, Abdu Abdelkadir, Jonathan Muriuki, Gemedo Dalle, Tewodros Assefa, Kathleen Guillozet, Habtemariam Kassa, Ian K. Dawson, Eike Luedeling, & Cheikh Mbow, 2013. Farmers' Strategies for Adapting to and Mitigating Climate Variability and Change through Agroforestry in Ethiopia and Kenya. Forestry Communications Group, Oregon State University, Corvallis, Oregon.**

Climate change is real and happening in East African countries including Ethiopia and Kenya. Climate change is manifested in the recurrent drought, floods, and famine that have threatened millions of people and livestock in recent decades. Subsistence farming practices are the main livelihood for most people living in this region, which is characterized by degraded soils, small farm sizes, and low agriculture outputs. Agroforestry, which is an ecologically based traditional farming practice, integrates trees into the farming systems to increase agricultural productivity and ameliorate soil fertility, control erosion, conserve biodiversity, and diversify income for households and communities. In early 2011, Oregon State University was invited by the World Agroforestry Center to renew institutional collaboration for student and faculty exchanges, exchange scientific information, and to collaborate in agroforestry research and outreach. As part of this initiative an Agroforestry synthesis paper was proposed on farmers' adaptation and mitigation to climate variability and change through agroforestry practices in Ethiopia and Kenya. The purpose of the synthesis paper was to document traditional and scientific knowledge on how farmers cope with climate variability and change. Four case studies were identified from highland farming and dryland pastoral systems in both Ethiopia and Kenya. The Gedeo Home garden from Ethiopia and Meru highland farming from Kenya were identified as good representatives of highland farming. The Afar pastoral system and Kibwezi district dryland farming from Kenya were identified as good representatives of dryland farming systems. The lead authors for each chapter were selected based on their experiences working in the case study areas, and are knowledgeable of the farming systems and constraints thereof. The synthesis paper has helped us document information from the respective case study areas, including both the traditional ecological knowledge and the current agroforestry practices in the context of climate change. By no means is the information in this paper exhaustive, but it gives a better understanding of the situation currently faced by these countries. The paper suggests scaling up some of the already available agroforestry practices in these countries and identifying gaps in knowledge, which then point to what kinds of agroforestry research should be conducted to address climate change mitigation and adaptation in the future. This paper has brought together scientists from various education and research institutions in Ethiopia and Kenya with expertise in agriculture, agroforestry, plant genetics, agroforestry, and economics and social sciences. This concourse has helped us understand the importance of interdisciplinary work to address complex natural resources management issues from ecological, economic and social issues. We hope this collaborative effort will continue beyond the literature synthesis and create opportunities for future collaboration in agroforestry education, research, outreach, and student and faculty exchange among the involved institutions.

**Fikre Tesfyehe, 2011. Woody Species Diversity, Management and Carbon Stock along an Elevation Gradient in Coffee-Based Agroforestry in Yirgacheffe, Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Despite the significance of coffee-based agroforestry in terms of economic and environmental benefits, there have been limited efforts to systematically study these ecosystems. This study is intended to determine the structure, composition, carbon density and importance of woody species in the traditional Yirgacheffe coffee-based agroforestry systems along an elevation gradient. Woody plants inventory was conducted along five elevation contours and eight transects. Seventy-six soil samples were taken from randomly selected subplots at 0-15 and 15-30 cm soil depths. Within the vegetation sampling quadrats 38 households were interviewed through structured and semi-structured questionnaires. 886 recorded woody plants, 39 % were trees, 50% shrubs, and 11% seedling and saplings. Native and exotic woody species represented 87.5 and 12.5 %, respectively. Woody plant diversity indices appear to slightly decrease with increasing elevation. Species richness ranged from 13-17 along the elevation gradient. Tree density, Canopy cover and coffee shrub density shows non significance variation along the elevation gradient. However, tree and coffee shrub density showed a slight increase until 2040 m a.s.l and then declined with increasing elevation. Canopy cover of shade trees showed a decreasing trend with increasing elevation. Total aboveground woody plant biomass carbon was 29.13 Mg C ha<sup>-1</sup>. Soil carbon stock did not vary significantly across elevation gradients with a mean soil C stock of 66.65 Mg ha<sup>-1</sup>. These results indicate that the coffee-based agroforestry system has significant potential of storing and enhancing ecosystem carbon stocks. The findings generally suggest that coffee-based agroforests in the study area are diverse, structurally complex with significant carbon storage in the soil and woody perennial. This study revealed that farmers manage shade tree species that have a greater ecological (*Millettia ferruginea*) and economic (*Eucalyptus camaldulensis*) values. Few shade trees dominate the system with a noticeable decline in frequency of some indigenous woody species plants. Therefore, shade tree management strategies should focus on a balance between woody species diversity and coffee production.

**Keywords:** Structure, Composition, *Coffea arabica* L., Carbon stock, Shade tree, Ethiopia

**Getachew Mulugeta, 2014. Evergreen Agriculture: Agroforestry for Food Security and Climate Change Resilience. *Journal of Natural Sciences Research*, 4 (11): 2224-3186.**

This paper examines the role of agroforestry in food security and climate change resilience as a sustainable evergreen agriculture. Agroforestry technologies are ensuring food security and are lifting many out of poverty and mitigating declining agricultural productivity and natural resources. Remarkable examples are: fertilizer trees that when integrated with inorganic fertilizers can double or triple crops yields in degraded lands, fodder trees that can be used in smallholder zero-grazing systems in ways that supplement or substitute commercial feeds, improved varieties of temperate and tropical fruits that can be used to supplement household incomes and nutrition, medicinal trees that are utilized on farm and conserved *insitu*, and fast-growing timber and fuel wood trees that can be grown in various niches within the farm and in commercial woodlots and plantations. The survey showed that about 88% of the respondents were attained food security through local purchasing from

local market ranging from a month to six months depending on households. Agroforestry helped the households to attain food security as source of cash for all assessed households and as a source of food for 72% of the assessed households. Agricultural lands are believed to be a major potential sink and could absorb large quantities of C if trees are reintroduced to these systems and judiciously managed together with crops and/or animals. Thus, the importance of agroforestry as a land-use system is receiving wider recognition not only in terms of agricultural sustainability but also in issues related to climate change. C storage data in some tropical agroforestry systems and to discuss the role they can play in reducing the concentration of CO<sub>2</sub> in the atmosphere. The C sequestration potential of agroforestry systems is estimated between 12 and 228Mgha<sup>-1</sup> with a median value of 95Mg ha<sup>-1</sup>. Agroforestry interventions, because of their ability to provide economic and environmental benefits, are considered to be the best measures in making communities adapt and become resilient to the impacts of climate change. The important elements of agroforestry systems that can play a significant role in the adaptation to climate change include changes in the microclimate, protection through provision of permanent cover, opportunities for diversification of the agricultural systems, improving efficiency of use of soil, water and climatic resources, contribution to soil fertility improvement, reducing carbon emissions and increasing sequestration, and promoting gender equity.

**Keywords:** Agroforestry, Food security, Climate change, Carbon sequestration, Resilience, Productivity

**Luedeling E., Kindt R., Huth N. & Koenig K., 2014. Agroforestry Systems in a Changing Climate: Challenges in Projecting Future Performance. *Current Opinion in Environmental Sustainability*, 6:1–7.**

Agroforestry systems are complex assemblages of ecosystem components, each of which responds to climate. Whereas climate change impacts on crops grown in monocultures can reasonably well be projected with process-based crop models, robust models for complex agroforestry systems are not available. Yet impact projections are needed because of the long planning horizons required for adequate management of tree-based ecosystems. This article explores available options for projecting climate change impacts on agroforestry systems, including the development of process-based models, species distribution modeling, climate analogue analysis and field testing in climate analogue locations. Challenges and opportunities of each approach are discussed.

**Lott J.E., Howard S.B., Ong C.K. & Black C.R., 2000. Long-term productivity of a *Grevillea robusta* Based Overstorey Agroforestry System in Semi-arid Kenya II. Crop growth and system performance. *Forest Ecology and Management*, 139:187-201**

Maize and cowpea were grown as sole stands or in agroforestry systems containing grevillea trees (*Grevillea robusta* A.Cunn.). Crop and system performance were examined over a 4.5-year-period (nine growing seasons) commencing in October 1991; failure of the rains caused the loss of one cropping season. A rotation of cowpea (*Vigna unguiculata* L. Walp.) and maize (*Zea mays* L.) was grown during the first five seasons after planting the trees, while maize was grown continuously during the final four seasons. Sole maize was also grown under spectrally neutral shade netting which reduced incident radiation by 25,

50 or 75% to establish the relative importance of shade and below-ground competition for water and nutrients in determining the performance of understorey crops. The above-ground biomass and grain yield of understorey crops were not significantly affected by the presence of grevillea during the first four seasons, but were greatly reduced in subsequent seasons as the trees became increasingly dominant; maize yields reached 50% of the sole crop values only once during the final four seasons, when rainfall was unusually high. The hypothesis that competition for water was the primary limiting factor for understorey crops was supported by the observation that above-ground biomass and grain yield were greater in the shade net treatments than in agroforestry maize, demonstrating that shade was not solely responsible for the substantial yield losses in the latter treatment. Performance ratios (ratio of values for the agroforestry system relative to sole stands) for total above-ground and trunk biomass in grevillea were initially low, reflecting the impact of competition with associated crops during tree establishment, but increased to unity within 2.5 years. Performance ratios for the understorey crops exhibited the reverse trend, initially being close to unity but approaching zero for three of the final four seasons. Performance ratios were never close to unity for both trees and crops during the same season, indicating that there was always competition for available resources irrespective of crop species or tree size. The implications for agroforestry system design and future research are discussed.

**Mesele Negash, 2013. The Indigenous Agroforestry Systems of the South-Eastern Rift Valley Escarpment, Ethiopia: Their Biodiversity, Carbon Stocks and Litterfall. Doctoral thesis, University of Helsinki.**

Agroforestry systems integrate trees into agricultural landscapes and provide a number of ecosystem services. Studies on agroforestry systems have so far mainly focused on their spatial design, food production, soil fertility management and system interactions, and little attention has been given to their ecosystem services, such as biodiversity conservation and carbon sequestration. The objectives of the study were to determine and evaluate the floristic diversity, the above and below-ground biomass carbon (C) and soil organic carbon (SOC) stocks, and the litterfall production and associated C and nitrogen (N) fluxes of three indigenous agroforestry systems in south-eastern Rift valley escarpments, in Gedeo, Ethiopia. Three indigenous agroforestry systems studied were Enset (*Ensete ventricosum* (Welw.) Cheesman), Enset-coffee, and Fruit-coffee. C stocks in biomass and soil (0–60 cm layer) ( $\text{Mg C ha}^{-1}$ ) were determined for each agroforestry system, and litterfall collected for seven woody species for a period of 12 months. Allometric equations were derived to estimate the biomass of enset and coffee while published allometric equations were used to determine the biomass of other tree and shrub species. The biomass values were then converted into C stocks. A total of 58 woody species, belonging to 49 genera and 30 families were recorded. Of all woody species identified, 86% were native. The Enset and Enset-coffee systems contained the highest proportion native woody species (92% and 89%, respectively). In all, 22 native woody species were recorded as “of interest for conservation” using International Union for Conservation of Nature (IUCN) Red lists and local criteria. The square power equation using stump diameter at 40 cm ( $d_{40}$ ),  $Y = b_1 d_{40}^2$  ( $R^2 > 0.80$ ) and the power equation using  $d_{10}$  (diameter at 10 cm height) and height,  $Y = b_1 d_{10} b_2 h b_3$  ( $R^2 > 0.90$ ) were found to be the best for predicting aboveground biomass of coffee (*Coffea arabica* L.) and total biomass of enset, respectively. The agroforestry C stock (biomass C plus SOC) was the highest for the Enset-coffee system ( $293 \text{ Mg C ha}^{-1}$ )

and the lowest for the Enset (235 Mg C ha<sup>-1</sup>) system. Biomass (above- and belowground) C stocks were the highest for the Ensetcoffee system (116 ±65 Mg C ha<sup>-1</sup>), followed by Fruit-coffee (79 ±24) and Enset (49 ±44) systems. Trees (fruit and non-fruit) formed 81, 89 and 80% of total biomass C stocks for Enset, Enset-coffee and Fruit-coffee agroforestry systems, respectively; the remainder being coffee, enset, litter, herbaceous plants, and fine root biomass. SOC to biomass C ratios were 4:1 for the Enset system, 2:1 for Fruit-coffee system, and 1.5:1 for the Enset-coffee system. Monthly litterfall production per unit crown area decreased in the order: *Croton macrostachyus* Del. > *Erythrina brucei* Schweinf. > *Cordia africana* Lam. > *Persea americana* Mill. > *Mangifera indica* L. > *Coffea arabica* L. > *Millettia ferruginea* (Hochst.) Bak. The annual litterfall production (sum of seven species) averaged 7430 kg ha<sup>-1</sup> (land area) for the Enset system, 10187 for the Enset-coffee system and 12938 for the Fruit-coffee system. The associated annual C fluxes (kg ha<sup>-1</sup>) were 2803 (Enset system), 3928 (Ensetcoffee system) and 5145 (Fruit-coffee system) and the corresponding N fluxes were 190 (kg ha<sup>-1</sup>), 257 and 278. This research shows that the native woody species and C stocks observed in the three indigenous agroforestry systems were among the highest reported for tropical agroforestry systems. Thus, it should be given more attention, to counteract the local threat of these species from the wild and offset greenhouse gases (GHGs) emission. The indigenous agroforestry systems of the south-eastern Rift Valley escarpment in Ethiopia form a win-win opportunity by supporting livelihoods and providing food for a dense human population while also maintaining native floristic diversity and mitigating climate change through carbon sequestration.

**Keywords:** Biomass, Carbon sequestration, Coffee, Enset, Floristic diversity, Gedeo, Indigenous agroforestry system, Litterfall fluxes, South-eastern Ethiopia

**Mesele Negash & Mike Starr, 2013. Litterfall Production and Associated Carbon and Nitrogen Fluxes of Seven Woody Species Grown in Indigenous Agroforestry Systems in the South-Eastern Rift Valley Escarpment of Ethiopia. Nutrient Cycling in Agroecosystems, 97:29–41.**

We compared the litterfall production and associated carbon (C) and nitrogen (N) fluxes for seven woody species grown in three agroforestry systems practiced on the slopes of the south eastern Rift Valley escarpment of Ethiopia. Five of the species were native (*Coffea arabica* L., *Cordia africana* Lam., *Croton macrostachyus* Del., *Erythrina brucei* Schweinf. and *Millettia ferruginea* (Hochst.) Bak) and two were non-native fruit tree species (*Mangifera indica* L. and *Persea americana* Mill.). Together, these species accounted 85% or more of the crown area of each agroforestry system: the Enset system (occurring at 2,100–2,400 m asl), the Enset-Coffee system (1,900–2,200 m asl), and the Fruit-Coffee system (1,500–1,900 m asl). Enset or false banana (*Ensete ventricosum* (Welw.) Cheesman) is a staple food crop in this region of Ethiopia and coffee and fruit trees are grown as cash crops. Monthly litterfall was collected from 4 to 6 trees of each species during 2010 and dry mass, carbon and nitrogen contents determined. The annual litterfall production per unit area of crown decreased in the order: *C. macrostachyus* (1,014 g m<sup>-2</sup>), *E. brucei* (929), *C. africana* (917), *P. americana* (809), *M. indica* (807), *C. arabica* (446) and *M. ferruginea* (362). The simple linear regression equation using breast height diameter explained 95% of the variation in the litterfall production of *M. ferruginea*, but only 55% for *C. africana*. The annual litterfall production of the seven species combined per unit area of land was the highest for the Fruit-Coffee system (average 12,938 kg ha<sup>-1</sup>), followed by the Enset-Coffee

system (10,187) and the Enset system (7,430). The associated annual C fluxes ( $\text{kg ha}^{-1}$ ) were 5,145 (Fruit-Coffee system), 3,928 (Enset-Coffee system) and 2,803 (Enset system), and corresponding N fluxes  $278 (\text{kg ha}^{-1})$ , 257 and 190. The combined litterfall production of the seven species in our study was higher than has been reported for other agroforestry systems and tropical forests.

**Keywords:** Agroforestry system, Climate change mitigation, Litterfall fluxes, Native species, South-eastern Ethiopia

**Mesele Negash, Mike Starr & Markku Kanninen, 2013. Allometric Equations for Biomass Estimation of Enset (*Ensete ventricosum*) Grown in Indigenous Agroforestry Systems in the Rift Valley Escarpment of Southern-Eastern Ethiopia. *Agroforestry Systems*, 87:571–581.**

Enset (*Ensete ventricosum*), commonly known as false banana, is a large thick, singlestemmed, perennial herbaceous banana-like plant growing in the wild of sub-Saharan Africa, Madagascar and parts of Asia. In Ethiopia it has been domesticated and serves as a food plant. While the productivity and management of enset for food (pseudostem and corm) has been studied, little attention has been given to total biomass production and associated carbon sequestration. The objective of this study was to develop and evaluate allometric models for estimating above and belowground biomass and organic matter contents of enset grown in indigenous agroforestry systems in Rift Valley escarpment of south-eastern Ethiopia. Biomass harvesting of 40 plants was carried out at altitudes from 1900 to 2400 m.a.s.l. The mean plant dry weight was  $9.4 \pm 0.84 \text{ kg}$  and organic matter content 94%. Pseudostem biomass accounted for highest (64%) of total biomass, followed by corm (24%) and foliage (12%). Basal diameter ( $d_{10}$ ) was the best predictor variable for total and all biomass components (Spearman  $r = 0.775\text{--}0.980$ ,  $p < 0.01$ ). The power model using  $d_{10}$  and height (H) ( $Y = 0.0007d_{10}^{2.571} H^{0.101}$ ;  $R^2 = 0.91$ ) was found to be the best performing model (highest ranking over six good-of-fit statistics) for predicting total biomass. Model performance decreased in the order pseudostem > corm > foliage biomass. The models presented can be used to accurately predict biomass and organic matter of enset in the agroforestry systems of Rift Valley escarpments Ethiopia.

**Keywords:** Agroforestry, Biomass, Carbon sequestration, Enset, Gedeo

**Mesele Negash, Mike Starr, Markku Kanninen & Leakemariam Berhe, 2013. Allometric Equations for Estimating Aboveground Biomass of *Coffea arabica* L. Grown in the Rift Valley Escarpment of Ethiopia. *Agroforestry Systems*, 87:953–966.**

Coffee, *Coffea arabica* L., which is native to Ethiopia, is the world's most widely traded tropical agricultural commodity. While much is known about the productivity and management of coffee for coffee beans little attention has been given to the plants overall biomass production and carbon sequestration. The objective of this study was to develop and evaluate allometric equations for estimating the aboveground biomass of *C. arabica* plants growing in indigenous agroforestry system in the Rift Valley escarpment of south-eastern Ethiopia. Coffee plays an important role in providing income and in sustaining these productive systems. Biomass harvesting of 31 plants with 54 stems was carried out in a 40 km<sup>2</sup> area varying in elevation from 1,500 to 1,900 m. The stem accounted for most (56%)

of plant biomass, followed by branches (39%) and twigs plus foliage (5%). Plant mean biomass was  $22.9 \pm 15.8$  kg. Power equations using stem diameter measured at either 40 cm ( $d_{40}$ ) or at breast height ( $d$ , 1.3 m) with and without stem height ( $h$ ) were evaluated. The square power equation,  $Y = b_1 d_{40}^2$ , was found to be the best (highest ranked using goodness-of-fit statistics) for predicting total and component biomass. The reliability of the prediction decreased in the order: stem>branches>twigs plus foliage. A cross-validation procedure showed that equation parameterization was stable and coefficients reliable. Our parameterized square power equation for total aboveground biomass was also found to be better than the equations parameterized by Hairiah et al. (Carbon stocks of tropical land use systems as part of the global C balance: effects of forest conversion and options for clean development activities, International Centre for Research in Agroforestry, Bogor, 2001) and Segura et al. (Agroforest Syst 68:143–150, 2006) for *C. arabica* grown in agroforestry systems, confirming the importance of parameterization of allometric equations with site specific data when possible.

**Keywords:** Carbon sequestration, Coffee, Cross validation, Indigenous agroforestry systems, South-eastern Ethiopia

**Malmer A., Murdiyarso D., Bruijnzees L. A. & Ilstedt U., 2010. Carbon Sequestration in Tropical Forests and Water: A Critical Look at the Basis for Commonly Used Generalizations. *Global Change Biology*, 16: 599–604.**

Tree planting in the tropics is conducted for a number of reasons including carbon sequestration, but often competes with increasingly scarce water resources. The basics of forest and water relations are frequently said to be well understood but there is a pressing need to better understand and predict the hydrological effects of land-use and climate change in the complex and dynamic landscapes of the tropics. This will remain elusive without the empirical data required to feed hydrological process models. It is argued that the current state of knowledge is confused by too broad a use of the terms 'forest' and '(af) forestation', as well as by a bias towards using data generated mostly outside the tropics and for non-degraded soil conditions. Definitions of forest, afforestation and reforestation as used in the climate change community and their application by land and water managers need to be reconciled.

**Mohamed Abaoli, 2011. Carbon Under Native Forest and Adjacent Land Use Systems at Gera, Jimma Zone, South-West Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Conversion of land from native forests to agricultural ecosystems is known to change both biomass and soil organic carbon (SOC) pools. This study evaluated the differences in soil and biomass carbon (BC) stocks of three land uses namely: native forest, annual crop field and coffee-based agroforestry at Gera, Jimma Zone, South-west Ethiopia. For this study coffee-based agroforestry, annual crop field and native forests land uses were considered. After measuring parameters such as height, diameter at breast height of plants (diameter > 5 cm), above-ground BC was estimated by using regression models from literatures. The below-ground BC was estimated from shoot: root ratios based on above-ground biomass BC. A total of 24 soil samples were collected from the three land use systems and SOC, soil



texture, bulk density and pH were analyzed. The results showed that BC (above-ground BC+ below-ground BC) significantly varied with land use types. The BC stock in the native forest, coffee-based agroforestry and annual crop field was  $134.34 \pm 26.94 \text{ Mg C ha}^{-1}$ ,  $58.26 \pm 12.30 \text{ Mg C ha}^{-1}$ ,  $0.02 \pm 0.01 \text{ Mg C ha}^{-1}$ , respectively. On the other hand, the SOC under the native forest was  $95.76 \pm 3.63 \text{ Mg C ha}^{-1}$ ,  $92.48 \pm 7.02 \text{ Mg C ha}^{-1}$  under the coffee-based agroforestry, while  $65.17 \pm 2.48 \text{ Mg C ha}^{-1}$  was under the annual crop field. The present study indicated that the total carbon stock in the coffee based agroforestry is much greater than annual crop field. This may indicate conversion of annual crop field to coffee-based agroforestry in the study area can lead to carbon sequestration.

**Keywords:** Annual crop field, Coffee-based agroforestry, Native forest, Biomass carbon, Soil organic carbon

**Solomon Estifanos, 2013. Comparative Study on Plant Diversity and Carbon Stocks in Forest, Semi-Forest and Garden Systems in Gimbo Woreda, Southwest Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

This study is intended to compare the structure, composition, carbon density and importance of woody species in the three traditional Gimbo district coffee-based agroforestry systems. Woody plant inventory was conducted at 90 quadrats, 30 from each coffee system. 45 composited soil samples were taken from those 90 quadrats at 0-30cm. 86 different plant species including coffee shrubs were recorded under 39 plant families. Plant diversity indices of Shannon showed higher diversity and evenness for natural forest and semi-forest coffee systems than homegarden coffee systems. The three traditional coffee systems didn't differ in Simpson's diversity index and evenness. The study showed that there is strong significance difference in tree density  $\text{ha}^{-1}$  among the three systems, ranging  $222.500 \pm 18.70 \text{ stems/ha}$  to  $522.500 \pm 34.31 \text{ stems/ha}$ . Natural forest coffee system had the lowest coffee shrub density ( $1343.33 \pm 147.99 \text{ stems/ha}$ ) and also had significance difference from homegarden ( $1946.67 \pm 154.53 \text{ stems/ha}$ ) and semi-forest ( $1910.00 \pm 151.80 \text{ stems/ha}$ ) coffee systems, but there was no significance difference among the shrub density of homegarden and semi-forest coffee systems. *Olea welwetschia* (8.32%), *Millettia ferruginea* (10.18%) and *Ficus vasta* (14.78%) were the most dominant woody species in natural forest, semi-forest and homegarden coffee systems respectively. In total biomass carbon stock for both coffee shrubs and trees including enset and banana, a strong scientific significance difference was observed between homegarden and semi-forest coffee systems. Semi-forest coffee system stocked higher carbon ( $81.03 \pm 4.49 \text{ Mg C ha}^{-1}$ ) than forest ( $64.25 \pm 4.03 \text{ Mg C ha}^{-1}$ ) and homegarden ( $61.33 \pm 3.0 \text{ Mg C ha}^{-1}$ ) coffee systems. These findings indicate that the traditional coffee based agroforestry system has significant potential of storing and enhancing ecosystem carbon stocks. Generally, the traditional coffee based agroforests of the study area are diverse and structurally complex with significant carbon storage in plant biomass and in the soil.

**Keywords:** Diversity, Composition, Structure, *Coffea arabica* L., Carbon stock

**Worku Belayhun, 2011. Structure, Diversity, Carbon Stocks and Management of Trees in Parkland Agroforestry Practices in the Central Rift Valley of Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Among several agroforestry practices in the Central Rift Valley (CRV) of Ethiopia, *Acacia tortilis* and *Faidherbia albida* dominated parkland agroforestry practices are common. But structure, diversity, carbon stock status and management of these parklands were not well-studied. A study was conducted to evaluate these parameters in the two study areas, in Debre Zeit and Bulbula. After reconnaissance survey tree inventory was carried out on 7 transects with 59 plots of each with 5000 m<sup>2</sup> in the two selected sites. For woody species that have  $\geq 5$ cm dbh, measurements of dbh, tree height and crown diameter were taken. For the two parklands, tree density, basal area, canopy cover were computed to characterize structure of tree communities. Additionally, species diversity and carbon stocks were determined. Further, carbon stocks in the biomass were estimated by allometric equations and soil organic carbon was determined at two depths (0–15 cm and 15–30 cm). Results showed that high density of tree in Bulbula (15.70 per ha), low in Debre Zeit (7.12 per ha). The canopy cover for Debre Zeit *Faidherbia* parkland agroforestry (PAF) was 2.4%, while the corresponding cover at Bulbulla was 7.4%. The highest number of tree species (7 tree species) at Debre Zeit; at Bulbula only 5 tree species were recorded. The mean above-ground biomass carbon (AGBC) in *A. tortilis* based PAF is 9.3 Mg/ha. The mean AGBC in Debre Zeit is 5.5 Mg/ha. Below ground biomass of the trees was estimated as 25% of the AGB. SOC in Bulbula ranges between 5.7 Mg to 22.4 Mg with a mean of 11.25 Mg/ha, while in Debre Zeit area it ranges from 16.1 Mg to 23.3 Mg/ha with a mean of 19.8 Mg/ha. A significant difference was found in the SOC at two sites. There are also significance differences in structure, composition and carbon storage among the two parklands which could be attributed to the difference in the period since the original vegetation was converted to agricultural fields and level of intensity of crop production. Generally, as compared to other parklands in Africa, the structure, species diversity and carbon storage in the studied parklands are lower suggesting that there is a room for increasing tree component in the future. To realize this, there is great prospect and willingness from farmers' side to further increase the woody component of the parkland agroforestry, which is required to enhance their role in sustainable crop production, increased benefits from trees and contribution towards climate change mitigation and adaptation.

**Keywords:** Bulbulla, Canopy cover, Debre-Zeit, Species richness, Tree density

## 1.7. Socio-economics Aspects of Agroforestry practices

**Abeba Nigussie, 2011. Role of Women in Agroforestry Practices Management: A Case Study of Yirgacheffe Woreda, Gedeo Zone, Southern Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Ethiopian rural women are the mainstay of the farm labor. Despite their vital contributions, they are given little recognition for their efforts due to lack of understanding and insight on women roles in agricultural production. This study was, thus, intended to assess role of women in agroforestry practices management in Yirgacheffe *woreda*, one of the areas with strong tradition of agroforestry practice. A multistage random sampling technique was used to sample 120 households from three *kebeles* of six villages. Various data collection

methods including household survey, key informant interviews, focus group discussion as well as field observations were used to glean and evaluate data. The qualitative data was summarized and quantitative data analyzed by using Microsoft office EXCEL and SSPSS version 16. The result indicated that homegarden, village forest garden and woodlots are the major type of agroforestry practices. Women in the study area perform a decisive role in agroforestry production. In *enset*, food crop production, women have showed much contribution in manure application, harvesting, processing and marketing 93.8%, 100%, 100% and 100%, respectively. With regard to *enset* women make most of decisions such as clone selection (49.6%), time of harvest (81.7%) and they have the control and decision power of income from *enset* product selling (98%). In coffee, cash crop, they are involved mostly in harvesting (55%) and processing (48%). Compared to *enset* men have a strong say (56.6%) as to how, when and how much to sell their coffee. In livestock production women contribute significant in feeding and cleaning livestock sheds by 52% and 96.8% respectively, whereas, men undertake selling animals (90%). The results further indicate that both men and women are involved in on farm tree management, while women have higher contribution to transplanting of fruit trees (30%) and lopping (53.3%) especially for collection of twigs and leaves for fuel wood and fodder. Preferences of trees by women were high for tree species in the order of *Millettia ferruginea*, *Cordia africana* and *Persea americana*. The findings of the study also show that women from FHHs and women from the poor households carry out more management activities than women from wealthy households and MHHs. Women play important roles in agroforestry practices management in Yirgacheffe *woreda*. Therefore, the role of women in this system should be understood by different stakeholders and be given impetus to enable this agroforestry production system to remain sustainable.

**Keywords:** Homegarden, Village forest garden, Enset, Gender, Woodlot, Livestock

**Abiyot Legesse, Bogale Teferi & Axel Baudouin, 2013. Indigenous Agroforestry Knowledge Transmission and Young People's Participation in Agroforestry Practices: The Case of Wonago Woreda, Gedeo Zone, Southern Ethiopia. Ph.D. Thesis, Dilla Univerity.**

Research was conducted in the Wonago Woreda in Gedeo Zone, Ethiopia, to examine the transmission of indigenous agroforestry knowledge (IAK) from elders to young people. The study participants (elders, young people, and development agents) were purposely chosen from three kebeles in the woreda based on their sex, age, and status in the society. In-depth interviews and group discussions were held, observations were made, and participatory methods, including card sorting, cognitive mapping, neighbourhood walks, free listing, and informal discussions, were employed to collect necessary data from the participants. Thematic content analysis and case summaries were used to analyse and interpret the data. The findings revealed that the level of articulation regarding the IAK being practised in the area varied with age, gender, everyday experiences, and exposure to worldviews. Some young Gedeo participants were unable to articulate IAK. Young females were found to be better than males at articulating IAK. Young people attending school and fully engaged in off-farm activities were found to be less knowledgeable, while those whose daily activities depended on farming and related tasks articulated IAK adequately. Despite changes in social, economic, and cultural phenomena, the traditional practice of parents transmitting indigenous knowledge (IK) to youths still occurs. However, the rate of transmission is reduced compared to how it was in the past. The transmission rate is

declining due to internal and external factors, such as schooling, religion, poverty, land fragmentation, weakened child-parent relationships, and mass media. Ultimately, the decline in the transmission of IK is likely to result in total loss of IK, as there will be few or no generations holding such knowledge and passing it on to younger generations. Therefore, it is of paramount importance to strengthen the local institutions, belief systems, and rituals that give young people an opportunity to appreciate their culture, value, and norms and hence show an interest in passing their knowledge to the next generation.

**Keywords:** Agroforestry, Indigenous agroforestry knowledge, Knowledge transmission

**Alem Mezgebo, Worku Tessema & Zebene Asfaw, 2013. Economic Values of Irrigation Water in Wondo Genet District, Ethiopia: An Application of Contingent Valuation method. *Journal of Economics and Sustainable Development*, 4(2): 23-36.**

The study attempts to determine the economic value of irrigation water in Wondo Genet area by eliciting households' willingness to pay (WTP) using contingent valuation method (CVM) in the form of double bounded closed ended WTP questions with open ended follow up questions. Bivariate probit and probit models were applied to determine the mean and factors affecting willingness to pay for irrigation water, respectively. A sample of 154 households was randomly selected, and the survey was used for face to face interviews. The descriptive analysis shows that the irrigation water from Wosha and Werka rivers of Wondo Genet area is insufficient to produce cash crop and domestic use especially during the dry season. That is, 92.05% of the respondents reported that the reasons attributed to the insufficient availability of irrigation water for irrigation purpose were inequitable water distribution, population pressure, deforestation and illegal dweller. Furthermore, the econometric result shows that the total willingness to pay from double bound elicitation method was computed at 156,785.1 birr (1 US\$=17 birr) per annum for five years, while the willingness to pay from open ended elicitation method was computed at 128,264.55 birr per year. The total annual WTP for irrigation water from double bound elicitation method was greater than from open ended elicitation method. Hence, policy makers should target double bounded elicitation method than open ended elicitation method to eliciting the willingness to pay for irrigation water. This study empirically proved that households' income, age, cultivated land, initial bids, awareness and educational level are the key determinants of demand for irrigation water. Therefore, significant socio-economic variables should also be considered while designing irrigation water related projects at household level.

**Keywords:** Contingent Valuation Method, Willingness to Pay, Irrigation Water, Double Bounded Dichotomous Choice, Ethiopia

**Arsema Andargatchew, 2011. Value Chain Analysis for Bamboo Originating from Shedem Kebele, Bale Zone. *Journal of the Ethiopian Wildlife and Natural History Society; Special Edition on the Bale Mountains*, pp. 213-224.**

Ethiopia has approximately 1 million ha of natural bamboo forest, which is about 7% of the world total and 67% of the African bamboo forest area. The Bale Mountains has the largest percentage (38.7%) of reported highland bamboo in Ethiopia. Local communities use bamboo mainly for construction, fences, furniture and household utensils. Shedem is

a kebele in the Goba woreda, Bale zone where a large number of people are involved in bamboo culms extraction. Due to concerns regarding the current rate of extraction and the potential importance of bamboo as a means of livelihood, value chain analysis was carried out in this kebele. Results show that communities in Shedem depend highly on bamboo as a source of income. On average 47% of the annual income is estimated to be derived from bamboo sale. It is estimated that 3,356,055–3,750,885 bamboo culms are consumed per year from Shedem which accounts for 1.18–1.3% of all bamboo resources in the kebele. This study suggests that despite additional utilisation of bamboo in neighbouring kebeles, current harvest rates do not seem to be unsustainable. However, the harvesting method used, which often damages young shoots, has led to some concerns. Results indicated that there are three independent chains for bamboo culms bought directly from harvesters: crafts people, intermediaries and locals purchasing for construction. Craft producers were found to derive the largest income from bamboo (6.6 ETB/culm) followed by farmers/harvesters (1 ETB/culm). Value chain analyses revealed little or no communication among actors thereby reducing the efficacy of bamboo resource utilization.

**Biruk Birhan, 2013. Diversity and Socio-Economic Assessment of Cultivated Species in Homegardens of Sub-Humid Zones in Waderadistrict of Oromia, Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

Homegarden agroforestry is widely practiced in the Wadera district of Guji zone, Oromia region, but no study has been made to understand their management as well as species diversity and composition. Homegardens were surveyed with an objective of investigating management and utilization of homegarden products, factors that affect diversity and composition of cultivated plant species and determination of diversity indices. Out of 2150 households, a total of 60 were selected for socioeconomic assessment and 36 were inspected on diversity of cultivated species. Variations in occurrence of homegardens, size of homegardens were observed. The variations observed were best attributed to the difference in; geographic location of homegardens, farm size, distance from market and family size conditions. An average size of homegarden was 0.51ha. The gardens studied could be grouped in to backyards (21.78%), front yards (4.44%), side yards (8.89%), combination yards like side and back yards (50.22%), side and front yards (7.56%) and enclosed yards (7.11%). A total of 36 homegardens were inspected further with an objective of determining diversity and composition of cultivated species in homegardens of the study area. A total, 65 cultivated plant species belonging to 36 families were recorded with an average of 27.5 plant species per homegarden. Rutaceae was the dominant family with 6 species followed by Lamiaceae and Solanaceae 5 species each. Diversity indices ( $H'$ ) of 1.63, 1.99 and 2.06 were recorded for Wadera 01, Chelo Segida and Handoya Keno homegardens respectively. Underlining main use of species, a total of 13 use categories were recognized. Among the recorded species, *Zea mays* L. and *Solanum tuberosum* L. were major food crops and *Catha edulis* (Vahl) Forssk. ex Endl. and *Coffea arabica* L. were major cash crops which were the most frequent specie in the homegardens of the study area.

**Keywords:** Agroforestry, Cash crops, Food crops, Guji zone, Species diversity, Wadera

**Ermias Melaku, 2011. Contribution and Determinants of Non-Timber Forest Products Use in the Household Economy: the Case of Bonga Forest Area, Southwest Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Among the many functions and benefits of forests, non-timber forest products (NTFPs) have received considerable attention in the last decades due to their significant contributions to households, importance as conservation strategy and potential to meet sustainable rural development. However, the economic value of NTFPs and their contribution to household income were overlooked due to lack of adequate research data across the country. Bonga Forest, which is found in the south-western part of the country, is a rich ecosystem that provides economic, social and ecological benefits. Nevertheless, little information is available about the economic values of NTFPs, their contribution to household income and factors influencing the use of NTFPs. Therefore, this study was initiated to identify the major NTFPs, their contribution to household income and the factors influencing engagement of households in using NTFPs. The study was conducted in Gimbo and Decha Woredas of Kaffa Zone where Bonga Forest is located. Six Kebele Administrations were selected from the two Woredas and a total of 150 households were randomly selected using probabilities proportional to size techniques based on the number of farm household in the KAs. Moreover, secondary data were collected and focus group discussions were conducted with the selected individuals. The results of the study indicated that farmers have diversified livelihood activities such as crop and livestock production, production of NTFPs and off-farm activities. Within such diversification, NTFPs still play significant role in the household income. The contribution from the major NTFPs (forest coffee, honey and spices) was estimated at 47% of the annual household income. However, the role that NTFPs played was influenced by a number of factors. For example, variables such as being native to the area (+), total land holding (+), possession of livestock (+) and access to extension (+) had significantly affected forest coffee production. Variables such as age of household head (-), land holding (+) and distance of the market from the residence (-) affected honey production significantly. Moreover, size of landholding (+), distance of the market from the residence (-) and distance of the forest from the residence (-) were significant variables that determined income derived by the households from NTFPs. Therefore, in any design of policies and strategies focusing on the wellbeing of households should give attention to the contribution of NTFPs to the local people and take into consideration the different variables that affect the production of NTFPs.

**Keywords:** Bonga forest, Determinants of NTFP production, Household income, Livelihood activities, NTFPs

**Ewketu Linger, 2014. Agro-ecosystem and Socio-Economic Role of Homegarden Agroforestry in Jabithenan District, North-Western Ethiopia: Implication for Climate Change Adaptation. *A Springer open Journal*, 3 :154.**

Homegarden agroforestry is believed to be more diverse and provide multiple services for household than other monocropping system and this is due to the combination of crops, trees and livestock. The aim of this study was to assess socio-economic and agro-ecological role of homegardens in Jabithenan district, North-western Ethiopia. Two sites purposively and two villages randomly from each site were selected. Totally 96 households;

in which 48 from homegarden agroforestry user and 48 from non-tree based garden user were selected for this study. Socio-economic data and potential economic and agro-ecosystem role of homegarden agroforestry over non-tree based garden were collected by using semi-structured and structured questionnaires to the households. Homegarden agroforestry significantly ( $P < 0.05$ ) improved the farmers cash income than non-tree based garden. With insignificant garden size; homegarden agroforestry practice provides good socio-economical and agro-ecological service for farmers which have a higher implication for climate change adaptation than non-tree based garden.

**Keyword:** Non-tree based garden, Socio-economic role, Agro-ecological role, Climate change adaptation

**Gebremedhin Chameno, 2009. Management and the Influence of Socio-economic Factors on Tree Species Diversity in Traditional Agroforestry Practices in Demba goffa Woreda, South Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

The study was conducted at Demba Goffa Woreda of the South Ethiopia with objective of assessing status of tree species richness and their uses, local knowledge in use to manage trees/shrubs species and socioeconomic factors that influence tree species diversity management in traditional agroforestry practices. Interview and discussion with key informants and formal survey with structured questionnaires were employed ( $n=90$ ) to collect primary data. The assessment of tree species richness was done by inventorying trees at the sampled plots of the different agroforestry practices belonging to three social classes. Secondary data were collected from various online and documented sources. Data were analyzed by SPSS 13.0 computer program. The result indicated that most farmers preferred planting trees around homesteads, woodlots and boundaries. The type of trees planted were those meant for fuel wood productions (77.6%), construction materials (68.5%) and improvement of soil (51.1%). Wealthy farmers maintained more number of trees due to their larger farm size than medium and poor. The highest proportion of tree stems/ha was found in boundary plantation followed by woodlots and homegardens. The present result also indicated that *Terminallia brownii* (95.6%), *Moringa stenopetala* (88.9%), *Eucalyptus* species (85.6%) and *Cordia africana* (84.4%) were widely maintained and the most abundant tree species in all study sites. Majority of the tree species are common to all sites though there are differences in some rare species. Tree species richness ( $p < 0.01$ ) was positively and significantly correlated to farm size but negatively correlated to number of livestock owned. The present result also indicated that most farmers prune (56.1%), pollard (45.1%) and coppice (39.5%) trees. Smaller farm size (100%) and limitation of knowledge (80.8%) was the major socioeconomic factors that constraints tree species diversity management. From the present study, it can be concluded that consideration must be given to the local knowledge in use, and wealth status of the community in dealing with agroforestry practices, experiences, resources and needs of farmers who became involved in agroforestry practices in the area.

**Keywords:** Tree species, Wealth status, Local knowledge, Constraints, Demba Goffa

**Getachew Olana, 2002. Some Socio-Economic Aspects of biomass Energy in Ethiopia: A Review Energy, in Desta et al. (Eds.). Energy in Ethiopia: Status, Challenges, and Prospects. Proceedings of energy Conference, Professional Associations Joint Secretariat, Addis Ababa, Ethiopia.**

In Ethiopia, the household sub-sector is the major consumer of energy and almost the entire energy demand of this sub-sector is met from biomass sources. Poverty, the state in which about half of the population of Ethiopia is existing, is instigated, among the others, by the fast degradation of the natural vegetation of the country. The ever-increasing need existing for biomass energy is among factors that constitute the top causes of this degradation. All regions of the country are in short of biomass energy supply to meet their current level of demand. In year 2014, the supply of fuel wood for the country is estimated to be only about 10% of the demand. Therefore, the fact that scarcity of the biomass energy on one hand and the continuously increasing fuel prices on the other are suggesting that, timely and continuing interventions are required to halt the household energy problem in this country. Notwithstanding complaints regarding its inadequacy, some policies and strategies have been issued and a couple of institutions have been intervening to ameliorate the problem. This paper reviews some theoretical and empirical works undertaken, principally domestically, in the area of socio-economic aspect of biomass energy. It indicates that, in an attempt to improve efficiency of the use of the available energy, some technologies that are proved to be technically sound were adapted and introduced. However, responses of the intended target groups have not been encouraging. Incompatibility of the innovations with circumstances of the target group and other factors that are related to approaches, institutional and policy matters are identified to be behind the unsatisfactory responses.

**Getahun Kassa, 2012. Economic Analysis and Determinants of Fruit Tree Based Agroforestry System in Wondo District, Ethiopia: Comparative Analysis with Monocropping System. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Worldwide, concerns have developed on the long-term sustainability of farming systems due to the adverse environmental consequences of intensive monoculture. Fruit-tree based agroforestry represents a more environmentally friendly system, the economic returns and adoption determinants of which have only been modestly studied to date. This thesis investigated the determinants of practicing fruit-tree based agroforestry and the associated costs incurred and returns earned by practitioners. It contrasts the economic performance of agroforestry based systems and monocropping systems using economic performance indicators at the household level in Wondo District. Two Kebeles were selected based on the presence and ease of accessibility of fruit production. Data were collected from 149 selected households through structured interviews, focus group discussions, key informant interviews, market assessments as well as field observation. The quantitative data were analysed by employing Cost Benefit Analysis and Annual Equivalent Value. In the Cost Benefit analysis, Net Present Value (NPV) and Benefit-Cost Ratio (BCR) were calculated and compared. The qualitative data were also summarized and interpreted. The results of the enterprise budget showed that the agroforestry net profit is about two times higher than the net profit of sugarcane monocropping, nearly three times higher than the net profit of the sequential monocrop of tomato with maize, and five times higher than the net profit of the sequential monocrop of potato with maize. Cost Benefit Analysis aggregated over twenty



five years indicated that the NPV of fruit-tree based agroforestry may be as much one and half times higher than the NPV of sugarcane, more than two times higher than the NPV of the sequential monocrop of tomato with maize, and around four times higher than the NPV of the sequential monocrop of potato with maize. Similarly the BCR produced the same decision with the NPV. The result of Annual Equivalent Value (AEV) showed that fruit-tree based agroforestry system has a potential to create the highest income through out the project life. The result of a sensitivity analysis showed that fruit-based agroforestry is highly sensitive to changes in the discount rate. A logit model was used to identify the factors affecting agroforestry adoption. Ten variables were included in the model out of which five significantly affected agroforestry adoption. Nearness to the main road and farming experience affected adoption at less than a 1% significance level. Labor affected adoption at 5% significance level where as land size and income affected adoption at 10% significance level. Therefore, the fruit-tree based agroforestry system is more attractive financially, in addition to being labor saving and less risky investment than the monocropping systems. By providing improved varieties with short maturity period the fruit-tree based agroforestry system should be promoted.

**Gezahegn Kassa, 2011. Tree Species Diversity and Determinants of Tree Growing in Agroforestry Practices of Yem Special District, Southern Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

Conserving tree species diversity cannot be restricted in forest areas because of increasing encroachment to remnant forests. Agricultural landscapes that have good tree cover can maintain tree species diversity while providing complementary products and services. The present study was therefore conducted in Yem Special district, Southern Ethiopia, to determine the diversity of tree species, and assess the factors that influence farmers' decision making in tree growing. The data used for this research were collected through two consecutive field surveys involving structured household questionnaires and woody species inventory administered to 126 households. Data were analyzed using one way ANOVA, Chisquared, Kruskal-Wallis test, Mann-Whitney test and t-test, and logistic and multiple regression models. The status of tree species richness and diversity were quantified for different agroforestry practices. Within the 98 individual household farms surveyed, a total of 100 tree and shrub species belonging to 57 families and 83 genera were recorded in the different agroforestry practices, of which 11(or 11%) were exotic and 89(or 89%) native species. The mean number of tree species per household for the overall agroforestry practices was 14.04 and it was found to be significantly different among study sites, reflecting differences in site conditions. Tree species richness was influenced by distance to major roads, wealth, farm size and family size. Boundary plantings and live fences were occurring in 50% and 70.41% of the total household farms, with mean effective length of 0.21 km ha<sup>-1</sup> (ranging from 0.01 to 1.48 km) and 0.22 km ha<sup>-1</sup> (ranging from 0.019 to 0.963 km ha<sup>-1</sup>) per household, respectively. The present study revealed that the existing agroforestry practices contribute to the conservation of biodiversity in agroecosystems. Results of the logistic regression model showed that three variables were significant in explaining farmers' decisions to tree growing. Among the variables considered, age of household head, farm size, and livestock size were found to positively and significantly influence farmers' tree growing decisions. On the other hand, Ordinary least squares (OLS) indicated that only family size was positively and significantly influenced extent of tree growing. The findings imply

that it is appropriate to distinguish farmers' household- and farm-specific characteristics in order to better intensify tree growing activities/agroforestry practices.

**Keywords:** Human-dominated landscapes, Species richness, Biodiversity, Household and farm-specific, Tree growers.

**Gregory S. Amacher, Lire Ersado, William F. Hyde & Amy Osorio, 2004. Tree planting in Tigray, Ethiopia: the importance of human disease and water micro dams. *Agroforestry Systems*, 60:211-225.**

We examine the decision to plant trees and level of tree planting for two sites, public micro dam areas and household agricultural land, and two species groups in Tigray, Ethiopia. Both sites are not perfect substitutes, as they vary with respect to distance from the household and tenure security. The role of permanent pooled water irrigation micro dams to tree planting is important but unknown, because water borne diseases, which may influence household income and productivity, are thought to be enhanced by the dams. We find both disease and micro dams to be important predictors to tree planting. Disease seems more important in determining whether households plant at all, and less important in the level of planting for those that do plant. For example, disease increases the probability of planting both eucalyptus and other species groups on household-own land, but households suffering from malaria plant higher-cost eucalyptus trees with lower probability at both sites, while planting of other lower-cost species increases at dam sites where other villagers can monitor the trees. We also establish a connection between planting and agricultural residues, finding a strong substitution effect on own-land. Micro dam access and age are also important. Households living nearer to dam sites will plant both species groups there with higher probabilities, but the decision to plant on agricultural own-land is not affected. For older dams with more developed irrigation, households are more likely to grow crops rather than plant trees on their own land, but they plant more trees at the dam sites.

**Hafta Mebrahten, 2012. Socio-economic Assessment of Biogas Technology and its Contribution to Crop Production in the Rural Households, the Case of Meskan Woreda, Southern Ethiopia. M.Sc. Thesis, College of Agriculture, Hawassa University.**

One of the major constraints of rural development in developing countries is lack of efficient and affordable energy technology and low level of crop production due to scanty use of fertilizer. Adopting a new technology that provides basic energy needs is an important issue for the rural people where the majority of farmers are living at subsistence level. Biogas technology can play a vital role in enhancing the socio-economic status of the farmers by providing environmentally friendly and economically beneficial energy from animal dung, a by-product of farming system with livestock and enhancing crop production by utilizing the bioslurry which is an organic fertilizer. This study dealt with the socio-economic assessment of biogas technology and its contribution to crop production in Meskan woreda, Southern Ethiopia. It further captures the current challenges facing the adoption of the technology and its impact on development, effective application and dissemination. Data were collected using structured and semi-structured questionnaires from households (HHs), extension agents and woreda experts and by conducting focus group discussion. The study was carried out by surveying forty (40) HHs whose biogas plant has already started production,

and 36 key informants and woreda experts. The sample was taken from four (4) purposely selected kebeles of the woreda. Data were analyzed using SPSS and Microsoft Excel. The study revealed that biogas provides different social, economic and environmental benefits such as, use as source of organic fertilizer, creation of employment, clean and healthy environment, reduced use of fuelwood and agricultural residues, reduction in cost of kerosene and chemical fertilizer, gender benefits and costs and overall contribution to household income. Enhancing crop production by using the bioslurry also contributes to food security and global environmental protection. The bioslurry in slurry form was used as organic fertilizer by 36 households out of 40 households. The remaining 4 households used both composted slurry and slurry form. From reduced use of kerosene, chemical fertilizer and fuelwood the surveyed households of the study area have obtained total savings of birr 9352 per yr per HH.

**Keywords:** Biogas technology, Bioslurry, Rural development, Environmental benefit

**Kahuranga J., Alemayehu Y., Tadesse S. & Bekele T., 1992. Informal Surveys to Assess Social Forestry at Dibandiba and Aleta Wendo, Ethiopia. *Agroforestry Systems*, 24: 57-80.**

Two surveys were carried out at Dibandiba, a semi-arid site in central Ethiopia, and Aleta Wendo, a sub-humid site in southern Ethiopia, to assess farmers' attitudes toward and perceptions of tree planting, levels of social forestry and uses of tree products. At Dibandiba, farmers planted mostly *Eucalyptus camaldulensis* trees, exclusively on homesteads and *Acacia albida* was left on farmland. Trees were planted mainly for construction (32%), fuel wood (29%), shade (11%) and cash (11%). Major (85%) uses were fencing, fuel wood, construction and plough handles. Dung was the major source of fuel (56%). At Aleta Wendo, planting consisted of *Eucalyptus globulus* mostly on private woodlots and homesteads, of *Milletia ferruginea* and *Cordia abyssinica* on farms, and of *Euphorbia abyssinica* on fences and boundaries. Avocado and pears were also planted. The uses were the same as at Dibandiba. Major constraints were lack of seedlings and shortage of land at both sites, plus shortage of water at Dibandiba. Also, a review of information obtained from previous surveys on household composition and income, farm holding, cropping pattern, livestock composition and the use of labour was made.

**Long A.J & Nair R.P.K., 1999. Trees Outside Forests: Agro, Community, and Urban Forestry. *New Forests*, 17: 145–174.**

Planted forests are often considered to consist of tree plantings at a scale large enough to satisfy such objectives as commercial production of timber and fiber, protection of watersheds, and preservation of natural habitats. However, trees are planted also at greatly reduced scales in agroforestry systems or as community woodlots to provide a mixture of products and services to resident households, local communities, and regional cultures. Agroforestry systems represent a major form of small-scale tree planting, where trees are grown in purposeful combinations with agricultural crops and/or livestock in order to take advantage of tree-crop interactions, and thereby enhance crop production, diversify farm output, stabilize or improve soils, or ameliorate harsh environmental conditions. Some important examples of these systems in tropical countries include homegardens,

alley cropping, improved fallows, intercropped trees for shade and fodder production, and trees planted in hedgerows and along fence lines. Throughout the tropics, there is a large variety of indigenous practices and species mixtures that represent adaptations of these systems to meet localized needs and opportunities. Research and development programs have supported the expansion and refinement of many of these systems during the last 20 years, but substantial constraints on tree planting still exist in the form of land-tenure practices, population pressures that relegate agroforestry practices to degraded lands, subsistence needs that prevent extended periods of tree growth, and insufficient technical information or technology dissemination. Agroforestry systems in temperate, industrialized countries include combinations of trees, pasture, and livestock; fruit or nut trees interplanted with vegetable or grain crops; windbreaks and shelterbelts; multispecies riparian buffer strips; and forest farming systems for specialty crops. Compared to the tropics, however, temperate-zone systems tend to focus on one or two high-value crops, often involve some level of mechanization, and frequently represent an opportunistic approach to improving the economic profitability of farms rather than meeting subsistence needs. In both tropical and temperate regions, agroforestry systems and community woodlots will be an important component of new sustainable agriculture and environmental protection programs. Although species diversity is an essential feature of all agroforestry systems, community forests generally involve planting only a few species in small woodlots near farms, around villages, along roads, and as riparian buffers. Provincial or state governments and the local populace are often involved in landownership and plantation establishment. Major objectives of these forests are production of fuelwood for local consumption and of other tree products for market; soil stabilization, reclamation, or improvement; and protection of water quality. As with many other planted forests, the number of species widely used in community forests has been relatively small, with the genera *Eucalyptus*, *Pinus*, and *Acacia* providing the bulk of the species. Major issues with these “planted forests” focus on rights for use of the products, tending responsibilities once trees are established, protection until trees are large enough for their designated use, increasing interest in using “native” species, and greater community involvement in planning and management. Trees planted along streets and waterways, or as woodlots in parks and other public places, represent a major group of planted forests in many urban and periurban landscapes. In addition to providing many of the same environmental services that agroforests and community forests do, these urban plantings have unique aesthetic and recreational value. For much of the world’s ever-increasing urban population, these may be the only tangible reference points for understanding planted forests. These relatively little-recognized forms of planted forests – planted trees, to be more appropriate – are now receiving much greater attention. There are, however, some serious technical and socio-politico-institutional constraints to their development as more widely adopted systems in both tropical and temperate regions.

**Lalisa Alemayehu, 2013. Financial Analysis of Agroforestry Land Uses and Its Implications for Smallholder Farmers Livelihood Improvement In Ethiopia. *Agroforestry Systems*, 87 (1):217-231.**

A study was conducted in central highland Ethiopia to: (1) assess the financial feasibility and relative financial attractiveness of three agroforestry practices (small-scale woodlot, homestead tree and shrub growing and boundary tree and shrub growing); (2) evaluate the impacts of implementation of these land uses on farm households income and (3) identify

the constraints for the implementation and expansion of the agroforestry practices. Then, 82 different land uses (21 small-scale woodlots, 35 homesteads and 26 boundary plantings) which were older than 15 years and established by the current owner were selected for the financial analysis. The input and output data were filled in a data sheet by face-to-face interview with the owners. The results showed that small-scale woodlot is the most profitable agroforestry practice followed by boundary plantings and homesteads. An ex-ante analysis of implementing the agroforestry practices showed that with minimum land area allocated for the practices, a household can generate net discounted revenues ranging from 5,908 to 26,021 Ethiopian Birr (532–2,342 USD) in 15 years at 10 % interest rate. Hence, the expansion of such agroforestry practices has a vital effect on farm household's income. Lack of proper planning and poor in-depth understanding about roles of trees and shrubs for household's income, land and seedling shortage, financial constraints and labor scarcity were identified as major problems for the expansion of agroforestry practices in the area. A thorough extension service comprising both efficient land resources utilization and proper planning practices could enhance the expansion of agroforestry practices and thereby positively influence the farmer's livelihood.

**Mulugeta Sisay, 2011. Socioeconomic and Biophysical Issues Impacting Tree and Shrub Species Integration at Borodo Watershed, Central Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

The watershed approach was introduced in Ethiopia in order to better control land degradation and to sustain a variety of ecosystem functions. Similarly, tree and shrub integration in a watershed has been promoted as a means to enhance rural livelihoods through sustaining its potential services. Thus, rural tree planting on different niches are a history of long time in Ethiopia. However, the efforts made were unsuccessful mainly due to various socioeconomic and biophysical factors. Owing to this fact, this study was conducted at Borodo watershed, Dendi district to identify the existing tree and shrub species, explore those multiple factors impacting tree and shrub integration, and to investigate major soil physical and chemical properties of potential tree and shrub planting niches. The analysis is based on a survey of 89 household heads and focus group discussions, key informant interview and field observations were also conducted to achieve the study objectives. A total of 45 soil samples (5 niches \* 3 replicates \* 3 depths) were collected to investigate major soil physical and chemical properties of the potential tree and shrub planting niches. The study identified a total of 42 tree and shrub species at different niches in the watershed. The study also found out improved access to information, availability of market for tree products, positive prospect of land tenure, cash availability and land certification as the most important encouraging factor for farmers to plant more tree and shrub species. Concerns identified include: shortage of planting area, soil cracking, free grazing, poor seedling survival, lack of seed and seedlings of desired species, and water– logging are found to be decisive constraints to tree and shrub species integration at the watershed. In relation to farmers' species preference, 91% of interviewees prefer *Eucalyptus* Spp., 64% *Sesbania sesban* and 43% *Grevillea robusta* as the first, second and third priority species. The potential tree and shrub growing niches that farmers identified and preferred were homestead (95.5%), gully side (67.4%), streamside (61.8%), road side (60.7%), and outfield (12.4%). The soil property examined exhibited significant variations for SOC and total N. Sand, silt and clay were showed significant variation at 30-50cm sampling depth at  $p < 0.05$ . CEC (15-30),

K<sup>+</sup> and Na<sup>+</sup> were also showed significant variation at 0–15 sampling depth. On the other hand pH, Mg<sup>2+</sup> and Ca<sup>2+</sup> values didn't show significant variation among potential niches. It is essential to address the factors that hinder tree and shrub species integration at various landscape position of the watershed so as to improve the availability of tree products and services. Moreover, the capacity of farmers should be upgraded through training and demonstration of best tree planting, management and utilization practices.

**Keywords:** Household, Landscape, Niche, Soil properties, Species preference

**Scherr S.J., 1995. Economic Factors in Farmer Adoption of Agroforestry: Patterns Observed in Western Kenya. *World Development*, 23 (5):787-804.**

A study of agroforestry adoption by 3,000 project participants in Siaya and South Nyanza Districts in Kenya supports three hypotheses. (1) Historical increases in tree domestication and management intensity are responses to declining supply of uncultivated tree resources, increased subsistence and commercial demand for tree products, and perceived risks of ecological degradation. Adoption of agroforestry is most likely where consistent with economic incentives for land use change. (2) High variability in individual farmers' tree-growing strategies reflects differences in resources and livelihood strategies, and household-level returns to agroforestry relative to alternative options for meeting specific objectives. (3) Farmers reduce risks associated with new agroforestry practices through incremental adoption and adaptation, and cost- and risk-reducing modifications in technology design.

**Scheckenberg K., Awono A., Degrande A., Mbosso C., Ndoye O. & Tchoundjeu Z., 2006. Domesticating Indigenous Fruit Trees as a Contribution to Poverty Reduction. *Forests, Trees and Livelihoods*, 16: 35–51.**

The contribution that domesticated indigenous fruit trees make to many farmers' livelihoods is often not acknowledged in either national- or international-level poverty reduction strategies. Current agricultural data tend to be restricted to a narrow range of exotic fruit (e.g. mango, avocado, citrus). Existing data on indigenous fruit are often not presented in the kinds of income-related terms used in the policy debate, nor are they linked to simple policy recommendations. Drawing predominantly on the examples of *Dacryodes edulis* and *Irvingia gabonensis* in Cameroon and Nigeria, this paper presents evidence for the contribution of these fruit trees to poverty reduction. Evidence on the numbers and types of people obtaining an income from indigenous fruit trees, the proportion and value of that income and whether the income acts as a safety-net or can help to move people out of poverty, is presented. Non-income related impacts on health and the environment are also discussed. Finally, key policy interventions required to sustain and increase the already valuable contribution of domesticated indigenous fruit trees are outlined.

**Teshome Soromessa & Sebsebe Demissew, 2002. Some Uses of Plants by the Benna, Tsemay and Zeyise people, Southern Ethiopia. *Ethiopian Journal of Natural Resources*, 4(1): 107-122.**

The study was carried out on uses of plants among the three ethnic groups of southern Ethiopia, the Benna, Tsemay and the Zeyise. Information on uses and vernacular names

of plants were gathered by interviewing local people. Plant specimens were collected, processed identified and deposited at the National Herbarium in Addis Ababa University. A total of 80 different species of plants representing 37 families were recorded providing. The scientific family and vernacular names as well as uses by the three ethnic groups are presented. The integration of indigenous knowledge in the activities pertinent to development and afforestation by indigenous species is recommended.

**Tewfik Bamud, 2012. Economic Contribution to Local Livelihoods and Household Dependence on Non-Timber Forest Products: The Case of Yeki Woreda Forests, Southwest Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Forest ecosystems have long been acknowledged for the multiple benefits they provide. Among these, there has been a growing consciousness about NTFPs in recent decades partially for the roles they play in local livelihoods. In the case of Ethiopia, NTFPs provide valuable economic contributions both at local and national level. However, the contribution of NTFPs is often underestimated. This is because neither reliable market data nor empirical knowledge on the benefits of NTFPs is adequately available. Yeki Woreda forest is one of the ecosystem resources in southwest Ethiopia which provides several economic, ecological and social benefits. The local livelihood contribution of NTFPs from the forest is particularly important, yet it was not adequately assessed so far that only little information is available. The main purpose of this study was, therefore, to evaluate the economic contribution of NTFPs to the livelihoods of households living around Yeki Woreda forest. Specifically the study was undertaken to identify the major NTFPs used by local households, assess the subsistence and cash income contribution of NTFPs to local households and identify the determinants of household dependence on NTFPs around Yeki Woreda forest. The study was conducted in three purposively selected potential NTFP Kebeles and a total of 170 households were randomly selected from the Kebeles using the proportions-to-size technique of sample allocation. Besides, secondary data were collected and, group discussions and household survey were conducted to collect the necessary data. The results indicated that NTFPs are more than a safety-net and households living around forests in the study area are considerably dependent on NTFPs. The range of the NTFPs includes forest honey, climbers, forest coffee, spices (Korerima and Timiz) wild food (ero and acho), fuel wood (fire wood and charcoal) and other products (bamboo, ensosila, forest fodder, medicinal products such as damakese etc). These products provide important sources of income (13.1%) for households living around forests who also practice agricultural production. Honey is the most important NTFP in the study area followed by forest coffee and fuel wood. Honey, coffee, wild spices and 'ensosila' are mainly used for cash purposes whereas climbers, bamboo, wild food, fuel wood, forest fodder and medicinal NTFPs are mainly (sometimes even entirely) used for subsistence. However, household dependence on NTFPs varied with differences in socioeconomic factors. Logistic regression predicted that households which are less educated, married, having more land, having non-farm income, closer to forests and residing longer in the study area are more likely to participate in NTFP collection. Similarly, OLS regression predicted that smaller households and those having more livestock, having more workers and residing more far-away from town are more dependent on NTFPs for income. So,

the local government line offices should pay adequate attention to the importance of NTFPs and integrate them to the rural development programs. The differences among local groups, such as the rich and the poor, should be considered in designing and implementing NTFP based development programs.

**Keywords:** Rural development, Safety-net, Household income, Subsistence income, Cash Income

**Tougiani A., Guero C. & Rinaudo T., 2009. Community Mobilisation for Improved Livelihoods through Tree Crop Management in Niger. *GeoJournal*, 74:377–389.**

Effective natural resource management requires interrelated technical practices and social arrangements that are appropriate to a region's biophysical characteristics and that address protection and sustainable management of resources. This is illustrated from our experience in the Republic of Niger, West Africa. In 1980 barren plains, infertile soils, drought, dust storms, severe fodder shortages, and agricultural pest outbreaks were normal occurrences in Niger's rural regions. In general, despite large investments of time and funding, conventional reforestation efforts had little impact. However by 2008 over five million hectares of once barren land had been transformed through wide adoption of an agroforestry method known as 'Farmer Managed Natural Regeneration' (FMNR), introduced in 1983. In the Aguié Department, the practice of FMNR was formalized through the Desert Community Initiative (DCI), addressing interrelated technical and social issues in resource management. New governance structures, which include marginalized groups, implement monitoring and enforcement systems enabling communities to manage land and regenerating trees. These, together with technical solutions that build on local knowledge and skills and use previously undervalued indigenous tree species, have generated a sustainable fuel-wood market for the first time. Increased linkage and compatibility between institutions at local and national levels and strengthened social capital have been crucial to these impacts. Food security and community resilience to drought have been markedly enhanced and local incomes have increased. The experience provides important lessons for approaches to addressing environmental degradation and poverty in other semi-arid areas and facilitating the spread and adoption of new agroforestry systems.

**Victor A.J. Adekunle & Yekini Bakare, 2004. Rural Livelihood Benefits from Participation in the Taungya Agroforestry System in Ondo State of Nigeria. *Small-scale Forest Economics, Management and Policy*, 3(1): 131-138.**

This study examines the strategies and benefits of the taungya farming system to both the government and the rural economy in Nigeria. An interview survey was conducted in which data were collected from 115 randomly selected farmers in five villages in the Oluwa forest reserve, Ondo State, Nigeria. The study examines the extent of participation of rural dwellers in plantation development through taungya farming and the degree of success of this system as an afforestation method. The farmers were predominantly illiterate, within the age bracket of 35-54 years and with small farm holdings. Twenty nine percent relied totally on food from the forest reserve for their livelihood, while 71% also had farm holdings in free areas. Land within the reserve is allocated to farmers free of charge but compensation is paid to landlords on land from free areas. A statistically significant difference was detected



in income from the two sources of farmland for the households and but not in the size of land allocated under taungya and free areas. About 184 farmers are involved in taungya annually, and 410 ha of *Tectonia grandis* has been established for the government of Ondo State.

## 1.8. Adoption of Agroforestry Practices

**Badege Bishaw & Abdu Abdulkadir, 1989. Strategies for On-Farm Research in Agroforestry in the Hararge Highlands, Eastern Ethiopia. IAR proceeding, First Natural Resources Conservation Conference. Addis Ababa, Ethiopia.**

Climate change is real and happening in East African countries including Ethiopia and Kenya. Climate change is manifested in the recurrent drought, floods, and famine that have threatened millions of people and livestock in recent decades. Subsistence farming practices are the main livelihood for most people living in this region, which is characterized by degraded soils, small farm sizes, and low agriculture outputs. Agroforestry, which is an ecologically based traditional farming practice, integrates trees into the farming systems to increase agricultural productivity and ameliorate soil fertility, control erosion, conserve biodiversity, and diversify income for households and communities. In early 2011, Oregon State University was invited by the World Agroforestry Center to renew institutional collaboration for student and faculty exchanges, exchange scientific information, and to collaborate in agroforestry research and outreach. As part of this initiative an Agroforestry synthesis paper was proposed on farmers' adaptation and mitigation to climate variability and change through agroforestry practices in Ethiopia and Kenya. The purpose of the synthesis paper was to document traditional and scientific knowledge on how farmers cope with climate variability and change. Four case studies were identified from highland farming and dryland pastoral systems in both Ethiopia and Kenya. The Gedeo Home garden from Ethiopia and Meru highland farming from Kenya were identified as good representatives of highland farming. The Afar pastoral system and Kibwezi district dryland farming from Kenya were identified as good representatives of dryland farming systems. The lead authors for each chapter were selected based on their experiences working in the case study areas, and are knowledgeable of the farming systems and constraints thereof. The synthesis paper has helped us document information from the respective case study areas, including both the traditional ecological knowledge and the current agroforestry practices in the context of climate change. By no means is the information in this paper exhaustive, but it gives a better understanding of the situation currently faced by these countries. The paper suggests scaling up some of the already available agroforestry practices in these countries and identifying gaps in knowledge, which then point to what kinds of agroforestry research should be conducted to address climate change mitigation and adaptation in the future. This paper has brought together scientists from various education and research institutions in Ethiopia and Kenya with expertise in agriculture, agroforestry, plant genetics, agroforestry, and economics and social sciences. This concourse has helped us understand the importance of interdisciplinary work to address complex natural resources management issues from ecological, economic and social issues. We hope this collaborative effort will continue beyond the literature synthesis and create opportunities for future collaboration in agroforestry education, research, outreach, and student and faculty exchange among the involved institutions.

**Lemelem Tagebe, 2012. Income Contribution and Determinants of Adoption of Apple Based Agroforestry System: the Case of Dendi Woreda, Oromia Regional State. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Ethiopian highlands have suitable climatic condition and less disease incidences thus are selected by most people for habitation. Consequently, the population growth in these areas has become a grave concern. In order to alleviate the pressing problems and to enhance fruit tree based farming system in Dendi Woreda, Oromia region, in the central highlands of Ethiopia, high value apple tree seedlings were provided to households by outsiders a decade ago. Four introduced apple varieties viz. Anna, Crispin, Dorset-golden and Princeasa have started fruit yielding to land users/ local farmers. However, despite the provision of such variety of seedlings to the farmers in the area, a study on the contribution of the fruit trees to the household economy improvement, and on the various determinant factors that limit the adoption of the technology was lacking. Therefore, this study was initiated to estimate and compare households' income from apple based agroforestry system and identify factors that influence its adoption by smallholder farmers in Dendi Woreda. Two Kebeles were purposefully selected and from which 250 households were randomly selected where 33 were adopters of the technology and the remaining 217 were non-adopters. To gather the necessary information both primary and secondary data were collected and focus group discussions were conducted. The results showed that farmers predominantly carry out various livelihood activities such as production of grain crops, livestock, vegetables, and apple fruit. In agri-horticulture agroforestry approach apple trees were integrated with vegetables at homesteads by adopters. The mean gross income of adopters from apple fruit was 58,234.85 ETB ha<sup>-1</sup> yr<sup>-1</sup>. Adopters mean annual gross income from vegetable + apple fruit was 344,602.3 ETB ha<sup>-1</sup> yr<sup>-1</sup> and mean annual gross income of non-adopters from vegetable was 219,932.9 ETB ha<sup>-1</sup> yr<sup>-1</sup>. The income obtained from apple contributes 17 per cent to the income of agri-horticultural system. Non-adopters annual net income from vegetables was 191,645.13 ETB ha<sup>-1</sup> yr<sup>-1</sup> and adopters' annual net income from vegetable + apple was 312,378.79 ETB ha<sup>-1</sup> yr<sup>-1</sup>. The agri-horticulture system contributed 1.63 times higher net revenue for adopters in addition to its nutritional value. However, adoption of apple based agroforestry systems was significantly influenced by different factors such as age (+), formal educational levels (+), livestock holding (+), distance from market to home (+), sex (-) and total land holding (-). In order to maximize the benefits from the system land users are advised to follow integration of apple fruit trees in their food production activities incorporating their own farm resources to minimize input costs. Policy makers are also expected to advocate the systems performance in the study area and beyond.

**Keywords:** Agri-horticulture system, Apple tree adoption, Household income

**Lemma Gizachew, Abubeker Hassen & Diriba Gelete, 1996. Adaptation and Yield Performances of Herbaceous and Multipurpose Tree Legumes in Sub Humid Climates of Western Ethiopia. Proceeding of the fourth ESAP conference, pp 187-195.**

The environmental adaptation, length of growing season and productivity of herbaceous and multipurpose tree (MPT) legume species at Bako were investigated during 1992-1995 using

a randomized complete block design with four replicates. Most of the herbaceous perennial legumes attained their peak dry matter (DM) yield in the second year of establishment and steadily declined thereafter. *Stylosanthes guianensis* acc. (ILCA 4) and *Desmodium intortum* acc. (ILCA 104) were consistent and superior ( $P < 0.011$ ) DM producers. They also had a long growing season. *Clitoria tematea*, *Rhynchosia minima*, *Macrotyloma axillare* and *Zomia latifolia* were the least ( $P < 0.011$ ) DM yielders. Respective DM yields in 1992, 1993, 1994 and 1995 for *S. guianensis* and were 7.33, 11.53, 11.89, and 9.79 t/ha and for *D. intortum* 6.30, 12.42, 14.31 and 13.07 t/ha, respectively. *C. tematea*, *Vigna unguiculata*, *Centrosema brasilianum* and *Neotonia weightii*; were susceptible to leaf diseases common to the area. In 1993 and 1995 both accessions of *Calliandra calothyrsus* (ILCA 16310 and ILCA 14981) gave the highest ( $P < 0.01$ ) foliage DM yield but surpassed by *Sesbania sesban* (ILCA 10865) in 1994. In terms of wood and total biomass DM yield, *S. sesban* (ILCA 10865) was on top ( $P < 0.01$ ) of all tested MPT accessions. *Cajanus cajan* and *S. sesban* took short time to flower but found to be more susceptible to termite attack under repeated cutting. The result of this study suggests that *S. guianensis* ILCA 4, *D. intortum* ILCA 104, *C. calothyrsus* ILCA 16310, and *S. sesban* ILCA 10865 are the most appropriate legume species for Bako and other areas with similar environment.

**Kindu Mekonnen, 1994. The Role, Potential and Research Needs of Agroforestry For Dryland Areas of Ethiopia. Proceeding of the First National Workshop on Dryland Farming Research in Ethiopia. pp130-143.**

Agroforestry is basically a landuse strategy that integrates agriculture and forest production. Agroforestry plays important roles in increasing the sustainability of farming systems, production of fuel wood, production of animal fodder and cash products, and diversification of agricultural products. In Ethiopia, research on agroforestry is still in its infancy as compared to crop and livestock. In contrast to the highlands, the agroforestry potentials and research needs of the arid and semiarid areas of Ethiopia have not been studied. However, experiences in other countries like Kenya and India showed the potential of various agroforestry practices for dryland farming systems. Among agroforestry systems, alley cropping, scattered trees, windbreaks, gully plantation and sylvopastoral practices are suitable to the dryland areas of Ethiopia.

**Kindu Mekonnen, 2001. Practices, Constraints and Agroforestry Interventions in Yeku Watershed Northeastern Ethiopia. *Ethiopian Journal of Natural Resources*, 3 (1):161-178.**

Integrated watershed development has been considered as one of the strategies to create a healthy environment and boost crop production in Amhara region, Ethiopia. Based on this understanding Yeku watershed was selected as one of four pilot watersheds in the region. The watershed is administratively located in Woleh 06 Kebele (the lowest administrative unit), Sekota wereda and Waghamra Zone. The survey was conducted in 1999 to characterise agroforestry practices and tree species in the watershed, to identify and prioritise constraints, and to suggest solutions together with the farmers. The Participatory Rural Appraisal Technique was used for the detailed study. Existing agroforestry practices in the watershed are trees and shrubs in closed areas, trees and shrubs in sylvopastoral lands, trees on farmlands, trees along rivers, and trees in homesteads. Soil erosion, shortage

of animal feed and wood, and prevalence of desiccating wind are critical problems in the farming system. Suggested agroforestry interventions are protection and management of naturally regenerated trees on farmlands, planting agroforestry trees in homesteads and riverbanks, introduction and expansion of vegetative strips on farmlands, and strengthening of temporarily closed areas through enrichment planting. Moreover, alternatives such as use of fuel wood conservation systems, introduction of other fuel sources, incentives for farmers who properly plant and manage trees, and development of farmers' confidence in tree and land ownership are proposed as strategies to minimise the gap between wood demand and supply. Intensive agroecology-based multipurpose tree/shrub screening and management research programmes are essential in the determination of appropriate species for specific areas.

**Russell D & Franzel S., 2004. Trees of Prosperity: Agroforestry, Markets and the African Smallholder. *Agroforestry Systems*, 61: 345–355.**

In many developing countries, especially in Africa, farmers have been introduced to agroforestry with little consideration for the markets for trees and tree products aside from potential productivity gains to food crops. It is now being recognized that expanding market opportunities for smallholders particularly in niche markets and high value products is critical to the success of agroforestry innovations. Some recent work presented in this paper on marketing agroforestry products in Africa, linking farmers to markets and assisting farmer organizations, shows how constraints are tied to both long-standing market structures as well as shifting market imperatives. Forest policy, physical and social barriers to smallholder participation in markets, the overall lack of information at all levels on markets for agroforestry products, and the challenges to outgrowing schemes and contract farming inhibit the growth of the smallholder tree product sector in Africa outside of traditional products. Notwithstanding these constraints, there are promising developments including contract fuelwood schemes, small-scale nursery enterprises, charcoal policy reform, novel market information systems, facilitating and capacity building of farmer and farm forest associations, and collaboration between the private sector, research and extension.

**Solomon Mulu, 2009. Assessment of Farmers' Perception and Determination of Agroforestry Technologies Adoption in South Wello North East Ethiopia. M.Sc. Thesis, Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Agroforestry is one of the approaches to restore degraded land where land resource is limited like the case in the Amhara region and especially in south wello. The Amhara National Regional State Bureau of Agriculture designed different agroforestry technology packages since the year 1996. Despite the big effort made by the office of agriculture in extending the agroforestry technologies less attention has been paid to study the status of the introduced packages. With an objective to assess the perception and adoption of agroforestry technologies by the local farmers and factors influencing it in south wello, the study was conducted in two districts Dessie Zuria and Kallu. Using Multistage sampling approach in the first and second stage, District and Kebele were selected purposively, in the third stage house hold selection was employed using stratified random sampling techniques. From the three Kebeles 180 farmers 90 adopters and 90 non adopters were selected randomly. Formal survey with structured questionnaire, key informant interview,

semi-structured interview for extension staffs and inventory of the packages were conducted. Descriptive statistics and inferential statistics of logit model were employed to analyze the collected data. The result revealed that home garden agroforestry is the most widely adopted technology. The analysis of logit model on the factors influencing adoption of agroforestry technologies revealed that among the fifteen different explanatory variables hypothesized to affect adoption of agroforestry technologies farmer's age, land holding size, incentives, local by law and labor were positively and significantly related to farmers' adoption decision of agroforestry technologies in the study area. Since farmer's awareness and belief in the agroforestry technologies is an important starting point establishing more efficient agroforestry extension system is paramount important to improve the knowledge and attitude of farmers consistently in all areas.

**Keywords:** Agroforestry technologies, Adoption, Perception, South Wello

**Teshome Tesema, 1996. Socio-economic Issues That Affect Adoption Conditions of Farmers in Agroforestry Developments in Eastern Gojam Zone, Ethiopia. M.Sc. Thesis Swedish University of Agricultural Sciences, Sweden.**

This work provides an assessment of the development problems affecting the adoption of agroforestry technologies in two communities of Eastern Gojam Zone, Amhara Regional State. Questionnaire survey covering 10 per cent of the households in both communities and Participatory Rural Appraisal techniques were used to generate the primary data. The report indicates that lack of access to production resources, cattle damage, uncertainties in land holding rights, and health problems were the major bottlenecks hindering a wider use of agroforestry practices. It then recommends that measures that would tackle each of the problems identified in the course of data analysis.



## 2. AREA ENCLOSURES



### COMPILED BY

Yigremachew Seyoum, Tefera Mengistu, Emiru Berhane, Negusse Esmael, Niguse Hagazi, Habtemariam Kassa

## 2.1. Definition of Area Enclosure

**Raf Aerts, Jan Nyssen & Mitiku Haile, 2008. On the Difference Between “Enclosures” and “Enclosures” in Ecology and the Environment. *Journal of Arid Environments*, 73 (8): 762-763.**

Rehabilitation of degraded land in arid and semiarid environments often involves excluding livestock from degraded sites. The main objective of such “enclosures” is to allow native vegetation to regenerate as a way to reduce soil erosion, increase rain water infiltration and provide fodder and woody biomass. Some alternative names for this practice that are increasingly used in the literature, including ‘enclosure’, ‘area enclosure’, ‘range enclosure’ and ‘grazing reserve enclosure’, may lead to confusion and misunderstanding, because enclosures and enclosures are not synonyms. Here we aim to illustrate the difference using recent ecological and environmental literature and provide guidance for their proper use. Enclosures are “areas surrounded by walls, objects or other structures” and serve to keep objects, usually animals, inside a given area. Oppositely, enclosures are “areas from which unwanted animals, etc., are excluded” and their main purpose is to keep things (animals) out of a given area. Typical examples of enclosures feature fences that prevent animals from entering, and to increase experimental control, it is possible to only exclude targeted species from the fenced area while allowing other animals to move freely. Fencing off areas in this way is a common practice in forest management throughout the world because high tree seedling mortality is often related to high browsing pressure by large or small herbivores. Some pastoralist and agropastoralist communities traditionally set aside some of their grazing land during the rainy season so that it can be grazed during the dry season. These temporary range enclosures, where recovery of palatable species is the primary goal, are also known as (communal) feed, fodder or forage reserves.. The term “closed area” is primarily used in marine and freshwater biology where it usually refers to areas where fishing is forbidden or suspended. “Protected area” has a similar, but broader meaning, and usually refers to more formal conservation areas. Nevertheless, in a well-defined context both can be used as a synonym for enclosure - i.e. closed to cattle and protected by guards and bylaws against grazing and cutting. Similarly, “area closure” can be used for describing the act of establishing an enclosure, but not as a synonym for it. Thus areas where, for management or research purpose, certain animals are excluded or biomass harvesting is controlled, should never be described as enclosures but as enclosures. For reasons of uniformity, clarity and increased indexing performance, we strongly recommend the terminology “enclosure” for any area or activity that involves excluding unwanted species or practices from degraded sites.



## 2.2. Regeneration in Enclosures

**Abiyu Hailu, 2008. Regeneration/Rehabilitation of Native Vegetation Following Establishment of Area Enclosures and/or Exotic Plantations in North East Highlands of Ethiopia. Poster presentation in Mountain Forests in a Changing World Advances in Research on Sustainable Management and the Role of Academic Education, April 2-4, 2008, BOKU – University of Natural Resources and Applied Life Sciences, Vienna. pp 63.**

The diversity and density of colonizing native woody species (CWS) were compared under two land rehabilitation strategies, plantations of exotic tree species and area enclosure, in Ethiopia. The adjacent grazing land, which was left untreated, was used as a control. The exotic tree species considered include *Eucalyptus globulus* and *Cupressus lusitanica*. The plantations and enclosures were established on former agricultural lands 25 years ago. A totally of 33 families and 65 species of native woody species were identified. The most frequent families are Asteraceae, Lamiaceae, Malvaceae and Verbenaceae. Each represented with 4 species. The most frequent species are *Juniperus procera*, *Cupressus lusitanica*, *Olea europea* ssp *cuspidata*, *Maytenus arbutifolia*, *Clusia abyssinica*, *Jasminium abyssinicum*. There were significant differences in the total number of species recorded, density of individuals of a species, number of seedlings/ha and the basal area of the CWS. In terms of number of species observed, the order from highest to lowest was Enclosure >Eucalyptus Plantation (EP) > Cupressus Plantation (CP) >and Grazing land (GL). The highest density of plants was observed in enclosures, followed by CP, EP and GL.

**Aerts R., Aklilu Negussie, Maes W, November E, Hermy M and Muys B., 2006. Survival of Planted African Wild Olive Seedlings in Northern Ethiopian Enclosures Depends on Planting Season And Shrub Cover. *Journal of the Drylands*, 1(1): 64-71.**

Vegetation such as shrubs and grass tussocks is usually considered to present a competitive barrier for seedlings planted in reforestation programs. However, shrubs also have the ability to facilitate the establishment of seedlings of woody species under their canopy, especially in ecosystems under high abiotic stress. An experiment was set up in enclosures in northern Ethiopia to test the use of shrubs as nurse plants for reforestation. Seedlings of African wild olive *Olea europaea* ssp. *cuspidata* were planted in three microhabitats: (1) bare soil between shrubs, (2) under individuals of the dominant thorn shrub *Acacia etbaica*, and (3) under individuals of *Euclea racemosa*, a fruit-bearing evergreen shrub which supports the majority of naturally established olive seedlings. Experimental seedlings were planted during the short spring rains (March-April) and long summer rains (June-September). The present study reports early seedling survival, i.e. until the end of the first winter (February 2004). Olive survival was significantly higher when planted under shrub cover as compared to open areas, especially under *Euclea* canopies, but spring rain enrichment planting showed high mortality in all three microhabitats due to drought stress soon after planting. Reduction of solar radiation by shrub canopies and thus control of soil-water evaporation and seedling transpiration most likely controlled the observed facilitation. We conclude that planting under shrubs during above average summer rains, as occurring during La Niña episodes, may have important advantages in assisting natural regeneration of dry Afromontane vegetation,

and that conserving the pre-existing shrubs at the same time reduces the risk of erosion and keeps levels of indigenous biodiversity high.

**Keywords:** Facilitation, Forest restoration, Nurse plant, Succession, Survival analysis

**Alemayehu Wassie, 2007. Ethiopian Church Forests: Opportunities and Challenges for Restoration: Ph.D. Thesis. Wageningen University, Wageningen, The Netherlands.**

Dry Afromontane forests of Ethiopia have faced vast exploitation. Almost all forests have been converted to agricultural lands, except for small fragments that are left in the most inaccessible areas or around churches ("Church forests"). We investigated post-dispersal seed predation and the long term behavior of seeds in forest soil of selected tree species from these forests, and their implications for regeneration of trees in church forests. We addressed the questions (1) How intense is post-dispersal seed predation in church forest, and does this seed predation vary with species and/or habitat, and (2) for how long tree seeds maintain their viability while buried in forest soil. Each question is addressed in one experiment. In the seed predation experiment we monitored seeds of six tree species in four habitats for a period of 14 weeks. In the seed viability experiment we assessed seed viability of five species in four sites after being buried 6, 12, or 18 months. 92% of the tree seeds were predated within 3.5 months. Predation was mainly dependent on species whereas habitat had a weaker effect. Predation was higher in closed canopy plots than in gaps. Plots in forest interior and edges were not different. Over time the differences in seed survival between species and between gaps and closed canopy increased. Seed viability decreased sharply with burial time in soil for all species except for seeds of *Juniperus*, which still had 91% of viability after 18 months. Species significantly affect the viability of the seeds after 18 months of burial. The quick decline of seed viability in forest soil indicates that the study species do not have a persistent soil seed bank. An absent or only transient soil seed bank of the studied species, combined with a high seed predation suggests a seed availability limitation for regeneration in the forest. In order to maintain such species in the forest the standing vegetation needs to be persistently managed and conserved. A continuous seed rain coming from a large enough population of adult trees may safeguard successful regeneration. Additional seed sowing, and seed and seedling protection (by e.g. animal enclosures) may increase successful regeneration of important species in these forests.

**Abiyu Hailu, 2008. Regeneration/Rehabilitation of Native Vegetation Following Establishment of Area Enclosures and/or Exotic Plantations in North East Highlands of Ethiopia. Poster presentation in Mountain Forests in a Changing World Advances in Research on Sustainable Management and the Role of Academic Education, April 2-4, 2008, BOKU – University of Natural Resources and Applied Life Sciences, Vienna. pp 63.**

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**Demel Teketay, 2005. Seed and Regeneration Ecology in Dry Afromontane Forests of Ethiopia: I. Seed Production - Population Structures. *Tropical Ecology*, 46(1): 29-44.**

A series of events occur in the process of regeneration, namely flowering, seed production and dispersal, incorporation of seeds into the soil, seed predation or germination, seedling establishment and growth and formation of seedling banks. Forests are subjected to both natural and anthropogenic disturbances, which disrupt the process of plant regeneration. In response to these disturbances, succession is triggered in which different plants use varying strategies to regenerate themselves. For instance, tropical forest plants regenerate from one or more pathways, namely seed rain, soil seed bank, seedling bank or advance regeneration and coppice. The objective of this paper is to present the first part of an overview of the available information on seed and regeneration ecology in dry Afromontane forests (DAF) of Ethiopia. The review focuses on: (i) seed production and dispersal; (ii) soil seed banks: incorporation of seeds into the soil, species richness and densities, spatial and temporal variation and depletion of seeds in the soil; (iii) seed dormancy and germination, requirements for seed germination: light, temperature, interaction between light and temperature, scarification, moisture and dry storage; and (iv) seedling banks, seedling survival, seedling growth and population structures of woody plants. Thematic areas for future research are recommended.

**Feyera Senbeta & Demel Teketay, 2001. Regeneration of Indigenous Woody Species Under the Canopies of Tree Plantations in Central Ethiopia. *Tropical Ecology*, 42:175-185.**

The hypothesis that tree plantations may foster the regeneration of native woody species, was tested through studies of understory floristic composition, height-class distribution of naturally regenerated seedlings and saplings of indigenous woody species, and soil seed banks in the native and exotic tree plantations in Central Ethiopia. A total of 70 plots, having 10 x 10 m area each, were studied in six monoculture plantation stands of four exotic species, i.e. *Cupressus lusitanica* (2 stands of different age), *Eucalyptus globulus*, *Pinus patula*, *P. radiata* and *Juniperus procera*, an indigenous coniferous species. Ages of the plantations ranged between 14 and 42 years. Soil seed bank analysis was also undertaken from soil samples collected in each of the 70 plots to examine the similarity between the soil seed flora and aboveground vegetation. Vegetation diversity was assessed through analyses of floristic composition, species richness and abundance. A total of 37 naturally regenerated indigenous woody species were recorded beneath all plantation stands, with densities ranging between 1630 and 18270 individuals ha<sup>-1</sup>. There was considerable variation

among plantation stands/species with respect to the density of naturally regenerated native woody species. Generally, seedling populations were the most abundant components of the regeneration in most of the plantation stands, forming 85% of the total regeneration count. A total of 68 plant species represented by 53 herbs, eight woody species and seven grasses were recorded in the soil seed bank from all stands. Similarity between the soil seed banks and aboveground flora (both seedlings and larger plants) was very low implying that the role of soil seed banks in the regeneration is low and dispersal of seeds from the adjacent natural forest plays an important role in the process. These results support the concept that forest plantations can foster the regeneration of native woody species and increase biodiversity in the plantation stands, if seed sources are available in the vicinity of the plantations.

**Keywords:** Cupressus, Eucalyptus, Floristic composition, Juniperus, Pinus, Soil seed banks

**Girma Amente, Huss J. & Tennigkeit T., 2006. Forest Regeneration Without Planting: The Case of Community Managed Forests in the Bale Mountains of Ethiopia. *Journal of the Drylands*, 1(1): 26-34.**

The participatory forest conservation approach adopted by the forest dwellers associations/ user groups in Adaba-Dodola forest priority area has substantially reduced illegal utilization and further degradation of the forests. However, the forests were already degraded before they were handed over to the user groups due to illegal logging. Therefore, to make the conservation efforts of the user groups more beneficial there is a need to improve the production potential of the forests. The present study assessed the potential of the forests to be transformed into semi-natural productive forests based on potential crop tree focused management. A diagnostic survey conducted in the year 2003 in the forests managed by the three user groups revealed that more than 30 % of the total area had a sufficient number of potential crop trees per hectare to start the transformation process. In this area forest rehabilitation seems to be feasible without replanting. However, a rotating grazing system has to be introduced to enable the establishment of highly palatable species like *Hagenia abyssinica*.

**Keywords:** Forest regeneration, Community forest, Potential crop tree, *Hagenia abyssinica*, *Juniperus excelsa*, *Afrocarpus falcatus*

**Kitessa Hundera, 2010. Status of Indigenous Tree Species Regeneration under Exotic Plantations in Belete Forest, South West Ethiopia. *Ethiopian Journal of Education and Science*, 5(2): 19-28.**

The potential for regeneration of native woody species in exotic plantation stands and in the adjacent natural forest in Belete forest, Jimma zone was studied. The objective of the study was to assess the diversity and density of the naturally regenerated woody species in plantations at Belete forest. Vegetation assessment within the stands was conducted using a line transect survey using square plot of size 10 mx10 m which were established at 100m intervals along line transects which were 100 m apart. A total of 60 woody plant species belonging to 50 genera and 31 families were recorded regenerating under the canopy of exotic plantations and a natural forest at Belete forest. Only 40 of the species were found

in the plantations while 20 of them found only in the natural forest. The highest density of regeneration was recorded for *Pinus patula* followed by *Cupressus lucitanica*. *Cupressus lucitanica* plantation stand exhibited the highest value of Shannon diversity and evenness (2.5 and 0.84) followed by *Eucalyptus saligna* (2.13 and 0.83). Highest similarity index was observed between the plantation stands of *Cupressus lucitanica* and *Eucalyptus saligna* (0.67). On the other hand the *Cupressus lucitanica* and *Eucalyptus camaldulensis* plantation stands showed relatively weak similarity (0.36). *Pinus patula* and *Cupressus lucitanica* plantations had the highest similarity to the natural forest. The regeneration of native woody species under the canopies of exotic plantations in moist montane forest areas suggests the possibility of restoring degraded areas in southwestern Ethiopia using these exotic plantation stands.

**Keywords:** Exotic, Regeneration, Belete forest, Restoration

**Mastewal Y., Kindeya G., Stein M., & Wolde M., 2006.. Impact of Area Enclosures on Density, Diversity, and Population Structure of Woody Species: the Case of May Ba'ati-Douga Tembien, Tigray, Ethiopia. *Ethiopian Journal of Natural Resources*, 8 (1): 99-121.**

Regional authorities in Tigray, northern Ethiopia have been promoting rehabilitation of degraded lands through area enclosures since 1991. Area enclosures have proven to be the best land management practices for establishing ecologically and economically sustainable land-use planning. There is a need for further investigation and documentation of the impact of area enclosures on density and diversity of woody species. This is because Ethiopia in general, and Tigray in particular, have varied climate, soil and cultural differences in natural resource management, and because there few studies have been conducted on the impact of enclosures on ecological restoration. The present study was conducted in Douga Tembien, Tigray. Data were collected using systematic line plot sampling. The results of the study showed that enclosures have higher density and diversity of woody species than the adjacent unprotected areas. Following the age gradient, the older enclosures had higher density and diversity of woody species than the younger enclosures. This suggests that man and livestock affect the density and diversity of woody species. The frequency distribution of woody species showed almost an inverted J-shape. However, although the study sites show good regeneration, there are few or no individuals seen as one goes to higher diameter classes. This could be due to selective removal of bigger woody species for fuel wood and construction purposes. From the view point of ecological restoration, it is suggested that area enclosures are effective for increasing biodiversity and for rehabilitating degraded areas in a few years, if they are well protected from human and livestock disturbance.

**Keywords:** Ecological restoration, Enclosures, Land management, Livelihood

**Molla Mekonnen, Kindeya Gebrehiwot, Emiru Birhane & Sarah Tewoldeberhan, 2009. Regeneration, Density and Diversity of Woody Vegetation in Awash National Park, Ethiopia. *Journal of the Drylands*, 2(2): 101-109.**

Awash National Park located in north-eastern Ethiopia is highly threatened due to human intervention. This study was conducted with the aim of assessing the current regeneration, density and diversity of the woody vegetation as an indicator of the ecological status of the

Awash National Park. Fifty seven experimental plots (each 400 m<sup>2</sup>) which were grouped under three land management types: protected, less human interference and high human interference were laid systematically along six transect lines. In addition, 3 controlled plots were set at 200-400 meters from the head quarter to see the current level of human disturbance in the land management types. The results showed that land management had a highly significant effect on density and basal area distribution of woody vegetation in Awash national park (ANP). A highly significant difference in species composition among the different land management types of the park for the mature trees and seedlings ( $P < 0.05$ ) were also observed. It is only *Acacia senegal*, the dominant tree species of the park, showed a better regeneration potential. Avoidance of interference is a necessity for ANP for the remaining vegetation to regenerate successfully.

**Keywords:** Species, Awash National Park, Density, Diversity, Regeneration, Ethiopia

**Wassie A., Sterck F.J., Teketay D., & Bongers F., 2009. Effects of Livestock Exclusion on Tree Regeneration in Church Forests of Ethiopia. *Forest Ecology and Management*, 257: 765–772.**

Tree regeneration is severely hampered in the fragmented afro-montane forests of northern Ethiopia. We explored how trees regenerate in remnant forests along the gradient from open field, forest edge to closed sites and canopy gaps inside the forest. We investigated the effects of seed sowing, litter removal, and weeding on the regeneration success along this gradient. Regeneration success was investigated for four indigenous tree species, and measured in terms of seedling establishment, growth, and survival. Species performed differently according to site conditions. Within the forest, local canopy openings facilitated seed germination (*Ekebergia*), seedling growth (all species except *Olea*), or survival (*Ekebergia* and *Olea*), suggesting that all species benefited from local high light conditions in the forest. Outside the forest, germination (all species) and growth rates (*Juniperus* and *Olea*) were lower in the open field, most probably due to water stress in the dry season. Outer edge conditions favored growth for three of the four species. Natural seed germination was, however, zero at any site for *Juniperus* and *Olea* and low for *Ekebergia* and *Prunus* in the open field. Soil scarification influenced germination positively, while weeding did not have a positive effect. These results suggest that simple measures may improve seedling establishment, and that, for some species, forest edges are particularly useful for growth and survival after successful establishment. Together with erecting fences, needed to protect seedlings against grazing, seed sowing, planting seedling, and soil scarification may contribute to maintain and restore church forests in the fragmented landscapes of northern Ethiopia.

**Keywords:** Dry forest, Forest litter, Seed sowing, Weeding

**Wassie A., Frank J. Sterck, Teketay D. & Frans Bongers, 2009. Tree Regeneration in Church Forests of Ethiopia: Effects of Microsites and Management. *Biotropica*, 41(1): 110–119.**

In Ethiopia, forests near churches, are the last remnant forest patches. These forests are currently under threat, probably due to diminishing areas of the forest itself and repeated grazing for extended periods by cattle. We assessed the effect of livestock exclusion on the

regeneration of four indigenous tree species in two church forests. The four species have a high abundance and socioeconomic value, but limited regeneration in the two forests. We investigated the effect of grazing and trampling on seed germination, seedling survival, and seedling growth. Livestock grazing had a strong negative effect on germination, seedling growth and mortality. In fenced plots, more seeds germinated, seedling survival was higher and seedlings grew faster. Seed germination was higher inside the forest than in the adjacent open area for all species. Seedling survival was not different between forest interior and open fields, except for unfenced plots in the open fields where survival was lower because of the higher grazing pressure. In unfenced plots, no seedlings survived until the end of the year, indicating that grazers destroyed the seedling bank in and around the forest. The significant interaction between fencing and species on seed germination and seedling survival revealed that the magnitude of damage due to grazing can vary with species. We conclude that for effective indigenous tree species regeneration in these church forests, the control of livestock pressure is necessary. Seeds dispersed outside the forest will not have a chance to establish seedlings, grow and colonize the surroundings. Livestock grazing thus has a paramount impact on the long-term sustainability of church forests and their role in restoring the degraded surroundings.

**Keywords:** Ethiopia, Forest fragmentation, Livestock grazing, Regeneration, Tropical dry forest

**Yitebitu Moges & Mengistie Kindu, 2006. Effects of Fencing and Ground Cultivation on Natural Regeneration of *Boswellia Papyrifera* in Metema Wereda, Ethiopia. *Journal of the Drylands*, 1(1): 45-51.**

Dryland woodlands have significant economic and ecological functions in Ethiopia. *Boswellia papyrifera* woodland provides commercial frankincense in which over thirty specialized enterprises are currently involved. Scarce natural regeneration is more serious in *B. papyrifera* woodlands and urgent action is needed if sustainable utilization of the species is to be assured. A factorial experiment in a completely randomized block design consisting six treatment combinations of fencing and ground cultivation has been set up with the objective of improving natural regeneration. Ground cultivation seems to affect the natural regeneration negatively. Seedling height does not show significant difference among treatments ( $p < 0.939$ ). Apparently, although not statistically significant ( $p < 0.304$ ), fencing appears to be beneficial in facilitating regeneration recruitment and maintaining healthy seedlings. Further inspection to the data disclosed that majority of seedlings are growing closer to the nearest mother trees. About 78% of the *B. papyrifera* regeneration was found nearer than 2m from the nearest mother trees. This pattern of regeneration triggered us to further investigate the phenomenon, and eventually it was discovered that root sucker was the major origin of natural regeneration of *B. papyrifera* in the study area. It should be mentioned however that the amount of regeneration is extremely low (50 seedlings/ha) and needs further research to initiate more root suckers and improve overall regeneration.

**Keywords:** Grazing, Root suckers, Fencing, Ground cultivation

### 2.3. Restoration Impacts of Enclosures

**Abebe M.H., Oba G., Angassa A. & Weladji R.B., 2006. The Role of Area Enclosures and Fallow Age in the Restoration of Plant Diversity in Northern Ethiopia. *African Journal of Ecology*, 44:507-514.**

This study investigated the roles played by area enclosures and fallow age in the restoration of plant species richness and soil seed bank species richness in degraded mountain rangelands in northern Ethiopia. Management types (enclosures versus grazed) influenced woody and herbaceous species richness, while fallow age showed no effect on the woody species. Management, age and the doubling of fallow age influenced the herbaceous species richness and species diversity. Management showed no effect on soil seed bank species richness. Fallow age and the doubling of fallow time also showed no influence on the soil seed bank of grass species, but they were influential on the forbs species soil seed bank. The trends for restoration of plant species richness and diversity and grass seed bank in response to fallow age were positive-linear, but they declined when the fallow ages were doubled. The exception was the forbs seed bank showed linear trends when age of restoration was doubled. The data suggest that the restoration of degraded rangelands in the high mountain zones of northern Ethiopia was still in the weedy succession stages. Long-term monitoring will be required to gain an informed understanding of the roles played by area enclosures and fallow age in the restoration of plant biodiversity.

**Keywords:** Age chronosequence, Plant species richness, Restoration trends, Soil seed bank

**Abiy Tsetargachew, 2008. Area Closure as a Strategy for Land Management: A Case Study at Kelala Dalacha Enclosure in the Central Rift Valley of Ethiopia: M.Sc. Thesis. Addis Ababa University, Addis Ababa, Ethiopia.**

Land degradation, which includes degradation of vegetation cover, soil degradation and nutrient depletion, is a major ecological problem generally in Ethiopia and particularly in central Ethiopia. A field study was conducted in the Busuqi and Gubesay Peasant Association of Adaa'a wereda, Eastern Shewa zone, Oromia Region of Ethiopia to assess the effects of area closure on soil nutrients and on gully and sheet erosion. The enclosure sites were compared with other land use types (free grazing land) in similar landscape positions for soil fertility buildup, sheet erosion, and gully erosion. Degradation Indices were computed for young Kelala enclosure and free grazing land through comparison with the old Biyo enclosure. Five and twenty one year closed areas had significantly higher levels for soil chemical properties (soil organic matters, total nitrogen and available potassium, etc) compared to free grazing lands. The highest bulk density was recorded in the free grazing land, whereas the lowest was in old Biyo enclosure. Among the two land use types selected free grazing land was the most degraded one with a degradation index of -150.95% with respect to the old Biyo enclosure. Gully density of 14m ha<sup>-1</sup> was recorded in the enclosed side and 28m ha<sup>-1</sup> in the free grazing side, which implies that the sampled farm land bellow enclosure area was severely degraded and sampled farm land bellow free grazing land was very severely degraded. The soil loss by sheet erosion was 0.37 and 1.68 mm yr<sup>-1</sup> for young Kelala enclosure and free grazing land, respectively. The overall output from the research showed that chemical and physical soil properties in enclosure areas with restoring



vegetation are improving that enclosures act as important sinks of water and reduce soil erosion and as such contribute to soil and water conservation. If appropriate interventions are not carried out in the free grazing land for the future, the soil nutrient depletion extent and soil erosion rate would escalate and reversing the process would become difficult.

**Keywords:** Land use, Closed areas, Free grazing land, Soil nutrients, Erosion, Pin, Gully density

**Angassa A., Oba G., Treydte A.C. & Weladji R.B., 2010. Role of Traditional Enclosures on the Diversity of Herbaceous Vegetations in a Semi-Arid Rangeland, Southern Ethiopia. *Livestock Research for Rural Development*, 22 (163).**

Grazing management and seasonality strongly influence the recovery potential of herbaceous vegetation in semi-arid rangelands of southern Ethiopia after history of heavy grazing. The study investigated effects of management (enclosures versus grazed landscapes), age of enclosures and seasonality related to rainfall (i.e., independent variables) on herbaceous biomass, grass basal cover, herbaceous species abundance, species richness and diversity in a savanna rangeland of southern Ethiopia. The study further assessed the relationship between the herbaceous biomass and species richness. Management significantly affected most of the herbaceous response variables (i.e., comparing enclosures and open grazed). Herbaceous biomass, grass basal cover, herbaceous species richness and diversity were greater in enclosures than in grazed areas. Rainfall was also influential on herbaceous biomass, grass basal cover, abundance of herbaceous species, herbaceous species richness and diversity. Herbaceous biomass, abundance and diversity did not however vary with the age of enclosures, while herbaceous species richness appeared to decrease as the age of enclosures advanced. Grass basal cover initially decreased and later on increased with the age of enclosures, so that the older enclosures disclosed improvement of grass basal cover.

**Keywords:** Herbaceous layer, Management, Rainfall variability, Savannas, Southern Ethiopia

**Asefa D. T., Oba G., Weladji R. B. & Colman J. E., 2003. An Assessment of Restoration of Biodiversity in Degraded High Mountain Grazing Lands in Northern Ethiopia. *Land Degradation and Development*, 14: 25–38.**

Loss of biodiversity is the single most important threat to the conservation and sustainable use of drylands in northern Ethiopia due to many centuries of cultivation and heavy livestock grazing pressure. The current study assessed the restoration of biodiversity in highly degraded areas in eastern Tigray, northern Ethiopia using area enclosures (AEs). The study assessed whether the differences in biodiversity between AEs and open management schemes and time of land abandonment influenced diversity of plant life forms (i.e. herbs, shrubs and trees). Changes in biodiversity were compared using the state-and-transition model. Management types and time since abandonment (hereafter called age) had a significant effect on herbaceous plant species abundance but not in shrub species, while site factors had a greater effect on diversity of plant life forms in general. Herbaceous species richness increased with age of restoration, reaching a maximum after three years of rest and declined thereafter, most probably as a result of hay harvesting and replacement

of annual species by perennial grass species. Tree species richness increased gradually with age of land abandonment up to the maximum age of eight years. Four vegetation states and seven possible transitions that could guide management were identified. The vegetation states differed in terms of diversity of herbs and tree species but not those of shrubs. Promotion of tree species states will require longer periods of rest, while promotion of herbaceous species richness will need shorter periods. The state-and-transitional model could, therefore, be used to guide future management by promoting vegetation states that are desired by land users.

**Bongers F., Alemayehu Wassie, Sterck F.J., Tesfaye Bekele & Demel Teketay, 2006. Ecological Restoration and Church Forests in Northern Ethiopia. *Journal of the Drylands*, 1 (1): 35-44.**

Disturbance of ecosystems by humans is of all times. The extent, however, has increased drastically over the last decades, leading to many degraded areas. Restoration of these areas is highly needed and should be based on sound knowledge of successional pathways of existing ecosystems and how people can tune-in into these pathways by directed restoration activities. Conceptual frameworks are available to help understand the process. We try to use these for developing restoration activities for church forests in northern Ethiopia. For the church forests studied we may conclude that (a) diversity and forest area protected are important, (b) each church forest fragment has its own unique species composition, (c) they harbour good wood stock compared to some of the natural state forests, (d) population structures suggest at least two major types of plants: species able to regenerate in the forest understory and species with difficulties to reproduce, (e) church traditions to conserve forest resources: tree seeds collection, traditional medicine and contemplation are permitted, while collection of fuel wood, construction wood and fodder are forbidden for the community, and (f) there is a high respect and trust of the local community with respect to the church organization and their activities and rules. These results can be used as points of departure for restoration of the church forests themselves as well as for restoration of areas surrounding these forests.

**Keywords:** Mountain dry forests, Vegetation composition, Tree regeneration, Church forest restoration

**Descheemaeker K., Muys B., Nyssen J., Poesen J., Raes D., Haile M. & Deckers J., 2006. Litter Production and Organic Matter Accumulation in Enclosures of the Tigray Highlands, Ethiopia. *Forest Ecology and Management*, 233: 21–25.**

To determine annual litter production of regenerating forest areas in the Tigray highlands of northern Ethiopia monthly litter production was monitored over a two-year period in areas with varying degree of vegetation cover restoration. Total annual litter production varied from 30 to 425 g m<sup>2</sup> and increased significantly where areas were closed for a longer time. Litter production was depending on vegetation cover through an exponential relation and was influenced also by soil fertility. Leaf litter typically constituted between 70 and 85% of total litter production, while contributions of woody and reproductive litter varied according to species composition. Strong seasonality in litter fall was explained by pronounced seasonal variation in rainfall. Standing crop of litter built up once an area was closed for grazing,

increasing from around 20 g m<sup>2</sup> in degraded grazing lands to nearly 600 g m<sup>2</sup> in an old enclosure. Litter accumulation was mainly determined by litter input, but was also influenced by litter quality, species composition and microclimate development in the restoring forest areas. A detailed study of nine dominant shrub and tree species revealed three distinct litter production patterns, corresponding to drought-deciduous species, evergreen species and (semi-)evergreen Acacia species respectively.

**Keywords:** Litter accumulation, Litter quality, Microclimate, Succession, Tropical dry forest, Vegetation restoration

**Emiru Birhane, 2002. Actual and Potential Contributions of Enclosures to Enhance Biodiversity in Drylands of Eastern Tigray, with Particular Emphasis on Woody Plants. M.Sc. Thesis, Swedish University of Agricultural Sciences, Sweden.**

Vegetation, soil seed bank and socio-economic settings were studied in the enclosures and open areas in Wukro Wereda, Aynalem tabia of eastern Tigray with the objective to investigate the role of enclosures in the rehabilitation of degraded drylands that would, ultimately, offer viable promises for both actual and potential socio-economic and environmental benefits to the society. Based on 50 plots in the enclosure and 30 in the open area measuring 20 x20m (400m<sup>2</sup>) the following results were found. A total of 27 species representing 18 families in the enclosures and 14 species representing 12 families were recorded in the open area. Abundance 2659; density 1329 stems/ha; basal area 22 m<sup>2</sup>/ha; Importance value index (IVI) 99.99, Shannon index 1.468; evenness 0.455; and species richness 27 woody species per 2 ha for the enclosure: and Abundance 746; density 621 stems/ha; basal area 9.6 m<sup>2</sup>/ha; IVI 100, Shannon index 1.514; evenness 0.573; and species richness 14 woody species per 1.2 ha for the open area was found. The dominant species in the enclosure have an expanding type of population structure whereas it has more of an obstructed type of structure in the open area. The three types of population structure found showed the direction of succession. No woody species were found in both the enclosure and open degraded area soil seed bank dominated with herbaceous species. The people's perception and attitude towards the programme of area enclosures is positive. 84% of the respondents support the expansion and conservation of enclosures. The people were aware of the role of area enclosures. All the respondents expressed their need to be involved in the management and utilization of enclosure. All the respondents need the local laws (serit) to be improved and to contribute to the management of enclosures rather than as a punitive role. The subdivision of the enclosures, with care for individual management, was also supported by 52 % of the respondents, which might be a threat to the expansion and collective management of enclosures. Finally, the local people suggest their need to be allowed to collect dead wood from enclosures and involved in the management, planning and implementation of enclosure.

**Keywords:** Soil seed bank, Natural regeneration, Biological diversity, Socio-economic study, Rehabilitation, Degradation.

**Eshetu Yirdaw, 2002. Restoration of the Native Woody-Species Diversity, Using Plantation Species as Foster Trees, in the Degraded Highlands of Ethiopia. Ph.D. Dissertation, Viikki Tropical Resources Institute, University of Helsinki, Finland.**

The potential of fast-growing forest plantation species to enhance the recruitment, establishment and succession of native woody species in the degraded Ethiopian highlands was studied. The naturally-regenerated woody species diversity and ground layer vegetation cover were studied in plantations of *Eucalyptus globulus*, *Pinus patula*, *Cupressus lusitanica*, *Grevillea robusta*, and *Juniperus procera*, and in surrounding natural forests in Wondo Genet, Menagesha and Chancho, Ethiopia. Furthermore, the growth of native *Podocarpus falcatus* seedlings in canopy gaps of plantations were investigated. At Wondo Genet, a total of 53 naturally regenerated tree and shrub species belonging to 31 families were recorded in the understory of the plantations; important indigenous timber species were also represented. Trees accounted for 72% of all naturally regenerated woody plant species. In eucalypt plantations at Menagesha and Chancho, a total of 22 and 20 woody species belonging to 18 and 17 families were found and, out of these, trees accounted for 68 and 55%, respectively. About 77 and 83% of the woody species found in the adjacent natural forest were also represented in the understory of plantations at Wondo Genet and the eucalypt plantation at Menagesha, respectively. However, the relative abundance of species in the plantations and the adjacent natural forest varied considerably. The understory woody plant density in plantations was up to 8,325 stems/hectare. There was no significant variation in understory woody species richness among plantations. The herbaceous ground cover percentage in *G. robusta* and *P. patula* stands was considerably higher than that observed in *C. lusitanica* and *J. procera* stands. Woody species richness and abundance at Menagesha were on the average 2.4 times and 5.7 times higher, respectively, than the corresponding values at Chancho, and these differences were significant. This result demonstrated the crucial role of the remnant small patches of natural forests, as a source of diaspores for the restoration of the woody species diversity in degraded areas of the Ethiopian highlands. Canopies of *E. globulus*, *P. patula* and *G. robusta* transmitted about three times as much photosynthetic photon flux density as *J. procera* or *C. lusitanica* plantations. In contrast to *J. procera* and *C. lusitanica*, *E. globulus* and *G. robusta* had relatively open crowns, higher crown-bases and lower leaf area indices, and, as a result, their canopies had a higher photosynthetic photon flux density transmittance percentage as well as higher below-canopy red/far-red ratio and temperature. The mean height and root-collar diameter of *P. falcatus* seedlings decreased steadily from gap centre towards gap edge and further to the plantation understory. As the gap size decreased from 668 m<sup>2</sup> to 449 m<sup>2</sup>, the height and root-collar diameter of *P. falcatus* seedlings decreased by 27% and 19%, respectively. In general, opening of gaps in plantations of heavy-shading tree species seems to increase the herbaceous layer ground cover, enhance the colonization and growth of native woody species and, consequently, may also increase the floral diversity of mono-specific plantations. The density of naturally-regenerated woody plants in plantations was over three times the usual planting density in Ethiopia, indicating a high potential of forest plantations for restoring the natural forest ecosystems on degraded lands at a comparatively low cost. In order to fully re-establish the diverse and economically valuable natural forest, complementary measures such as enrichment planting of missing primary forest species may be required. The small isolated remnant natural forests are the only native woody species refuges left in many parts of the highlands, and they are also the only source of diaspores. Therefore, the linkage between plantations and natural forests should be realized and hence the conservation of these

natural stands should be given high priority. Although there is a lack of quantifiable practical standards for biodiversity evaluation, natural forest stands near a restoration site can initially provide baseline data for the evaluation of the extent and rate of woody plant recruitment and establishment in plantations.

**Keywords:** Afromontane forests, Degraded lands, Plantations, Natural regeneration, Natural succession, Restoration, Woody species diversity, Ethiopia

**Jiregna Gindaba, 2006. Overview of Water and Nutrient Relations of Eucalyptus and Deciduous Tree Species and Implications for Their Use in Land Rehabilitation. *Journal of the Drylands*, 1(1): 15-25.**

Considering the need for planting trees to rehabilitate dry and nutrient deficient sites in Ethiopia, this paper provides an overview of the water and nutrient relations of three indigenous deciduous tree species of Ethiopia: *Cordia africana* Lam., *Croton macrostachyus* Del. and *Millettia ferruginea* (Hochst.) Baker and two widely used exotic tree species: *Eucalyptus camaldulensis* Dehnh and *Eucalyptus globulus* Labill. Glasshouse experiments show that the deciduous species grow comparable to the eucalypts when sufficient moisture is available. Growth of the eucalypts exceeds that of the deciduous species under prolonged water stress. However, seedlings of eucalypts are more vulnerable to severe drought compared to the deciduous species. Leaves of *C. macrostachyus* and *C. africana* transpire more water and plants have lower water use efficiencies compared to *M. ferruginea* and the eucalypts. Stomatal closure, leaf shedding, allocation of more biomass to roots and leaf re-orientation are some of the identified mechanisms employed to cope with water stress depending on the species. Whereas the deciduous species accumulate more nitrogen (N) and phosphorus (P) compared to the eucalypts, the latter show superior growth in N and P-deficient soils. *M. ferruginea* uses N efficiently. *C. macrostachyus* and *C. africana* produce extensive lateral roots that may deplete surface soil nutrients. However, field studies show positive impacts on soil nutrients due to their short leaf lifespan, high leaf nutrient content and rapid decomposition to release nutrients. *E. camaldulensis* produced extensive roots with negative impact on adjacent croplands. The implications of these findings for using the studied species in land rehabilitation as components of agroforestry or in plantations are discussed.

**Keywords:** Drought, Ethiopia, Eucalyptus, Growth, Nitrogen, Phosphorus

**Kahsay Berhe, 2004. Land Use and Land Cover Changes in the Central Highlands of Ethiopia: The Case of Yerer Mountain and Its Surroundings. M.Sc. Thesis, Addis Abeba University, Ethiopia.**

The objective of this study is to understand the dynamics of Land Use and Land Cover in and around Yerer Mountain and analyze implications of Land Use and Land Cover changes in terms of soil erosion and nutrition of both human and livestock. Two sets of remotely sensed data, aerial photograph (1971/72) and Landsat ETM+ imagery (2000), with a time span of thirty years were used for the study. In addition to the biophysical data, socio-economic characteristics of households was also used to interpret the biophysical feature occurring in the study area. Results from land cover change analysis show cultivated land increased from 25% in 1971/72 to 56.4% in 2000. The increase in cultivated land

in three decades was 125%, which was mainly at the expense of the grasslands. At the same time, grasslands decreased from 65.35% in 1971/72 to 32.7% in 2000. The area, which was under mainly *Juniperus procera* in 1971/72 changed to dense shrubland where Juniper trees became remnants, while the overall size also decreased. Size of water body increased by about 65.2% mainly because of the manmade dam (Wedecha dam) but also because of the fact that the imagery was taken in February, when the seasonal water was not dry. Based on the survey data and 2000 imagery, about 80% of the human minimum daily maintenance energy, 72% livestock minimum annual energy (+20% production) and 81% of the household fuelwood requirements are met. These shortfalls in food, feed and fuelwood are indications that the study area is not sustainable. Giving land use rights to individuals (other than crop fields), for planting trees on hilly areas could contribute to this effect. This will contribute to the conservation of natural resources as well as the betterment of livelihoods. Experiences regarding this can easily be drawn from some parts within the country. Construction of physical structures to minimize concentration of water to avoid effects of gully erosion, early planting and re-instatement of grass boundaries on farmers' fields will be important activities in order to minimize effects of erosion in the study area. The existing efforts of introducing appropriate forage and fodder plants in backyards should also be strengthened along with mixed cropping (cereals and forages) in the fields. This will improve availability and quality of livestock feed as well availability of fuelwood in the area. In addition, identification of alternative sources of energy, like biogas, could help foster tethering of livestock and at the same time help alleviate health problems that arise from using other bio-fuels. Along with all these efforts however, education of households about the impacts of population increase is essential. Strong family planning and sex education should also go hand in hand with these efforts.

**Kebrom Tekle & Tesfaye Bekele, 2000. The Role of Soil Seed Banks in the Rehabilitation of Degraded Hillslopes in Southern Wello, Ethiopia. *Biotropica*, 32(1): 23-32.**

The species composition in the soil seed bank of degraded hillslopes in southern Wello, Ethiopia, was assessed using the seedling emergence method and compared with that of the standing vegetation. Surface soils were sampled at 0-to 5cm depth from 49 plots of four physiognomic vegetation classes: forests, shrublands, grasslands, and degraded sites. Soils were spread on sterile sand in a glasshouse and watered. Emerging seedlings were recorded for five months until no new seedlings emerged. A total of 3963 seedlings belonging to 71 species and 30 families germinated. The species composition of the seed bank was dominated by 53 herb species (75%) compared to 2 tree species which accounted for only 3 percent of the total number of species. Seedling density differed significantly among vegetation classes and ranged from 391 to 7807 seeds/m<sup>2</sup>. Mean species richness also differed significantly among the vegetation classes. Forty-two species were found to be common to the seed banks and the standing vegetation: however, correspondence between species numbers and composition of the seed banks and the standing vegetation was poor. Although most of the species that germinated in the seed banks were herbs and grasses, they can develop a vegetative cover and contribute to reduction of soil erosion. Regeneration of the tree species (some of which have seed viability up to four years) however, requires both time and the presence of mature individuals. Together with hillside closure and soil conservation measures (e.g., terracing), planting of native woody seedlings might help to expedite rehabilitation of degraded hillslopes devoid of trees and shrubs.

**Keywords:** Afiomontane, Ethiopia, Floristic similarity, Regeneration, Seedling density, Seedling emergence, Southern Wello, Species composition, Standing vegetation, Vegetation classes.

**Mekuria Wolde & Mastewal Yami, 2013. Changes in Woody Species Composition Following Establishing Enclosures on Grazing Lands in the Lowlands of Northern Ethiopia. *African Journal of Environmental science and Technology*, 7(1): 30-40.**

Restoring vegetation in low rainfall areas is difficult and urges the need to design an effective and low-cost method of vegetation restoration. This study was undertaken in the lowlands of northern Ethiopia to: (1) investigate how enclosure age affects restoration of degraded native plant species richness, diversity and aboveground standing biomass, and (2) identify soil characteristics, which affect effectiveness of enclosures to restore degraded native vegetation. Replicated (n = 3) 5-, 10- and 15- year-old enclosures were selected and each enclosure was paired with an adjacent grazing land to detect changes in vegetation variables following establishing enclosures on communal grazing lands. All enclosures displayed higher species richness, diversity and aboveground biomass when compared to the adjacent grazing lands. Results on vegetation composition indicate that all enclosures are at early stage of succession. In all enclosures and grazing lands, vegetation variables displayed significant correlations with soil variables indicating that consideration of soil fertility will help enhance natural regeneration in enclosures. Our study indicates that the establishment of enclosures on degraded communal grazing lands can be effective in restoring degraded native vegetations, and with time, enclosures may obtain an important role as source of seeds of indigenous woody species.

**Keywords:** Grazing pressure, Land degradation, Land use conversion, Native vegetation, Soil variables, Vegetation restoration.

**Mengistu T., Teketay D., Hulthen H. & Yemshaw Y., 2005. The Role of Enclosures in the Recovery of Woody Vegetation in Degraded Dryland Hillsides of Central and Northern Ethiopia. *Journal of Arid Environment*, 60: 259–281.**

The role of enclosures in the recovery of woody vegetation was investigated by studying species composition, density, diversity and regeneration status of woody species and soil seed banks in enclosures and adjacent open areas at two widely separated sites known as Biyo–Kelala and Tiya in central and northern Ethiopia, respectively. Fifty-eight woody species, representing 30 plant families, were recorded at Biyo–Kelala, of which only 25 were recorded both in the enclosure and open area while two were recorded outside of the sample plots. At Tiya, 31 woody species, representing 19 families, were recorded in the enclosure but only 15 of these species were encountered in the open area. Woody plant densities were 1746 and 2215 individuals/ha in the enclosure and open area at Biyo–Kelala, respectively, and 3705 and 3048 individuals/ha in the enclosure and open area at Tiya, respectively. *Dodonaea angustifolia* and *Acacia etbaica* were the most dominant species at Biyo–Kelala and Tiya, respectively. The enclosure at Biyo–Kelala had about twice the diversity value of the open area, while the corresponding values were 2.5 and 2 for the enclosure and open area at Tiya, respectively. The total numbers of species recovered from

the soil samples collected in Biyo–Kelala site were 48 for the enclosure and 30 for the open area with mean seed densities of 2765 (7124) and 1663 (7117) seeds/m<sup>2</sup>, respectively. At Tiya, 30 and 16 species were recovered in the enclosure and open area, respectively, with mean seed densities of 2811 (7276) and 996 (7243) seeds/m<sup>2</sup>, respectively. The diversity of all plant species in the soil seed bank was greater in the enclosure than the open area at both sites. Herbs and grasses dominated the soil seed banks at both sites while several of the woody species recorded in the above-ground vegetation were not represented at all. Overall results from this study indicate strongly that establishment of enclosures is very advantageous over other methods since it is a fast, cheap and lenient method for the rehabilitation of degraded lands.

**Keywords:** Species composition, Density, Diversity, Diameter class, Population structure, Regeneration, Soil seed banks

**Mulugeta Lemenih, 2006. Expediting Ecological Restoration with the Help of Foster Tree Plantations in Ethiopia. *Journal of the Drylands*, 1(1): 72-84.**

The biophysical degradation of land and its formidable impediment to sustainable rural and economic development in Ethiopia has been discussed for several decades. What is required is to develop and implement scientific solutions to the problem. Obviously, in a country like Ethiopia, where vast degraded ecosystems and a rapidly growing human population occur, and where still all livelihood and economic development emerge from agriculture and biological resources, the restoration of the productive capacity of the degraded ecosystems will have a valid and crucial role to bring about sustainable development. A key question, however, is how to successfully and quickly restore the degraded landscapes in the country. An ecological management tool that is receiving considerable attention in recent years for enhancing ecological restoration in the tropics is the use of tree plantations as foster ecosystem. (Re)forestation of heavily degraded lands with fast growing tree species has been shown to expedite the recovery of soil fertility as well as the rehabilitation of a diverse native flora and fauna faster than sites that are left bare or unplanted. In this paper information is collected by reviewing primary literature. Ample evidence is presented from wide geographical areas, both from outside and from inside Ethiopia, to substantiate this potential of tree plantations. It is also known that several factors related to the design and management of plantation forests affect their usefulness in restoration ecology. These issues that require special attention in using tree plantations in restoration ecology are discussed in detail. The paper concludes that, supported with sound silvicultural management, tree plantations can be employed as one effective method capable of reversing soil, biomass and biodiversity degradation, while providing diverse socio-economic services.

**Keywords:** Species Biodiversity, Soil restoration, Vegetation restoration, Exotic species, Indigenous species

**Mulugeta Lemenih & Demel Teketay, 2005. Effect of Prior Land Use on the Recolonization of Native Woody Species Under Plantation Forests in The Highlands of Ethiopia. *Forest Ecology and Management*, 218:60-73.**

Effect of prior land use on the recolonization of native woody species in plantation forests was investigated by assessing naturally regenerating flora (NRF) and soil seed banks



(SSB) in plantation forests established on abandoned farmland and cleared natural forest sites in southern highlands of Ethiopia. *Eucalyptus saligna* and *Cupressus lusitanica*, two of the most widely planted tree species in the highlands of Ethiopia, were considered in the plantation treatments. About 66 plant species were recorded in the NRF and 55 plant species germinated from the soil samples collected for SSB analysis. Seedlings from the SSB were dominantly herbs, which accounted for 75% of the identified species germinated from the SSB, and native woody species accounted only for 10%. On the contrary, in the NRF native woody species were slightly more dominant (49%) than the herbs (45%). There was high species similarity between the NRF beneath the plantations and the standing vegetation in the adjacent natural forest. On the contrary there was very low similarity between the seedlings emerged from the SSB and the standing vegetation in the adjacent natural forest. Effect of prior land use was apparently stronger on the species composition of the SSB than the species richness of NRF under the plantations. The results also showed that overstory plantation species had stronger influence on the species richness of NRF rather than the pre-plantation land use history. As the SSB of the plantation sites lacked viable seed reserves for most of the naturally regenerating woody plants recorded underneath the plantations of both sites, it was assumed that seed dispersal from the adjacent natural forest has played major role in the recolonization process. From these results it could be shown that establishment of plantation forests either on abandoned farmland or directly on degraded natural forest sites can create comparable enabling environment for the recovery of the native forest flora, even if SSB are devoid of viable seeds of woody species, provided that there is a natural forest in the vicinity to donate seeds.

**Keywords:** Biodiversity, *Cupressus lusitanica*, *Eucalyptus saligna*, Natural regeneration, Restoration, Seed dispersal, Soil seed bank, Repeated cultivation

**Raf Aerts, Aklilu Negussie, Wouter Maes, Eva November, Martin Hermy & Bart Muys, 2007. Restoration of Dry Afromontane Forest Using Pioneer Shrubs as Nurse-Plants for *Olea europaea* ssp. *cuspidata*. *Restoration Ecology*, 15(1): 129–138.**

Shrubs are often considered competitive barriers for seedlings planted in reforestation programs, although they can facilitate tree recruitment, especially in ecosystems under high abiotic stress. An alternative reforestation technique using pioneer shrubs as nurse-plants for *Olea europaea* ssp. *cuspidata* was tested in exclosures in northern Ethiopia. Seedlings were planted in three different microhabitats, and their survival was monitored. The microhabitats were bare soil patches between shrubs, patches under the dominant shrub *Acacia etbaica*, and patches under *Euclea racemosa*, an evergreen shrub, which supports the majority of naturally established *Olea* recruits. The ability of shrubs to offer protection against browsing goats was tested experimentally. Controlled shading was used to determine whether solar irradiation causes seedling mortality in environments without water stress. *Olea* survival was significantly higher and shoot damage by goats was lower when planted under shrub cover compared to bare soil patches, particularly under *Euclea* canopies, although high shade levels reduced seedling performance. Reduction of solar radiation by shrub canopies and thus control of soil–water evaporation and seedling transpiration most likely controlled the observed facilitation. Planting under shrubs may increase seedling survival and assist regeneration of dry Afromontane vegetation. Preserving pioneers also reduces soil erosion and conserves biodiversity. Excluding livestock is essential for *Olea* woodland restoration and allows persistent but morphologically modified *Olea* shrubs to develop vigorous

regrowth. Facilitative processes are guiding principles for assisted forest restoration, but above-average rains may be critical to restore higher biomass levels in semiarid areas.

**Keywords:** Dry forest restoration, Facilitation, Rainfall, Seedling establishment, Semiarid ecosystems.

**Raf Aerts, Tim Wagendorp, Eva November, Mintesinot Behailu, Jozef Deckers, Bart Muys, 2004. Ecosystem Thermal Buffer Capacity as an Indicator of the Restoration Status of Protected Areas in the Northern Ethiopian Highlands. *Restoration Ecology*, 12(4): 586–596.**

The restoration status of recovering degraded forests can be assessed by comparing their ecosystem characteristics with those of a reference system, most often what is considered the natural climax vegetation. However, comprehensive measurements needed for traditional vegetation description are often hard or impractical in complex ecosystems. Therefore, an alternative approach is the identification of simple indicators of ecosystem integrity. The use of such indicators can speed up availability of resource inventories and thus contribute to the accelerated implementation of successful rehabilitation practices. Thermal buffer capacity (TBC) of ecosystems has previously been proposed as an overall indicator of ecosystem integrity. In this paper, sequential surface temperature measurements are proposed as a method for TBC assessment of different land use types. Surface temperatures of 7 land units in Central Tigray (Northern Ethiopia), each with uniform land use type (degraded and bushy grazing land, enriched (planted) and non-enriched restoration area and forest), were measured with a hand-held infrared thermometer in the rainy and the dry season. Results clearly demonstrate a differentiation between protected (low heat-up rate) and grazed areas (high heat-up rate). Overall ranking suggests that the remnant forest has the highest TBC of all surveyed land use types, followed by the enriched protected area. Results of this study show that thermal buffer capacity quickly responds to protection and can therefore be used to monitor the development of protected areas. It is strongly recommended that a detailed monitoring strategy for protected areas, based on this technology, be devised, validated and finally transferred to the local communities.

**Keywords:** Closed area, Ecosystem restoration, Ethiopia, Grazing enclosure

**Reubens B., Heyn M., Kindeya Gebrehiwot, Hermy M. & Muys B., 2007. Persistent Soil Seed Banks for Natural Rehabilitation of Dry Tropical Forests in Northern Ethiopia. *Tropicultura*, 25(4): 204-214.**

Dry tropical forests are threatened world-wide by conversion to grazing land, secondary forest, savannah or arable land. In Ethiopia, natural dry forest cover has been decreasing at an alarming rate over the last decennia and has reached a critical level. Efforts like the rehabilitation of dry forests to curb this ecological degradation, need a stronger scientific basis than currently available. The aim of the present research was to test the hypothesis whether soil seed banks can contribute to natural forest regeneration in the dry forest of Ethiopia. Therefore, the composition of the seed bank in relation to vegetation and abiotic environment was analyzed in four forest relics and four enclosures, i.e. demarcated land areas under strict conservation management, in the highlands of Tigray, northern Ethiopia. Results show strong relationships between natural vegetation, seed bank composition,

soil chemical characteristics and environmental degradation, as evidenced through characteristics such as land use impact and soil depth. Most striking is the presence of only very few woody species in the seed bank of degraded areas. This suggests that seed banks only play a minimal role in natural forest recovery in the study area. If this is true, natural recovery will primarily depend on presence of seed trees in the vicinity and successful seed dispersal mechanisms. This result underlines the importance of sustainable management of the few remaining forest relics and trees outside these relics.

**Shiferaw Alem & Jindrich Pavlis, 2012. Native Woody Plants Diversity and Density under *Eucalyptus camaldulensis* Plantation, in Gibie Valley, South Western Ethiopia. *Open Journal of Forestry*, 2: 232-239.**

The aim of the study was to assess the impact of *E. camaldulensis* plantation established in a semi-arid area on native woody plants diversity and density. Nested quadrant plot design, having an area of 15 m × 15 m used to collect data. Totally, 37 species at the plantation and 30 species at the native woodland, belonging to 24 families, identified. Species diversity (H') was 1.57 at the plantation and 2.09 at the woodland forest. As for density of understory woody plants (height ≥ 1 m) the plantation forest harbored 6,604 stems/ha while the native woodland had 7,347 stems/ha. Seedling density (height < 1 m) at the native woodland and at the plantation there were 11,436 stems/ha and 8,865 stems/ha, respectively. The similarity of woody species composition between the woodland forest and the plantation was low. However, in terms of autochthonous tree seed bank availability, authentic hypothesis seems to prove that if clear-cut patches replanted by introduced species that do not exceed 5 ha, they still significantly favour original forest regeneration and composition in a semi-arid area and surprisingly favors the regeneration of *Dodonaea angustifolia* and other native species important for soil conservation, timber, bee forage and medicinal use.

**Keywords:** *Eucalyptus camaldulensis*, Plantation, Diversity, Natural Regeneration, Semi-Arid, Woodland

**Tekle Kebrom & Lars Hedlund, 2000. Land Cover Changes between 1958 and 1986 in Kalu District, Southern Wello, Ethiopia. *Mountain Research and Development*, 20(1): 42–51.**

This paper evaluates changes in land use/land cover (hereafter land cover) in a specific area in Kalu District, Southern Wello, Ethiopia, by comparing two aerial photographs from 1958 and 1986. An attempt is also made to discuss possible implications of these land cover changes for land degradation. By applying Geographic Information Systems (GIS), two maps of the study area (for the years 1958 and 1986) were produced. The maps show a decrease in coverage by shrublands, riverine vegetation and forests, and an increase in remaining open areas, settlements, floodplains, and a water body. The areal extension of nine categories of land cover was calculated and, by overlaying the two maps, the percentage of each type of land cover that was converted into other categories was computed. Land cover changes were most noticeable for shrublands, with a decrease of 15.5 km<sup>2</sup> (–51%), and for remaining open areas (ie, excluding cultivated areas and settlements), with an increase of 14.3 km<sup>2</sup> (+333%). Areas under cultivation remained more or less unchanged. By and large, land cover changes observed in this study were the result of clearing of

vegetation for fuelwood, grazing lands, new cultivation areas, etc., thus contributing to the current problem of land degradation in the country. If coordinated efforts are not made to rehabilitate degraded hillslopes, further deterioration of shrublands, forests, and riverine vegetation into areas with little or no plant cover will adversely affect the hillslopes and eventually those areas that are currently used for crop production.

**Keywords:** Land degradation, Land use changes, GIS, Remote sensing, Ethiopia.

**Workneh S., 2008. Study on the Impact of Land Use Change on Soil Properties in the North Western Highlands of Ethiopia. Poster presentation in Mountain Forests in a Changing World Advances in Research on Sustainable Management and the Role of Academic Education, April 2-4, 2008, BOKU – University of Natural Resources and Applied Life Sciences, Vienna. Pp. 89-90.**

The highlands of Northern Ethiopia are now largely devoid of forest vegetation, with almost all available land cultivated or used as pasture. In this study the effects of these land use types on some soil properties were investigated in Addis Zemen Tara Gedam area, North Western Highlands of Ethiopia. Soil samples were collected from the three neighboring geographically similar plots with different land uses namely forest land, cultivated land, and grazing land, at two depths (0-10cm and 10- 30 cm). The forest land serves as reference for comparing changes in soil properties as the result of the land use change. The soil in the forest showed significantly higher total C, total N, and pH than cultivated land and grazing land in both depths. Bulk density is significantly higher for cultivated soil than grazing land and forest soil. Bulk density and soil pH increased from 0-10 cm depth to 10-30cm depth. Except for bulk density the land use changes resulted in lower values for cultivated land and grazing land in almost all parameters compared to forest land. This emphasizes the fact that changes in land use have caused dramatic losses in soil fertility due to insufficient soil management, in particular replacement of lost nutrients by fertilization. The need for change in policies and strategies for sustainable land use that will integrate development with sustainable management of the environment is evident.

**Wassie Alemayehu, 2002. Opportunities, Constraints and Prospects of Ethiopian Orthodox Tewahido Churches in Conserving Forest Resources: The Case of Churches in South Gonder, Northern Ethiopia. M.Sc. Thesis, Swedish University of Agricultural Sciences, Skinnskatterberg, Sweden.**

In addition to religious activities, the Ethiopian Orthodox Tewahido Church (EOTC) has long history of planting, protecting and preserving trees. If a traveler can see a patch of indigenous old aged trees in the northern highlands of Ethiopia, most probably he/she can be sure that there is an Orthodox Church in the middle. The main objectives of this study were to study the diversity and regeneration status of woody species in the church forest, to carry out a socio-economic survey that would enable us to understand the philosophy, guiding principles and attitudes of the community. Accordingly, eight churches were selected at different altitudes purposively. For the socioeconomic survey, 122 household heads were selected randomly amongst the followers and at least three church scholars from each church. From vegetation sampling it was found that forests enveloped the church with an area ranging from 1.6 ha to 100 ha. The total number of species and families in each of the

eight churches ranged from 22 and 18 to 42 and 22 respectively. The minimum plant density was 731/ha and the maximum was 2250/ha while the minimum basal area, calculated from woody plants with dbh  $\geq$  10 cm was 24.9 m<sup>2</sup>/ha and maximum 109.7 m<sup>2</sup>/ha. Different regeneration status was revealed from the height and diameter class distribution for some of the woody species. The height and diameter class distributions for all individuals in each studied church showed that the forests are at different secondary stages of development. The classification of the species group by ordination techniques showed the differentiation in species group types has a strong relationship with altitude. Results indicated that it is by the commitment of the church based on strong theological thoughts and a biblical basis. It was found that the local community respects and protects church forests, and considers the church as a central institution and platform. In general, from the results, it was concluded that forests conserved by EOTC and its tradition provide an opportunity to establish in-situ and ex-situ conservation sites for forest resources. They also have greater prospects in implementing forestry conservation, development, research and education programs with some avoidable threats and constraints for which recommendations were presented.

**Keywords:** Church forests, Indigenous Woody Species diversity, Density, Basal Area, Ordination, Conservation, Sustainability, Indigenous institution, Tradition

**Yayneshet T., 2011. Restoration of Degraded Semi-Arid Communal Grazing Land Vegetation Using the Enclosure Model. International Journal of Water Resources and Arid Environments, 1(5): 382-386.**

Degradation of communal grazing land vegetation is a widespread problem throughout sub Saharan Africa and its restoration is a challenge for the management of many semi-arid areas. This study assessed the effectiveness of different age (young versus old) enclosures on species composition and diversity, biomass production and woody structure in northern Ethiopia. The species composition and diversity of herbaceous and woody plants was higher in the enclosures than in the grazed areas. The mean aboveground biomass measured inside the enclosures was more than twice that of the adjacent grazed areas and more biomass was produced from the young than the old enclosures. The study showed that degraded semi-arid vegetation is able to recover in a relatively short time when protected. Extended protection, however, reduces herbaceous species diversity and biomass. Therefore, it is suggested that a slight shift in management where enclosures protected for longer periods may be moderately used by livestock.

**Keywords:** Biomass, Diversity, Herbaceous, Rangeland, Woody

**Yayneshet T., Eik L.O. & Moe S.R., 2009. The Effects of Enclosures in Restoring Degraded Semi-Arid Vegetation in Communal Grazing Lands in Northern Ethiopia. Journal of Arid Environment, 73:542-549.**

Rangeland degradation is a widespread problem throughout sub Saharan Africa and its restoration is a challenge for the management of many semi-arid areas. This study assessed the effectiveness of enclosures that have been protected from livestock from 5 to 15 years in restoring vegetation in northern Ethiopia. The species composition and diversity of herbaceous and woody plants were higher in the enclosures than in the grazed areas. Species richness responded positively to an increase in herbaceous productivity.

The mean aboveground biomass measured inside the enclosures was more than twice that of the adjacent grazed areas and more biomass was produced from the young than the old enclosures. Stem height, canopy height, canopy cover, and browsing capacity of woody species were higher in the enclosures than in the grazed areas. Our study shows that degraded semi-arid vegetation is able to recover in a relatively short time when protected. Extended protection, beyond 8–15 years, reduces herbaceous species diversity and in one of the sites also the herbaceous biomass. Therefore, we suggest a slight shift in management where enclosures protected for longer periods may be moderately used by livestock.

**Keywords:** Biomass, Diversity, Herbaceous, Rangeland, Tigray, Woody.

## 2.4. Socio-Economic Impact of Enclosures

**Girma Taddese, 2001. Land Degradation: A Challenge to Ethiopia. *Environmental Management*, 27(6): 815–824.**

Land degradation is a great threat for the future and it requires great effort and resources to ameliorate. The major causes of land degradation in Ethiopia are the rapid population increase, severe soil loss, deforestation, low vegetative cover and unbalanced crop and livestock production. Inappropriate land-use systems and land-tenure policies enhance desertification and loss of agrobiodiversity. Utilization of dung and crop residues for fuel and other uses disturbs the sustainability of land resources. The supply of inputs such as fertilizer, farm machinery and credits are very low. The balance between crop, livestock, and forest production is disturbed, and the farmer is forced to put more land into crop production. For environmentally and socially sustainable development, there is an urgent need to promote awareness and understanding of the interdependence of natural, socioeconomic, and political systems at local and national levels. Understanding the current status and causes of land degradation is very important. This paper reveals the important elements of land degradation in Ethiopia and suggests possible solutions that may help to ameliorate the situation.

**Keywords:** Deforestation, Land tenure, Land degradation, Soil conservation, Crop production systems, Pollution, Soil erosion

**Haile Getseselassie, 2012. Effects of Enclosure on Environment and its Socioeconomic Contributions to Local People: In the case of Halla enclosure, Tigray, Ethiopia. M.Sc. Thesis, Norwegian University of Life Science, Norway.**

This study was held to identify and quantify effect of Halla enclosure on environment and its socio-economic contribution to local community at Kebelle Aynibrkekein, Woreda Degua Tembien, Tigray North Ethiopia. Two mountains: closed and non-closed were selected. To measure important parameters of trees and shrubs, herbs and grasses, 8 plots having 10\*10m, 4\*4m and 1\*1m (nested each other) were taken respectively in each mountain. Accordingly, 10 trees & shrubs representing 93 individuals and 11 herbs representing 173 individual were found in the sample plots of the closed whereas 5 trees & shrubs representing 41 individual and 7 herbs representing 149 individual were found in the non-closed. Height structure of trees and shrubs at the closed seems like bell shaped being most individuals concentrated to 1-2m while at the non-closed seems like inverted J shape

being most individuals concentrated to less than 0.5m. The closed area was significantly different over the non-closed in terms of tree and shrubs moist biomass, oven dry biomass, carbon dioxide sequestration, biomass of forage grass, and biomass of thatching grass. The closed area had 438108 kg moist biomass, 303600 oven dry biomass and 669240 sequestered carbon dioxide of trees and shrubs, and 165000kg forage grass, and 132000kg thatching grass more than the non-closed area. All (16) of the respondents under the closed mountain responded they were getting benefits from the enclosure but under the non-closed, only 8 attributed the non-closed area is giving them some benefits. May using fuel wood from the enclosure is illegal, all respondents, said, they do not use fuel wood from it while 4 respondents under the non-closed said they fetch firewood from the non-closed. 4 respondents under the closure and 3 from the non-closed said their honey production is increasing due to their respective areas but at the bottom of the enclosure there were two bee keeping enterprises having 93 bee colonies producing about 4525kg/year but nothing was in the non-closed area. All of the respondents under the enclosure said that they get forage and thatching grass from the enclosure every year. About 13500kg and 64800kg forage and thatching grass respectively have been cut per year by the local people but nothing under the non-closed. 65 % respondents under the enclosure identified the enclosure is also giving them environmental benefits such as decreasing erosion and increasing discharging potential of springs and wells whereas under the non-closed area. In addition the respondents under the closure said they are getting social benefits like job opportunity and they feel proud of having such closure. On contrary the respondents under the non-closed were not attributed social benefits and hence some feel shame and envy of the neighbor's closure. Although the closure had environmental and socio-economical potential and all the residents under it are getting benefits (though not optimum), most of them were not happy with the benefits because of poor management and immediate benefit needs. In addition, most of them could not quantify its benefits. Therefore, concerned body should interfere to manage appropriately and to persuade especially to the pessimistic people by giving quantitative evidence of its merits over if it were not closed and this study can be used as base.

**Keywords:** Environment, Socio-economy, Carbon dioxide sequestration, Closed area, Non-closed area, Trees and shrubs, Herbs, Forage grass, Thatching grass, Respondents

**Mekuria W., Veldkamp E., Haile M., Nyssen J., Muys B. & Gebrehiwot K., 2007. Effectiveness of Enclosures to Restore Degraded Soils as a Result of Overgrazing in Tigray, Ethiopia. *Journal of Arid Environment*, 69: 270–284.**

The study investigated how effective enclosures are in the fight against soil erosion and how they are perceived as a means to control soil erosion by the local community (farmers and local experts). The universal soil loss equation (USLE) used to estimate potential soil erosion. Data on local community perception obtained from a survey of 62 farm households and five local experts. In-depth interview, group discussion and non-participant field observation also carried out to obtain additional information. The USLE results agreed with the farmers' (67%) and local experts' opinion that erosion at study area is severe and affect the quality of lives of residents. Insignificant difference ( $p > 0.05$ ) was observed in the estimated soil loss among treatments. However, the estimated soil loss from free grazing lands was higher by 47% than soil loss from enclosures which illustrated that enclosures are effective to control soil erosion. The majority of farmers (70%) also rated enclosures effectiveness

to control soil erosion as high. Local communities were optimistic about the chances to rehabilitate degraded lands and make them productive. The majority of farmers (60%) did not consider population growth as a cause of soil erosion. For the majority of interviewed farmers, poor land management is more important. Efforts to create awareness within the rural communities should focus on the link between high population growth, environmental degradation and poverty. The optimistic view of local communities can be considered as an asset for the planning and development of degraded lands rehabilitation efforts.

**Keywords:** Ethiopia, Enclosures, Local experts, Perception, Rural community, Soil erosion.

**Mesfin Tilahun, Roland Olschewski, Christoph Kleinn & Kindeya Gebrehiwot, 2007. Economic Analysis of Closing Degraded *Boswellia papyrifera* Dry Forest from Human Interventions - A study from Tigray, Northern Ethiopia. *Forest Policy and Economics*, 9 (8): 996-1005.**

In Ethiopia, environmental degradation leads to a reduction of forest areas with economically important tree species like *Boswellia papyrifera*. In an attempt to reverse this development and assist natural rehabilitation, closing degraded forest from free grazing, fuel wood collection and other interference is practiced in Tigray. Sustainability of this management will, among other things, depend on the resources' tangible benefits. This study aimed to determine and compare net benefits (in Ethiopian Birr (ETB) per ha) from the closed and open *Boswellia papyrifera* forestlands. Production and household surveys were carried out in Jijike and Siye tabias of Abergelle woreda in northern Ethiopia. Data on costs and benefits of frankincense production were collected from firms trading the product. Net benefits from forestlands and croplands were determined using the Net Present Value criterion. The estimated mean frankincense productions were 127 kg/ha/yr for closed forest land and 84.54 kg/ha/yr for open forestland. A significant difference ( $p < 0.05$ ) was observed between per tree mean frankincense yield of closed and open sites. The average grass harvest from closed area was 2851 kg/ha/yr. The financial Net Present Values were 8622 ETB/ha for closed and 6468 ETB/ha for open forestlands. These values were by 4574 ETB and 2005 ETB higher than the sum of NPV from crop and crop residuals of a hectare of cropland in the study area of the two sites, respectively. Exporting frankincense could generate foreign exchange of 53.28 and 39.05 USD/ha/yr from closed and open sites, respectively. Rural households earn about 74% of the annual total revenue (ETB/ha) from closed and open area as wage for tapping and collecting frankincense and using of grass. Sensitivity analysis showed that managing degraded *Boswellia papyrifera* forestland as closed area always generates a higher NPV than the open one in case of changes in discount rate and prices of inputs and outputs. Thus, managing the forest through closed areas is a competitive land-use alternative and provides higher net benefits than both open forestland and agricultural croplands.

**Keywords:** Degraded dry forests, *Boswellia papyrifera*, Cost–benefit analysis, Frankincense



**Sisay A.C., 2008. Beekeeping as an Additional Livelihood Source in Mountain Forest Areas of South-West Ethiopia and Its Role for Forest Conservation (Project Experience). Poster presentation in Mountain Forests in a Changing World Advances in Research on Sustainable Management and the Role of Academic Education, April 2-4, 2008, BOKU – University of Natural Resources and Applied Life Sciences, Vienna.**

The forests of South-West Ethiopia are rich sources of Non-Timber Forest Products (NTFPs) supporting the livelihood and economic wellbeing of the local people. However, the forests have suffered due to mismanagement throughout the different administrations of the country. The NTFPs research and development project South- Western Ethiopia was initiated in 2003 to find sustainable forest management and biodiversity conservation approaches with pivotal role of NTFP. It has been working on beekeeping, spice and forest coffee in Bench-Maji, Keffa and Sheka zones of the southern Ethiopia. The traditional way of beekeeping in the forest is not attractive and could lead into destruction of the forest resource in the long run. Thus, trainings were given to farmers on modern beekeeping technologies and sustainable forest management through participatory learning-teaching approach. Following the trainings farmers- led participatory research on farmers` home gardens started in 2006 with some technical and logistic support from the project and government staffs. Five types of beehive (four introduced and one traditional) were tested. The purpose of the trial was to select better bee-hive/s for home garden apiary based on ease of management, yield, effect on the forest, bees preference, and etc. According to the result derived from 32 trial farmers in 2006 and 2007, the following beehives were selected, respectively. Mud beehive (78.12%), stick and mud beehive (56.25%), Kenya top bar (50%) and box bee hive (5%). Including up-scaled farmers in 2006 and 2007, 43 farmers produced a total of 3194 Kg honey. This was sold by average price in that time, a total of USD 4259 has been contributed towards poverty alleviation, and each farmer generates USD 50 per annum. The trial has showed that the modern beekeeping system has helped to manage the forest resource through dependable incentive.

**Tefera Mengistu, Demel Teketay, Håkan Hultén & Yonas Yemshaw, 2005. The Role of Communities in Closed Area Management in Ethiopia. Mountain Research and Development, 25 (1): 44–50.**

Much of the Earth is degraded, is being degraded, or is at risk of degradation. Dry Afromontane forests in Ethiopia are one of the ecosystems affected by this phenomenon. This study focuses on assessment of community perceptions of experiences with, and benefits from, enclosure practices meant to prevent or mitigate land degradation. Communities around Biyo-Kelala and Tiya enclosure areas, in central and northern Ethiopia respectively, were used for the study. The assessment was carried out on the basis of a semi-structured questionnaire survey and focus group discussions. Results showed that an overwhelming majority of the people have a positive attitude about enclosures and feel that they have gained benefits. However, people prefer not to ensure private ownership, but favor maintaining the existing communal (village level) management system instead. This demonstrates that groups emerge to manage common property when they live close to the resource. Yet the issue of benefits and their equitable distribution among community members was found to be the basis for developing a sense of security for ownership and hence the success of enclosures. The other finding was that rehabilitation of deforested lands provides economic benefits by supplying raw material to meet the local demand for

wood, reducing the pressure on the remaining forests and supplying various non-timber products. Nevertheless, it is not possible to design a national model for the management of this practice: the design of management rules is specific to a particular locality.

**Keywords:** Enclosure, Rehabilitation, Benefit sharing, Ownership, Participation, Ethiopian Highlands

**Tewelde Berhan Gebre Egziabher, 2006. The Role of Forest Rehabilitation in Poverty Alleviation in Drylands. *Journal of the Drylands*, 1(1): 3-7.**

Though poverty exists also in urban areas, it is perhaps most prevalent in rural areas. Of all rural areas, it is the drylands that experience destitution the most. This is so because droughts are the most frequent and intense in these areas, though because of global warming, these vagaries of nature are now globally more common. Forest rehabilitation helps mitigate the impact of drought for several reasons. Afforestation attracts more rain and improves the microclimate of a dry area. It also decreases both wind and rain erosion. It builds up soil organic matter, increases soil fertility, moisture holding capacity and resistance to erosion. Consequently, both crop and animal production increase in good years. The impact of droughts also decreases making some production possible even in bad years. The improved woody biomass and animal and crop production provide cash income to both farmers and pastoralists. This enables them to buy food when droughts strike. It also enables them to send their children to school and to obtain medical care. Afforestation, therefore, helps alleviate poverty directly by yielding cash, and indirectly by improving both crop and animal production.

**Keywords:** Land degradation, Forest restoration

**Wakjira D. T., Pinar M. A., & Fischer A., 2013. Governance Change and Institutional Adaptation: A Case Study from Harenna Forest, Ethiopia. *Environmental Management*, 51:912–925.**

Many common pool resources have traditionally been managed through intricate local governance arrangements. Over time, such arrangements are confronted with manifold political, social, economic and ecological changes. However, the ways in which local governance arrangements react to such changes are poorly understood. Using the theoretical concept of institutional adaptation, we analyse the history of Harenna forest, Ethiopia, to examine processes of institutional change over the last 150 years. We find that the traditional institutions that governed Harenna's resources persisted, in essence, over time. However, these institutions were modified repeatedly to address changes caused by varying formal, supra-regional governance regimes, the development of markets for forest products, increasing population pressure and changes in formal property rights. A key mechanism for adaptation was combining elements from both informal and formal institutions, which allowed traditional rules to persist in the guise of more formal arrangements. Our findings also highlight several constraints of institutional adaptation. For example, by abolishing fora for collective decision-making, regime changes limited adaptive capacity. To conclude, we argue that such insights into traditional resource governance and

its adaptability and dynamics over time are essential to develop sustainable approaches to participatory forest management for the future, both in Harenna and more generally.

**Keywords:** Adaptive capacity, Coffee, Oromo Gada, Informal institutions, Historical trend analysis, Pastoralism

**Wolde Mekuria, 2007. Vegetation Restoration in Area Closures: The Case of Douga Tembein, Central Tigray, Ethiopia. Tropentag 2007, Conference on International Agricultural Research for Development, October 9-11, 2007. University of Kassel-Witzenhausen and University of Göttingen.**

Since 1991, communities in Tigray region have started to establish area closures (enclosures) to deal with shortage of biomass and land degradation. Although the need of scientific information is clear, studies made to assess vegetation restoration in enclosures are very limited. This study assesses the population structure and biomass of two dominant woody species: *Acacia etbaica* and *Euclea racemosa* subsp. *schimperii* and compare with communities fuel wood demand. For this study contrasting age of enclosures (5 and 10) were selected. Vegetation assessment was done using systematic line plot sampling in an area of 3600 m<sup>2</sup>. One way analysis of variance and regression analyses were used to analyse the data. A strong relationship was not found between the diameter and height of the two woody species in both enclosures. However, with the increase in year of protection, the relationship for *A. etbaica* gets better ( $R^2 = 15.4 - 22.8\%$ ). This shows the improvement of sites with an increase in age of protection. The frequency distribution of woody species showed almost an inverted J-shape with few or no individuals at higher diameter classes. This could be due to selective removal of bigger woody species for fuel wood and construction. Mean density of the two woody species within treatments varied between 194 and 1078 trees ha<sup>-1</sup>; basal area 1.74 and 8.7 m<sup>2</sup> ha<sup>-1</sup>; volume 1.98 - 13.98 m<sup>3</sup> ha<sup>-1</sup>; live above ground biomass 3014.40 - 5268.30 kg ha<sup>-1</sup>; and dry above ground biomass 359.98 - 462 kg ha<sup>-1</sup>. The result showed that there is a significant difference ( $p < 0.05$ ) in vegetation parameters investigated between the two wood species within treatments. The result also indicated that from the total of 114.6 ha of enclosures investigated, 51 tons of dry above ground biomass could be harvested. Given the estimated firewood consumption of 1-1.2 t yr<sup>-1</sup> per household and taking the number of households (200), the amount of dry aboveground biomass produced from the two dominant woody species would cover around 25% of their yearly consumption. Thus, enclosures have considerable contribution in solving shortage of biomass for fuel. Vegetation management such as pruning could help to increase vegetation growth and biomass produced.

**Keywords:** Area closure, Biomass, Ethiopia, Fuel wood, Population structure, Tigray

**Wolde Mekuria, 2013. Changes in Regulating Ecosystem Services following Establishing Enclosures on Communal Grazing Lands in Ethiopia: A Synthesis. Journal of Ecosystems, 2013:1-12.**

In four separate studies undertaken in the northern highlands of Ethiopia, changes in regulating ecosystem services, economic viability, and the perception of local communities following establishing enclosures on communal grazing lands were investigated. Replicated ( $n = 3$ ) 5-, 10-, 15-, and 20-year-old enclosures were selected and paired each enclosure

with an adjacent grazing land. All enclosures displayed higher ecosystem services than communal grazing lands. Differences between enclosures and grazing lands varied between 29 ( $\pm 4.9$ ) and 61 ( $\pm 6.7$ ) Mg C ha<sup>-1</sup> for ecosystem carbon stock (ECS), 2.4 ( $\pm 0.6$ ) and 6.9 ( $\pm 1.8$ ) Mg ha<sup>-1</sup> for total soil N stock, and 17 ( $\pm 3$ ) to 39 ( $\pm 7$ ) Kg ha<sup>-1</sup> for the available P stock, and all differences increased with enclosure duration. Differences in plant species richness and biomass between an enclosure age and communal grazing land were higher in oldest than in youngest enclosures. Over a period of 30 years, sequestered carbon dioxide was 246 Mg ha<sup>-1</sup>, total soil nitrogen increased by 7.9 Mg ha<sup>-1</sup>, and additional available phosphorous stocks amounted to 40 kg ha<sup>-1</sup>. The Net Present Value of enclosures ecosystem services under consideration was about 28% (837 US\$) higher than alternative wheat production indicating that enclosures are competitive to alternative land uses. There are substantial opportunities to mobilize the local communities in efforts to establish enclosures, given that more than 75% had a positive view on enclosures effectiveness to restore degraded ecosystems. Establishing enclosures on communal grazing lands can be effective for restoring degraded ecosystems and the services that they provide.

**Yami M., Mekuria W., & Hauser M., 2012. The Effectiveness of Village Bylaws in Sustainable Management of Community-Managed Enclosures in Northern Ethiopia. *Sustainability Science*, 8 (1):73-86.**

Communities in Tigray, Northern Ethiopia, have established enclosures on formerly degraded grazing lands and other land uses to promote natural regeneration of plants. Village bylaws devised by communities govern the management of enclosures. We analysed the effectiveness of village bylaws that are used to manage enclosures in addressing forest degradation, resolving conflicts among users over natural resource use, and meeting high expectations of users to realise economic benefits from enclosures through enhancing revenue from sale of grass and dry wood. We collected data using qualitative methods during July and November 2008 in two villages of Tigray. The village bylaws mitigated forest degradation by facilitating users to have common goals in the management of enclosures, and resolved conflicts among users by using monetary sanctions including penalties. The village bylaws were not effective in meeting the high expectations of users to realise economic benefits from enclosures. In some cases, the enforcement of village bylaws was constrained by high social capital, which resulted in the negligence among users in exposing free riders. This indicates that high social capital does not always enhance communal resource management. Moreover, recurrent drought, shortage of fuel wood, and the growing number of landless youths in both villages constrained the effectiveness of village bylaws and further expansion of enclosures. Village committees should focus on addressing the low level of rule enforcement and minimize negligence among users of enclosures through developing a sense of responsibility among users rather than focusing on penalties.

**Keywords:** Closed areas, Communal forest, Institutions, Land degradation, Rules.

**Yemiru T., Roos A., Bohlin F., 2012. Attitudes of Local People Towards Collective Action for Forest Management: the Case of Participatory Forest Management in Dodola Area in the Bale Mountains, Southern Ethiopia. *Biodiversity and Conservation*, 21:245–265.**

The theory of planned behaviour was applied to study the attitude and intention of households towards participating in collective forest management (tree planting) activity. Households were randomly selected from 22 forest user groups. The results indicate that the success of planting activities in terms of survival rate of seedlings has a strong effect in motivating households to participate in planting. Although households in general show a positive attitude and intention to participate in tree planting, there were significant differences among households on the basis of socio-economic characteristics. Dependence on crop income, possession of bigger farmlands and better physical assets, and higher education level are positively related to intention to participate in planting activity. On the other hand, dependence on forest income is negatively related to attitude and intention. A continuous exchange of ideas and information between user groups and the government counterparts that provide technical support and advice is recommended.

**Keywords:** Theory of planned behavior, Co-management, Perceptions, Collective action

## **2.5. Restoration, Carbon Sequestration and Climate Change**

**Fisseha Itanna, Mats Olsson & Karl Stahr, 2011. Effect of Land Use Changes on Soil Carbon Status of Some Soil Types in the Ethiopian Rift Valley. *Journal of the Drylands*, 4(1): 289-299.**

Land use changes such as conversion of forestlands into agricultural fields or deforestation for construction and fuel purposes have significantly contributed to the decline of soil organic carbon in the Ethiopian Rift Valley, which is a home of diverse soil types. The diversity in climate and vegetation coupled with the diverse soil types makes the Ethiopian Rift Valley an attractive place for increased human habitation and intense agricultural activities. Five major soil types in the Rift Valley were selected for comparison of organic carbon status over a given span of time. In four of the five soils studied, organic carbon losses amounted to 60-75 percent in less than three decades. Other studies also confirm that surface organic carbon declines with increasing years of cultivation following deforestation. Comparing the five soil types, soil organic carbon content ranked from highest to lowest in the order of Solonetz, Vertisols, Andosols, Nitisols and Fluvisols. Alkali and clay rich soils have more organic carbon compared to the coarse textured soils. Loss in organic carbon has contributed to regular decline in crop yields. The recurring forest fires and the consequent losses of carbon to the atmosphere likely contribute to climate change.

**Keywords:** Rift Valley soils, Land use changes, Deforestation, Carbon losses, Climate change;

**Mekuria W. & Aynekulu E., 2013. Enclosure Land Management for Restoration of the Soils in Degraded Communal Grazing Lands in Northern Ethiopia. *Land Degradation & Development*, 24(6): 528–538.**

In the northern highlands of Ethiopia, establishment of enclosures to restore degraded communal grazing lands has been practiced for the past three decades. However, empirical data on the effectiveness of enclosures in restoring degraded soils are lacking. We investigated the influence of enclosure age on degree of restoration of degraded soil and identified easily measurable biophysical and management-related factors that can be used to predict soil nutrient restoration. We selected replicated ( $n = 3$ ) 5-, 10-, 15-, and 20-year-old enclosures and paired each enclosure with samples from adjacent communal grazing lands. All enclosures showed higher total soil nitrogen (N), available phosphorus (P), and cation exchange capacity than the communal grazing lands. The differences varied between 2.4 ( $\pm 0.61$ ) and 6.9 ( $\pm 1.85$ ) Mgha<sup>-1</sup> for the total N stock and from 17 ( $\pm 3$ ) to 39 ( $\pm 7$ ) kg ha<sup>-1</sup> for the available P stock. The differences in N and P increased with enclosure age. In enclosures, much of the variability in soil N ( $R^2=0.64$ ) and P ( $R^2=0.71$ ) stocks were explained by a combination of annual average precipitation, woody biomass, and enclosure age. Precipitation and vegetation canopy cover also explained much of the variability in soil N ( $R^2=0.74$ ) and P ( $R^2=0.52$ ) stocks in communal grazing lands. Converting degraded communal grazing lands into enclosures is a viable option to restore degraded soils. Our results also confirm that the possibility to predict the changes in soil nutrient content after enclosure establishment using regression models is based on field measurements.

**Keywords:** Enclosures, Field measurements, Native vegetation, Restoration of degraded lands, Soil properties, Ethiopia

**Mekuria W., Veldkamp E., Corre M.D. & Mitiku H., 2011. Restoration of Ecosystem Carbon Stocks Following Enclosure Establishment in Communal Grazing Lands in Tigray, Ethiopia. *Soil Science Society of American Journal*, 75(1):246-256.**

Degraded lands are common in human-influenced tropical semiarid areas, and the potential for C sequestration through rehabilitation of these areas is substantial. In this study, we investigated changes in ecosystem C stocks (ECS) after establishing enclosures on degraded communal grazing lands, and identified easily measurable biophysical and management-related factors that can be used to predict ECS restoration in the highlands of Tigray, Ethiopia. We selected replicated ( $n = 3$ ) 5-, 10-, 15-, and 20-yr-old enclosures and paired each enclosure with an adjacent communal grazing land. All enclosures displayed higher ECS than the communal grazing lands. Differences in ECS between enclosures and grazing lands varied between 29 ( $\pm 4.9$ ) and 61 ( $\pm 6.7$ ) Mg C ha<sup>-1</sup> and increased with enclosure duration. In enclosures, much of the variability in ECS was explained by a combination of the following variables: precipitation, clay content, vegetation canopy cover, woody biomass, and enclosure duration ( $R^2 = 0.77-0.90$ ). Precipitation and vegetation canopy cover also explained much of the variability of ECS in communal grazing lands ( $R^2 = 0.48-0.55$ ). Our results help to establish baseline information for C sequestration projects and to predict the expected ecosystem C sequestration under enclosures. Expansion of enclosures would increase grazing pressure on the remaining communal grazing area. Therefore, the decision to establish additional enclosures should also include an economic analysis and an evaluation of the social consequences.

**Mengistu Gebremariam & Fasil Kebede, 2010. Land Use Change Effect on Soil Carbon Stock, Above Ground Biomass, Aggregate Stability and Soil Crust: A Case from Tahtay Adyabo, North Western Tigray, Northern Ethiopia. *Journal of the Drylands*, 3(2): 220-225.**

This study was conducted to evaluate the effect of land use change on soil physical and chemical properties, above ground biomass, aggregate stability and soil crust in Tahtay Adyabo, North western Tigray, Northern Ethiopia. Three adjacent land use types, viz. farmland, forest and uncontrolled grazing lands were considered. Soil samples were collected from two slope ranges (1-10% and 11-20%) at depths of 0-15 and 15-50 cm. The study revealed that conversion of forest into farmland showed a significant increase in bulk density at the two depths. High values of crusting index were observed in farmland and uncontrolled grazing land. In addition, cultivation decreased total soil organic carbon significantly. The mean weight diameter of the soil showed significant difference in the three land uses and slope ranges at both depths. But the WSA% has shown significant difference among the three land uses due to slope effect with more WSA% in the forest land. Furthermore, comparison of spatial distribution of the above ground biomass of the three-land use types had shown much decrease in the uncontrolled grazing land and higher for tree and farmland. The study concludes that forest clearing exacerbates physical land degradation.

**Keywords:** Carbon stock, Crust index, Above ground biomass, Land degradation

**Mulugeta Lemenih, Bekele Lemma & Demel Teketay, 2005. Changes in Soil Carbon and Total Nitrogen Following Reforestation in Previously Cultivated Land in the Highlands of Ethiopia. *Ethiopian Journal of Science*, 28:99-108.**

Changes in soil C and total N stocks were investigated following reforestation of previously cultivated soil in comparison with soil subjected to continuous cultivation and soil under an adjacent natural forests in south central highlands of Ethiopia. Two of the most widely planted tree species in the highlands of Ethiopia, namely *Eucalyptus saligna* and *Cupressus lusitanica*, were considered in the plantation treatments. Soil C and total N contents in the upper 0–10 and 10–20 cm soil layers were significantly different in the order: Natural forest > C. lusitanica > E. saligna > Farmland. Differences in soil C and total N contents among the sites for soil depths greater than 20 cm were negligibly small and statistically not significant. Soil C and total N stocks in the upper 0.80 m mineral soil also varied significantly in the same order as above. Estimated average annual soil C accruals were 156 and 37 g C m<sup>-2</sup> yr<sup>-1</sup> for *Cupressus lusitanica* and *Eucalyptus saligna*, respectively. The results demonstrate that reforestation of former arable soils in the dry Afromontane region of Ethiopia could yield significant restoration of soil C and total N that are lost in the process of natural forest conversion into arable lands and subsequent cultivation. However, the two plantation species differed considerably with respect to the rate of soil C and total N accrual. This suggests that proper selection of tree species will considerably affect the magnitude and rate of soil C sequestration.

**Keywords:** Continuous farming, *Cupressus lusitanica*, *Eucalyptus saligna*, Soil carbon sequestration, Soil carbon loss

**Lemma Belay & Fassil Kebede, 2010. The Impact of Woody Plants Encroachment on Soil Organic Carbon and Total Nitrogen Stocks in Yabello District, Borana Zone, Southern Ethiopia. *Journal of the Drylands*, 3(2): 234-240.**

Woody plant encroachment in savannas can alter carbon (C) and nitrogen (N) stocks over the long-term which have regional or global environmental implications. The impacts of woody plant encroachment on soil organic carbon (SOC and soil total nitrogen (STN) stocks were surveyed across two woody encroached areas and a non-encroached savanna grassland ecosystem in Yabello district, Borana zone, southern Ethiopia. Soil organic carbon and STN stocks were studied across *A. mellifera* and *A. drepanolobium* encroached rangeland and non-encroached *P. mezianum* dominated savanna grassland in two soil layers (0–25 cm and 25–50 cm). Soil organic carbon ranged from 50.41 to 59.63 t C ha<sup>-1</sup> in the top layer of 0-25cm and from 46.74 to 56.48 t C ha<sup>-1</sup> in the lower layer of 25-50 cm. Soil organic carbon decreased with an increase in soil depth. Soil total nitrogen stock ranged from 2.83 to 4.22 t N ha<sup>-1</sup> in the top 0-25 cm and from 2.59 to 3.42 t N ha<sup>-1</sup> in the lower layer. A general decrease of STN was observed with an increase in soil depth under all the three species. Both SOC and STN stocks were in the order of *A. mellifera*, *P. mezianum*, and *A. drepanolobium*.

**Keywords:** Soil organic carbon, Soil total nitrogen, Woody plant encroachment, Savanna grassland, *A. drepanolobium*, *A. mellifera*, *P. mezianum*.

**Tsegay Wolde-Georgis, Kiros Meles Hadgu, Amanuel Zenebe & Aklilu Habtu, 2010. Climate Change Adaptation and Impact Mitigation: A Case Study of Abraha Wa Atsebaha Village in Tigray, Northern Ethiopia. *Journal of the Drylands*, 3(1): 150-157.**

In the last two decades, Ethiopia has been implementing a community based environmental rehabilitation program that focused on water and soil conservation with optimistic outcomes. This paper describes the experience of a successful local based and cost effective intervention that transformed a food-insecure, drought-prone Ethiopian village into a sustainable food secure community in Tigray region of northern Ethiopia. The result of the study indicates a partnership between the local community, the government, micro-credit institutions and extension agents which the regional food security bureau calls it a food security demonstration project. Sharing this experience with the wider world is timely as “climate change adaptation” has become a buzz phrase. The experience of this “bright spot” as opposed to “hotspot” is important because it is a testimony that climate change adaptation policies should be considered part of the development process and be implemented at the local level. It is believed that when such holistic interventions are upscaled the problems associated with food security might be resolved sustainably.

**Keywords:** Climate Adaptation, Environmental rehabilitation, Ethiopia, Food security, Tigray



**Wolde Mekuria & Edzo Veldkamp, 2005. Impacts of Land Use Changes on Soil Nutrients and Erosion in Tigray, Ethiopia. Deutscher Tropentag 2005, Conference on International Agricultural Research for Development, October 11-13, 2005, Stuttgart-Hohenheim.**

Land degradation, which includes degradation of vegetation cover, soil degradation and nutrient depletion, is a major ecological problem in Tigray, Northern Ethiopia. As a response of the ever expanding land degradation, rehabilitation of degraded lands through closed areas has been promoted by regional authorities since 1991. Despite this concern, there are relatively few studies in the region, which would provide a measure of usefulness of closed areas as one strategy to help prevent decline of soil degradation and thereby increase agricultural productivity. This study was conducted to assess the effects of land use changes on soil nutrients and erosion. Soil samples were collected at different slope positions in closed areas and free grazing lands in Dega Temben, Tigray. Five and ten years closed areas had significantly ( $p < 0.05$ ) higher levels for SOM, TN and AP compared to free grazing lands. The highest levels in SOM, TN and AP were observed at foot slope position in closed areas. An increasing trend from upper slope to foot slope position for soil nutrients was also found in closed areas. The calculated soil loss using USLE indicated that there is no significant difference ( $p < 0.05$ ) between closed areas and free grazing land. However, the soil loss in free grazing land was higher by 47%. Under the present land use management and climate conditions of the study area, free grazing areas in hilly lands must be changed to closed areas before soil organic matter and other nutrient contents are depleted more. Besides, free grazing lands in hilly lands may aggravate erosion processes and result in further degradation.

**Keywords:** Land use, Closed areas, Free grazing land, Soil nutrients, Erosion, Tigray, Ethiopia.



### **3. MANAGEMENT OF DRY FORESTS AND WOODLANDS**



COMPILED BY

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### 3.1. Socio Economics Research on Dry Forest

**Amede T., Kassa H., Zeleke G., Shiferaw A., Kismu S. & Teshome M., 2007. Working with Communities and Building Local Institutions for Sustainable Land Management in the Ethiopian Highlands. *Mountain Research and Development*, 27 (1): 15-19.**

Land management is a multi-dimensional and multi-institutional engagement that demands collective analysis, design, and implementation of innovations. Its importance for Ethiopia cannot be overemphasized, as land degradation threatens food security and environmental sustainability. Building on a specific case study of a project in Southern Ethiopia, the present article describes how the government and non-state agencies are collaborating to learn together while promoting improved land management practices and implementing land rehabilitation programs in communal areas and farmlands in the Ethiopian highlands. Ensuring full involvement and commitment of stakeholders at different levels, building the capacity of local institutions, and redefining the role of communities and the state in a dynamic way are essential prerequisites for success. Suggestions have also been formulated to facilitate wider adoption and scaling up of improved land management innovations.

**Andargatchew A., 2008. Value Chain Analysis for Bamboo Originating from Shedem Kebele, Bale Zone. Masters Thesis. Addis Ababa University, Addis Ababa.**

Ethiopia has a natural bamboo forest estimated about 1 million ha, which is about 7% of the world total and 67% of the African bamboo forest area. The Bale Mountains has the largest percentage of reported highland bamboo in Ethiopia. Local communities use bamboo mainly for construction, fences, some rudimentary furniture and household utensils. There are a large number of people involved in bamboo culms extraction for sell in Goba town. These are mainly farmers from Shedem. Kebele. Concerned with the rate of extraction and to understand the existing value chain in order to harness the bamboo potential as a means of alternative livelihoods, the value chain analysis was carried out in this kebele. The results show that communities in Shedem depend on bamboo resources highly. On average 47% of the annual income is estimated to be derived from bamboo sale for Shedem farmers. 17,000 – 23,000 bamboo culms are consumed on each market day in the Goba market with 90% bought by intermediaries. The annually harvested bamboo however accounts only for 1.18 -1.3 % of the total 14,272 ha bamboo resource in the Kebele. Even with the consumption of neighboring kebeles, the harvest rate does not seem to be unsustainable as bamboo culms are ready for harvest every 3 -4 years. However, the harvesting method being applied damages young shoots and has resulted in high sustainability concern. Three independent chains are identified for bamboo culms originating from Shedem. Crafts people, intermediaries and house constructors directly buy culms from the Shedem farmers. Despite the high economic value of bamboo in the area, little value is added to the bamboo; the largest culm value identified was 6.6 Birr at the crafts producers' stage. Farmers are found to be the second highest income earners, getting 1 Birr / culm. The value chain studied was found to be very weak with little or no communication among actors. In order to efficiently use the available resource, it is essential to have a stronger and well-coordinated value chain. For this to happen, coordinated works need to be carried out by the chain actors with support from local governmental and non-governmental organizations as well as the private sector.

**Anderson J., Benjamin C., Campbell B. & Tiveau D., 2006. Forests, poverty and equity in Africa: new perspectives on policy and practice. *International Forestry Review*, 8: 44-53.**

This paper places forestry in the larger context of rural development and therefore in the current debates on poverty and inequality. While Africa has high levels of natural and human capital it is the poorest and most unequal region in the world. In order for natural assets to contribute to environmental, economic and empowerment outcomes four principle interlinked changes are needed: 1) Improve the recognition of the fundamental role of natural resources in economic growth of poor countries and poor populations and in the development of democracies and good governance; 2) Better distribute resource rights, both property and procedural, giving the poor greater security, access and control; 3) Develop and implement frameworks, regulations and enforcement to assure that natural resource markets work for the poor; 4) Redefine the role of science and technology, and associated planning and institutions.

**Keywords:** Africa, Forest policy, Equity, Natural resource management, Poverty

**Bedru Babulo B., Muys B., Nega F., Tollens E., Nyssen J., Deckers J. & Mathijs E., 2008. Household livelihood strategies and forest dependence in the highlands of Tigray, Northern Ethiopia. *Agricultural Systems*, 98:147–155.**

Forest environmental resources provide substantial contributions to the wellbeing of many rural dwellers. However, the level of forest use and the degree of reliance on forest environmental products differ across households. The factors that condition a household's economic reliance on a particular economic activity in general and on forest environmental resources in particular may vary depending on the resource endowment of the household, the household's demographic and economic characteristics, and exogenous factors such as markets, prices and technologies. This paper identifies the factors that condition a household's livelihood strategy choice with a particular focus on forest products. For this, we use the livelihood approach as a framework of analysis. Environmentally augmented household income data were collected from 360 sample households in Tigray, Northern Ethiopia. On the basis of the share of forest environmental income in total household income, sample households were clustered into distinct livelihood strategies. Student's t-test and ANOVA were used to test income differences among the clusters. Multinomial logit (MNL) regression on asset-based explanatory variables was run to identify the main factors that determine households' livelihood strategy choice and forest dependence. The analyses indicate that differential access to, or endowment of, livelihood assets determines the choice of a household's strategy. Asset-poor households should be encouraged to engage in activities with higher economic return.

**Bedru Babulo, Bart Muys, Fredu Nega, Eric Tollens, Jan Nyssen, Jozef Deckers & Erik Mathijs, 2009. The Economic Contribution of Forest Resource Use to Rural Livelihoods in Tigray, Northern Ethiopia. *Forest Policy and Economics*, 1:109–117.**

By explicitly incorporating forest environmental products (FEPs) in household income accounting, this paper examines the role and significance of FEPs in household income and in rural poverty and inequality. As most conventional household surveys do not incorporate

income from environmental sources, substantial gaps exist in our understanding of the actual functioning of rural economies and the extent of rural poverty and inequality. Using data from 360 randomly sampled rural households from 12 villages in Tigray (northern Ethiopia), we measure forest environmental resource use with a monetary yardstick and compares the value of FEPs with other household economic activities. We found that products from environmental sources represent an important component in rural livelihoods. Our analyses indicate that in the study area income from forest environmental sources occupies the second largest share in average total household income next to crop income. Poverty and inequality analyses show that incorporating forest environmental incomes in household accounts significantly reduces measured rural poverty and income inequality. Therefore, we suggest that sustainable forest management schemes should be adopted to maintain and enhance the flow of economic benefits to the surrounding communities without damaging the natural resource system.

**Keywords:** Enclosures, Ethiopia, Rural households, Forest resources, Environmental incomes, Rural poverty, Income inequality

**Belcher B. & Schreckenberg K., 2007. Commercialisation of Non-timber Forest Products: A Reality Check. *Development Policy Review*, 25 (3): 355-377.**

This article challenges the pervasive view that commercialisation of nontimber forest products can (easily) achieve ecosystem and species conservation as well as improving livelihoods. Following a brief review of who and what is involved, it focuses on the main ecological and livelihood risks of unconsidered promotion of NTFP commercialisation, drawing on a wide range of case studies from around the world. It concludes with some recommendations, emphasising the lack of 'magic-bullet' products, and the importance among other things of not ignoring national policy, taking an integrated view of the value chain, considering the implications of different production options, and improving both quality and quantity.

**Caplow Susan, Pamela Jagger, Kathleen Lawlor & Erin Sills, 2011. Evaluating Land Use and Livelihood Impacts of Early Forest Carbon Projects: Lessons for Learning about REDD+. *Environmental Science and Policy*, 14: 152-167.**

The 'Bali Road Map' of UNFCCC COP-13 calls for sharing lessons learned from demonstration activities that aim to reduce emissions from deforestation and degradation and enhance forest carbon stocks (now known as 'REDD+'). To develop a feasible yet rigorous strategy for learning from these REDD+ pilots, it is critical to assess previous efforts to evaluate the impacts of 'pre-REDD+' avoided deforestation projects. Further, because REDD+ remains a politically volatile issue, with both critics and supporters pointing to the impacts (or lack thereof) of these pre-REDD+ projects, it is important to critically examine the methods employed to assess those impacts. We review the body of literature that makes claims about the socioeconomic and biophysical impacts of pre-REDD+ projects. We find assessments of outcomes or impacts for only five pre-REDD+ projects. The design, data collection, and analysis methods for understanding the impacts of pre-REDD+ projects frequently lack rigor. In particular, the counterfactual scenarios for establishing socioeconomic impacts are vague, unscientific, or omitted completely. We conclude that drawing specific lessons from pre-REDD+ projects for the design or evaluation of current REDD+ projects is tenuous.

Rigorous project evaluations are challenging, expensive, and time-consuming, but because they are so critical for learning about what works for people and forests, evaluations of current REDD+ projects must use improved methods. In particular, much better care should be taken to construct credible and where possible, consistent, counterfactuals for both biophysical and socioeconomic outcomes.

**Degnet Abebaw, Habtemariam Kassa, Girma T. Kassie, Mulugeta Lemenih, Bruce Campbell & Worku Teka, 2012. Dry Forest Based Livelihoods in Resettlement Areas of Northwestern Ethiopia. *Forest Policy and Economics*, 20:72-77**

While the importance of forests for livelihoods has long been well-recognized, empirical knowledge of the factors influencing the extent and diversity of household engagement in the extraction of forest products across different socio-economic groups remains limited. In this paper, we use primary data collected through a household survey of 180 households in a resettled dry forest areas of Northwestern Ethiopia. The paper mainly aims at identifying the main drivers of household behavior regarding collection of main forest products in the context of dry forest environment. A multivariate probit analysis was used to explain variation in household participation in collection of different forest products. The results show that households' participation in collection of different forest products is significantly determined by a combination of household demographic characteristics, ownership of oxen and of cows, proximity to forest, access to health and school infrastructure, resettlement history and self-reported change in standard of living. The estimation results also suggest households most likely to engage in collection of forest honey, gum, and wood for fuel and other purposes are those located farther from the forest. Policy implications and outlook for further study are discussed in the paper.

**Keywords:** Africa, Dry forest, Ethiopia Multivariate probit, Poverty, Resettlement

**Dovie D.B.K., Charlie M. Shackleton & Witkowski T.F., 2002. Direct-Use Values of Woodland Resources Consumed and Traded in a South African Village. *International Journal of Sustainable Development and World Ecology*, 9(3) :269-283.**

This paper examines the contribution of secondary resources harvested from a savanna ecosystem to household income in Thorndale village, South Africa. The valuation of these resources provides a key tool for adopting sustainable development practices. The study shows the relevance of the dependence of rural people on secondary resources and implications for social and economic equity. Fuelwood, edible herbs and thatch grass contributed 80.6% (\$492.53) of the total gross direct-use value (\$559.46) of all the resources per household per annum. The net direct-use value of eight directly harvested resources was \$455.11 after accounting for the opportunity cost of labour. The value of secondary resources traded amounted to \$126.62 per household, equivalent to 22.6% of values from direct consumption, suggesting a high degree of dependence of villagers on natural resources harvested for household consumption. There were high relative direct-use values for fuelwood (44%) and edible herbs (25.9%) reflecting the high energy requirement, and substitute for cultivated vegetables, respectively. It was generally perceived that resources were in short supply probably due to the level of dependence, and as a coping strategy.

**Dovie, D. B. K. 2003. Rural Economy and Livelihoods from the Non-Timber Forest Products Trade. Compromising Sustainability in Southern Africa?. *International Journal of Sustainable Development & World Ecology*, 10: 3: 247 – 262.**

The role of non-timber forest products in sustaining rural economies of the southern African region has been underestimated because of inadequate policy recognition. As a result, factors affecting the sustainability of these important resources are being undermined. The aim of the paper is to examine trade in two selected NTFPs and implications for sustaining the resource base in Zimbabwe and South Africa. In eastern Zimbabwe, baobab (*Adansonia digitata*) bark is harvested for craft purposes, but in danger of destruction in the short term as a result of harvesting and trade arrangements. Unless appropriate harvesting and marketing mechanisms including harvesting cycles and adaptive management are adopted, the baobabs and livelihoods of humans will be threatened in the next decade. For wood products from communal woodlands in the South African study, uncontrolled trade poses danger to sustaining the natural woodlands. In both case studies, the role of non-resident NTFP dealers is a source of inevitable threat in promoting sustainable harvesting and trade. Market forces of demand and supply factors are identified as opportunities or threats and presented in a conceptualized framework. Additionally, the NTFP sector management will need to include opportunistic improvement of small-scale agropastoralism.

**Dougill A.J., Lindsay C. Stringer, Julia Leventon, Mike Riddell, Henri Rueff, Dominick V. Spracklen & Edward Butt, 2012. Lessons from Community-Based Payment for Ecosystem Service Schemes: from Forests to Rangelands. *Philosophical Transactions of the Royal Society: Biological Sciences*, 367 (1606): 3178-3190.**

Climate finance investments and international policy are driving new community-based projects incorporating payments for ecosystem services (PES) to simultaneously store carbon and generate livelihood benefits. Most community-based PES (CB-PES) research focuses on forest areas. Rangelands, which store globally significant quantities of carbon and support many of the world's poor, have seen little CB-PES research attention, despite benefitting from several decades of community-based natural resource management (CBNRM) projects. Lessons from CBNRM suggest institutional considerations are vital in underpinning the design and implementation of successful community projects. This study uses documentary analysis to explore the institutional characteristics of three African community-based forest projects that seek to deliver carbon-storage and poverty-reduction benefits. Strong existing local institutions, clear land tenure, community control over land management decision-making and up-front, flexible payment schemes are found to be vital. Additionally, we undertake a global review of rangeland CBNRM literature and identify that alongside the lessons learned from forest projects, rangeland CB-PES project design requires specific consideration of project boundaries, benefit distribution, capacity building for community monitoring of carbon storage together with awareness-raising using decision-support tools to display the benefits of carbon-friendly land management. We highlight that institutional analyses must be undertaken alongside improved scientific studies of the carbon cycle to enable links to payment schemes, and for them to contribute to poverty alleviation in rangelands.



**Efrem Garedeu, 2010. Land-Use and Land-Cover Dynamics and Rural Livelihood Perspectives, in the Semi-Arid Areas of Central Rift Valley of Ethiopia. Ph.D. thesis, Swedish University of Agricultural Sciences, Umeå, Sweden.**

Global environmental changes in climate, land-use and bio-diversity are increasingly on top of scientific and political agenda. The impacts of climate change are manifested on all dimensions of food security: availability, accessibility, utilization and stability. This study presents land-use and land-cover (LULC) dynamics, rural livelihoods, and a dynamic simulation model of a socio-economical and environmental system in the Central Rift Valley of Ethiopia. Using different methods and approaches (remote sensing and participatory field point sampling, household survey, PRA and use of secondary data) the analyses revealed rapid LULC change over the past three decades. The area is characterized by high rate of conversion from woodland and wooded-grassland to farmland. For decades, subsistence agriculture has been the most important livelihood strategy but low level of its income does not meet basic everyday household expenditure. The importance of livelihood diversification has grown in response to population pressure that led to a decline in farm size and agricultural shocks due to biophysical factor limitations. Food insecurity is persistent and widespread. Using STELLA software, the dynamic model simulated an extensive land-use change, largely driven by the decisions of the people and population growth. It is characterized by rapid population growth, declining household farm size, declining household income, deterioration of the remnant forest and worsening land degradation if the situation remains unchanged. The simulated strategies, such as forest increase, and the projected micro-finance, better family planning and better education, are likely to improve forest cover and area, decrease land degradation, raising household income and help to slowing down population growth. The following conclusions can be drawn from the study: 1) monitoring LULC dynamics using a combination of remote sensing and participatory field point sampling is a valuable approach for land-use inventory; 2) the dramatic trends in LULC were associated with rapid population growth, recurrent droughts, rainfall variability and declining agricultural productivity; 3) food security is vulnerable to climatic change; 4) Currently, opportunities for additional income generating activities are limited. External interventions are important to improve farmers' livelihoods and to heal the natural environment.

**Keywords:** Food insecurity, Global environmental change, Livelihood Diversification, Participatory field point sampling, Remote sensing, Simulation modelling.

**FAO, 2010. Guidelines on Sustainable Forest Management in Dry Lands of Sub-Saharan Africa. Arid Zone Forests and Forestry Working Paper No. 1. Rome.**

More than elsewhere, forests in the drylands of sub-Saharan Africa have the potential to contribute to poverty reduction and food security, as long as they are well valued and sustainably managed. The inhabitants of these areas are mostly farmers, herders and forest product gatherers. Their livelihoods are therefore largely dependent on forest and woodland services, and forest management has to respond to their many and diverse needs. During recent decades, scarcer water resources, droughts, increased human pressure on forests and rangelands, and bushfires have created conditions conducive to degradation, deforestation and desertification. These dynamics are driven by interrelated factors, including inadequate land-use policies, poor governance, complex land tenure

issues, and a general lack of understanding of the importance of forest and woodland resources, leading to a lack of investment in their sustainable management. In sub-Saharan Africa, the majority of natural resources remain under government control, but governance issues are a fundamental constraint to their adequate management. For drylands (with their rich and diverse but fragile ecosystems and resources) to be effectively protected and sustainably managed, communities must derive the consequent benefits, but this is rarely the case. Instead, the situation is marked by a lack of appropriate, integrated land-use planning, and poor practices in natural resource and forest management. In response to the request of member countries, FAO launched and coordinated a process for the preparation of “Guidelines on sustainable forest management practices in drylands of sub-Saharan Africa”. They are intended to guide forestry decision-makers and managers in prioritizing the issues and aspects that need to be addressed.

The guidelines’ objective is to improve forest planning and management in the drylands of the region, so as to contribute to the well-being of local populations and enhance their social, cultural, environmental and economic benefits. This document was developed with enormous contributions from international, regional and national forestry experts and partners active in the region. It is based on: (i) the experience and process of preparing *Guidelines on good forestry and range practices in arid and semi-arid zones of the Near East* (FAO and Near East Forestry Commission, 2009); (ii) FAO’s in-house forestry expertise and the inputs of international experts and consultants; (iii) written contributions and comments from partner organizations and experts active in the region and involved in forest issues; (iv) comments and recommendations from the expert consultation workshop organized in Addis Ababa, Ethiopia, in March 2009 involving experts from several countries and the African Union Commission; (v) outcomes and recommendations of the technical validation workshop organized in Dakar from 20 to 22 January 2010 by FAO, in collaboration with the *Agence Nationale de la Grande Muraille Verte* (Senegal), which gathered more than 70 participants representing forestry and environment related departments and ministries from 12 countries, regional and international organizations, non-governmental organizations (NGOs), United Nations agencies, research centres and networks; (vi) recommendations resulting from the 17th session of the African Forestry and Wildlife commission, held in Brazaville in February 2010. The guidelines are based on widely accepted international standards for sustainable forest management. The area they cover comprises the arid, semi-arid and sub-humid zones of sub-Saharan Africa, and the major forest and tree formations concerned are: (i) xeric desert and desert fringe formations of scrubs and steppes; (ii) arid tree and grass savannah formations; (iii) semi-arid to sub-humid tree formations and dry forests and woodlands. The main body of the document is organized in four sections: an introduction to dryland forests in the sub-Sahara; a section highlighting the economic significance of these forests with the example of gums and resins, another section focuses on major challenges facing forests and the forest sector in this region; and a section giving details on the nine guiding principles. These four sections are followed by a glossary and a list of references. It is hoped that the extensive consultation process and significant participation of national experts and regional and international institutions in the preparation of these guidelines will encourage their widespread use and further improvement and adaptation for the benefit of all stakeholders. FAO will pursue a facilitating role in this regard, and I seize this opportunity to convey our thanks to all the individuals and institutions who contributed to this exercise, while inviting other partners who did not have the chance to participate to join this long-term and iterative process.

**FAO, 2011. Country Programming Framework for the Republic of Sudan-CPF (2012-2016). FAO, Rome, Italy.**

The Government of the Republic of the Sudan through the line Ministries of Agriculture; Animal resources and Fisheries; Irrigation, and Environment, Forests and Physical Development and the Food and Agriculture Organization of the United Nations (FAO) took up the initiative of developing a Country Programming Framework (CPF) for the Agricultural Sector in Sudan. The objective of the initiative is to strengthen the effectiveness of the FAO's assistance to Sudan through a coherent programming framework. The CPF, among other things, identifies and defines Agricultural priority areas, including Fisheries, Forestry and Natural Resources and Rural Development. In addition, the CPF indicates the broad commitments and assistance strategy of FAO, subject to the availability of required funding, to assist Sudan in its efforts to achieve the national development objectives, described in the 2nd National Five Year Development Plan (2012-2017), the coming Second Agricultural Revival Programme (2012-2016), The Three Year Economic Crash Programme (2012-2015) and the I-PRSP. The CPF also supplements and contributes to the United Nations (UN) common system as expressed in the UN Development Assistance Framework (UNDAF) (2008-2012) and the successor UNDAF (2013-2016). The CPF-Sudan (2012-2016) is the result of extensive consultations held with a wide range of stakeholders and partners within the country and the relevant technical units of FAO at the Headquarters in Rome, the Sub- Regional Offices in Cairo and Addis Ababa. The co-owners of this document, GoS and FAO express their sincere appreciation to all who have so willingly made constructive comments and suggestions through this consultative process. The CPF will be pursued in partnerships, as broad as possible, and in alignment with the joint efforts of the Government of the Republic of Sudan and the Community of Cooperating Partners for enhanced coordination and aid effectiveness. Therefore, GoS and FAO look forward to seeking collaboration and support from all concerned partners' to work hand in hand to ensure the successful implementation of the CPF 2012-2016. By endorsing the CPF 2012-2016 both FAO and the GoS agree to rise up to the challenges of realizing the priorities of the CPF. The CPF document will constitute the sole framework for cooperation between Sudan and the Government. FAO which is represented through its Office in the Sudan, Food and Agriculture Office Sudan (FAOSD), is committed to provide the leadership and mobilize the resource needed to implement the CPF. The GoS on its part agreed to collaborate to the fullest possible extent to make available the resources and a capacity at its disposal and to facilitate by all means the unhindered implementation of the programme. Moreover the GoS is also expected to use the CPF as an important tool to mobilize NGOs, the civil societies and the general public at large to rise in unison for the fight against hunger and poverty.

**Fischer C., Kleinn C., Fehrmann L., Fuchs, H. & Panferov O., 2011. A National Level Forest Resource Assessment for Burkina Faso: a Field Based Forest Inventory in a Semiarid Environment Combining Small Sample Size with Large Observation Plots. *Forest Ecology and Management*, 262:1532–1540.**

Even though considerable parts of the global tropical forests are located in Africa, reliable data on African forest resources is limited. While this is widely recognized for tropical moist forests, it also holds for tropical dry forests. To partially fill the gap a forest inventory was carried out in Burkina Faso, West Africa. In this paper we present a methodological approach and sample based estimates of the tree and forest resources including estimates

of (1) land cover classes, (2) species composition, and (3) above ground tree carbon stocks. Following the land classification of the Food and Agriculture Organization of the United Nations (FAO), the forest cover of Burkina Faso was estimated as 42.6% (116,847 km<sup>2</sup>). For the classes “other wooded land”, “other land” and “other land with tree cover” the estimates were 1.6%, 53.6%, and 9.1%, respectively. We found notable differences to the estimates published by FAO, in particular when considering the classes “forest” and “other wooded land” separately, but lesser so when the two classes are combined. That points to a major issue in applying these class definitions in semiarid environments. Given the relatively small sample size (n = 46 field observed plots), relative standard errors (SE%) of area estimates are high (around 9% for the larger area classes). Aboveground tree carbon stocks were estimated to be 6.640, 5.580 and 7.222 Mg ha<sup>-1</sup> for “forest”, “other wooded land” and “other land with tree cover”, respectively (SE% around 18% for all three estimates). Availability of biomass models is very limited for all classes, in particular when it comes to shrubs. Furthermore, it was estimated that the most abundant tree species in Burkina Faso is *Vittelaria paradoxa*, the “shea butter tree” which is a multi-use tree species of high relevance for rural livelihoods. To our knowledge this study is the first field-based forest inventory on national level in Burkina Faso where the estimation of errors was possible on statistical grounds, and done. The results of this study revealed major issues that should be taken into account when doing similar studies, including carbon monitoring and accounting: increasing the sample size will lead to smaller standard errors (at a higher costs, of course), but will not solve the crucial points (1) of non-availability of suitable biomass models, in particular for shrub lands and (2) of implementation issues regarding the definition of land cover types.

**Gbetnkom Daniel, 2009. Forest Depletion and Food Security of Poor Rural Populations in Africa: Evidence from Cameroon. *Journal of African Economies*, 18(2):261-286.**

Forests play an important role in contributing to the food security of a large portion of Africa's food insecure. However, under current practices, this contribution is not sustainable because forests are experiencing a high rate of depletion in this continent. This paper investigates the immediate factors of deforestation in Cameroon in relation to food security of poor populations. Quantitative estimates show that cocoa producer prices, food crop prices and timber export price index on one hand, and the oil boom, the structural adjustment policies and the devaluation of the CFA franc on the other hand are quite important in stimulating the clearing of forests. Equally, the agricultural value added per hectare increases the profitability of maintaining forests. Finally, food security has a negative relationship with forest depletion. Therefore, in order to protect the remaining forest areas and render the contribution of forests to food security sustainable, attention to non-forest policies should be a first-order priority in the future.

**Gebrehiwot K., Muys B., Haile M. & Mitloehner R., 2003. Introducing *Boswellia Papyrifera* (Del.) Hochst and its Non-Timber Forest Product, Frankincense. *International Forestry Review*, 5(4):348 –353**

*Boswellia papyrifera* has been an important multipurpose tree species in central and eastern Africa since ancient times. The species is best known for its non-timber forest product, frankincense. In addition, it has numerous environmental, socio-economic,

traditional and industrial uses. However, the species is declining at an alarming rate and thus needs priority in conservation. Populations are facing degradation due to agricultural expansion, overgrazing, fire, poor incense harvesting practices, shifting cultivation, termite and other infestations and urgent conservation measures are required to save the species. Conservation strategies could include promotion of natural regeneration through closed areas and enrichment planting. Nevertheless, more ecological and silvicultural studies are required in order to streamline specific interventions.

**Keywords:** non-timber forest products, *Boswellia papyrifera*, frankincense, Ethiopia

**Jagger Pamela, Gerald Shively and Arthur Arinaitwe, 2012. Circular Migration, Small-scale Logging, and Household Livelihoods in Uganda. *Population and Environment*, 34: 235-256.**

Little is known about the contribution of migrant logging to rural livelihoods in East Africa. In this paper, we analyze logging by circular migrants in land constrained and population dense southwestern Uganda. Drawing on a sample of 180 households, including both migrant and non-migrant households, we describe the demographic and socioeconomic characteristics of migrant loggers, estimate the contribution of migrant logging to household income portfolios, test several hypotheses regarding why households decide to undertake this relatively risky activity, and explore the role of social networks as a determinant of higher incomes for migrant loggers. We find that household endowments of land, labor, and capital are different for migrant logger and comparison group households. Above all, labor endowments appear to be driving decisions to participate in logging. We find support for two migration hypotheses: higher expected incomes and wages at destination; and relative deprivation at origin. We find strong evidence that migrant logging reduces income inequality in the home community.

**Jamnadass R.H., Dawson I.K., Franzel S., Leakery R.R.B., Mithofer D., Akinnifesi F.K. & Tchoundjeu Z., 2011. Improving Livelihoods and Nutrition in Sub-Saharan African Through the Promotion of Indigenous and Exotic Fruit Production in Smallholders' Agroforestry Systems: A Review. *International Forestry Review*, 13 (3): 338-354.**

The cultivation of indigenous and exotic fruits for sub-Saharan Africa's domestic markets can bring increased revenues for smallholders and improve the diets of local consumers. There are, however, many bottlenecks which need to be addressed so that wider benefits from such activities are realised. Here, we describe key interventions being taken to address current constraints. For indigenous fruit trees, it is necessary to set priorities for which species to promote and to engage in participatory domestication for the improvement of yield, quality and germplasm delivery to farmers. For exotic fruits, 'south-south' transfer of advanced cultivars and the development of small-scale commercial suppliers of planting material are required to reinvigorate production. For both indigenous and exotic species, a focus on improving market value chains to bring greater benefits to producers is needed. We describe where further work is required to increase efficiency in the sector and to favour smallholder involvement.

**Jan Nyssena, MitikuHaileb, Jozef Naudtsc, Neil Munrod, Jean Poesene, Jan Moeyersonsf, Amaury Frankla, Jozef Deckersg & Richard Pankhursth, 2009. Desertification? Northern Ethiopia Re-photographed after 140 years. *Science of the Total Environment*, 407: 2749 – 2755.**

A collection of sepia photographs, taken during Great Britain's military expedition to Abyssinia in 1868, are the oldest landscape photographs from northern Ethiopia, and have been used to compare the status of vegetation and land management 140 years ago with that of contemporary times. Thirteen repeat landscape photographs, taken during the dry seasons of 1868 and 2008, were analyzed for various environmental indicators and show a significant improvement of vegetation cover. New eucalypt woodlands, introduced since the 1950s are visible and have provided a valuable alternative for house construction and fuelwood, but more importantly there has also been locally important natural regeneration of indigenous trees and shrubs. The situation in respect to soil and water conservation measures in farmlands has also improved. According to both historical information and measured climatic data, rainfall conditions around 1868 and in the late 19th century were similar to those of the late 20th/early 21st century. Furthermore, despite a ten-fold increase in population density, land rehabilitation has been accomplished over extensive areas by large-scale implementation of reforestation and terracing activities, especially in the last two decades. In some cases repeat photography shows however that riparian vegetation has been washed away. This is related to river widening in recent degradation periods, particularly in the 1970s–1980s. More recently, riverbeds have become stabilized, and indicate a decreased runoff response. Environmental recovery programmes could not heal all scars, but this study shows that overall there has been a remarkable recovery of vegetation and also improved soil protection over the last 140 years, thereby invalidating hypotheses of the irreversibility of land degradation in semi-arid areas. In a highly degraded environment with high pressure on the land, rural communities were left with no alternative but to improve land husbandry: in northern Ethiopia such interventions have been demonstrably successful.

**Keywords:** Desertification, Environmental rehabilitation, Land degradation, Land resilience, Repeat photography

**Joseph Kweku & Fikirte Regassa, 2013. Livelihood Impacts of Environmental Conservation Programmes in the Amhara Region of Ethiopia. *Journal of sustainable development*, 6 (10): 87-105.**

In an era where climate change and environmental variability is having an overwhelming impact on the livelihoods and well-being of poor rural households, ecological conservation and development interventions that ensure sustainable livelihood security of such households have been posited as the most effective approach in addressing both environmental degradations and household well-being in the rural communities of Ethiopia. This study investigated the impact of the 'Tree Gudifecha' ecological conservation project on the livelihoods and well-being of rural households located in two villages in the Amhara regional states of Ethiopia. The data collection and analysis was done using mixed approaches involving household surveys, interviews and focus groups meetings over a period of twelve weeks. The findings show an increase in both household income and savings after the implementation of the 'Tree Gudifecha' ecological conservation project with disparities between households and communities. A moderate association was observed between

livelihood diversifications and household income after the 'Tree Gudifecha' ecological conservation project has been implemented. The study also revealed that the extent and amount of the share that each diversification activity brings to the household income is equally important for participation in conservation programmes. The research revealed that skill enhancement interventions in livelihood activities by itself does not necessarily make a contribution to increasing community participation or household income unless a comprehensive livelihood package and adequate credit scheme is made available for potential diversification activities. The results suggest the need to incorporate indigenous livelihood security programmes at both development practice and policy levels aimed at addressing environmental/ecological degradation in rural Ethiopia. Such programmes should involve a composite framework that includes the profitability of diversification activities, identification of new livelihood activities and capacity enhancement.

**Keywords:** Ethiopia, Community resource governance, Environmental/ecological degradation, Well-being, Tree Gudifecha' project, Sustainable livelihood diversification

**Kabubo Mariara J., 2013. Forest-Poverty Nexus: Exploring the Contribution of Forests to Rural Livelihoods in Kenya. *Natural Resources Forum*, 37: 177-188.**

This paper explores the contribution of forests to the livelihoods of local communities in Kenya. The paper uses survey data to explore resource extraction and the economic reliance of households on forests. The results suggest that both rich and poor households depend on forests, and that membership in forest user groups, and therefore participation in forest activities, may be based on a household's monetary rather than asset income. The results imply that forests support the living standards of the poor through the diversification of household income sources. The econometric results point to the role of household heterogeneity in private resource endowments in influencing dependence on forests. Participation in collective action and farm size are also significant determinants of forest dependence. The results call for a balanced policy approach to forest management that facilitates both access to forests by poor households and forest conservation.

**Keywords:** Forest dependency, Non-resident cultivators, Poverty, Household heterogeneity, Kenya

**Kigomo Bernard N., 2003. Forests and Woodland Degradation in Dryland Africa: A Case for Urgent Global Attention. Paper Presented at the 12<sup>th</sup> World Forestry Congress, Quebec City, Canada.**

The African dry forests and woodlands cry for attention as they continue to degrade and desertification to set and intensify. Africa is the driest of the world continents with 45% of its landmass falling under dry lands. Furthermore 38% of this land is occupied by hyper-arid or desert land. About 50% of the African population lives in the arid, semi-arid, dry sub-humid and hyper-arid areas. A total of 340 million ha of woody vegetation in dryland zones of Africa have become degraded through human activities like; overgrazing, agricultural expansion, overexploitation, and deforestation, in the order of importance. Small-scale farming activities in the dry areas have, in particular, caused the greatest impact on vegetation degradation. Frequent fires and droughts have continued to accelerate degradation of woodlands and dry forests. About 482 million ha of drylands in Africa have suffered desertification through

several physical factors. Such physical agents of desertification includes, in the order of importance; wind erosion, water erosion, loss of nutrients, salinisation, land compaction and water-logging. Very few case studies have been followed for enough time to provide adequate data to enable effective interventions. Methodologies for monitoring extent and impacts of agents of degradation and desertification also vary greatly. Regional and local initiatives geared towards rehabilitation of the degraded vegetations need to be urgently identified and focused support by partners provided.

**Kibwage J.K., Odondo A.J. & Momanyi G.M., 2008. Structure and Performance of Formal Retail Market for Bamboo Products in Kenya. *Scientific Research and Essay*, 3 (6): 229-239.**

In Kenya, bamboo is mostly found in Central, Western and Coastal provinces. It is mainly used in residential fencing, horticultural flower farming, handicrafts and minor cottage industry products. This study focused on bamboo market segments in Nairobi, Mombasa and Kisumu with the aim of addressing uncertainties in the market structure and lack of concrete information on market potentials of the products. A stratified random sample of 20 branches of major supermarkets (i.e. Uchumi Supermarket Limited and Nakumatt Holdings Limited) was conducted. Standard questionnaires, key informant interviews and participant observation were used to obtain primary data. Secondary data were obtained from International Network for Bamboo and Rattan database, conferences/workshops proceedings reports, scientific journals, periodicals and textbooks. This study revealed that most bamboo products are imported, a scenario that results in high product prices and low demand. Thus, the need to encourage domestic production of the products. Conditions of imperfect competition with oligopolistic tendencies characterize the formal retail market, hence the need to strengthen its competition through consumer enlightenment and information dissemination.

**Lisa Petheram, Bruce Campbell, Crispin Marunda, Daniel Tiveau & Sheona Shackleton, 2006. The Wealth of the Dry Forests: Can Sound Forest Management Contribute to the Millennium Development Goals in Sub-Saharan Africa?. *CIFOR Livelihood Brief No.5*. Bogor, Indonesia, Center for International Forestry Research.**

Dry forests in Sub-Saharan Africa (SSA) cover approximately 43% of the continent. They are inhabited by nearly 236 million people, many of these the poorest in the world. A majority of the population of these regions is dependent on traditional energy sources (i.e., firewood, charcoal and organic wastes), subsistence farming, generally free-ranging livestock, and products harvested from the dry forests. Growing pressure on dry forest resources to meet human and socioeconomic development needs mean that dry forests are increasingly being utilised unsustainably. Continued degradation of dry forests poses serious problems for a large number of people, especially poorer people who depend on these forests for their livelihoods. In the past, dry forests have been seriously undervalued and much attention has instead been directed towards management of tropical humid forests and their biodiversity. Recently, a number of studies indicate that dry forests can play a critical role in helping mitigate affects of extreme poverty in SSA (Campbell et al. 2002; Shackleton and Shackleton 2004) – yet in many countries their contribution is still ignored in terms of national policy and forest management. Many African governments do



not take dry forests seriously and/or fail to make the link between degradation of dry forests and increasing poverty. Continued degradation of forests and increasing poverty in these regions points to the need to focus much more attention on dry forest management than in the past. In doing this we need to explore some important questions, such as: What type of benefits can dry forests provide and who do they benefit? Can these benefits help address the Millennium Development Goals? How can forest management be improved to help maximise these benefits? In September 2000 leaders from around the world gathered to adopt a UN Millennium Declaration. In this declaration countries committed to a new global partnership designed to reduce extreme poverty by 2015 - by addressing a series of eight Millennium Development Goals (MDGs). The MDGs are highly relevant to forestry in SSA given that it is in dry forest countries that poverty is most prevalent.

**Mahapatra A.K., Albers H.J. & Robinson E.J., 2005. The Impact of NTFP Sales on Rural Households' Cash Income in India's Dry Deciduous Forest. *Environmental Management*, 35 ( 3): 258–265.**

In recent years, researchers and policy makers have recognized that non timber forest products (NTFPs) extracted from forests by rural people can make a significant contribution to their well-being and to the local economy. This study presents and discusses data that describe the contribution of NTFPs to cash income in the dry deciduous forests of Orissa and Jharkhand, India. In its focus on cash income, this study sheds light on how the sale of NTFPs and products that use NTFPs as inputs contribute to the rural economy. From analysis of a unique data set that was collected over the course of a year, the study finds that the contribution of NTFPs to cash income varies across ecological settings, seasons, income level, and caste. Such variation should inform where and when to apply NTFP forest access and management policies.

**Margaret M. Skutsch & Libasse B., 2010. Crediting Carbon in Dry Forests: The Potential for Community Forest Management in West Africa. *Forest Policy and Economics*, 12: 264–270.**

Policy on Reduced Emissions from Deforestation and Degradation in Developing Countries (REDD) is currently being debated under the auspices of the UNFCCC. The paper reviews developments in this, particularly as regards potential crediting for reduced forest degradation in places such as the Sahel, given that degradation in the tropical dry forests and savanna woodlands is a considerable source of carbon dioxide emissions. It then presents field data from sites in Guinea Bissau, Mali and Senegal where the Kyoto: Think Global Act Local project has been working for a number of years. In these sites, the local communities had been managing their forests under a variety of different programmes before KTGAL started. The purpose of KTGAL was to record the carbon outcomes of typical community forest management regimes, and to assess whether local communities were capable of making carbon stock measurements themselves. The results indicate that carbon savings range from 5 to 14 tons carbon dioxide per hectare, if both avoided degradation and increased biomass due to forest enhancement are included. They also show that communities can be trained relatively easily to make stock (and thus carbon) assessments, at a much lower cost than employing professional forest surveyors. It is not clear yet whether both reduced degradation and enhanced stock will be rewarded under REDD, nor is it sure how much of

the financial reward might potentially be claimed by the communities, but even if only 10% of the financial value of the carbon were to filter back to the communities, this would still represent a considerable incentive for participation.

**Keywords:** REDD, Community forest management, Forest degradation

**Mulugeta L., Feleke S. & Tadesse W., 2007. Constraints to Smallholders Production of Frankincense in Metema District, North-Western Ethiopia. *Journal of Arid Environments*, 71: 393–403.**

Frankincense, an aromatic exudate obtained from several *Boswellia* species, is an important commodity with the potential to invigorate economic development of the drylands of Ethiopia. Local people have been producing and trading frankincense for centuries to diversify their income sources. However, local people's involvement in the production of frankincense varies considerably among the producing dryland regions of the country. The objectives of this study were to investigate: (i) the potential of frankincense production, (ii) socio-cultural, economic and policy factors affecting the involvement of local people in the production of frankincense, and (iii) the current status of *Boswellia* woodlands in Metema district, which is one of the major frankincense producing areas in Ethiopia. The results showed that *Boswellia papyrifera* comprised 51% of the species composition of the vegetation of the district with 253.5 kg/ha/year production potential. The total annual frankincense production potential of the district was estimated to be 79,168 tons. However, almost all inhabitants do not benefit economically from the species due to: (i) cultural influence (67%), (ii) unattractiveness of income from frankincense compared to other economic activities in the area (38%), property tenure (27%), government policy on incense production (20%), poor knowledge on frankincense production (19%) and unawareness of the potential of frankincense as a source of income (5%). The absence of direct economic benefits for the local people from the woodlands is triggering their widespread degradation mostly from human induced fire, improper forest use and agricultural land expansion.

**Keywords:** *Boswellia papyrifera*, Dryland, Government policy, Livelihood, Socio-culture, Property tenure

**Mulugeta Lemeniha, Tarekegn Abebe & Olsson M., 2003. Gum and Resin Resources from Some Acacia, Boswellia and Commiphora Species and Their Economic Contributions in Liban, South-East Ethiopia. *Journal of Arid Environments*, 55: 465–482.**

Oleo-gum resins, hardened resinous plant exudates obtained from some Acacia, *Boswellia* and *Commiphora* species in the lowlands of Ethiopia, have been traded for centuries both on the international and domestic markets. However, their economic contribution to the rural households is little documented. A reconnaissance survey was carried out in Liban, one of the administrative zones in the Ethiopian Somali National Regional State, to investigate major oleo-gum-resins collected for commerce and their economic contributions to rural households. The results showed that five types of oleo-gum-resins are collected for commerce in Liban. These are gum arabic obtained from *Acacia senegal*, gum talha obtained from *A. seyal*, frankincense obtained from *Boswellia neglecta* and *B. ogadensis*, myrrh obtained from *Commiphora myrrha* (syn. *C. molmol*), *C. truncata* and *C. borensis*

and hagar obtained from *C. africana*. The average annual cash income generated per household was estimated to be US\$ 80.00. This income contributes to 32.6% of annual household subsistence, and ranks second after livestock in the overall household livelihood. The contribution from crop farming was estimated to be 12%, which is about one-third of the contribution from oleo-gum resins. These results show that oleo-gum resins obtained from the vegetation resources play a significant role in the economy of rural households in Liban. The vegetation resources and their oleo-gum resins also provide various goods and services for the rural households in Liban. Fodder for livestock, traditional medicines for human and livestock disease treatments, incense for fumigation, cultural and religious rituals, and emergency foods during droughts are among the most common. Opportunities and constraints for oleo-gum-resin-based development in Liban and other similar areas in Ethiopia are discussed. The results could be used as baseline information for evaluating the potential of the arid and semi-arid land vegetation resources of the country, to plan for extensive studies of their management, conservation and proper utilization.

**Mulugeta L., Kassa H., Kassie G. T., Abebaw D. & Teka W., 2014. Resettlement and Woodland Management Problems and Options: A Case Study from North-Western Ethiopia. *Land degradation & development*, 25 (4): 305–318.**

Deforestation in African dry forests is widespread and its drivers are complex and vary in space and time. In this paper, we assessed impacts of immigration on dry forests and options for improved management in a resettlement district in north-western Ethiopia. Key informants interviews, focus group discussions and household questionnaire survey were used to collect data. The results indicated that forests of the district are degrading in spatial coverage and quality. The most important drivers were land use change, excessive wood harvest, grazing pressure and forest fire following immigration. The continuous influx of people with different origins, cultures, religions and lengths of residence in the district underscores absence of social bonds for collective action to regulate access. This, coupled with weak formal regulatory system, market forces and policy incentives for farming, resulted in a near open access situation. Our findings confirm the negative relationships between migration and environment not necessarily because of the mere population number added through immigration but because of lack of regulatory frameworks (formal or informal) and poor social capital. Enforcing existing policy of farm size and putting institutional framework on the ground to regulate rate of immigration, extraction of forest products and to encourage tree planting to meet wood demand are suggested measures. We conclude that Government programmes that opt for resettlement as a measure for poverty alleviation must also have mitigating measures to reducing negative impacts on the natural resource base. Thus, the trade-off between environment and development must be carefully managed.

**Keywords:** Community heterogeneity, Ethiopia, Forest degradation, Policy, Resettlement, Woodlands

**Mulugeta L., Wiersum K. F., Woldeamanuel T. & Bongers F., 2011. Diversity and Dynamics of Management of Gum and Resin Resources in Ethiopia: A Trade-off between Domestication and Degradation. *Land degradation & development*, 25(2):130-142.**

Although the human domestication of forest and tree resources is often considered to result in resource degradation, it may also lead to improved resource potentials. This paper assesses the nature and dynamics of gum and resin focused woodland exploitation and management systems in Ethiopia in the context of degradation and domestication processes. In three sites with commercial gum resin producing woodlands and production history, we studied variation in (i) woodland management and gum resin production systems and (ii) socio-economic and biophysical factors that condition the management and production systems. On the basis of their organizational features, we formulated nine production models and related them to different phases of domestication and different degrees of ecosystem degradation. The production systems gradually evolved from the extraction of wild trees to production in an adapted forest system. However, domesticated woodlands with an adapted forest structure and composition and increased provisioning services are still little developed despite decades of production history. Many of these woodlands are undergoing serious degradation because of low quality management practices. This is mainly attributable to existing land use practices and the social arrangements for the production of and trade in the gums and resins. The findings illustrate that domestication involves not only a change in ecological and production systems but also the development of social arrangements for production and trade. We conclude that the status of domestication in a social sense determines whether forests and/or specific forest resources are degraded or aggraded in the sense of resource enrichment.

**Keywords:** Abergelle, Access right, Borana, Dry woodlands, Frankincense, Land use dynamics, Metema, Ethiopia

**Namaalwa J., Hofstad O. & Sankhayanm P.L., 2009. Achieving sustainable charcoal supply from woodlands to urban consumers in Kampala, Uganda. *International Forestry Review*, 11(1): 64-78.**

A bio-economic model is used recursively to analyze charcoal supply from the charcoal zone to urban consumers in Kampala. The model is a combination of a non-linear matrix forest growth model and an economic model with the objective of maximizing annual profit from charcoal production for the period 2003-2050. Standing stock and charcoal production for each time period are predicted for the base scenario, and alternate scenarios relating to technological advances and regulatory interventions. In the base scenario, harvest levels are above the sustainable yield, with 85% reduction in standing stock by the year 2050. A sudden collapse in charcoal supply occurs in the year 2019. Combining technological advances and regulatory interventions leads to more sustainable charcoal supply as compared to implementation of any single regime. Policy makers are therefore faced with the challenge of such implementations in order to achieve sustainable resource utilization.

**Njenga Mary, Nancy Karanja, Cristel Munster, Miyuki Iiyama, Henry Neufeldt, Jacob Kithinji & Ramni Jamnadass, 2013. Charcoal Production and Strategies to Enhance Its Sustainability in Kenya. *Development in Practice*, 23(3): 359-371.**

In sub-Saharan Africa, 72 per cent of urban and 98 per cent of rural households use fuelwood for energy. In Kenya use of charcoal in urban areas has risen by 64 per cent in two decades. Despite the charcoal industry providing employment to 500,000 people and generating over US\$427 million that benefits grassroots communities, it has been kept out of the formal economies of this country. This review presents the status of the charcoal industry in Kenya, highlighting its contribution to livelihoods, production, utilisation, and implications for the environment; policy issues; and stakeholders' involvement. The review also proposes strategies to improve the sustainability of this sector.

**Patrick J. Baker, Sarayudh Bunyavejchewin, Chadwick D. Oliver & Peter S. Ashton, 2005. Disturbance History and Historical Stand Dynamics of a Seasonal Tropical Forest in Western Thailand. *Ecological Monographs*, 75(3):317 - 343.**

Disturbances influence forest dynamics across a range of spatial and temporal scales. In tropical forests most studies have focused on disturbances occurring at small spatial and temporal scales (i.e., gap dynamics). This is primarily due to the difficulty of reconstructing long-term disturbance histories of forests in which most tree species lack annual growth rings. Consequently, the role of past disturbances in tropical forests is poorly understood. We used a combination of direct and indirect methods to reconstruct the historical disturbance regime and stand development patterns in mature and regenerating seasonal dry evergreen forest (SDEF) in the HuaiKha Khaeng Wildlife Sanctuary in western Thailand. Direct estimates of long-term establishment and growth patterns were obtained from 12 tree species that form annual growth rings as a consequence of the region's strong intra-annual rainfall seasonality. Indirect estimates of establishment patterns were obtained from analyses of stand structure and individual tree architecture and application of age-estimation models to 10 dominant canopy-tree species using demographic data from a large-scale, permanent forest-dynamics plot. The combination of direct and indirect methodologies revealed a complex disturbance history in the seasonal evergreen forest over the past 250 years. In the mid-1800s, 200-300 ha of forest were destroyed by a catastrophic disturbance, which led to the synchronous establishment of many of the trees that presently dominate the forest canopy. Since then wide-spread disturbances of variable intensity have occurred at least three times (1910s, 1940s, and 1960s). These disturbances created discrete temporal pulses of establishment in small to large gaps in the forest matrix across several square kilometres. Background mortality and gap formation were evident in every decade since 1790, but these varied in intensity and frequency. The SDEF retains a distinct structural and floristic legacy from the catastrophic disturbance of the mid-1800s. The single-age cohort that established after the disturbance has developed a complex three-dimensional structure as a consequence of differences in interspecific growth patterns of the canopy-tree species and subsequent disturbances of moderate and low intensity. While no single methodological approach provided a complete picture of the disturbance history and stand development patterns of the seasonal evergreen forest, taken together they offered new insights into the long-term dynamics of a primary tropical forest. In particular, the study highlighted the role of disturbance at multiple spatial and temporal scales and varying intensities in determining the structure and composition of a complex, species-rich tropical forest and raises important

questions about the role of rare, catastrophic events on tropical forest dynamics.

**Keywords:** Age estimation, Catastrophic events and tropical forest regeneration, Dendroecology, Disturbance history, Hopea odorata, Huai Kha Khaeng, Wildlife Sanctuary, Thailand, Stand-development patterns, Tree architecture, Tropical forest dynamics.

**Persha Lauren, Arun Agrawal & Ashwini Chhatre, 2011. Social and Ecological Synergy: Local Rule making, Forest Livelihoods, and Biodiversity Conservation. Science, 331(6024):1606-1608.**

Causal pathways to achieve social and ecological benefits from forests are unclear, because there are few systematic multicountry empirical analyses that identify important factors and their complex relationships with social and ecological outcomes. This study examines biodiversity conservation and forest-based livelihood outcomes using a data set on 84 sites from six countries in East Africa and South Asia. We find both positive and negative relationships, leading to joint wins, losses, and trade-offs depending on specific contextual factors; participation in forest governance institutions by local forest users is strongly associated with jointly positive outcomes for forests in our study.

**Petursson Jon Geir, Paul Vedeld & Marieke Sassen, 2013. An Institutional Analysis of Deforestation Processes in Protected Areas: The Case of the Transboundary Mt. Elgon, Uganda and Kenya. Forest Policy and Economics, 26: 22-33.**

Protected areas (PAs) are a country's key strategy to conserve and manage forest resources. In sub-Saharan Africa, the effectiveness and efficiency of PA institutions in delivering sustainable outcomes is debated, however, and deforestation has not been avoided within such formal regimes. This paper analyzes the processes that led to deforestation within the PAs on the transboundary Mt. Elgon, Uganda–Kenya, employing institutional theory. Landsat satellite imagery helped identify and quantify forest loss over time. The study showed how, since 1973, about a third of all forests within the PAs on Elgon have been cleared in successive processes. Within formal protected area regimes, complex political and institutional factors drive forest loss. We argue, therefore, that policies to counter deforestation using a PA model have to be considered and understood against the broader background of these factors, originating both inside and outside the PA regimes.

**Keywords:** Mt. Elgon, Uganda, Kenya, Institutions, Deforestation, Protected areas

**Polansky Cecilia, 2003. Participatory Forest Management in Africa: Lessons Not Learned. International Journal of Sustainable Development and World Ecology, 10(2):109-118.**

A workshop held in Tanzania in early 2002 brought practitioners of Participatory Forest Management (PFM) from 25 African countries together with donors and other interested organizations. One objective was to search for ways forward to improve and streamline implementing PFM. It was agreed that forest legislation permitting PFM is currently widespread and that many countries are somewhere on the path of implementation. It was also agreed that more needs to be done to further the definition and sharing of benefits

from PFM forests in order for the practice to be successful and sustainable. The alarming rate of deforestation in many countries has not been sufficiently monitored or addressed by PFM. Lessons not yet learned from at least 30 years of experience include how to write satisfactory management plans and conduct inventories that would help define PFM benefits and monitoring aspects. This paper suggests ways to improve on these aspects of PFM planning. It also proposes a greater emphasis on inclusion of pitsawyer organization as a key component in sustaining forests for a longer time.

**Prasad R. & Kotwal P.C., 2001. Progress of implementation of Sustainable Management of Dry Forests in Asia with special emphasis on Indian initiative. Paper contributed for the International expert meeting on Monitoring, Assessment and Reporting (MAR) on the progress toward Sustainable Forest Management, 5-8 November 2001, Yokohama, Japan.**

The Criteria and Indicators for sustainable forest management offer best monitoring mechanism for measuring the direction of change. It may provide necessary feedback to forest managers, communities and other stakeholders to improve forest management conditions and lifestyle of dependent population. Dry zone forests provide sustenance to millions of forest dependent people. Due to increasing pressure, these forests are fast degrading, depriving the communities to get optimum benefits from products and services. The ecosystems are very fragile and need immediate action. Community participation in this region has been institutionalized. However, there has been no mechanism to monitor the progress towards different dimensions of sustainability. As a result, these countries are lagging behind in respect of development of C&I and its implementation. FAO has provided impetus through regional initiative on developing national level C&I for sustainable management of dry zone forests of Asia. This process has to be taken forward by organising further technical and financial assistance. Lack of political commitment has forced the action remain within the four-walls of academic institutions. This mindset has to be overcome through series of activities enumerated elsewhere in this presentation. In India SFM initiatives started in 1998 with Bhopal-India Process with the development of criteria and 43 related indicators at national level. The process has initiated a dialogue on SFM in the country and generated awareness about C&I and SFM across the country. The Government of India accepted adoption of SFM in the country as a follow-up of the report of the National Task Force on SFM and also recognised IIFM as the nodal agency for operationalising SFM in the country. A pilot project is being implemented at eight sites in representative forest types for development and implementation of C&I at FMU level involving local communities. Accordingly, a set of 8 criteria and 55 indicators has been developed for FMU level. This will help standardize the implementation mechanisms for replication in the whole country.

**Rahim A. H., van Ierland E.C. & Wesseler J., 2007. Economic Incentives for Abandoning or Expanding Gum Arabic Production in Sudan. *Forest Policy and Economics*, 10: 36–47.**

In this paper we use a real options approach to analyze farmers' economic incentives to abandon gum production or expand by creating new plantations. Our results indicate that agricultural crops currently provide higher economic benefits as compared to gum agroforestry. However, we show that the incentives for gum producers to abandon gum

production is low, because (i) land is abundant, (ii) gum arabic is produced during the dry season and agricultural crops mainly during the wet season, and (iii) the dry season opportunity cost of labor is low. Hence, an increase in deforestation in the near future is not expected. The analysis further shows that an increase in the prices of gum arabic of about 315% is needed to induce an expansion of gum agroforestry and a shift in land use system from continuous agricultural production to gum agroforestry system. Hence, also an expansion of gum forests and/or agroforests in the near future is not expected. Price policies to improve incentives for expanding gum forests are discussed.

**Shackleton C.M., Shackleton S.E., Buiten E. & Bird N., 2007. The Importance of Dry Woodlands and Forests in Rural Livelihoods and Poverty Alleviation in South Africa. *Forest Policy and Economics*, 9: 558– 577.**

Indigenous forests and savannas, along with plantation forests, offer numerous benefits to rural communities and society at large. Yet, the role of forests and forestry in contributing to sustainable livelihoods and poverty alleviation are widely debated. However, much of the debate pertains to lessons from the humid tropics, with little consideration of the widespread dry forests and savannas. This paper considers the role of dry forest types, including savannas, using South Africa as a case example. It concludes that a large proportion of the population makes use of forests and the resources from them. These are vital components of local livelihoods, which probably prevent people from slipping into deeper poverty. Moreover, for a measurable proportion, engagement in informal forest activities, as well as the formal forestry sector, has resulted in them being able to move out of poverty. Additionally, the generally dry nature of forests in South Africa, coupled with the high unemployment rate, limit the extent of alternative locally based livelihood options, thereby magnifying the contributions from forests and forest products. The depressing effects of widespread HIV/AIDS on labour availability, economic activities and livelihoods has exacerbated peoples' dependence on forest products

**Shackleton S., Campbell B., Lotz-Sisitka & Schackleton C., 2008. Links between the Local Trade in Natural Products, Livelihoods and Poverty Alleviation in a Semi-arid Region of South Africa. *World Development*, 36 (3): 505–526.**

Can the local commercialization of natural products contribute to reduced poverty and vulnerability? Commentary on this issue is mixed, with some observers being quite optimistic, while others hold a counterview. This paper explores the poverty alleviation potential of four products traded in Bushbuckridge, South Africa traditional brooms, reed mats, woodcraft, and “marula” beer. While key in enhancing the livelihood security of the poorest households, these products were unlikely to provide a route out of poverty for most, although there were exceptions. Incomes often surpassed local wage rates, and some producers obtained returns equivalent to the minimum wage. Non-financial benefits such as the opportunity to work from home were highly rated, and the trade was found to represent a range of livelihood strategies both within and across products.



**Skutsch M. M. & Ba L., 2010. Crediting Carbon in Dry Forests: The Potential for Community Forest Management in West Africa. *Forest Policy and Economics*, 12: 264–270.**

Policy on Reduced Emissions from Deforestation and Degradation in Developing Countries (REDD) is currently being debated under the auspices of the UNFCCC. The paper reviews developments in this, particularly as regards potential crediting for reduced forest degradation in places such as the Sahel, given that degradation in the tropical dry forests and savanna woodlands is a considerable source of carbon dioxide emissions. It then presents field data from sites in Guinea Bissau, Mali and Senegal where the Kyoto: Think Global Act Local project has been working for a number of years. In these sites, the local communities had been managing their forests under a variety of different programmes before KTGAL started. The purpose of KTGAL was to record the carbon outcomes of typical community forest management regimes, and to assess whether local communities were capable of making carbon stock measurements themselves. The results indicate that carbon savings range from 5 to 14 tons carbon dioxide per hectare, if both avoided degradation and increased biomass due to forest enhancement are included. They also show that communities can be trained relatively easily to make stock (and thus carbon) assessments, at a much lower cost than employing professional forest surveyors. It is not clear yet whether both reduced degradation and enhanced stock will be rewarded under REDD, nor is it sure how much of the financial reward might potentially be claimed by the communities, but even if only 10% of the financial value of the carbon were to filter back to the communities, this would still represent a considerable incentive for participation.

**Stave Jorn, Gufu Oba, Inger Nordal & Nils Chr. Stenseth, 2007. Traditional Ecological Knowledge of a Riverine Forest in Turkana, Kenya: Implications for Research and Management. *Biodiversity Conservation*, 16:1471-1489.**

The present study explores traditional ecological knowledge (TEK) of Turkana pastoralists and cultivators in the context of a riverine forest in northern Kenya. The Turkwel River and its floodplain sustain a thick forest, which is used for grazing and extraction of non-timber forest products. However, sedentarisation and agricultural expansion have resulted in localised clear-felling of trees, while river damming has altered the natural flow regime. A series of structured, semi-structured, and group interviews were combined with a botanical inventory in order to assess the relevance of TEK to ecological research and forest conservation. Turkana informants gave 102 vernacular names for the 113 woody species. Of these, 85% had a domestic or pastoral use among the 105 specific uses that were described. Ethnobotanical knowledge was relatively homogenous and not related to age, gender, or source of livelihood. The informants had in-depth knowledge of some key ecological processes. The conceived threats to forest survival were primarily cultivation and permanent settlements, while the effects of river damming and livestock grazing were disputed. A claimed decline in rainfall was confirmed by official data. There is strong evidence that TEK could be used to generate hypotheses for research and to design sustainable conservation strategies. A revised version of the indigenous system of tree management should be incorporated into the official forestry policy in order to resolve future conflicts between pastoralists and cultivators.

**Syampungani S., Chirwa P.W., Akinnifesi F.K., Sileshi G. & Ajayi O.C., 2009. The Miombo Woodlands at the Cross Roads: Potential Threats, Sustainable Livelihoods, Policy Gaps and Challenges. *Natural Resources Forum*, 33:150–159.**

The Miombo, the most extensive tropical woodland formation of Africa directly supports the livelihoods of over 100 million people through the provision of many tree products and ecosystem services essential to both the rural and urban communities. While the destruction of the Miombo has often been blamed on the rural communities dwelling near the forest resources, many urban dwellers depend heavily on the various products derived from the woodlands. This paper highlights the importance of the Miombo in the livelihoods of rural people, the potential threats to this ecosystem and opportunities for its sustainable management. About 70% of energy consumed in southern Africa is in the form of fuelwood or charcoal. The economic importance of the Miombo especially from non-timber forest products (NTFPs) is usually understated due to their perceived non-economic value yet they play an important role in sustaining livelihoods of forest dependent people in the miombo ecoregion. The Miombo also contributes to health services through the use of medicinal plant and products, in some cases, contributing up to 80% to rural health, including helping in coping with effects of HIV/AIDS, malaria and several diseases. The possibility of developing payment for environmental services schemes through public–private partnerships, and community-based sustainable management models are proposed. Through conservation and commercialization of some of the products and services, there is a potential to provide income and improve the livelihood of people involved in the trade along the value chain.

**Teshome B., Kassa, H., Mohammed, Z. and Padoch, C. (2015) Contribution of Dry Forest Products to Household Income and Determinants of Forest Income Levels in the Northwestern and Southern Lowlands of Ethiopia. *Natural Resources*, 6: 331-338.**

Dry forests are dominant vegetation types in East Africa. The contribution of these resources to local livelihoods is poorly understood. This study was conducted to quantify the contribution of dry forest products to household income and to identify factors that influence forest income level in the northwestern and southern lowlands of Ethiopia. Data was collected using key informant interviews, focus group discussions and formal survey administered to 428 randomly selected households from representative districts in three regional states. Regression analysis, one way ANOVA, chi-square and t-tests were used to analyze the quantitative data. The major sources of household income are crop production, livestock farming, forest products, off- and non-farm activities, and remittances and aid, contributing respectively to 46.3%, 27.6%, 17.0%, 6.3% and 2.8% of the household income. The relative importance of forest income to total household income varied significantly across wellbeing categories ( $P < 0.001$ ), representing 31.8%, 15.5% and 9.9% respectively for poor, medium and rich households and also between male headed (16.1%) and female headed (23.5%) households ( $P < 0.001$ ). In terms of magnitude, however, forest income differed significantly ( $P < 0.05$ ) with wealth category of households but not with the gender of the household head. Forest income level was significantly and positively influenced by family size ( $P < 0.01$ ) and being a member of gums and resins producers cooperative ( $P < 0.01$ ), while distance to the forest resource ( $P < 0.01$ ) and being in Tigray or Amhara Regional States (Oromia being reference state) negatively and significantly affected forest income levels of households. Attempts to promote sustainable management of dry forests should recognize these factors that influence access to forests and forest income level of

different members of the community to ensure equitable responsibility and benefit sharing arrangements and inclusive participation for better livelihoods and conservation outcomes.

**Keywords:** Gender, Gums and Resins, Fire Wood, Forest Management, Livelihoods, Wealth Category

**Tilahun M., L. Vranken, Muys B., Decker J., Gebregziabher K., Gebrehiwot K., Bauer H. & Mathijs E., 2011. Valuing Dry Land Forest Ecosystem Services: A Case of Rural Households' Willingness to Pay and Contribute Labor for Frankincense for Forest Conservation in Ethiopia. Fourth ESP Conference, on Ecosystem Services: Integrating Science and Practice. Workshop 6: Case Studies: Use of ES in Practice. Wageningen, the Netherlands.**

Frankincense from *Boswellia papyrifera* forest (BPF) is a traded commodity used in the pharmaceutical, food, cosmetic and chemical industries. Ethiopia is an important producer of frankincense, but the resource is under continuous degradation and requires conservation. We applied a contingent valuation to assess rural households' willingness to pay (WTP) and willingness to contribute labor (WTCL) for BPF conservation. Next to the bid, WTP is influenced most by income, education, and WTCL by family labor and gender of the household head. A household is willing to pay at least US\$ 4.86 or contribute 7.17 labor days per year, which amounts to US\$ 6.64 at per capita daily income. This suggests using per capita daily income rather than market wage rates could result in convergence in response asymmetry of labor and cash payment vehicles. The potential local demand for conservation of BPF could be mobilized effectively with complementary policy interventions aimed at sustainable use and poverty reduction.

**Tuck M.W., 2009. Woodland Commodities, Global Trade, and Local Struggles: the Beeswax Trade in British Tanzania. *Journal of Eastern African Studies*, 3 (2): 259-274.**

This article examines African production and sale of beeswax during the period of British colonial rule in Tanzania. It argues that the Nyamwezi and Ngindo people in particular were active in the exploitation of this forest product as a means to pay taxes and gain access to imports in a way that synchronized with subsistence agriculture and which gave them a measure of control over their economic lives. However, while supported by some colonial officials who tried to increase beeswax exports, African producers had to struggle against forestry and game officers who attempted to prevent their access to prime beeswax areas. The purchase and export of this lucrative product was controlled by a small number of Asian traders who also represented a barrier to the producers' efforts to gain a fair price.

**Wynberg R.P. & Laird, 2007. Less is Often More: Governance of a Non-Timber Forest Product, Marula (*Sclerocarya Birrea* Subsp. *Caffra*) in Southern Africa. *International Forestry Review*, 9(1): 475-490.**

Non-timber forest products (NTFPs) are often seen as tools to promote rural development and biodiversity conservation but little attention has been given to the different policy approaches adopted for their governance, nor to the role played by customary law. Through the lens of one of the most revered and economically important trees in Africa, marula

(*Sclerocarya birrea*), NTFP governance is explored in case studies across South Africa and Namibia. Results are presented from a study that examined the interface between statutory and customary rules and regulations governing marula conservation and use. The major finding is that 'less' is often 'more' when it comes to government regulation of marula, a result that resonates with other NTFP studies from around the world that indicate the need for state-led interventions to be purposely crafted to reflect local circumstances and needs. Such interventions are also most effective when government and traditional authorities cooperate, authorities have legitimacy and sufficient capacity, and there is acceptance of the rules by user groups. It is suggested that state intervention may be least useful where traditional governance is strong, and with the exception of areas and cases in which customary law and traditional authority fall short and commercial pressures on species are significant, governments might do best by leaving well enough alone.

**Yahia Omar Adam, Jürgen Pretzsch & Davide Matteo Pettenella, 2013. Contribution of Non-Timber Forest Products livelihood strategies to rural development in drylands of Sudan: Potentials and failures. *Agricultural Systems*, 117: 90-97.**

In recent decades there has been growing interest in the contribution of Non-Timber Forest Products (NTFPs) livelihood strategies to rural development and poverty alleviation. However, the potential of NTFPs to contribute to development remained limited and open to doubt. The study objectives were to: (i) analyze the role of NTFPs livelihood strategies in rural development in order to explain their potentials and failures; and (ii) identify and analyze the factors influencing the contribution of NTFPs livelihood strategies to household income. The study was carried out analyzing three NTFPs in Rashad locality in the Nuba Mountains, Sudan in 2008–2009. The data were collected through interviews, direct observations and market surveys. Purposive sampling technique was applied to select 221 and 62 collector and trader households, respectively. The results revealed that *Adansonia digitata* fruit sale represents a subsistence strategy for some sampled households and accumulative strategy for others, while *Ziziphus spina-christi* and *Balanites aegyptiaca* fruits sale is a subsistence strategy for all the surveyed households. The study results also showed that the income from selling the fruits was positively and negatively influenced by different external and internal factors. The study concluded that any assumption regarding the potential of NTFPs to positively affect rural development depends on their role in an accumulative strategy that lifts people out of poverty. Institutional, technical and financial supports are necessary to influence the future direction of the NTFP contribution toward accumulative strategy.

**Keywords:** NTFPs, Livelihood strategies, Income generation, Expenditure, Capital accumulation, Sudan

**Yemiru Tesfaye, Anders Roos, Bruce M. Campbell & Folke Bohlin, 2011. Livelihood Strategies and the Role of Forest Income in Participatory-Managed Forests of Dodola Area in the Bale Highlands, Southern Ethiopia. *Forest Policy and Economics*, 13: 258-265.**

To describe livelihood strategies in the context of a participatory forest management arrangement in the Bale highlands of southern Ethiopia, data were collected using four quarterly household income surveys and a focus group discussion. A principal component

analysis followed by cluster analysis was used to establish typologies of households based on livelihood strategies. The result distinguishes five livelihood strategies with different outcomes and levels of livelihood diversification. Both the poorest and the better-off households pursue diversified strategies. However, in terms of income level and food security, business-based and crop-based strategies have better outcomes. Forest income is an important source of cash income and particularly for low income groups it provides opportunity to diversify their livelihoods. Household characteristics such as age of household head and possession of cropland together with geographical factors like altitude and distance from market were found to be the most important determinants of livelihood strategy choices. Implications of the results for policy and poverty alleviation are discussed.

**Keywords:** Income diversification, Forest Users Groups, Livelihood, Rural, Livelihoods, Co-management

**Yonas B., Beyene F., Negatu L. & Angassa A., 2013. Influence of Resettlement on Pastoral Land Use and Local Livelihoods in Southwest Ethiopia. *Tropical and Subtropical Agroecosystems*, 16(1): 103-117.**

This study was conducted in southwest Ethiopia with the aim of understanding the influence of resettlement on pastoral land use. Data were collected using a semi-structured questionnaire and focus group discussion. Respondents in non-resettled kebele reported that livestock keeping was the main source of their livelihoods. Our results showed that resettlement accelerated crop cultivation and contributed to shifts in land use due to the expansion of crop farming. Respondents mentioned that the condition of grazing resources and livestock economy were adversely affected. The community further claimed that ownership right and changes in resource use were additional deriving forces of conflict over resources. It was also indicated that the deteriorating condition of rangelands linked to resettlement greatly undermined local livelihoods and land tenure security. Recognizing the livelihood strategy of pastoral communalities and tenure security could improve sustainable use of natural resources and conservation of biodiversity. We suggest active participation of the local community to minimize the negative impacts of resettlement on the host community, while implementing resettlement as a strategy to secure food self-sufficiency. A robust understanding in planning and implementation of resettlement is needed in consolidating concerns of the host community for minimizing conflict and securing land tenure.

### 3.2. Bio Physical Research on Dryforest

**Abeje Eshete, 2011. The Frankincense Tree of Ethiopia: Ecology, Productivity and Population dynamics. Ph.D. Thesis, Wageningen University, the Netherlands.**

*Combretum – Terminalia* woodlands and *Acacia – Commiphora* woodlands are the two dominant vegetation types that cover large parts of the dry land areas in Ethiopia. Several of their tree and shrub species yield economically valuable products such as gum Arabic, frankincense and myrrh. *Boswellia papyrifera* provides the widely traded frankincense that accounts for >80% of the export revenues that the country is earning from gum and resin resources. Unfortunately, the Ethiopian dry woodlands and the *B. papyrifera* populations are disappearing rapidly due to the combined effects of over-harvesting gums and resins,

overgrazing by livestock, recurrent fires, and excessive wood harvesting. The current lack of small saplings in the remaining populations of *Boswellia* suggests that the populations may not be sustained for the future. The main objectives of this thesis were to determine diversity and production patterns in *B. papyrifera* dominated dry woodlands, to show the regeneration status in various *B. papyrifera* populations, and to evaluate the effects of environment, frankincense harvesting, and grazing on the population dynamics of *B. papyrifera*. The main research questions were: (1) how do environmental conditions affect the tree/shrub species richness and production of Ethiopian dry woodlands? (2) what factors determine the frankincense production by *B. papyrifera* trees? (3) how do the vital rates and population dynamics of *B. papyrifera* vary across habitats that differ in soil conditions and biotic factors? (4) What are the major bottlenecks in the life cycle of the trees that hinder the sustainability of the remaining populations? To address these questions, tree populations were studied in the highlands of Abergelle and the lowlands of Metema. Metema also has a longer wet season length, higher annual rainfall and better soil fertility status than Abergelle. In total 36 and 22 tree and shrub species representing 20 and 9 families were recorded in Metema and Abergelle woodlands, respectively. The most dominant plant families were *Burseraceae*, *Fabaceae*, *Combretaceae* and *Anacardiaceae*. The vegetation at both sites was dominated by *B. papyrifera*. The two sites differed in species richness, diversity and production. Metema, the site with the longer wet season, had a higher species richness, diversity and production than Abergelle. The productivity of woodlands also increased with a higher clay content and greater soil depth. Population's structures indeed lacked the saplings, except for one very isolated population on a steep mountain slope. The studied frankincense trees produced 41 to 840 gram of frankincense during a year with seven collection rounds, and 185 to 1826 gram of frankincense during a year with 14 collection rounds. The variation in frankincense production was large across individuals. Frankincense production increased with tree size, tapping intensity, and tapping frequency. The increase in production, however, levelled-off beyond a stem diameter of 20 cm, a tapping intensity of 9 spots, and a tapping intensity of 10 rounds. Growth rate, survival rate and fruiting probability varied across populations, but were not related to soil conditions or biotic factors. The growth rates of the 12 Metema populations varied between 0.86 to 0.98, suggesting that they were all decreasing. Matrix model analyses indicated that the mortality of adult trees was the major bottleneck for sustainable population growth, and that the lack of sapling recruitment was a second major bottleneck. These bottlenecks appear both in tapped and non-tapped stands. Remarkably, tapped stand showed higher growth rates than non-tapped stands, probably because productive stands were selected for harvesting resin. All results suggest that the remaining populations of *B. papyrifera* will disappear in the near future if the current situation continues. Frankincense production is expected to halve in 15-20 years. Unexpectedly, tapping had no negative effect on vital rates, nor on population growth rates indicating that other factors are responsible for the decline of the populations. Adult mortality by insect infestation and windfall, and the negative impact of grazing and fire on the establishment of saplings need extra attention. Management should be directed towards releasing two major population bottlenecks (improve sapling regeneration, reduce adult mortality) to maintain the *Boswellia* populations and frankincense production in the future.

**Keywords:** *Boswellia papyrifera*, Frankincense tree, Matrix model, Population dynamics, Population bottleneck, Tapping.

**Abeje Eshete, Demel Teketay, Mulugeta Lemenih & Frans Bongers, 2012. Effects of Resin Tapping and Tree Size on The Purity, Germination and Storage Behavior of *Boswellia papyrifera* (Del.) Hochst. Seeds from Metema District, Northwestern Ethiopia. *Forest Ecology and Management*, 269: 31–36.**

*Boswellia papyrifera* (Del.) Hochst. is one of the tree species in dry woodlands of Ethiopia that provides several goods and services. Despite its wide economic and ecological importance, its area coverage is dwindling from time to time, and its natural regeneration is hampered. Hence, long-term prospect for a sustained supply of the goods and services from the species is becoming questionable. The objectives of this study were to investigate: (i) the effect of resin tapping and tree size (DBH) on seed susceptibility to insect attack and the production of viable seeds; and (ii) seed longevity and germination ecology of the seeds of *B. papyrifera*. We collected seeds from tapped and untapped *B. papyrifera* stands at Lemlem Terarain Metema District, northwestern Ethiopia. The result showed that both tapped and untapped stands produced comparable insect attacked seeds (tapped stands = 16.6%; untapped stands = 15.8%). Untapped trees yielded significantly ( $P < 0.0001$ ) higher viable seeds (59%) than continuously tapped trees (49.3%), and trees with medium size (20 cm DBH) provided more viable seeds than bigger (30 cm DBH) and younger trees (10 cm DBH). Longevity of *B. papyrifera* seeds indicated significant difference in viability under three different temperature regimes (5, 15 and 21 °C), three storage periods (6, 9 and 12 months) and two tapping regimes (tapped and untapped populations). Fire that produced temperatures above 100 °C was lethal to the seeds as it caused complete loss of germinability regardless of exposure time. However, heat with temperatures less than 100 °C did not cause loss of germinability even after an hour of exposure. We also found that light conditions had no significant impact on the germination percentage. In general, viability of the seeds was affected by tapping and tree size but not by storage conditions and period, modest temperature and light conditions.

**Keywords:** Frankincense, Fire, Insect attack, Tree size, Resin tapping, Storage

**Abeje Eshete, Frank Sterck & Frans Bongers, 2011. Diversity and Production of Ethiopian Dry Woodlands Explained by Climate and Soil-Stress Gradients. *Forest Ecology and Management*, 261:1499–1509.**

Dry woodlands cover about 14% of the total African land surface and represent about 25% of the natural vegetation. They are characterized by a seasonal climate, with a dry season of 4–7 months. Large parts of these ecosystems are degrading due to grazing, fire or exploitation by people. We studied species richness and productivity patterns of dry woodlands in Ethiopia. For such ecosystems, classic productivity and diversity hypotheses predict that species richness and productivity increase as the wet season length increases, and decrease when soil conditions create water stress. We inventoried and measured trees in 18 2-ha plots distributed in two sites, one higher altitude site with a shorter wet season than the lower altitude site. We found that the stand volume per hectare was lower in the site with a shorter wet season. Across all 18 plots we observed that stand volume decreased with soil water stress (estimated from texture and depth). This was in line with the prediction. The species richness was lower in the short-wet season woodlands, but was unaffected by variation in soil conditions. This suggests that climate driven constraints (wet season length) set the limits to species richness, and not soil conditions. As far as we know, this study is one

of the first studies that evaluated these productivity and diversity hypotheses for dry African woodlands.

**Keywords:** Ethiopia, Dry woodlands, Species composition, Species richness, Productivity

**Abeje Eshete, Frank J. Sterck & Frans Bongers, 2012. Frankincense Production is Determined by Tree Size and Tapping Frequency and Intensity. *Forest Ecology and Management*, 274:136–142.**

Resin production in trees probably depends on trade-offs within the tree, its environment and on tapping activities. Frankincense, the highly esteemed resin from dry woodland frankincense trees of *Boswellia papyrifera* is exploited in traditional ways for millennia. New exploitation practices lead to weak trees and non-sustainable resin production. For 500 trees from four populations of *B. papyrifera* we evaluated how frankincense yield is affected by different tapping intensities (number of incision spots) and frequencies (number of resin collection rounds during the dry season), since both of them have been intensified recently. These effects are considered for trees of different size, since larger trees probably provide more resources for resin production. We predicted that frankincense production would initially increase with tapping intensity and tapping frequency, but later level-off because of resin depletion. Frankincense production varied highly: yield per tree per year of all 500 monitored trees averaged 261 g ( $\pm 231$ , but largely varied and ranged from 41 to 1829 g. We indeed found that resin yield increased with tapping intensity, but not anymore beyond an intensity of 6–9 incision spots. Yield peaked around the seventh collection round, and declined thereafter. Yield increased with trunk diameter, but leveled-off beyond trees with a stem diameter of >20 cm. These patterns were similar across populations, and between contrasting areas. Our results suggest that high tapping intensity risks short-term resource depletion, warranting tuning down the intensity of the current collection practices. Less intense tapping rounds per season will reduce damage, increase the health of tree populations, and contribute to long term frankincense production. This study thus allows for developing less damaging and more sustainable management for frankincense trees.

**Keywords:** Gum-resin, Insect attack, Non-timber forest product, Resin canals, Tapping intensity

**Abrham Abiyu, Harald Vacik & Gerhard Glatzel, 2006. Population Viability Risk Management Applied to *Boswellia papyrifera* (Del.) Hochst in North-eastern Ethiopia. *Journal of the Drylands*, 1(2): 98-107.**

*Boswellia papyrifera* (Del.) Hochst, is an ecologically and economically important tree species found in the arid lowlands of Ethiopia. As Ethiopia is one of the world's largest producers of Frankincense (olibanum), the exploitation of olibanum is one of the top employment generating activities in the remotest parts of Ethiopia and therefore a very important source of income for the rural people residing there. Due to this exploitation the potential range of forest communities with *B. papyrifera* is greatly reduced and the species itself is classified as endangered. In Amhara region, there is a large reserve of approximately 604,000 ha of this forest in Tekeze and Abay (Blue Nile) catchments, where the species is cohabiting the same niche with *Acacia* and *Commiphora* species. Based on this background the framework of a Population viability risk management (PVRM) is used for the design and evaluation of in-situ conservation strategies for *B. papyrifera* population in Amhara region. As part of the PVRM



the Analytical Hierarchy Process (AHP) is used to evaluate the conservation strategies with regard to the viability of *Boswellia*. The viability of *B. papyrifera* is described based on the results of an analysis of the current environmental, social and economical state and a characterization of the ecological parameters of its population. The significant risk factors such as successful regeneration, pressures like grazing and tapping or of ownership are compared and prioritized against their impact on the viability of *B. Papyrifera* population. Effects of different conservation strategies (e.g. change of tapping frequency, grazing regime) are determined through a qualitative assessment of the probability of a decrease of *B. papyrifera* population along with scenarios under different environmental conditions. In this context strategies combining silvicultural measures that increase regeneration and growth of *Boswellia* and measures that consider ownership and benefit sharing seem to be the most effective. The rational and pitfalls using the concept of population viability risk management is discussed along with the results of the scenario analysis.

**Keywords:** Frankincense, Analytical Hierarchy Process, Multi-criteria Decision Making, Conservation strategy, Nature conservation, Dryland forest

**Aman Dekebo, Medhin Zewdu & Ermias Dagne, 1999. Volatile Oils of Frankincense from *Boswellia papyrifera*. *Bulletin of Chemical Society of Ethiopia*, 13 (1):93 – 96.**

The essential oil obtained by hydrodistillation of frankincense from *Boswelliapapyrifera* was analysed using GC, GC-MS and NMR, n-Octyl acetate (56%), octanol (8%) and limonene (6.5%) were found to be the major components.

**Angela L. Lamb, Melanie J. Leng, Mohammed Umer Mohammed & Henry F. Lamb, 2004. Holocene Climate and Vegetation Change in the Main Ethiopian Rift Valley, Inferred From the Composition (C/N and D13c) of Lacustrine Organic Matter. *Quaternary Science Review*, 23: 881–891.**

In order to track changes in the relative abundance of  $C_3$  and  $C_4$  plants in savanna vegetation, C/N and  $d^{13}C$  values were measured on bulk organic material in an 8840 14C-year record from Lake Tilo, Ethiopia. Between 8840 and 2500 BP, high C/N ratios suggest that input to the lake was predominantly from terrestrial plants. The corresponding  $d^{13}C$  values thus provide a proxy for changes in catchment vegetation that are supported by pollen data.  $d^{13}C$  values in the early Holocene are relatively low, reflecting the dominance of  $C_3$  vegetation (woody plants) and a more humid climate.  $d^{13}C$  shows no response to a known regional arid interval at 7800 yr BP, suggesting that woody vegetation was able to survive relatively prolonged dry periods. A gradual, rather than sharp,  $d^{13}C$  response to the end of the early Holocene humid interval at 4500 yr BP further supports this. Higher  $d^{13}C$  values at 2800–2300 and 1000 yr BP correspond to increases in sedge pollen, thought to be growing in freshwater springs, exposed as lake-level fell. The C/N and  $d^{13}C$  composition of bulk organic material complements the pollen evidence and may be useful in other lakes in savanna regions as indicators of terrestrial vegetation change.

**Asmamaw Alemu, Jürgen Pretzsch, , Tarig Mohamoud, Yahia Adam, 2012. Population Status of *Boswellia Papyrifera* (Del.) Hochst in the Dry Woodlands of Nuba Mountains, South Kordofan State, Sudan. *Agriculture & Forestry*, 54 (1/4): 41-50.**

*Boswellia papyrifera* (Del.) Hochst. is a dryland tree species with diverse ecological and economic benefits. It is a source of frankincense with wider applications in cultural uses and modern pharmaceutical and cosmetic industries. Despite the potential and actual economic and environmental conservation benefits of the tree species, the woodland harboring this species is degrading. Adequate knowledge on the resource base including the current status of its population is crucial for sustainable management of the resource. This paper presents (i) the population structure and density of *Boswellia*; (ii) the natural regeneration status of *Boswellia*; and (iii) assess the frankincense harvesting intensity and visible damages on *Boswellia* tree in the study area. The study was carried out in two woodlands in South Kordofan state, Sudan, namely Kajinat reserved forest and Tajmala unreserved forest. The results show that the population of the tree species is unstable characterized by lack of recruitment and threatened by interrelated factors. Low densities  $81 \pm 79$  trees ha<sup>-1</sup> and  $52 \pm 50$  trees ha<sup>-1</sup> was observed in Kajinat reserved forest and Tajmala unreserved forest, respectively. All the individuals in the two stands have diameter at breast height (DBH) greater than 11 cm. A complete lack of regeneration and juvenile individuals, high mortality, and damages by insect and browsing was observed. Additionally, 43 % of the trees were observed severely over tapped with more than 15 tapping spots. Due to the current threats, the resource base is under threat due to uncontrolled frankincense exploitation among others. Proper management plan and domestication of the species through artificial regeneration and area closure are urgently needed.

**Keywords:** *Boswellia papyrifera*, Species composition, Natural regeneration, Tapping of frankincense, Dry woodlands

**Aster Gebrekirstos, Ralph Mitlöhner, Demel Teketay & Martin Worbes, 2008. Climate–Growth Relationships of the Dominant Tree Species from Semi-Arid Savanna Woodland in Ethiopia. *Trees*, 22:631–641.**

Long-term climate–growth relationships were examined in tree rings of four co-occurring tree species from semi-arid Acacia savanna woodlands in Ethiopia. The main purpose of the study was to prove the presence of annual tree rings, evaluate the relationship between radial growth and climate parameters, and evaluate the association of El Niño and drought years in Ethiopia. The results showed that all species studied form distinct growth boundaries, though differences in distinctiveness were revealed among the species. Tree rings of the evergreen *Balanites aegyptiaca* were separated by vessels surrounding thin parenchyma band and the growth boundary of the deciduous acacias was characterized by thin parenchyma bands. The mean annual diameter increment ranged from 3.6 to 5.0 mm. *Acacia senegal* and *Acacia seyal* showed more enhanced growth than *Acacia tortilis* and *B. aegyptiaca*. High positive correlations were found between the tree-ring width chronologies and precipitation data, and all species showed similar response to external climate forcing, which supports the formation of one tree-ring per year. Strong declines in tree-ring width correlated remarkably well with past El Niño Southern Oscillation (ENSO) events and drought/famine periods in Ethiopia. Spectral analysis of the master tree-ring chronology indicated occurrences of periodic drought events, which fall within the spectral peak equivalent to 2–8

years. Our results proved the strong linkage between tree-ring chronologies and climate, which sheds light on the potential of dendrochronological studies developing in Ethiopia. The outcome of this study has important implications for paleoclimatic reconstructions and in restoration of degraded lands.

**Keywords:** Tree-ring width, Acacia species, *Balanites aegyptiaca*, Climate change, Dendrochronology

**Atela J., 2013. Governing REDD+: Global Framings Versus Practical Evidence from the Kasigau Corridor REDD+ Project, Kenya; STEPS Working Paper 55. Brighton, UK.**

This paper explores the governance and feasibility of globally-linked REDD+ projects in local African settings, focusing on the Kasigau project in Kenya, Africa's first REDD+ project accredited under internationally accepted standards. The project is a commercial venture and during the last five years it has unfolded in a relatively vulnerable Kenyan setting. A policy process analysis, interactive fieldwork and document review has explored its interrelationship with local livelihood assets and state institutional capabilities. The paper reveals that while REDD+ institutions are globally standardised through negotiations interlocked with political and development interests, projects are faced with state and local resource histories and perceptions, and in responding to such settings, these projects become highly contextual. Locally, the Kasigau project links carbon benefits to specific and significant local vulnerabilities such as low 'value' dryland, water scarcity and illiteracy. This has yielded an apparently uncontested acceptance and favourable perception of the project among the Kasigau people, appearing to reverse long histories of exclusion from their resources by centralized state-based resource management regimes. Yet the negative perception of state institutions that the Kasigau people have built up over time raises questions as to whether the state can ably oversee a successful REDD+ process, as is assumed by the international community. If resource management is not factually decentralised in particular countries, greater capture of local resource rights in REDD+ could result from state regimes than from private-commercial regimes. As such, international gains in safeguarding local communities in REDD+ could be seriously compromised. Kenya recently initiated land reforms as part of resource decentralisation, but the resulting regimes remain fuzzy, subordinate to powerful centralised interests, focused on individual title, and inadequately adapted to particular local contexts. Such reforms potentially re-shuffle the local engagement of the Kasigau project which draws its apparent success partly from a communalised land tenure system. This paper concludes that communal systems, if well-defined, may provide a better basis for the governance of REDD+ projects, enabling inclusivity, collective action and societal benefits. If projects can genuinely enable local people to manage and benefit from their forest resources, REDD+ promises to be a multi-governance programme that bridges the gap between global and local institutions and interests in the sustainable use of forests.

**Chavunduka Charles & Daniel W. Bromley, 2011. Climate, Carbon, Civil War and Flexible Boundaries: Sudan's Contested Landscape. *Land Use Policy*, 28: 907-916.**

The confluence of climate change, oil development, farmer–nomad interaction, and civil war has given rise to serious contestation over land and water resources in the heart of Sudan.

Here we report on direct involvement in the very difficult and protracted efforts to resolve these land-use conflicts. Repeated efforts to define and implement “hard demarcation” of boundaries in agroecological regions characterized by great temporal variability across space have been unsuccessful for many reasons. In semi-arid and savanna environments, where nomads share the use of land with sedentary communities, boundary disputes are minimized by the existence of flexible demarcations. Flexible boundaries are identifiable but subject to change in response to negotiation and agreement among resource users. It seems that the struggle is always over “rights” to particular areas of land. But it is necessary to understand the distinction between interests and rights. Each individual – and each group – has interests that they will seek to protect and, very often, enhance. But the conversion of interests into rights is a more difficult matter. As long as the need to deal with risk and uncertainty dominate livelihood strategies, flexible adaptation rather than rigid boundaries remains the optimal strategy in agro-pastoral economies.

**Chidumayo E.N. & Gumbo D.J., 2010. The Dry Forests and Woodlands of Africa: Managing for Products and Services. Earthscan, London, UK.**

Since time immemorial dry forests and woodlands of sub-Saharan Africa have provided diverse ecosystems goods and services to large populations of humans and livestock that depend on them. Dry forests and woodlands are profoundly important for local livelihoods, and yet, this role is hardly recognized by the respective sub-Saharan African governments – more so against the backdrop and importance accorded to tropical forests. Further, policy inadequacies are noted and dry forests are a low priority in sub-Saharan Africa. Lately, sub-Saharan Africa’s dry forests and woodland have been rapidly declining due to harvesting of wood for commercial and domestic purposes and this has had major implications for the local people. Sub-Saharan Africa is a developing region where deforestation and desertification have remained as major issues of concern. With these changes, biodiversity, which is not only important for ecotourism but also a significant source of non-wood forest products, is severely under threat. All the key attributes of the dry forests and woodlands are intricately linked and a change in one will affect the other. Thus, the threat posed by climate change on the forests will invariably affect livelihoods and therefore there is an urgent need to increase natural and human capacity to deal with the problems triggered by this development. This unique book brings together scientific knowledge on and about dry forests and woodlands from eastern, western and southern Africa, and describes the relationships between forests, woodlands, people and their livelihoods. Dry forest is defined as vegetation dominated by woody plants, primarily trees, the canopy of which covers more than 10 per cent of the ground surface, occurring in climates with a dry season of three months or more. This broad definition – wider than those used by many authors – incorporates vegetation types commonly termed woodland, shrubland, thicket, savanna and wooded grassland, as well as dry forest in its strict sense. The book provides a comparative analysis of management experiences from the different geographic regions of sub-Saharan Africa, emphasizing the need to balance the utilization of dry forests and woodlands between current and future human needs. Further, the book explores the techniques and strategies that can be deployed to improve the management of African dry forests and woodlands for the benefit of all, and especially the communities that live off this vegetation. This book aims to stoke local, regional, national and international discussion on these forests and woodlands that provide livelihoods to almost 60 per cent of sub-Saharan Africa’s population. In this way the

book is not only calling for a better understanding of the policy issues surrounding these forests but also the biophysical aspects of the same. Thus, the book lays a foundation for improving the management of dry forests and woodlands for the wide range of products and services they provide.

**Chirwa P.W., Syampungani S. & Geldenhuys C.J., 2008. The Ecology and Management of the Miombo Woodlands for Sustainable Livelihoods in Southern Africa: the Case for Non-Timber Forest Products. *Southern Forests: a Journal of Forest Science*, 70 (3): 237-245.**

There is new and increasing emphasis on the contribution of non-timber forest products (NTFPs) to improving the livelihoods of rural communities and therefore the need for sustainable management of forest ecosystems of the Miombo woodlands to ensure the continued availability of these NTFPs. This paper examines and reviews some of the work that has been done in the Miombo ecoregion on the ecology, utilisation and management of the Miombo woodlands. The review points to the richness of the Miombo regions' plant species, with an estimated 8 500 species of higher plants, of which over 54% are endemic. The review also highlights the response of the Miombo ecosystem to fire and other anthropogenic processes and the lack of wide-scale adoption or implementation of the major research findings. The review shows that there is a wide range of NTFPs that significantly contribute to the total household income in forest areas and to the national economies through provision of opportunities for small-scale trade especially in the rural areas. However, there is a concern that commercialisation usually results in overexploitation of the resource by the outsiders who become the major players. It is suggested from the review that the lack of capacity by national institutions to manage Miombo woodland resources could be addressed by using participatory approaches to natural resource management. It is also proposed that for sustainable use and management of NTFPs in the Miombo region, research should focus on issues that specifically address NTFPs. In order to facilitate commercialisation and benefit the economically weak, policies that incorporate post harvesting technical assistance and access to information on markets, technology and microcredit should be developed and promoted.

**Chretien M., Chikamai B., Lokatari E., Ngichili J., Loupa N., Odeee D. & Lesueur D., 2008. The Current Situation and Prospects for Gum Arabic in Kenya: A Promising Sector for Pastoralists Living in Arid Lands. *International Forestry Review*, 10(1):14-22.**

**Summary.** Gum arabic, a natural exudate produced by *Acacia senegal* trees, is available in abundance in Kenya, mainly in the northern part of the country, but its exploitation is marginal. This study, conducted among harvesters, traders and other actors involved in the development and business of the gum arabic industry in Kenya has shown and confirmed the results of other researches, that the supply chain is currently under-developed. Harvesters do not collect sufficient quantities of gum arabic because they are not linked to buyers, and when they are the low prices they receive discourage them from developing that income generating activity. Pastoralists currently only collect gum when they see it, and do not use modern harvesting techniques. They stand to benefit from that activity if they are more organized and if that business was more developed in the country. Recognizing the

unmet international demand for gum arabic and the largely untapped reserves growing in the wild and in abundance in the northern part of the country suggests that improvements can be made to harvesting and marketing. Through training, with specific attention to quality issues and international requirements, the constitution of stocks in collection areas and the development of direct links with traders, Kenya can penetrate the international market of gum arabic and improve its market share. Various activities have been undertaken and have already shown good results.

**Crona B. I., 2006. Supporting and Enhancing Development of Heterogeneous Ecological Knowledge among Resource Users in a Kenyan Seascape. *Ecology and Society*, 11 (1): 32.**

The heterogeneous nature of even small communities has been acknowledged, yet how such heterogeneity is reflected in local ecological knowledge (LEK) among groups of resource users in a community is poorly studied. This study examines the ecological knowledge held by fisher groups using differing gear and operating in different subsystems of a coastal seascape in south Kenya. Knowledge is compared to that of nonfishing groups and is analyzed with respect to the scales of ecological processes and disturbances affecting the ecosystem to identify mismatches of scale between local knowledge and ecological processes, as well as points of convergence upon which emerging scientific and local community information exchange can build and develop. Results reveal significant differences in the level and content of ecological knowledge among occupational categories with respect to the scale and nature of ecological interactions in the seascape. Nonfishing related groups were marked by consistently low levels of knowledge and understanding of all seascape components and processes. Gear-defined fisher groups appeared linked, through fishing methods, to specific functional groups defined by trophic level, although acknowledgment among users of trophic links and ecosystem effects were not always apparent. Knowledge appeared to be largely related to maximization of resource extraction rather than reflecting deep understanding of ecological processes and causal links. Demographic changes and erosion of traditional management systems may partly explain this. Based on the results it is suggested that future investments geared at enhancing socioeconomic standards, e.g., through investment in improved gear, run the risk of further propelling the system down the poverty trap through habitat degradation and stock depletion, if not simultaneously combined with support for development and enhancement of existing LEK.

**Keywords:** Heterogeneous, Local ecological knowledge (LEK), Seascape, Kenya, East Africa, Artisanal fishery

**Dagnew Yebeyen, Mulugeta Lemenih & SisayFeleke, 2009. Characteristics and Quality of Gum Arabic from Naturally Grown *Acacia Senegal* (Linne) Willd. Trees in the Central Rift Valley of Ethiopia. *Food Hydrocolloids*, 23: 175–180.**

Drylands of Ethiopia, including those in the Rift Valley, host good potential for commercial production of natural gums such as gum arabic. However, little researches have assessed the qualities of these gums for their commercial and industrial promotions. The objectives of this study were to assess the (i) quality of gum arabic collected from naturally grown *Acacia senegal* trees in the Central Rift Valley of Ethiopia and (ii) evaluate these quality

characteristics against reported quality attributes of the same kind of gum from known destinations such as the Sudan and with international specifications. Gum samples were collected from randomly identified 10 trees of *A. senegal* in the study area and composited in to one big sample by putting all in one plastic bag. The characteristics analyzed included: color, odor, moisture content, ash content, viscosity, pH, specific rotation, N and tannin contents, and concentration of several metals using standard laboratory procedures. The results yielded moisture content of 15%, ash content of 3.56%, intrinsic viscosity of 1.19 ml g<sup>-1</sup>, pH on 25% solution of 4.04, specific rotation of -32.5, nitrogen content of 0.35%, protein content of 2.31% and with no tannin content. Mineral contents of the gum arabic (g/100 g) are Ca 0.7, Mg 0.2, Na 0.01, K 0.95, Fe 0.001, P 0.6 and non-detectable traces of Pb, Co, Cu, Zn, Ni, Cd, Cr and Mn. These values agree well with values of same quality characteristics of gum arabic reported from Sudan and other exporting countries, and also conform well to international standards in all aspects. Indeed, it is possible to utilize the gum arabic resource of the Central Rift Valley of Ethiopia for commercial and/or industrial purposes.

**Keywords:** Drylands, International specifications, Physico-chemical characteristics, Industrial application

**Dessie G. & Kinlund P., 2008. Khat Expansion and Forest Decline in Wondo Genet, Ethiopia. *Human Geography*, 90 (2): 187–203.**

This study analyses the expansion of khat production in relation to forest decline in the Wondo Genet area in south-central Ethiopia. By assessing spatial variables and social factors, and using remote sensing and social survey techniques, the extent to which this new cash crop contributes to deforestation is explored. The results indicate that khat has expanded rapidly in terms of land area used for its production at forest frontiers, in isolated forest patches and within farmland since the mid-1980s. This is mainly due to high economic advantage, high market demand and favourable means of transport as well as the existence of a cohesive trade network. Moreover, the properties of the crop also facilitate expansion. The increased production of khat appears to be a result of conscious choice and rational decisions made by male farmers, regardless of religious, cultural and policy discouragement and despite khat's possible negative impact on livelihood security. Although it is found that khat expansion does not explain forest decline in the study area per se, it plays an important role in enhancing multifaceted interaction between people and forest. The expansion influences forest decline directly by conversion, and indirectly through increased human activity in proximity to forests. The conversion has resulted in a reduction of forest area, resilience and regeneration. Khat production has changed human settlement patterns, suppressed production of other crops and influenced women's income negatively. These aspects increase the demand for wood and it renders the forest an important source of supplementary incomes. Khat production may create tension, resulting from a conflict in interest between sustaining the native forests, with subsequent environmental benefits for the larger social group, and the economically driven choice land use made by khat farmers.

**Didier Zida, Louis Sawadogo, Muluaem Tigabu, Daniel Tiveau & Per Christer Ode'n, 2007. Dynamics of Sapling Population in Savanna Woodlands of Burkina Faso Subjected to Grazing, Early Fire and Selective Tree Cutting for a Decade. *Forest Ecology and Management*, 243:102–115.**

Fire, grazing, browsing and tree cutting are major anthropogenic determinants of vegetation patterns in African savannas. In Burkina Faso forest management policies prohibit grazing while recommending annual early fire and selective tree cutting of 50% of the merchantable standing volume on a 20-year rotation period. These management prescriptions are not based on long-term experimental evidence, particularly the responses of saplings to these management regimes are not well known. A factorial experiment with two levels was designed to examine the effects of moderate level of grazing, early fire and selective tree cutting on the dynamics of sapling populations on two sites, Laba and Tiogo, in the savanna woodland of Burkina Faso and assessed for 10 years from 1992 to 2002. Species richness, sapling population density, structure and growth were analysed. The results provide evidence that fire, grazing and selective cutting acted independently to influence the population dynamics of saplings. Annual early fire significantly reduced species richness ( $p = 0.037$  in Laba and  $p = 0.016$  in Tiogo), population density ( $p < 0.001$  in Laba and  $p = 0.003$  in Tiogo) and current annual increment (CAI) in basal area ( $p < 0.001$  in Laba and  $p = 0.016$  in Tiogo). Grazing and fire affected sapling morphology but the response was site specific. Selective removal of trees did not affect any of the parameters studied, except the CAI in dominant height at the Tiogo site which was significantly ( $p = 0.028$ ) reduced by the cutting treatment. Early fire also significantly reduced the CAI in dominant height at Laba. The height class distribution revealed that more than 93% of the saplings recorded were less than 400 cm tall, and fire significantly reduced the rate of change in density of saplings in the 200–400 cm height class. It can be concluded that annual early fire was the factor that most affected sapling recruitment. The sapling response to these management regimes was species specific.

**Keywords:** Regeneration, Sudanian savanna, Dry forest, Disturbance, West Africa

**Diress Tsegaye, Stein R. Moe & Mitiku Haile, 2009. Livestock Browsing, Not Water Limitations, Contributes to Recruitment Failure of *Dobera glabra* in Semiarid Ethiopia. *Rangeland Ecology & Management*, 62 (6): 540-549.**

The study used nursery and field experiments to investigate why recruitment of *Dobera glabra* (Forssk) Poir., a native food source for both humans and livestock, often fails in the semiarid rangelands of Afar, Ethiopia. We hypothesized that soil water limitations and browsing by livestock would be the primary mechanisms accounting for the failure of natural regeneration. We used three sets of experiments -1) seedling performance in response to shade and watering in a nursery, 2) field regeneration with and without browsing, and 3) regeneration beneath trees with and without browsing- to examine regeneration success. Seedlings were established in plots from seeds sown directly into the soil for nursery and field experiments, but natural germination occurred beneath trees. Survival and relative growth rates (RGR) were used to monitor seedling performance. Seedlings that received neither shade nor watering treatments had lower seedling survival ( $53 \pm 15\%$ ) as compared with other treatment combinations. Highest seedling survival was recorded under shade and 1 d watering  $\mu\text{wk}^{-1}$  treatment combinations ( $92 \pm 1\%$ ). However, shade treatments had a minimal increase on seedling RGR. Water limitation is not a crucial limiting factor for *D.*



*glabra* recruitment, as 53% of the seedlings survived without both shade and supplemental water for 1 yr. Field experiments, however, demonstrated that browsing greatly reduced seedling survival (below 15%) and suppressed growth of surviving seedlings, suggesting that browsing is the major factor preventing natural recruitment. Natural recruitment of *D. glabra* is unlikely with the existing continuous and intensive grazing/browsing in Afar rangelands, where the mobility of pastoralists is restricted. We suggest that planting nursery-raised seedlings in home gardens of settled pastoralists and establishment of grazing reserves in some key range sites that contain *D. glabra* could help offset the recruitment failure of native food species *D. glabra* in Afar rangelands

**Keywords:** Afar pastoralists, Herbivory, Seedling survival, Tree regeneration

**Dudley Nigel, David Baldock, Robert Nasi & Sue Stolton, 2005. Measuring Biodiversity and Sustainable Management in Forests and Agricultural Landscapes. *Biological Sciences*, 360 (1454): 457- 470.**

Most of the world's biodiversity will continue to exist outside protected areas and there are also managed lands within many protected areas. In the assessment of millennium targets, there is therefore a need for indicators to measure biodiversity and suitability of habitats for biodiversity both across the whole landscape/seascape and in specific managed habitats. The two predominant land uses in many inhabited areas are forestry and agriculture and these are examined. Many national-level criteria and indicator systems already exist that attempt to assess biodiversity in forests and the impacts of forest management, but there is generally less experience in measuring these values in agricultural landscapes. Existing systems are reviewed, both for their usefulness in providing indicators and to assess the extent to which they have been applied. This preliminary gap analysis is used in the development of a set of indicators suitable for measuring progress towards the conservation of biodiversity in managed forests and agriculture. The paper concludes with a draft set of indicators for discussion, with suggestions including proportion of land under sustainable management, amount of produce from such land, area of natural or high quality semi-natural land within landscapes under sustainable management and key indicator species.

**Keywords:** Criteria and indicators, Forest management, Agriculture, Convention on Biological Diversity

**Efrem Garedew, Mats Sandewall, Ulf Söderberg & Bruce M. Campbell, 2009. Land-Use and Land-Cover Dynamics in the Central Rift Valley of Ethiopia. *Environmental Management*, 44:683–694.**

Understanding the complexity of land-use and land-cover (LULC) changes and their driving forces and impacts on human and environmental security is important for the planning of natural resource management and associated decision making. This study combines and compares participatory field point sampling (pfps) and remote sensing to explore local LULC dynamics. The study was conducted in two peasant associations located in the central Ethiopian Rift Valley, which is a dry-land mixed farming area exposed to rapid deforestation. From 1973–2006, the area of crop land doubled at the expense of woodland and wooded-grassland in both of the study sites. Major deforestation and forest degradation took place from 1973–1986; woodland cover declined from 40% to 9% in one of the study sites, while the other lost all of its original 54% woodland cover. Our study concludes that assessing

LULC dynamics using a combination of remote sensing and pfps is a valuable approach. The two methods revealed similar LULC trends, while the pfps provided additional details on how farmers view the changes. This study documents dramatic trends in LULC over time, associated with rapid population growth, recurrent drought, rainfall variability and declining crop productivity. The alarming nature of these trends is reflected in a decrease in the livelihood security of local communities and in environmental degradation. Given these dry-land conditions, there are few opportunities to improve livelihoods and environmental security without external support. If negative changes are to be halted, action must be taken, including building asset bases, instituting family planning services, and creating opportunities outside these marginal environments.

**Keywords:** Deforestation, Dryland, Environmental degradation, Participatory field point sampling, Remote sensing

**Efrem Garede, Mats Sandewall & Ulf Soderberg, 2012. A Dynamic Simulation Model of Land-Use, Population, and Rural Livelihoods in the Central Rift Valley of Ethiopia. *Environmental Management*, 49(1): 151-162.**

The dynamic interactions between society and land resources have to be taken into account when planning and managing natural resources. A computer model, using STELLA software, was developed through active participation of purposively selected farm households from different wealth groups, age groups and gender within a rural community and some members of Kebele council. The aim of the modeling was to study the perceived changes in land-use, population and livelihoods over the next 30 years and to improve our understanding of the interactions among them. The modeling output is characterized by rapid population growth, declining farm size and household incomes, deteriorating woody vegetation cover and worsening land degradation if current conditions remain. However, through integrated intervention strategies (including forest increase, micro-finance, family planning, health and education) the woody vegetation cover is likely to increase in the landscape, population growth is likely to slow down and households' income is likely to improve. A validation assessment of the simulation model based on historical data on land-use and population from 1973 to 2006 showed that the model is relatively robust. We conclude that as a supporting tool, the simulation model can contribute to the decision making process.

**Keywords:** Forest increase, Household income, Land-use, Land degradation, STELLA software

**Ekta Khurana & Singh J.S., 2001. Ecology of Seed and Seedling Growth for Conservation and Restoration of Tropical Dry Forest: A Review. *Environmental Conservation*, 28 (1): 39–52.**

Dry forests are among the most threatened ecosystem sand have been extensively converted into grasslands, secondary forest, savanna or agricultural land. Knowledge of seed germination and seedling establishment is required for the success of efforts on restoration of these forests. This review focuses on the ecological requirements at seed and seedling stages, and collates the current knowledge of seed viability, dormancy, germination pattern and seedling behavior of dry tropical tree species. The spatio-temporal variations

within the tropical dry forest biome in soil moisture, light, temperature, nutrients and intensity of predation, significantly affect the seed and seedling traits of component species. The majority of dry tropical species possess orthodox seeds which are characterized by dormancy, while a few have recalcitrant seeds which possess little or no dormancy. Seed coat dormancy, which can be overcome by mechanical or acid scarification or sometimes by transit through animal guts, is most prevalent in the dry tropical forest species. Persistent species dominating the undisturbed portions of the forest have bigger seeds compared to those that mostly occur in disturbed regions and require shade for the survival of their seedlings. Shade demand is associated with drought endurance, and may be absolute in species such as *Guettardaparviflora* and *Coccolobamicrostachya*, or facultative as in *Plumerialba* and *Burserasimaruba*. The fluctuation in temperature significantly affects seed germination in several species of dry Afromontane forest trees of Ethiopia. Seedling mortality is primarily a function of moisture stress during the dry period. Adaptive responses of seedlings to drought stress include increased chlorophyll content, for example in *Acacia catechu*, and root biomass, as in several dry forest species (for example *Drypetesparvifolia*, *Tecliaverdoornia*) of Ghana. Mulching, application of fertilizers, inter planting of leguminous species and mycorrhizal inoculation are useful tools for promoting seedling establishment in nutrient-poor dry tropical soils. Periodic forest fires, and predation affect recruitment and seedling development according to their intensity. Many species experiencing frequent fires have evolved thick seed coats, produce fire-hardy seedlings, or escape the effect by temporal separation of seed dispersal and fire events. Predation may result in abortion of fruits or may enhance germination and recruitment by scarification and dispersal, as in most species of the Guanacaste dry forest. Exposure to elevated CO<sub>2</sub> has increased relative growth rate, total leaf area and water use efficiency in most of the dry tropical seedlings tested, but the magnitude of the effect has varied markedly among species. Due to the availability of a large source of energy, large seeds show higher germination percentage, greater seedling survival and increased growth. Seeds originating from different provenances exhibit differences in germination and seedling growth (for example *Prosopiscineraria*, *Albizialebeck*, *Eucalyptus camaldulensis* and *Acacia mangium*), efficiency of nodulation (for example *Acacia nilotica*, *A. auriculiformis*), and stress resistance (for example *Populusdeltooides*, *Dalbergiasissoo*). These view points out the need for coordinated, long-term, field-based studies for identification of multiple cues and niches for germination, on seed and seedling dynamics in response to fire, and on within-species genetic variability for selection of suitable provenances. Field-based studies at species and community levels are also needed to permit manipulations of biotic components to augment the recruitment of desired species and to suppress that of undesirable species.

**Keywords:** Mycorrhiza, Seed dormancy, Seed size, Seed viability, Shade demand, Restoration

**Emiru Birhane, Demel Teketay & Pia Barklund, 2006. Actual and Potential Contribution of Enclosures to Enhance Biodiversity of Woody Species in the Drylands of Eastern Tigray. *Journal of the Drylands*, 1(2): 134-147.**

Vegetation, soil seed bank and socio-economic settings were studied in enclosures and unprotected areas, to investigate the role of enclosures in the rehabilitation of degraded drylands. Woody vegetation was assessed in fifty plots in enclosure and 30 in unprotected area, each measuring 20 × 20 m<sup>2</sup>. Twenty-seven woody species representing eighteen

families were observed in exclosures and fourteen woody species representing twelve families were recorded in open area. Higher abundance, density and basal area were found in the exclosure. An expanding population structure in exclosure, and obstructed population structure in open area, showed favourable succession in the set-aside area. In both cases, woody species were absent in the soil seed bank. Perception and attitude of communities towards exclosures was positive. Eighty-four percent support conservation and expansion of exclosures. Respondents want local laws (serit) to be improved and contribute to the management of exclosures, rather than to be punitive. Fifty-two percent of the respondents supported subdivision of exclosures; with care for individual management, in our opinion a threat to expansion and collective management. Finally, local people stressed their need to collect firewood from exclosures and wanted to be more involved in management planning and implementation of exclosures.

**Keywords:** Degradation, Natural regeneration, Rehabilitation, Socio-economic survey, Soil seed Bank

**Elmqvist B., Olsson L., Elamin E.M. & Andrew Warren A., 2005. A Traditional Agroforestry System Under Threat: An Analysis of the Gum Arabic Market and Cultivation in the Sudan. *Agroforestry Systems*, 64: 211–218.**

The main aim of this study is to review the environmental and socioeconomic sustainability of the gum arabic farming system in central Sudan. A further aim is to analyse some of the main factors influencing production in recent decades in order to understand the future trade potential and consequently the smallholder livelihood. The study shows that end-user imports of gum arabic have increased during recent decades. Gum arabic is mainly for uses such as soft drinks, confectionary, and pharmaceuticals. However, even with this increased demand the production in Sudan, the main country of production, is declining. The producers, mainly smallholders, suffer from fluctuating prices. If the gum arabic farming system should be able to provide the environmental benefits of improved soil fertility and the socioeconomic benefits of risk spreading and dry season income opportunities, the prices paid to smallholders must be stabilized at a fair level, otherwise a shift to other crops or practices might take place.

**Eriksen Siri H., Katrina Brown & Mick Kelly P., 2005. The Dynamics of Vulnerability: Locating Coping Strategies in Kenya and Tanzania. *The Geographical Journal*, 171 (4): 287-305.**

We investigate how smallholder farmers at two sites in Kenya and Tanzania cope with climate stress and how constraints and opportunities shape variations in coping strategies between households and over time during a drought. On the basis of this analysis, we draw out implications for adaptation and adaptive policy. We find that households where an individual was able to specialize in one favoured activity, such as employment or charcoal burning, in the context of overall diversification by the household, were often less vulnerable than households where each individual is engaged in many activities at low intensity. Many households had limited access to the favoured coping options due to a lack of skill, labour and/or capital. This lack of access was compounded by social relations that led to exclusion of certain groups, especially women, from carrying out favoured activities with

sufficient intensity. These households instead carried out a multitude of less favoured and frequently complementary activities, such as collecting indigenous fruit. While characterized by suitability to seasonal environmental variations and low demands on time and cash investments, these strategies often yielded marginal returns. Both the marginalization of local niche products and the commercialization of forest resources exemplify processes leading to differential vulnerability. We suggest that vulnerability can usefully be viewed in terms of the interaction of such processes, following the concept of locality. We argue that coping is a distinct component of vulnerability and that understanding the dynamism of coping and vulnerability is critical to developing adaptation measures that support people as active agents.

**Keywords:** Kenya, Tanzania, Adaptation, Household vulnerability, Drought coping strategies, Environmental change

**FAO, 2003. Practical guidelines for the assessment, monitoring and reporting on national level criteria and indicators for sustainable forest management in dry forests in Asia. RAP publication 2003/05. Forestry Research Support Programme for Asia and the Pacific & Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific Bangkok, Thailand**

At the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992, countries across the world agreed to develop mechanisms for assessing progress towards sustainable management of their forests. Over the past decade, national and international initiatives concerned with the development and implementation of criteria and indicators (C&I) for sustainable forest management in Asian countries largely focused on boreal, temperate and tropical moist forests. Recognizing the need to develop criteria and indicators specifically oriented towards the unique demands and features of dry forest management, ten Asian countries started the “Regional Initiative for the Development and Implementation of National-level Criteria and Indicators for the Sustainable Management of Dry Forests in Asia” (also called the “Dry Zone Asia Process”). Within this initiative a “reference set” of criteria and indicators for dry forest management was developed. In their efforts to implement these criteria and indicators, participating countries commenced with an exchange of relevant information on methodologies, and cooperated with national institutions in conducting research and testing. The practical guide for the assessment, monitoring and reporting on national-level criteria and indicators for dry forests in Asia, is a comprehensive instruction book on the process of collecting and assembling national level information and reporting. The guidelines provide tools or detailed information on (a) formulating aspects to be assessed for each individual indicator, (b) describing how to obtain, compile and process the relevant information, (c) identifying the means (e.g. documents, sources) used for data collection, and (d) periodicity of measurement and measurement units to be used. In addition, a format for (a) reporting on each individual assessment aspect, and (b) monitoring the indicators using the information collected in two or more subsequent assessments is also provided. Following a brief introduction on dry forest management in Asia, the “reference set” of criteria and indicators developed by the regional initiative is presented. This set of eight criteria and 49 indicators provides the basis for the assessment system, subsequently described in terms of its components and formats used for reporting and monitoring. Some examples taken from the aforementioned set of criteria and indicators for dry forests are provided. In the main part of the guidelines a comprehensive outline of

the assessment system, including reporting and monitoring is presented. For each indicator the assessment procedures, means of verification, periodicity of measurement and units of measurements are outlined. In addition, a format for reporting the results for each indicator is proposed followed by a monitoring format to be used in identifying important aspects of the progress made towards sustainable forest management. The presentation of an individual indicator concludes with a paragraph on interpretation of results. Here, some ideas on positive trends towards sustainable forest management and/or levels to be achieved are given. These interpretations are intended to assist in drafting an overall synthesis on the progress made towards sustainable management for dry forests in a particular country. The guidelines conclude with a chapter on some aspects of assessment implementation such as institutional arrangements, preparations for the assessment, training needs and further application of the system for the improvement of forest management.

**Gemedo-Dalle T., Brigitte L. Maass, & Johannes Isselstein, 2005. Plant Biodiversity and Ethnobotany of Borana Pastoralists in Southern Oromia, Ethiopia. *Economic Botany*, 59(1):43–65**

A survey of plant biodiversity and ethnobotanical studies was conducted in southern Ethiopia using an integrated approach of botanical collections, group discussions, interviews and questionnaires. Species richness, growth forms and uses of native wild plants are described. Borana pastoralists distinguished and named 86% of the plant species identified. A total of 327 plant species distributed among 197 genera and 69 families are documented: 40% are trees/shrubs, 30% forbs (non-woody plants other than grasses and sedges), 16% grasses, 10% climbers, 2% sedges and 2% succulents. Based on richness of species and usefulness, the most important families are *Poaceae*, *Fabaceae*, *Lamiaceae* and *Asteraceae*. Two hundredforty-eight species (76%) are used by Borana pastoralists, out of which 42% have multiple uses. Indigenous knowledge of pastoralists on use and management of their plant resources is a valuable source of information for conservation and sustainable utilization of the plant biodiversity and, hence, conservation based on indigenous knowledge is recommended.

**Keywords:** Species richness, Ethnobotany, Forage, Food, Multi-purpose species.

**Getachew Eshete & Göran Ståhl, 1999. Tree Rings as Indicators of Growth Periodicity of Acacias in the Rift Valley of Ethiopia. *Forest Ecology and Management*, 116 (1-3): 107-117.**

In many arid and semi-arid parts of Ethiopia, acacia trees are important for the rural economy. However, very little is known about the dynamics of the acacia woodlands. In this study, an attempt was made to find out whether or not tree rings in acacias can be used as indicators of growth periodicity. In such a case, growth and yield models could be developed from tree-ring measurements. The study was made in the central part of the Rift Valley of Ethiopia and included samples from both, naturally regenerated and planted acacias. Standard techniques from tree-ring research were employed to study the relationship between tree-ring patterns and different moisture-related climatic variables (e.g. moisture balance, precipitation). Also, the number of rings in trees with known age was counted. The results indicate that the acacias form one ring per rainy season (year) in the dry parts

of this area. In a minor complementary study using X-ray densitometry, the wood density appeared to be correlated with moisture-related climatic variables. However, the technique appeared to be of very limited use for locating growth boundaries.

**Keywords:** *Acacia etbaica*, *Acacia senegal*, *Acacia seyal*, *Acacia tortilis*, Dendroclimatology, Tree-ring chronology, X-ray densitometry

**Gibbon H., Mbithi D., Mugo E.N. & Phiri M., 2005. Forest and Woodland Management in East and Central Africa: Emerging Models for Improvement in Livelihoods and Natural Resource Management in Kenya and Zambia. *International Forestry Review*, 7(3): 193-207.**

Participatory Forest Management is a new strategy for the Forest Departments of Kenya and Zambia. Over the last five years or so, an increasing number of small project initiatives have been supported in both countries to test this model. Progress has been slowed by a lack of policy and legal frameworks, as well as management reluctance to take responsibility for new ideas and ways of engaging with multiple stakeholders. The authors argue that both of these governments as well as the international donors need to collaborate to develop suitable systems for monitoring and assessing progress towards improvements in resource utilisation and livelihoods.

**Keywords:** Kenya, Participatory Forest Management, Zambia, Woodland after management

**Gorsevski Virginia, Martha Geores & Eric Kasischke, 2013. Human Dimensions of Land Use and Land Cover Change Related to Civil Unrest in the Imatong Mountains of South Sudan. *Applied Geography*, 38: 64-75.**

Civil unrest disrupts not only the lives of people in the impacted area, but also the environment in ways not well understood. While armed conflict generally has a negative impact on the immediate environment, the absence of people due to war can be beneficial to local ecosystems and wildlife. Lack of access to a warzone during conflict, however, makes it difficult to gather primary data on the effects of conflict in real time. Satellite imagery has been used successfully to document changes on the landscape during and after war, but additional information is needed to explain the underlying drivers of these observed changes in land use and land cover. To understand how human decisions and actions during war and peace impact land use and subsistence practices, we combined results from key informant interviews with observations made from remotely-sensed satellite imagery and compared expected results with findings in seven major thematic areas. In the high biodiversity region of the Imatong Mountains in South Sudan, we discovered that while some people fled the area during the various conflicts, many others escaped to higher ground to live off the resources available from the forest. Earlier studies indicated that the impact on forest cover during and after the war were minimal in the Imatong Mountains, and extensive in the nearby Dongotana Hills. Discussions with local inhabitants confirmed these findings and provided further insights for how migration and land use patterns impacted forest cover and wildlife in this volatile region.

**Haile G., Gebrehiwot K., Lemenih M. & Bongers F., 2011. Time of Collection and Cutting Sizes Affect Vegetative Propagation of *Boswellia papyrifera* (Del.) Hochst through Leafless Branch Cuttings. *Journal of Arid Environments*, 75: 873-877**

*Boswellia papyrifera* (Del) Hochst is a key dry land plant species in the Horn of Africa with high socioeconomic significance in Ethiopia, Eritrea and Sudan. In recent decades, populations of this species are declining due to lack of recruitment through natural regeneration. This study investigated the potential of vegetative propagation using leafless branch cuttings as an alternative means of reproduction for the species. The effect of time of collection and cutting sizes (length and thickness) on shooting and rooting of the cuttings was investigated. The effects of these three factors were analysed, two-by-two, in three separate factorial experiments each arranged in a randomized complete block design. Time of collection affected cutting performance: shooting percent, shoot number, cutting vigour, leaf number, leaf length, rooting percent and root length were best when cuttings were collected in February, March, and weakest in May. Medium to long cuttings (1.0 m, 2.0 m) and thicker cuttings (0.19e0.27 m) performed better than shorter or thinner cuttings. These results indicate that *B. papyrifera* is amenable to macro propagation via leafless branch cuttings. Reproduction of *B. papyrifera* through macro-propagation may help overcome the population recruitment bottleneck of this important species and will help the long-term yield possibilities of its precious product frankincense.

**Keywords:** Dry lands, Deciduous species, Ethiopia, Frankincense, macro-propagation

**Haubensak K., D'Antonio C. & Wixon D., 2009. Effects of Fire and Environmental Variables on Plant Structure and Composition in Grazed Salt Desert Shrublands of The Great Basin (USA). *Journal of Arid Environments*, 73: 643–650.**

Fire in shrub-dominated portions of the Great Basin, largely fueled by non-native annuals such as *Bromustectorum*, has become an important structuring force altering vegetation composition and soil characteristics. The extent to which fire affects native species in drier portions of the Great Basin, termed salt desert, is poorly documented. We conducted a survey of grazed salt desert habitat in northwestern Nevada 5 years after wildfires burned 650,000 ha, with the goal of investigating community response to fire and factors correlating with post-fire recovery. We found that recruitment of a dominant shrub, *Artemisia spinescens*, is severely restricted following fire: it occurred in only 2 of the 24 burned sites. The co-dominant shrub, *Atriplex confertifolia*, occurred in most burned sites although on average its percent cover was one-third lower than adjacent unburned sites. Biotic soil crust cover was four times lower, and non-native species cover 5 times higher, in burned sites compared to unburned. Ordination analyses confirmed differences among plant communities in burned versus unburned sites, with environmental variables soil conductivity, plant litter, soil potassium (Kb) and pH explaining 38% of the variance in community composition. However, we found no environmental predictors of recovery for native species in burned sites. Future recruitment is likely to be further limited, as fire frequency in the salt desert is expected to increase with invasion by non-native annual grasses and with global climate change.

**Keywords:** Cheat grass, Fire, Grass/fire cycle, Great Basin, Invasion, Non-native grasses, Post-fire recovery, Shrub recruitment



**Hogan C. Michael, 2011. *Forests and Woodlands in Africa*. Encyclopedia of the Earth. UNDP**

Forests and woodlands in Africa occupy an estimated 650 million hectares (ha) or 21.8 percent of the land area of this continent. These account for 16.8 percent of the global forest cover. Many of the forests are severely fragmented due to the encroachment of an expanding human population, leading to demand for firewood and extensive conversion of land to agricultural use. The distribution of forests and woodlands varies from one sub-region to the other, with Northern Africa having the least forest cover while Central Africa has the densest cover. The Congo basin in Central Africa is home to the world's second largest continuous block of tropical rainforest.

**Hassa R.M., 2003. Measuring the Asset Values and Flow Benefits of Non-traded products and Ecosystem Services of Forest and Woodland Resources in South Africa. *Environment, Development and Sustainability*, 5: 403–418.**

Conventional measures of economic output, national income and wealth highly underestimate the value and contribution of natural resources to economic welfare. This paper makes estimates of the asset values and flow benefits of non-traded goods and services from forests and woodland resources in South Africa. Four benefit categories were included, namely direct consumptive use values (timber and non-timber products), non-consumptive use values (recreation for example), indirect use values (environmental services such as carbon sequestration, watershed protection, etc.), and non-use values (based on contingent valuation by tourists). Asset values were calculated knowing the change in physical stocks and the relevant prices. In South Africa, the increase in assets was equivalent to 1.1% of gross domestic product (GDP) (forests were improving, but flows deteriorating), and the flow benefits were equivalent to 0.8% of GDP. These are large magnitudes.

**Irma Trejo & Rodolfo Dirzo, 2000. Deforestation of Seasonally Dry Tropical Forest: A National and Local Analysis in Mexico. *Biological Conservation*, 94: 133-142.**

Seasonally dry tropical forests in the neotropics reach their northernmost distribution in Mexico. This vegetation type has both a high diversity and endemism, yet information about its conservation situation is scarce. This study analyzes the loss of this forest at the national level, comparing its potential coverage with that of the early 1990s; and at the local, using a time-series of the potential vegetation and coverage in 1973 and 1989 in the state of Morelos (central Mexico). At the national level we found that only 27% of the original cover remained as intact forest by 1990. At the local level, close to 60% of the original vegetation has been lost, and only 19% remains in a forested condition. These remnant forests are restricted to areas with steep slopes. An annual deforestation rate of 1.4% was calculated and remaining areas are heavily fragmented and somewhat disturbed. If the trends detected continue, these remaining forests will be heavily reduced and degraded in the near future. Urgent measures to promote their conservation are required.

**Keywords:** Seasonally dry tropical forest, Mexico, Deforestation, State of Morelos, Land use patterns

**Jennifer C. Birch, Adrian C. Newton, Claudia Alvarez Aquino, Elena Cantarello, Cristian Echeverría, Thomas Kitzberger, Ignacio Schiappacasse & Natalia Tejedor Garavito. Cost-Effectiveness of Dryland Forest Restoration Evaluated by Spatial Analysis of Ecosystem Services. *Proceedings of the National Academy of Sciences of the United States of America*, 107 (5):21925-21930.**

Although ecological restoration is widely used to combat environmental degradation, very few studies have evaluated the cost-effectiveness of this approach. We examine the potential impact of forest restoration on the value of multiple ecosystem services across four dryland areas in Latin America, by estimating the net value of ecosystem service benefits under different reforestation scenarios. The values of selected ecosystem services were mapped under each scenario, supported by the use of a spatially explicit model of forest dynamics. We explored the economic potential of a change in land use from livestock grazing to restore native forest using different discount rates and performed a cost–benefit analysis of three restoration scenarios. Results show that passive restoration is cost-effective for all study areas on the basis of the services analyzed, whereas the benefits from active restoration are generally outweighed by the relatively high costs involved. These findings were found to be relatively insensitive to discount rate but were sensitive to the market value of carbon. Substantial variation in values was recorded between study areas, demonstrating that ecosystem service values are strongly context specific. However, spatial analysis enabled localized areas of net benefits to be identified, indicating the value of this approach for identifying the relative costs and benefits of restoration interventions across a landscape.

**Keywords:** Biodiversity, Conservation, Dry forest, Sustainable development

**Jerneck Anne & Lennart Olsson, 2013. Food first! Theorising Assets and Actors in Agroforestry: Risk Evaders, Opportunity Seekers and ‘The Food Imperative’ in Sub-Saharan Africa. *International Journal of Agricultural Sustainability*, 34 (2): 235-256.**

Little is known about the contribution of migrant logging to rural livelihoods in East Africa. In this paper, we analyze logging by circular migrants in land constrained and population dense southwestern Uganda. Drawing on a sample of 180 households, including both migrant and non-migrant households, we describe the demographic and socioeconomic characteristics of migrant loggers, estimate the contribution of migrant logging to household income portfolios, test several hypotheses regarding why households decide to undertake this relatively risky activity, and explore the role of social networks as a determinant of higher incomes for migrant loggers. We find that household endowments of land, labor, and capital are different for migrant logger and comparison group households. Above all, labor endowments appear to be driving decisions to participate in logging. We find support for two migration hypotheses: higher expected incomes and wages at destination; and relative deprivation at origin. We find strong evidence that migrant logging reduces income inequality in the home community.

**Jørn Stave, Gufu Oba, Inger Norda & Nils Chr. Stenseth, 2006. Seedling Establishment of *Acacia tortilis* and *Hyphaenecompressa* in the Turkwel Riverine Forest, Kenya. *African Journal of Ecology*, 44:178-185.**

This study reports on the spatial and temporal patterns of seedling establishment in the Turkwel riverine forest, Kenya. Seedlings of the dominant tree species *Acacia tortilis* and *Hyphaene compressa* were mapped and monitored to assess the underlying causes of seedling recruitment and mortality. The broad-scale distribution of *A. tortilis* was not correlated with any environmental variables, while *H. compressa* seedlings were confined to flood-exposed sites in the arid downstream section of the floodplain. One year of monitoring showed that seedling recruitment of *A. tortilis* was evoked by prolonged rainfall, while seedling mortality was caused by desiccation, browsing and trampling. In contrast, seedling recruitment and mortality of *H. compressa* was largely unaffected by rainfall and livestock, probably due to the high moisture requirements of seeds and the tolerance of seedlings to disturbance. There were no effects of soils, light, or seedling density on the establishment of *A. tortilis* and *H. compressa* seedlings. This study demonstrates the importance of parallel mapping and monitoring of riverine seedlings in order to understand patterns and processes of forest regeneration in arid and semi-arid floodplains.

**Keywords:** Floodplain, Forest regeneration, Herbivory, Rainfall, Seedling dynamics, Turkana

**Laurie Fajardo, Valois González, Jafet M. Nassar, Pablo Lacabana, Carlos A. Portillo Q., Fabián Carrasquel & Jon Paul Rodríguez, 2005. Tropical Dry Forests of Venezuela: Characterization and Current Conservation Status. *Biotropica*, 37(4): 531-546.**

Tropical dry forests are located predominantly in the northern portion of Venezuela, above 6°N. Although their potential extent covers ca 400,000 km<sup>2</sup> (44% of the land), they currently occupy about 10 percent of this area. The diversity and complexity of Venezuelan dry forests increases from north to south along a gradient of decreasing severity of the dry season. A typical dry forest in Venezuela presents ca 110-170 species of plants from ca 40 to 50 families within an area of approximately 10 ha. Species composition and forest structure, however, are dependent on local landscape conditions (e.g., soil type, topography), and nearby forest types can be very different. Our analysis of five dry forest variants showed a maximum family similarity of 67 percent, although most values fell in the 50-60 percent interval. They are currently considered as one of Venezuela's most threatened ecosystems, but only 5 percent of extant dry forests are included in protected areas; this represents 0.5 percent of their potential extent. It is fundamental to promote the creation of at least 3 or 4 more large protected areas (ca 5000 ha), with different climatic and orographic characteristics, in combination with the recovery of threatened species, the restoration of degraded systems, and the implementation of sustainable development projects. Their apparent high resilience suggests that with the proper management we can restore and maintain the integrity of Venezuelan dry forests.

**Keywords:** Composition, Conservation, Distribution, Functional aspects, Land cover change, Land use change, Remote sensing, Species composition, Structure, Tropical dry forests, Venezuela.

**Lera Miles, Adrian C. Newton, Ruth S. De Fries, Corinna Ravillious, Ian May, Simon Blyth, Valerie Kapos & James E. Gordon, 2006. A Global Overview of the Conservation Status of Tropical Dry Forests. *Journal of Biogeography*, 33: 491–505.**

To analyse the conservation status of tropical dry forests at the global scale, by combining a newly developed global distribution map with spatial data describing different threats, and to identify the relative exposure of different forest areas to such threats. We present a new global distribution map of tropical dry forest derived from the recently developed MODIS Vegetation Continuous Fields (VCF) product, which depicts percentage tree cover at a resolution of 500 m, combined with previously defined maps of biomes. This distribution map was overlaid with spatial data to estimate the exposure of tropical dry forests to a number of different threats: climate change, habitat fragmentation, fire, human population density and conversion to cropland. The extent of tropical dry forest currently protected was estimated by overlaying the forest map with a global data set of the distribution of protected areas. It is estimated that 1,048,700 km<sup>2</sup> of tropical dry forest remains, distributed throughout the three tropical regions. More than half of the forest area (54.2%) is located within South America, the remaining area being almost equally divided between North and Central America, Africa and Eurasia, with a relatively small proportion (3.8%) occurring within Australasia and Southeast Asia. Overall, c. 97% of the remaining area of tropical dry forest is at risk from one or more of the threats considered, with highest percentages recorded for Eurasia. The relative exposure to different threats differed between regions: while climate change is relatively significant in the Americas, habitat fragmentation and fire affect a higher proportion of African forests, whereas agricultural conversion and human population density are most influential in Eurasia. Evidence suggests that c. 300,000 km<sup>2</sup> of tropical dry forest now coincide with some form of protected area, with 71.8% of this total being located within South America. Virtually all of the tropical dry forests that remain are currently exposed to a variety of different threats, largely resulting from human activity. Taking their high biodiversity value into consideration, this indicates that tropical dry forests should be accorded high conservation priority. The results presented here could be used to identify which forest areas should be accorded highest priority for conservation action. In particular, the expansion of the global protected area network, particularly in Mesoamerica, should be given urgent consideration.

**Keywords:** Biodiversity, Climate change, Deforestation, Dry forests, Fire, Protected areas, Threat, Vulnerability

**Maas J., Balvanera P., Castillo A., Daily G. C., Mooney H. A., Ehrlich P., Quesada M., Miranda A., Jaramillo V. J., García-Oliva F., Martínez-Yrizar A., Cotler H., López-Blanco J., Pérez-Jiménez A., Búrquez A., Tinoco C., Ceballos G., Barraza L., Ayala R. & Sarukhán J., 2005. Ecosystem Services of Tropical Dry Forests: Insights from Long-Term Ecological and Social Research on the Pacific Coast of Mexico. *Ecology and Society*, 10 (1): 17**

In the search for an integrated understanding of the relationships among productive activities, human well-being, and ecosystem functioning, we evaluated the services delivered by a tropical dry forest (TDF) ecosystem in the Chamela Region, on the Pacific Coast of Mexico. We synthesized information gathered for the past two decades as part of a long-term ecosystem research study and included social data collected in the past

four years using the Millennium Ecosystem Assessment (MA) conceptual framework as a guide. Here we identify the four nested spatial scales at which information has been obtained and emphasize one of them through a basin conceptual model. We then articulate the biophysical and socioeconomic constraints and drivers determining the delivery of ecosystem services in the Region. We describe the nine most important services, the stakeholders who benefit from those services, and their degree of awareness of such services. We characterize spatial and temporal patterns of the services' delivery as well as trade-offs among services and stakeholders. Finally, we contrast three alternative future scenarios on the delivery of ecosystem services and human well-being. Biophysical and socioeconomic features of the study site strongly influence human-ecosystem interactions, the ecosystem services delivered, the possible future trajectories of the ecosystem, and the effect on human well-being. We discuss future research approaches that will set the basis for an integrated understanding of human-ecosystem interactions and for constructing sustainable management strategies for the TDF.

**Keywords:** Chamela Region, Ecological economics, Ecosystem services, Integrative research, Mexico, Pacific Coast, Millennium Ecosystem Assessment, Socioecological systems, Tropical dry forest

**MacKinnon Kathy, Chow Nola, Esikuri Enos & Platais Gunars, 2000. *Conserving and Managing Biodiversity in Dryland Ecosystems*. World Bank, Washington D.C.**

Drylands occur on all continents and are estimated to cover some 61 million square kilometers or just over 47 percent of the earth's land surface. For some time the World Bank has been assisting many of its member countries with projects that address natural resource management, resource degradation and desertification in dryland ecosystems. Throughout the world, the Bank is supporting establishment of new conservation areas and the strengthening of management of paper parks in dryland ecosystems. Outside protected areas, several projects focus on sustainable land use and improved natural resource management in dryland ecosystems. A new Global Environmental Fund window for strengthening conservation awareness has been through medium-sized grants. The overarching mission of the World Bank Group is poverty eradication. Consistent with that mission, the Bank recognizes that biodiversity underpins human welfare and economic development and that many sectors of national and local economies depend on biological diversity, natural ecosystems, productive landscapes and the environmental services they provide.

**Mastewal Yami, Kindeya Gebrehiwot, Steinand M. & Wolde Mekuria, 2007. Impact of Area Enclosures on Density, Diversity, and Population Structure of Woody Species: The Case of May Ba'ati-Douga Tembien, Tigray, Ethiopia. *East African Journal of Science*, 1(1):55-68.**

Regional authorities in Tigray, northern Ethiopia have been promoting rehabilitation of degraded lands through area enclosures since 1991. Area enclosures have proven to be the best land management practices for establishing ecologically and economically sustainable land-use planning. There is a need for further investigation and documentation of the impact of area enclosures on density and diversity of woody species. This is because Ethiopia

in general, and Tigray in particular, have varied climate, soil and cultural differences in natural resource management, and because there few studies have been conducted on the impact of enclosures on ecological restoration. The present study was conducted in Douga Tembien, Tigray. Data were collected using systematic line plot sampling. The results of the study showed that enclosures have higher density and diversity of woody species than the adjacent unprotected areas. Following the age gradient, the older enclosures had higher density and diversity of woody species than the younger enclosures. This suggests that man and livestock affect the density and diversity of woody species. The frequency distribution of woody species showed almost an inverted J-shape. However, although the study sites show good regeneration, there are few or no individuals seen as one goes to higher diameter classes. This could be due to selective removal of bigger woody species for fuel wood and construction purposes. From the view point of ecological restoration, it is suggested that area enclosures are effective for increasing biodiversity and for rehabilitating degraded areas in a few years, if they are well protected from human and livestock disturbance.

**Keywords:** Ecological restoration, Enclosures, Land management, Livelihood

**Matiru Violet, 1999. *Forest Cover and Forest Reserves in Kenya: Policy and Practice.* IUCN.**

This report is an update of the 1996 IUCN report on issues related to forests in Kenya. It brings up to date developments on the status of forests, including official excisions and additions to gazetted forests for the period of 1995-1999. The 1996 report has been revised to include legislation that was excluded. In addition, proposed legislation has been discussed. The report, based on official documentation publicly available, raises serious concerns about the management of Kenya's forests and their need to be addressed. Data has been collected, reviewed and analysed with a view to coming up with another source of available information for discussion on the forestry sector. Information pertaining to excisions and forest degradation have been derived from the Kenya Gazette, the Kenya Gazette Supplements, government institutions and departments. Although Kenya's policy and legal framework provides for a firm foundation for sustainable forest management, there are shortfalls in implementation. Excision and degradation of forests in Kenya continue, with little regard to the laws and the quality and importance of the forests. The last section of this publication discusses issues related to forest management including difficulties in obtaining accurate and timely data on forests, the implementation of policy and legislation, the management and co-ordination of implementing agencies, forest excisions and degradation and community participation in forest management.

**Matt W. Hayward & Graham I.H. Kerley, 2009. Fencing For Conservation: Restriction of Evolutionary Potential or a Riposte to Threatening Processes? *Biological Conservation*, 142(1):1-13.**

Fencing for conservation is an acknowledgement that we are failing to successfully co-exist with and, ultimately, conserve biodiversity. Fences arose during the Neolithic revolution to demarcate resource-rich areas (food sources) and exclude threats (intruders). Fencing for conservation can be viewed as fulfilling a similar function. The aims of this paper were to identify when fencing can and is used to conserve biodiversity; highlight the costs and

benefits of fencing for conservation; and make recommendations to ensure appropriate use of fencing for conservation in the future. The IUCN identifies ten major threatening processes and the impacts of eight of these can be mitigated via the use of fencing, however avoiding human–animal conflict and reducing the impact of introduced predators are the two most common uses. Fences implemented to achieve a conservation benefit are not necessarily physical barriers, but can also include ‘metaphorical’ fences of sound, smoke and smell, or even actual islands. Fences provide defined units for managers and separate biodiversity from threatening processes including human persecution, invasive species and disease. Conversely, they are costly to build and maintain; they have ecological costs through blocking migration routes, restriction of biodiversity range use which may result in overabundance, inbreeding and isolation; restriction of evolutionary potential; management; amenity and ethical costs. Despite these problems, fencing for conservation is likely to become increasingly utilized as biodiversity becomes increasingly threatened and methods of ameliorating threats lag behind. In the long-term, fences may ultimately prove to be as much a threat to biodiversity as the threats they are meant to exclude, and a new research agenda should arise to ensure that conservation fences do not remain a permanent part of the landscape.

**Keywords:** Biodiversity conservation, Fences, Human–wildlife conflict, Invasive species, Introduced predators, Bushmeat hunting, Poaching, Threatening processes, Tragedy of the commons

**Measham Thomas G. & Jared A. Lumbasi, 2013. Success Factors for Community-Based Natural Resource Management (CBNRM): Lessons from Kenya and Australia. *Environmental Management*, 52:649-659.**

Recent concerns over a crisis of identity and legitimacy in community-based natural resource management (CBNRM) have emerged following several decades of documented failure. A substantial literature has developed on the reasons for failure in CBNRM. In this paper, we complement this literature by considering these factors in relation to two successful CBNRM case studies. These cases have distinct differences, one focusing on the conservation of hirola in Kenya on community-held trust land and the other focusing on remnant vegetation conservation from grazing pressure on privately held farm land in Australia. What these cases have in common is that both CBNRM projects were initiated by local communities with strong attachments to their local environments. The projects both represent genuine community initiatives, closely aligned to the original aims of CBNRM. The intrinsically high level of “ownership” held by local residents has proven effective in surviving many challenges which have affected other CBNRM projects: from impacts on local livelihoods to complex governance arrangements involving non-government organizations and research organizations. The cases provide some signs of hope among broader signs of crisis in CBNRM practice.

**Miles Lera, Adrian C. Newton, Ruth S. De Fries, Corinna Ravilious, Ian May, Simon Blyth, Valerie Kapos & James E. Gordon, 2006. A Global Overview of the Conservation Status of Tropical Dry Forests. *Journal of Biogeography*, 33: 491-505.**

To analyse the conservation status of tropical dry forests at the global scale, by combining a newly developed global distribution map with spatial data describing different threats,

and to identify the relative exposure of different forest areas to such threats. We present a new global distribution map of tropical dry forest derived from the recently developed MODIS Vegetation Continuous Fields (VCF) product, which depicts percentage tree cover at a resolution of 500 m, combined with previously defined maps of biomes. This distribution map was overlaid with spatial data to estimate the exposure of tropical dry forests to a number of different threats: climate change, habitat fragmentation, fire, human population density and conversion to cropland. The extent of tropical dry forest currently protected was estimated by overlaying the forest map with a global data set of the distribution of protected areas. It is estimated that 1,048,700 km<sup>2</sup> of tropical dry forest remains, distributed throughout the three tropical regions. More than half of the forest area (54.2%) is located within South America, the remaining area being almost equally divided between North and Central America, Africa and Eurasia, with a relatively small proportion (3.8%) occurring within Australasia and Southeast Asia. Overall, c. 97% of the remaining area of tropical dry forest is at risk from one or more of the threats considered, with highest percentages recorded for Eurasia. The relative exposure to different threats differed between regions: while climate change is relatively significant in the Americas, habitat fragmentation and fire affect a higher proportion of African forests, whereas agricultural conversion and human population density are most influential in Eurasia. Evidence suggests that c. 300,000 km<sup>2</sup> of tropical dry forest now coincide with some form of protected area, with 71.8% of this total being located within South America. Virtually all of the tropical dry forests that remain are currently exposed to a variety of different threats, largely resulting from human activity. Taking their high biodiversity value into consideration, this indicates that tropical dry forests should be accorded high conservation priority. The results presented here could be used to identify which forest areas should be accorded highest priority for conservation action. In particular, the expansion of the global protected area network, particularly in Mesoamerica, should be given urgent consideration.

**Keywords:** Biodiversity, Climate change, Deforestation, Dry forests, Fire, Protected areas, Threat, Vulnerability

**Muhweezi Alex B., George M. Sikoyo & Mathia Chemonges, 2007. Introducing a Transboundary Ecosystem Approach in the Mount Elgon Region. *Mountain Research and Development*, 27(3): 215-219.**

The Mt Elgon ecosystem straddles the international boundary between Kenya and Uganda and is a watershed of international importance, feeding the waters of Lake Victoria, the Nile River system, and Lake Turkana. The core ecosystem in the Mt Elgon area is characterized by large montane forest landscapes; it comprises several protected areas. Adjacent is a vast, heavily populated agricultural landscape supporting up to 2 million people, whose livelihoods and economic activities are largely dependent on the ecosystem goods and services of the highlands. The mountain ecosystem of Mt Elgon is thus vital to the social and economic functioning of the surrounding areas, both in the highlands and in the lowlands. To manage this important ecosystem and sustain the multiple functions and services it offers local people and visitors, there is a need for a regional transboundary ecosystem management approach and strengthened institutional collaboration between all stakeholders concerned at different levels. The Mt Elgon Regional Ecosystem Conservation Programme (MERECP) aims to secure the multifunctionality of the Mt Elgon ecosystem and enhance sustainable development in the long term, in order to secure livelihoods and



alleviate poverty, both of which are priorities of the governments of Uganda and Kenya. The present article provides insights from experience and lessons learned to date regarding the planning and implementation of such a transboundary regional ecosystem approach.

**Mulugeta Lemenih & Demel Teketay, 2003. Frankincense and Myrrh Resources of Ethiopia: II. Medicinal and Industrial Uses. *Ethiopian Journal of Science*, 26(2):161–172.**

Oleo-gum resins such as frankincense and myrrh are some of the economically and culturally valuable products obtained from trees and shrubs of the genera *Boswellia* and *Commiphora*, respectively. They are important natural plant products used in several industries that include pharmacology, food, flavour, liqueur and beverage, cosmetics, perfumery and others. Moreover, frankincense and myrrh have several local applications in medicinal, hygienic, and insecticide areas that could be developed through research. They are widely used in traditional medicines of several countries for treatments of a wide variety of ailments from embalming to cancer, leprosy, bronchitis, diarrhea, dysentery, typhoid, mouth ulcers, inflammatory complaints, viral hepatitis, female disorders, infections/wounds, coughs, tumour, and others. Although Ethiopia is one of the few countries that are endowed with large frankincense and myrrh resources, little proper exploitation of these resources has been made so far. In this paper a review is presented on pharmacological and industrial applications of these valuable resources. The information is expected to prompt the enormous economic opportunity that these resources could provide both at national and local levels. Concurrently, this opportunity, if properly exploited, will contribute significantly towards the conservation and management of the vegetation resources that yield frankincense and myrrh as well as their ecosystems.

**Keywords:** *Boswellia*, *Commiphora*, Folk medicines, Industrial use, Pharmacology

**Motuma Tolera, Ute Sass-Klaassen, Abeje Eshete, Frans Bongers & Frank J. Sterck, 2013. Frankincense Tree Recruitment Failed Over the Past Half Century. *Forest Ecology and Management*, 304: 65–72.**

*Boswellia papyrifera* (Burseraceae) trees grow in dry woodlands south of the Sahara and produce frankincense the economically important olio-gum resin used for cultural and religious ceremonies throughout the world and as raw material in several industries. Across its distribution area, this species is threatened by farmland expansion, fire, improper tapping and overgrazing. Most of its populations lack saplings and small-sized trees (e.g. <10 cm). It is unknown whether the older, adult trees represent a single or several cohorts, representing single or plural regeneration and survival waves. To understand such long-term population dynamics, it is imperative to evaluate the age structure of the current populations. We used tree ring analysis to determine the age-diameter relationship. This study, (1) determines radial growth dynamics and age-diameter relationship of *B. papyrifera*, including verification of annual growth-ring formation, and (2) constructs the population age structure and discusses consequences thereof for population maintenance and long-term frankincense production. We could prove that *B. papyrifera* forms annual growth rings. The average radial annual growth rate of *B. papyrifera* is 1.15 mm (s.d. = 0.22) and varies significantly among the sampled trees. Age and diameter of *B. papyrifera* trees

are significantly correlated. From the population-age structure, it becomes obvious that the current *B. papyrifera* populations lack successful recruitment since 1955, which we attribute to intensive grazing and fire associated with the escalating increase of human settlement in the area. Lack of recruitment leads to rapidly declining populations resulting in strongly reduced frankincense production. Management aimed at seedling survival and sustainable use of relic trees is urgent.

**Keywords:** *Boswellia papyrifera*, Age structure, Pinning, Growth rings, Frankincense, Recruitment lack

**Namaalwa J., Eid T. & Sankhayan P., 2005. A multi-species Density-Dependent Matrix Growth Model for the Dry Woodlands of Uganda. *Forest Ecology and Management*, 213: 312–327.**

A density-dependent matrix growth model was constructed for the dry woodlands of Uganda basing on material collected from 42 sample plots with 7904 trees. The model was based on functions for individual tree up growth and mortality, and area based ingrowth, with explicatory variables representing tree size, stand density and stand structure. The trees were pooled into three species groups basing on ecological and morphological criteria. For all groups, parameter estimates for tree size and stand density were found highly significant ( $p < 0.001$ ) in predicting diameter increment and mortality except stand density for the upper storey species group ( $p = 0.067$ ), while stand structure was found highly significant only for the intermediate storey species group. Ingrowth was modelled by a two-stage approach. Parameter estimates for a logistic function predicting the probability of ingrowth were statistically significant ( $p < 0.05$ ) only for the intermediate storey species group, while no conditional ingrowth functions were built for any species group. A visual evaluation of the individual functions was carried out and the matrix model in totality was evaluated by comparing the number of trees ha<sup>-1</sup> and basal area ha<sup>-1</sup> for each plot at the time of the second inventory with the model predictions. Although the data used for model evaluation was not independent, it was concluded that the model is a reliable and fairly accurate tool for prediction of growth of dry woodland trees in of Uganda. The model may become a useful tool for a sustainable management of these woodlands, which are an important source of bioenergy for consumers in several urban centres.

**Peter Groenendijk, Abeje Eshete, Frank J. Sterck, Pieter A. Zuidema & Frans Bongers, 2012. Limitations to Sustainable Frankincense Production: Blocked Regeneration, High Adult Mortality and Declining Populations. *Journal of Applied Ecology*, 49: 164–173.**

Resins are highly valued non-timber forest products (NTFP). One of the most widely traded resins is frankincense, tapped from several *Boswellia* tree species (Burseraceae). Exploited *Boswellia* populations often show poor regeneration, but the demographic consequences of these bottlenecks are unknown. Here we report on the first large-scale demographic study of frankincense-producing trees. We studied 12 populations of *Boswellia papyrifera* in northern Ethiopia, varying in altitude and productivity. Six of these populations had been tapped before and were tapped during the study. Survival, growth and fecundity were determined for 4370 trees and 2228 seedlings, in 22.8 ha over a 2-year period. We

also studied a remote population where no grazing and tapping took place. Matrix models were used to project population growth and frankincense production under four restoration scenarios. Population structures of both tapped and untapped populations showed clear gaps. Small seedlings were abundant in all populations, but none developed into persistent saplings. Such saplings were only present in the remote population. Fire and grazing are the likely causes of this regeneration bottleneck. Adult mortality was high (6–7% per year) in both tapped and untapped populations, probably caused by beetle attacks and fire. Unexpectedly, tapped populations presented higher diameter growth rates and fecundity compared to untapped populations. These differences are probably caused by non-random selection of exploited populations by tappers. Under the ‘business as usual’ scenario, population models projected a 90% decline in the size of tapped and untapped populations within 50 years and a 50% decline in frankincense yield within 15 years. Model simulations for restoration scenarios revealed that populations and frankincense production could only be sustained with intensive management leading to full sapling recruitment and a 50–75% reduction in adult mortality. Synthesis and applications. Regeneration bottlenecks and high adult mortality are causing rapid decline in frankincense-producing tree populations in Ethiopia. This decline is unlikely to be a consequence of harvesting and is probably driven by fire, grazing and beetle attacks. Fire prevention and the establishment of non-grazing areas are needed. Our results show that other factors than exploitation may seriously threaten populations yielding NTFP.

**Keywords:** *Boswellia papyrifera*, Ethiopia, Frankincense, Matrix model, Non-timber forest products, Regeneration bottleneck, Resin, Restoration, Sustainable use, Tapping

**Peter G. Murphy & Ariel E. Lugo, 1986. Ecology of Tropical Dry Forest. *Annual Review of Ecology and Systematics*, 17: 67-88.**

According to the Holdridge system of life zone classification (42), dry tropical and subtropical forests and woodlands occur in frost-free areas where the mean annual biotemperature is higher than 17°C, where mean annual rainfall is 250-2000 mm, and where the annual ratio of potential evapotranspiration (PET) to precipitation (P) exceeds unity. The many types of woodland and forest ecosystems that fall within this climatic envelope are widespread, usually transitional between semi desert or savanna and moist forest. About 40% of the earth’s tropical and subtropical landmass is dominated by open or closed forest. Of this, 42% is dry forest, 33% is moist forest, and only 25% is wet and rain forest (sensu Holdridge, 42; 15). We will never know the true original or potential extent of dry forest because many savannas and scrub or thorn woodlands are thought to be derived from disturbed dry forest. Walter (110), for example, considers most or all of the grassland in India to have been derived from seasonal or dry forest. Some of the processes that cause this conversion are addressed later in this review. The largest proportion of dry forest ecosystems is in Africa and the world’s tropical islands, where they account for 70-80% of the forested area. In South America they The US Government has the right to retain a nonexclusive, royalty-free license in and to any copyright covering this work represent only 22% of the forested area but in Central America almost 50% (14). Although literature has proliferated concerning the ecology of certain types of tropical ecosystems, such as savanna (12,47,99) and rain forest (39a, 101, 103b, 114), far less attention has been given to tropical and subtropical dry forest and woodland. Our focus is on this relatively neglected category of ecosystems,

which we refer to in the collective sense as tropical dry forest. Our emphasis is on the plant, as opposed to animal, component of the system.

**Raf Aerts & Olivier Honnay, 2011. Forest Restoration, Biodiversity and Ecosystem Functioning (A Review). BMC Ecology, 11:29.**

Globally, forests cover nearly one third of the land area and they contain over 80% of terrestrial biodiversity. Both the extent and quality of forest habitat continue to decrease and the associated loss of biodiversity jeopardizes forest ecosystem functioning and the ability of forests to provide ecosystem services. In the light of the increasing population pressure, it is of major importance not only to conserve, but also to restore forest ecosystems. Ecological restoration has recently started to adopt insights from the biodiversity-ecosystem functioning (BEF) perspective. Central is the focus on restoring the relation between biodiversity and ecosystem functioning. Here we provide an overview of important considerations related to forest restoration that can be inferred from this BEF-perspective. Restoring multiple forest functions requires multiple species. It is highly unlikely that species-poor plantations, which may be optimal for above-ground biomass production, will outperform species diverse assemblages for a combination of functions, including overall carbon storage and control over water and nutrient flows. Restoring stable forest functions also requires multiple species. In particular in the light of global climatic change scenarios, which predict more frequent extreme disturbances and climatic events, it is important to incorporate insights from the relation between biodiversity and stability of ecosystem functioning into forest restoration projects. Rather than focusing on species per se, focusing on functional diversity of tree species assemblages seems appropriate when selecting tree species for restoration. Finally, also plant genetic diversity and above - below-ground linkages should be considered during the restoration process, as these likely have prominent but until now poorly understood effects at the level of the ecosystem. The BEF-approach provides a useful framework to evaluate forest restoration in an ecosystem functioning context, but it also highlights that much remains to be understood, especially regarding the relation between forest functioning on the one side and genetic diversity and above-ground-below-ground species associations on the other. The strong emphasis of the BEF-approach on functional rather than taxonomic diversity may also be the beginning of a paradigm shift in restoration ecology, increasing the tolerance towards allochthonous species.

**Rodolfo Rodríguez, Antonio Mabresa, Brian Luckmanb, Michael Evansc, Mariano Masiokasb & Tone M. Ektvedtd, 2005. “El Niño” Events Recorded in Dry-Forest Species of the Lowlands of Northwest Peru. *Dendrochronologia*, 22:181–186.**

The northwest coast of Peru (51S, 801W) is very sensitive to and impacted by the climate phenomenon El Niño or Southern Oscillation (ENSO). Though mainly desert, this warm, dry region contains an equatorial dry forest. We report the first dendrochronological studies from this region and identify several species that have dendrochronological potential. Short ring-width chronologies of Pal o Santo (*Bursera graveolens*) show a well-developed response to the ENSO signal over the last 50 years and good inter-site correlations. Preliminary isotopic studies in Algarrobo (*Prosopis* spp.) also show evidence of the 1997–98 El Niño event. ENSO events have a strong effect on the variability in the growth of several species and thereby on the economy of rural communities where the wood is used for housing, cooking,

furniture, tools, fodder and medicinal uses. The extensive use of wood in archeological sites also offers the possibility of ultimately developing longer records for some of these species.

**Sarah M. Otterstrom, Mark W. Schwartz & Ileana Velázquez-Rocha, 2006. Responses to Fire in Selected Tropical Dry Forest Trees. *Biotropica*, 38:592-598.**

Fire is a frequent disturbance in the tropical dry forests of Central America, yet very little is known about how native species respond to such events. We conducted an experiment in a tropical dry forest of western Nicaragua to evaluate plant responses to fire with respect to survivorship and recruitment. Measurement of woody vegetation of all size classes were carried out prior to the prescribed burn and three successive years post fire. We selected the 15 most abundant species <10cm DBH to assess percent survivorship and sprouting responses post fire. Changes in seedling densities for these 15 most abundant species and the 15 least abundant species were analyzed using a repeated measure ANOVA. We also assessed changes in seedling densities for three species of international conservation concern. We found three major fire-coping strategies among common dry forests plants: resisters (low fire-induced mortality), re sprouters (vigorous sprouting), and recruiters (increased seeding post-fire). While survivorship was generally high relative to tropical moist forest species, those species with lower survivorship used either seeding or sprouting as an alternative strategy for persisting in the forest community. Seed dispersal mechanisms particularly wind dispersal appear to be an important factor in recruitment success post-fire. Burn treatment led to a significant increase in the density of seedlings for two species of conservation concern: *Guaiacums anctum* and *Swieteniahumilis*. Results of this study suggest that common dry forest species in western Nicaragua are fire tolerant. Further study of individual species and their fire responses is merited.

**Sanchez Pedro A., Roland J. Buresh & Roger R.B. Leakey, 1997. Trees, Soils, and Food security. *Philosophical Transactions; Biological Sciences*, 352: 949-961.**

Trees have a different impact on soil properties than annual crops, because of their longer residence time, larger biomass accumulation, and longer-lasting, more extensive root systems. In natural forests nutrients are efficiently cycled with very small inputs and outputs from the system. In most agricultural systems the opposite happens. Agroforestry encompasses the continuum between these extremes, and emerging hard data is showing that successful agroforestry systems increase nutrient inputs, enhance internal flows, decrease nutrient losses and provide environmental benefits-when the competition for growth resources between the tree and the crop component is well managed. The three main determinants for overcoming rural poverty in Africa are (i) reversing soil fertility depletion, (ii) intensifying and diversifying land use with high-value products, and (iii) providing an enabling policy environment for the smallholder farming sector. Agroforestry practices can improve food production in a sustainable way through their contribution to soil fertility replenishment. The use of organic inputs as a source of biologically-fixed may be the key to increasing and sustaining phosphorus capital. High-value trees-'Cinderella' rewarding economically, in addition to diversifying and increasing rural incomes and improving food population pressure promotes deforestation, there is evidence that demonstrates that there are conditions under which increasing tree planting is occurring on farms in the tropics through successful agroforestry as human population density increases.

**Scherr Sara T. & Jeffrey A. McNeely, 2008. Biodiversity Conservation and Agricultural Sustainability: Towards a New Paradigm of 'Ecoagriculture' Landscapes. *Philosophical Transactions: Biological Sciences*, 363 (1491): 477-494.**

The dominant late twentieth century model of land use segregated agricultural production from areas managed for biodiversity conservation. This model is no longer adequate in much of the world. The Millennium Ecosystem Assessment confirmed that agriculture has dramatically increased its ecological footprint. Rural communities depend on key components of biodiversity and ecosystem services that are found in non-domestic habitats. Fortunately, agricultural landscapes can be designed and managed to host wild biodiversity of many types, with neutral or even positive effects on agricultural production and livelihoods. Innovative practitioners, scientists and indigenous land managers are adapting, designing and managing diverse types of 'ecoagriculture' landscapes to generate positive co-benefits for production, biodiversity and local people. We assess the potentials and limitations for successful conservation of biodiversity in productive agricultural landscapes, the feasibility of making such approaches financially viable, and the organizational, governance and policy frameworks needed to enable ecoagriculture planning and implementation at a globally significant scale. We conclude that effectively conserving wild biodiversity in agricultural landscapes will require increased research, policy coordination and strategic support to agricultural communities and conservationists.

**Keywords:** Ecoagriculture, Landscape, Biodiversity conservation, Agricultural production, Rural livelihoods

**Steenkampa C.J., Vogelb J.C., Fulsb A., van Rooyena N. & van Rooyena M.W., 2008. Age Determination of *Acacia erioloba* Trees in the Kalahari. *Journal of Arid Environments*, 72:302–313.**

High quality wood core samples were collected from individual *Acacia erioloba* trees of unknown age in the Kgalagadi Trans frontier Park. In the majority of samples examined, seasonal changes were reflected in the wood anatomy as bands of marginal parenchyma on the polished surfaces of discs or cores. Estimated radiocarbon age was determined by means of  $^{14}\text{C}$  analysis for all samples. There was a strong correlation between the annual growth ring count and estimated radiocarbon age. A correlation was also found between age and stem circumference. Age structure of several *A. erioloba* populations in the Kgalagadi Trans frontier Park was subsequently determined. It could be demonstrated that the populations growing in the bed of the Nossob River showed poor recruitment; however, no clear relationship was found between flooding and regeneration of *A. erioloba* in the riverbed. The population growing in the dune field had a healthy age structure.

**Keywords:** Age structure, Carbon dating, Dendrochronology, Population dynamics, Tree rings, Wood anatomy

**Stringer L.C. & Dougill A.J., 2013. Channeling Science into Policy: Enabling Best Practices from Research on Land Degradation and Sustainable Land Management in Dryland Africa. *Journal of Environmental Management*, 114: 328-335.**

Demands are increasing for scientific research to be explicitly and demonstrably policy relevant. Research funders are requiring greater returns on their investments and scientists

are expected to demonstrate clearly how their research can inform policy and regulation to deliver positive consequences for societal, economic and environmental wellbeing. Within the co-evolving context of environmental management research in dryland Africa and the policy approaches designed to mitigate land degradation, few academic analyses have deconstructed the practical 'bottom-up' actions that can help to channel scientific research into national decision-making and policy. Similarly, while international platforms developed by the United Nations Convention to Combat Desertification have started to facilitate greater knowledge exchange between scientists and policymakers, analyses have failed to consider the powerful informal actions that scientists can take to allow their research to inform evidence-based international policy. Drawing on examples in the literature from research on land degradation and sustainable land management across sub-Saharan African drylands, we identify key enabling activities that help make scientific research more visible, accessible to, and compatible with, policy processes at local, national and international levels. We argue that these enablers are applicable to other environmental research areas beyond land degradation, and suggest that improved understanding of science into policy processes that look across multiple scales and levels will help researchers and policymakers to better match information supply and demand to the mutual benefit of both groups.

**Sunnichan V. G., Mohan Ram H. Y. & Shivanna K. R., 2005. Reproductive Biology of *Boswellia serrata*, the Source of Salai Guggul, an Important Gum-Resin. *Botanical Journal of the Linnean Society*, 147: 73–82.**

Detailed studies were carried out on the phenology, floral biology, pollination ecology and breeding system of *Boswellia serrata* Roxb. (Burseraceae) the source of 'salaiguggul'. The trees remain leafless during the entire period of flowering and fruiting. The inflorescence is a terminal raceme and produces up to 90 bisexual, actinomorphic flowers. On average a flower produces starch-filled pollen grains. About 85% of the fresh pollen grains are viable; the pollen to ovule ratio is 3348 : 1. The stigma is of the wet papillate type. The style is hollow with three flattened stylar canals filled with a secretion product. The stylar canals are bordered by a layer of glandular canal cells. The inner tangential wall of the canal cells shows cellulose thickenings. The ovary is trilocular and bears three ovules, one in each locule. Flowers offer nectar and pollen as rewards to floral visitors. The giant Asian honeybee (*Apis dorsata*) and *A. ceranavar. Indica* (Indian honey bee) are the effective pollinators. The species is self-incompatible and the selfed pollen tubes are inhibited soon after their entry into the stigma. Self-pollen tubes develop a characteristic 'isthmus' as a result of enlargement of the tube soon after emergence through the narrow germ pore. Cross-pollinated flowers allowed normal pollen germination and pollen tube growth, and resulted in fruit and seed-set. Under open pollination fruit-set was only about 10%. Although manual cross-pollinations increased fruit set, it was only up to about 20%. Low fruit set appears to be the result of inadequate cross-pollination and other constraints, presumably limitation of available nutrients.

**Keywords:** Breeding system, Burseraceae, Pollen–pistil interaction, Pollination ecology, Self-incompatibility.

**Tadesse W., Desalegn G. & Alia R., 2007. Natural Gum and Resin Bearing Species of Ethiopia and their Potential Applications. *Investigación Agraria: Sistemas y Recursos Forestales*, 16(3): 211-221.**

Ethiopia is one of the countries well-endowed with various species of *Acacia*, *Boswellia* and *Commiphora* that are known to produce gum arabic, frankincense and myrrh, respectively. Over 60 gum and resin bearing species are found in the country. The total area of oleo-gum resin bearing woodlands cover about 2.9 million ha of land in the country, with over 300,000 metric tons of natural gum production potential. *Boswellia papyrifera* is a chief gum resin producing tree species in Ethiopia. The total area covered by the species is estimated to be more than 1.5 million ha. Frankincense and myrrh are used in medicines, beverages and liqueurs, cosmetics, detergents, creams and perfumery, paints, adhesives and dyes manufacturing. Gum Arabic is used as stabilizing, in food and drink industries; in pharmaceuticals, in printing and textile industries. Despite the enormous socio-economic importance of these natural products, the species are declining at an alarming rate due to degradation resulted from agricultural expansion, overgrazing, fire, poor incense harvesting practices, etc. Therefore, research and development efforts and international collaborations could have strong potentials to the conservation, production and commercialization for the benefits of the local, national as well as the international communities.

**Key words:** *Acacia*, *Boswellia*, *Commiphora*, Frankincense, Gum arabic, Myrrh.

**Tefera Mengistu, Frank J. Sterck, Masresha Fetene, Wubalem Tadesse & Frans Bongers, 2001. Leaf Gas Exchange in the Frankincense Tree (*Boswellia papyrifera*) of African Dry Woodlands. *Tree Physiology*, 31: 740–750.**

A conceptual model was tested for explaining environmental and physiological effects on leaf gas exchange in the deciduous dry tropical woodland tree *Boswellia papyrifera* (Del.) Hochst. For this species we aimed at (i) understanding diurnal patterns in leaf gas exchange, (ii) exploring cause–effect relationships among external environment, internal physiology and leaf gas exchange, and (iii) exploring site differences in leaf gas exchange in response to environmental variables. Diurnal courses in gas exchange, underlying physiological traits and environmental variables were measured for 90 trees on consecutive days at two contrasting areas, one at high and the other at low altitude. Assimilation was highest in the morning and slightly decreased during the day. In contrast, transpiration increased from early morning to midday, mainly in response to an increasing vapor pressure deficit (VPD) and gradual stomatal closure. The leaf water potential varied relatively little and did not influence gas exchange during the measurement period. Our results suggest that the same cause–effect relationships function at contrasting areas. However, leaves at the higher altitude had higher photosynthetic capacity, reflecting acclimation to higher light levels. Trees at both areas nevertheless achieved similar leaf assimilation rates since assimilation was down-regulated by stomatal closure due to the higher VPD at the higher altitude, while it became more light limited at the lower altitude. Gas exchange was thus limited by a high VPD or low light levels during the wet season, despite the ability of the species to acclimate to different conditions.

**Keywords:** *Boswellia*, Diurnal variation, Path analysis, Photosynthesis, Tropical dry woodlands



**Tefera Mengistu, Frank J. Sterck, Niels P.R. Anten & Frans Bongers, 2012. Frankincense Tapping Reduced Photosynthetic Carbon Gain in *Boswellia Papyrifera* (Burseraceae) Trees. *Forest Ecology and Management*, 278: 1–8.**

Whole-crown carbon gain depends on environmental variables and functional traits, and in turn sets limits to growth sinks of trees. We estimated the annual whole-crown carbon gain of trees of the species *Boswellia papyrifera*, which are tapped for frankincense, by integrating leaf photosynthetic rates over the total leaf area and leaf life span. We examined the effect of tapping on total leaf area and leaf photosynthesis and, in turn, on carbon gain and resin yield for trees of a dry highland population and a wetter lowland population. Highland and lowland trees had similar total leaf area, but highland trees had higher photosynthetic rates per unit leaf area than lowland trees since they received more light and had higher photosynthetic capacities. Highland trees therefore achieved a higher annual carbon gain than lowland trees, despite a shorter rainy season and shorter leaf lifespan. Intensive tapping reduced crown leaf area and the carbon gain in the lowland trees, but not in highland trees. These results highlight how the interplay between local conditions and functional traits determine regional variation in tree productivity. However, such differences in productivity and carbon gain did not influence frankincense yield across sites. We conclude that tapping *B. papyrifera* trees reduces annual carbon gain but the extent differs among different populations.

**Keywords:** *Boswellia*, Crown assimilation, Ethiopia, Frankincense, Plant trait, Tapping

**Toon Rijkers, Woldeselassie Ogbazghi, Marius Wessel & Frans Bongers, 2006. The Effect of Tapping for Frankincense on Sexual Reproduction in *Boswellia papyrifera*. *Journal of Applied Ecology*, 43: 1188–1195.**

In the Horn of Africa, frankincense (an aromatic hardened wood resin) is obtained by tapping *Boswellia papyrifera*. World-wide, frankincense is of great economic and social importance as an important element of incense and perfumes. The production is declining as a result of poor natural regeneration of the *Boswellia* woodlands, possibly as a result of the low production of viable seeds. We hypothesize that this is because of the current intensive tapping regime, which might favour allocation of carbohydrates for synthesis of resin at the expense of allocation for generative growth. Investigations were carried out at sites in different agro-ecological zones with annually tapped trees and with trees that had not been tapped for several years. Seed viability and germination success were determined for 200 randomly collected seeds in each site. For three stands, the sexual reproduction (number of flowers, fruits and seeds) was determined for different sized trees subjected to three experimental tapping intensities (no, normal and heavy tapping). At the stand level, non-tapped trees produced three times as many healthy and filled seeds as tapped trees. Germination success was highest in stands with non-tapped trees (> 80%) and lowest for those with tapped trees (< 16%). At the tree level, sexual reproduction decreased with increasing tapping regime irrespective of tree size. Overall, large trees tended to produce slightly heavier seeds than small trees, and seeds from non-tapped trees were heavier than those from tapped trees. In the stands where tapping was prohibited changes in tapping regimes had the greatest effect on sexual reproduction. Trees subjected to annual tapping always showed the lowest sexual reproduction. Tapping for frankincense results in limited flower and fruit production, and low production of mainly non-viable seeds in *B. papyrifera*. We argue that tapping causes competition for carbohydrates between frankincense

production, and fruit and seed setting. Consequently, the current tapping regimes will cause tree exhaustion and eventually a decline in vitality. Tapping may potentially reduce natural regeneration of the species. New tapping regimes are suggested that include periods of time in which tapping is prohibited in order for trees to recover and replenish their stored carbon pool, and a reduction in the number of tapping points per tree. This is important in view of the long-term sustainability of frankincense production, an internationally highly valued resource.

**Keywords:** Carbohydrate, Dry woodland, Germination success, Horn of Africa, Tree size, Wood exudates

**Watkins Cristy A., 2009. Natural Resource Use Strategies in a Forest-Adjacent Ugandan Village. *Human Ecology*, 37(6):723-731.**

This study documents natural resource use in a forest-adjacent western Ugandan village, and explains how what superficially appears to be a sustainable scenario is in fact quite unstable. Kibwona village is adjacent to Kasokwa Forest, comprised of a small Central Reserve owned by the National Forest Authority (NFA) and several contiguous community forests. Firewood and water collection is legal. However, empirical observations of women's daily activity budgets and details of resource acquisition show on average, women spent less than 5% of the time collecting natural resources. This is true for resources both in and out of the forest. This may be simply because firewood within household compounds, gardens and woodland-bush areas is abundant, accessible, and closer than the (also close) forest. However, two additional reasons for this behavior may, in fact, hinder long-term sustainability: (1) Many locals also plant eucalyptus trees for firewood, poles, and timber, which, although it is fast growing and makes good firewood, is water-draining and hard on the soils and thus a high cost to subsistence farmers. (2) Fears of harassment by NFA officials when collecting firewood inhibit local people from even entering the forest. Decentralized, collaborative forest management will not happen under oppressive and fear-based relationships, nor can a sustainable firewood supply be based on eucalyptus.

**Wekesa C., Makenzi P.M., Chikamai B.N., Luvanda A.M. & Muga M.O., 2010. Traditional Ecological Knowledge Associated with *Acacia Senegal* (Gum Arabic Tree) and Gum Arabic Production in Northern Kenya. *International Forestry Review*, 12(3): 240-246.**

This study documented traditional ecological knowledge (TEK) on the management of *Acacia Senegal* trees (Gum Arabic trees) using a structured questionnaire. A total of 149 randomly selected respondents from six locations in two districts of Samburu (Rift valley Province) and Isiolo (Eastern Province) were interviewed. Results show that local communities use their indigenous knowledge to manage natural gum Arabic tree resources to sustain and improve their livelihoods. Restriction to the collection of only dead and fallen wood, community by-laws and nomadism were the main conservation strategies employed by the locals to protect gum Arabic trees. Collection of gum Arabic from wild gum Arabic trees was mainly done by women during the dry months of the year. June to September season yielded higher quantities of gum Arabic than the January to March season. More gum Arabic was collected from gum Arabic trees located on hilly and rocky sites than on plain and flat areas and along riverbanks. Small sized trees with small girth were preferred to big trees with a wide girth during gum Arabic collection. Apart from harvesting gum Arabic from the trees and selling it to earn cash income, the local communities got fodder,

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fuel wood, traditional medicine, fencing material and fiber from the trees. Besides, gum Arabic is used as food during hunger season. There is strong evidence that TEK is a useful concept for sustainable management of gum Arabic trees and could be used in designing of sustainable conservation and exploitation strategies of gum Arabic trees and consequently environmental conservation.

**Woldeselassie Ogbazghi, Frans Bongers, Toon Rijkers & Marius Wesse, 2006. Population Structure and Morphology of the Frankincense Tree *Boswellia papyrifera* along an Altitude Gradient in Eritrea. *Journal of the Drylands*, 1(1): 85-94.**

In Eritrea, the frankincense tree *Boswellia papyrifera* is a multipurpose plant. Human induced factors such as land clearing for agriculture, overgrazing by livestock and over tapping of resin are threatening its distribution. Against this background, a study was carried out to investigate the species current population structure and tree morphology in five *Boswellia* areas along an altitude gradient (range 800 - 2000 m a.s.l.). In each area sample plots of 20 by 20 m were inventoried; a total of 144 plots were studied. The population structure analysis showed that there was an overall absence of juvenile trees between 1 and 8 cm DBH. Natural regeneration was found only in two areas in which trees were not tapped for resin and inaccessible to livestock. Tree height, DBH, crown depth and crown diameter decreased with increasing altitude. In the lowland areas trees were about two times taller (10 to 12 m) with deeper crowns than those growing in the highland areas. This indicates that the species grows better in the warm moist lowlands than in the moist and dry highlands. To promote natural regeneration and seedling establishment in existing *Boswellia* woodlands control measures are needed including proper tapping procedures and controlled grazing.

**Keywords:** Dry woodland, Grazing, Natural regeneration, Species composition, Resin tapping

**Woldeselassie Ogbazghi, Toon Rijkers, Marius Wesse & Frans Bongers, 2006. Distribution of the Frankincense Tree *Boswellia papyrifera* in Eritrea: The Role of Environment and Land Use. *Journal of Biogeography*, 33: 524–535.**

We determined the present and past distribution, and the abundance, of *Boswellia papyrifera* in Eritrea, and the environmental and land-use factors determining its distribution limits. Location Eritrea, in the Horn of Africa. In 1997 a *Boswellia* field survey was conducted in 113 village areas covering four administrative regions. Species occurrence was related to rainfall, air temperature and length of growing period. Additionally, the relationship between the abundance of *Boswellia* trees and selected physical and chemical soil factors, topography and land-use types was determined for five study areas (with a total of 144 plots) situated along an altitude gradient of 800–2000 m a.s.l. The geographical distribution of *B. papyrifera* was limited to the south western and southern parts of the country between 800 and 1850 m altitude receiving a mean annual rainfall of 375–700 mm, with a growing period of 45–100 days. Species abundance was affected by, in order of importance: altitude, land-use intensity and soil organic matter. Most trees were found in hilly areas; tree density increased from the foot slope to the hill summit; no trees occurred in valleys. Land-use intensity, especially agriculture, fallow and grazed areas, had a profound negative effect on tree abundance. Natural regeneration of the species was promoted in areas where grazing

by livestock was not allowed or regulated. The distribution of *B. papyrifera* in Eritrea has decreased during past decades, mainly due to an increasing human population, resulting in the conversion of woodlands into agricultural fields and increasing livestock pressure hindering natural regeneration. Consequently, *Boswellia* trees are found mainly in hilly areas on steep slopes with shallow soils of low fertility. The species appears to be able to adapt to these harsh growing conditions: in adjacent countries it was also found in comparable growth habitats.

**Keywords:** Altitude, *Boswellia papyrifera*, Dry woodland, Eritrea, Grazing, Horn of Africa, Rainfall, Soil.

**World Bank, 2007. Strategic Environmental Assessment of the Kenya Forests Act 2005. The World Bank, Washington D.C.**

November of 2005 the Government of Kenya (GOK) ratified a new Forests Act. The Forests Act is an outcome of the Kenya Forest Master plan finalized in 1994. In the new Forests Act the government embraces the concept of participatory forest management. The act gives particular consideration to formation of forest community associations, which will be recognized as partners in management. Furthermore, the act opens commercial plantations to lease arrangements by interested groups to supplement government efforts. This is a radical departure from previous practice where the government assumed full management responsibilities in gazetted forest reserves. The act can improve the forest productivity and increase availability of timber and other products/services for domestic use and export. At the time when this sector work was conceptualized, the GOK had finalized a road map for implementation of the Forest Bill. However, questions remained regarding how the Forest Department would reform itself, the level of stakeholder engagement in designing the reform process, and the capacity in the to-be-established Kenya Forest Service to implement the new Forests Act. The Bank identified the need for analytical work on economic, environmental and social implications of alternative ways of implementing key parts of the Forests Act. There also was a need to enhance interaction among key stakeholders, including interactions between key government actors such as the Kenya Wildlife Service (Ministry of Tourism) and the Forest Department (Ministry of Environment). The institution-centered strategic environmental assessment (SEA) aims to assist the GOK with the implementation of the Forests Act by informing the forest component of the Natural Resource Management project (2007–2012) and informing the Forest Reform Secretariat of priority areas for successful implementation. To achieve its objective, the SEA blends analytical work and consultations with key stakeholders. The SEA takes into account input from a wide range of stakeholders including communities, private sector and non-governmental organizations. It provides recommendations in terms of concrete actions necessary to implement the Forests Act in the form of a policy action matrix, and some immediate follow-up steps. The SEA has been coordinated and managed by the Bank with assistance from a consulting consortium and input from the GOK. The Kenya Forest Department and Forest Sector Reform Secretariat have been involved in the SEA process from the formulation of the scope of work to the finalization of the policy-action matrix. The analytical work associated with this report was completed in December 2006.

**Zida D., Sawadogo L., Tigabu M., Tiveau D. & Ode'n P.C., 2007. Dynamics of Sapling Population in Savanna Woodlands of Burkina Faso Subjected to Grazing, Early Fire and Selective Tree Cutting for a Decade. *Forest Ecology and Management*, 243: 102–115.**

Fire, grazing, browsing and tree cutting are major anthropogenic determinants of vegetation patterns in African savannas. In Burkina Faso forest management policies prohibit grazing while recommending annual early fire and selective tree cutting of 50% of the merchantable standing volume on a 20-year rotation period. These management prescriptions are not based on long-term experimental evidence, particularly the responses of saplings to these management regimes are not well known. A factorial experiment with two levels was designed to examine the effects of moderate level of grazing, early fire and selective tree cutting on the dynamics of sapling populations on two sites, Laba and Tiogo, in the savanna woodland of Burkina Faso and assessed for 10 years from 1992 to 2002. Species richness, sapling population density, structure and growth were analysed. The results provide evidence that fire, grazing and selective cutting acted independently to influence the population dynamics of saplings. Annual early fire significantly reduced species richness ( $p = 0.037$  in Laba and  $p = 0.016$  in Tiogo), population density ( $p < 0.001$  in Laba and  $p = 0.003$  in Tiogo) and current annual increment (CAI) in basal area ( $p < 0.001$  in Laba and  $p = 0.016$  in Tiogo). Grazing and fire affected sapling morphology but the response was site specific. Selective removal of trees did not affect any of the parameters studied, except the CAI in dominant height at the Tiogo site which was significantly ( $p = 0.028$ ) reduced by the cutting treatment. Early fire also significantly reduced the CAI in dominant height at Laba. The height class distribution revealed that more than 93% of the saplings recorded were less than 400 cm tall, and fire significantly reduced the rate of change in density of saplings in the 200–400 cm height class. It can be concluded that annual early fire was the factor that most affected sapling recruitment. The sapling response to these management regimes was species specific.



## 4. PARTICIPATORY FOREST MANAGEMENT



### **COMPILED BY**

Yemiru Tesfaye, Melaku Bekele, Hussein Kebede, Fekadu Tefera and Habtemariam Kassa

## 4.1. Approaches, Institutional Arrangements and Establishment Processes of PFM

**Andrea Cornwall, 2008. Unpacking ‘Participation’: Models, Meanings and Practices. Oxford University Press, Oxford.**

The world over, public institutions appear to be responding to the calls voiced by activists, development practitioners and progressive thinkers for greater public involvement in making the decisions that matter and holding governments to account for following through on their commitments. Yet what exactly ‘participation’ means to these different actors can vary enormously. This article explores some of the meanings and practices associated with participation, in theory and in practice. It suggests that it is vital to pay closer attention to who is participating, in what and for whose benefit. Vagueness about what participation means may have helped the promise of public involvement gain purchase, but it may be time for more of what Cohen and Uphoff term ‘clarity through specificity’ if the call for more participation is to realize its democratizing promise.

**Anne M. Larson, 2004. Democratic Decentralization in the Forestry Sector: Lessons Learned from Africa, Asia and Latin America. Center for International Forestry Research (CIFOR). Bogor, Indonesia.**

Many governments in Africa, Asia and Latin America claim to be decentralizing natural resource management to local actors. Though in many cases these processes are still quite new, it is precisely the moment to begin to analyze these experiences, assess the ways in which they are unfolding and identify promising trends as well as problematic developments that should be adjusted for the future. This paper synthesizes the results of selected research on forest sector decentralizations from about 20 Third World countries. It extracts a set of lessons learned that identify common patterns as well as key factors in success and failure, by focusing on the structure, actors and institutions that play a role in forest governance. To what extent do current experiments strengthen democratic processes by granting local actors, particularly representative and accountable local entities, greater decision-making power in forest management? The studies demonstrate that democratic decentralization is rarely implemented: substantial decision-making power, resources and benefits from forests are still centralized, and the local actors selected to receive new authority are often neither representative nor accountable. The results of current policies are sometimes harmful to poor local people. The paper highlights the importance of meaningful national dialogue and the empowerment of civil society and of marginal actors in particular. It argues that forestry decentralizations should begin by working with local people, building on the institutions that they have already built, and that representative and accountable local governments may be the most appropriate interlocutors for this process.



**Arun Agrawal & Ashwini Chhatre, 2007. State Involvement and Forest Co-Governance: Evidence from the Indian Himalayas. *Studies in Comparative International Development*, 42: 67–86.**

This article contributes to the literature on collective action around environmental co-governance by statistically analyzing original data on the experiences of 95 communities in the Indian Himalayas. We compare the performance of co-governance versus indigenous governance institutions, taking into account the causal influence of five classes of independent variables. Our analysis suggests that close involvement of government officials is negatively associated with efforts to manage forests sustainably. We identify contextual conditions that help explain why involvement of state officials has adverse consequences on resource governance outcomes. Our findings are relevant for studies of decentralization policies related to natural resource management that governments are currently pursuing in more than 60 countries.

**Asnarulkhadi Abu Samah & Fariborz Aref, 2009. People's Participation in Community Development: A Case Study in a Planned Village Settlement in Malaysia. *World Rural Observations*, 1(2): 45-54.**

In this study, the people's participation in community development activities is viewed as a process by which individuals are involved in initiating, deciding, planning, implementing and managing the group and its activities. It is also a process of social development in which people, as subjects in their own environment, seek out ways to meet their collective needs and expectations and to overcome their common problems. In pursuing this collective action, the self-help and mutual-help spirit that underlies the Asian traditional community spirit of working, helped to hasten the achievement of these shared interests through group-based-activities. Thus, by understanding this collective action in which members participate, it is possible to comprehend the dynamic aspect of the group process within which participation took place.

**Arun Agrawal, 2007. Forests, Governance, and Sustainability: Common Property Theory and its Contributions. *International Journal of the Commons*, 1 (1): 111-136.**

It would be no exaggeration to say that the study of forests as commons has been central to the development of scholarship on common property. Equally certainly, the interest in forests has generated a vast corpus of research outside the field of common property. The magnitude, variety, and depth of this body of research is an accurate reflection of the many different ways in which forests have been and continue to be central to human survival, livelihoods, and prosperity. This paper reviews some of the central concerns and findings of writings on forests as they related to the theoretical ambitions of commons scholars, and to efforts to govern forests more sustainably and equitably. The review is especially important in the context of unfolding efforts to govern forests in new ways over the past two decades. But as important as the review is an assessment of the achievements of this literature, existing blind-spots, and potential new areas of exciting research and investigation. The review suggests specific areas in relation to methods, data, and theories of common property that will advance the field further.

**Arun Agrawal, Ann Arbor Usa & Krishna Gupta, 2005. Decentralization and Participation: The Governance of Common Pool Resources in Nepal's Terai. *World Development*, 33(7): 1101–1114.**

Decentralization has emerged as an important instrument of environmental and development policy in the last two decades. Presumed benefits of environmental policy decentralization depend in significant measure on broad participation in the programs that governments create to decentralize decision making related to resource management. This paper uses data from protected areas in Nepal's Terai to examine who participates in environmental decentralization programs. On the basis of our statistical analysis, we highlight the fact that the likelihood of participation in community-level user groups is greater for those who are economically and socially better-off. We also find that individuals who have greater access to and who visit government offices related to decentralization policies more often are also more likely to participate in user groups created by state officials. Finally, we find a negative correlation between education and levels of participation. Our study and analysis support the argument that for decentralization policies to be successful on equity issues, it is important to build institutional mechanisms that encourage poorer and more marginal households to access government officials, improve access to educational opportunities, and create incentives to promote more interactions between less powerful rural residents and government officials.

**Arun Agrawal & Elinor Ostrom, 2001. Collective Action, Property Rights, and Devolution of Forest and Protected Area Management. *Politics & Society*, 29 (4): 485-514.**

National governments in almost all developing countries have begun to decentralize policies and decision making related to development, public services, and the environment. Existing research on the subject has enhanced our understanding of the effects of decentralization and thereby has been an effective instrument in the advocacy of decentralization. But most analyses, especially where environmental resources are concerned, have been less attentive to the political coalitions that prompt decentralization and the role of property rights in facilitating the implementation of decentralized decision making. By comparing decentralization in four cases in South Asia- Forest Councils in Kumaon in India, Joint Forest Management in India, the Parks and People Program in Nepal's Terai, and Community Forestry legislation in Nepal—this article provides answers to two questions: When do governments decentralize environmental decision making? And which types of property rights must be devolved if decentralized decision making is to be effective.

**Badege Bishaw, 1988. An Afforestation Programme in the Legambo Farmers' Producer Cooperative, Hararege Highlands, Ethiopia. *Mountain Research and Development*, 8 (2/3): 249-252.**

The Hararege Highlands have been heavily exploited and presently show only remnants of the previous dense forest. Afforestation programmes for provision of fuels and construction wood as an immediate solution to the energy crisis are therefore desperately needed. The Alemaya University of Agriculture, with partial funding from FAO/UNDP, has implemented a project with special emphasis on afforestation, soil conservation, and alternative energy

sources. Tree species that can help in soil conservation practices on gullies, steep slopes, and on other poor quality sites were planted. Road side and border row planting are intended to serve as shelter belts for crops, cattle, and people. The follow-up study on survival of the planted seedlings was carried out by the forestry team and showed that about 58 percent of the planted trees survived. Species were Cupressus, Casuarina, Acacia, Grevillea, and Eucalyptus; best survival was found with Cupressus arizonic and Grevillea robusta. The programme, which was implemented with close involvement of the members of the producers' cooperative, resulted in valuable conclusions on management practices and on the new methods applied; an important experience was obtained from the general approach.

**Bereket Kebede, 2002. Land Tenure and Common Pool Resources in Rural Ethiopia: A Study Based on Fifteen Sites. *African Development Bank*, 14 (1): 113-149.**

The evolution of land tenure in Ethiopia during the Imperial period directed towards private and individualized property is discussed both in general terms and by examining conditions at specific localities. This evolution was brought to an abrupt end by the land reform of 1975 with nationalization. The same logic of subsistence agriculture as in traditional tenures seems to be the basis for the reform. With the abandonment of the socialist transformation of agriculture no vision about future developments in land tenure seems to exist. Privatization is suggested to improve the security of land holding, to increase agricultural investment, to assist the development of other markets as well as preserve common pool resources.

**Braedt O. & Schroeder J. M., 2003. Institutions Governing the Use of Forest Products: Woodcraft Commercialization in southern Zimbabwe. *Forests, Trees and Livelihoods*, 13 (1): 59 - 78.**

The production and sales of woodcarvings rose substantially during the 1990s in Zimbabwe. Potential conflict between informal groups selling forest commodities and institutions that control the use of forest products is inherent in this fast growing sector. The aim of this study was to identify organisations, stakeholders, and institutions associated with the control and management of tree use on communal lands, to assess how familiar people are with these institutions, and to establish the level of enforcement of the various rules. Formal institutions governing natural resource use are part of state organisations that have published and codified control mechanisms in place. Informal institutions were considered to be traditional leadership structures. In rural areas knowledge of the official/codified control mechanisms was practically absent, being limited to the few persons in charge of the execution of the legal provisions. Effective control and prosecution of offenders under either the formal or informal system was rare. In practice an open-access situation without any form of controls on tree use for carvings was apparent, and a degree of confusion over who controls forest product use was prevalent.

**Brooke Ann Zanetell & Barbara A. Knuth, 2004. Participation Rhetoric or Community-Based Management Reality? Influences on Willingness to Participate in a Venezuelan Freshwater Fishery. *World Development*, 32 (5): 793–807.**

Community-based management (CBM) has progressed from the conceptual fringe to the

dialogical heart of environmental management. Despite its rhetorical popularity, limited quantitative data exist on factors influencing local involvement. A quantitative survey of three Venezuelan fishing villages resulted in a predictive model of willingness to participate in CBM. Sense of community and fishery dependence was significant positive influences. High level of concern about the current and future state of the fishery correlated with an unwillingness to participate, indicating a defeatist attitude about perceived insurmountable problems. We explore sense of community, defeatist attitudes, and education in CBM project formulation and implementation.

**Brian J. Parai & Thomas C. Esakin, 2000. Beyond Conflict in Clayoquot Sound: The Future of Sustainable Forestry. Canadian Foreign Service and Clayoquot Biosphere Trust (CBT).**

Parai and Esakin describe how the multiple stakeholders concerned with the forest resources around Clayoquot Sound, Canada, moved from conflict to collaboration in land-use planning. State-sanctioned plans for timber harvesting by a multinational corporation provoked protests from indigenous peoples, local residents and environmentalists, who challenged this policy through coalition building and other strategies. As the power imbalance declined among the disputants, the government and the corporation were drawn into collaborative arrangements with the other stakeholders.

**Chasca Twyman, 2000. Participatory Conservation? Community-Based Natural Resource Management in Botswana. *The Geographical Journal*, 166 (4):323-335.**

This paper examines the complexities of participatory conservation through a case study of the process of participation in a government under community-based natural resource management programme in Western Botswana. The paper argues that different stake holders have very different views on the levels of participation taking place in particular projects. Further more local people find it difficult to voice their concerns about the environment and issues of sustainability given the power relations involved in this 'participatory' process. The paper questions the accountability and motivation of the different stakeholders involved in participatory projects and suggests that implicit in the policy implementation process are mechanisms which constrain empowerment and dictate the forms of participatory conservation which can emerge. The paper concludes by reviewing the case study in the light of new policy developments in Botswana.

**Christopher E. Morrow & Rebecca Waits Hull, 1996. Donor-Initiated Common Pool Resource Institutions: The Case of the Yanasha Forestry Cooperative. *World Development*, 24 (10): 164-1657.**

Several authors have drawn on case studies of successful common pool resource (CPR) institutions to develop principles for predicting when a CPR regime will form and the likelihood of its success once created (Ostrom, 1990). This paper examines the development and dissolution of the Yanasha Forestry Cooperative in the Palcazu Valley of Peru to test the relevance of Ostrom's CPR design principles to indigenous forest management regimes involving donor assistance and other external influences. The paper expands several

principles and suggests ways in which external agencies can assist more effectively in the development of durable common pool resource institutions.

**Coulibaly-Lingani P., Savadogo P., Tigabu M. & Oden P-C., 2011. Decentralization and Community Forest Management in Burkina Faso: Constraints and Challenges. *International Forestry Review*, 13 (4): 476-486.**

Since the 1980s, developing countries have invested increasing efforts in decentralization initiatives intended to achieve development goals, improve governance and enhance popular participation in the management of natural resources, notably forests. However, better understanding of the issues pertaining to, and the challenges facing, the decentralization of forest management is paramount for the success of such initiatives. This study examines the issues and constraints related to implementation of a decentralizing, participatory forest management program in the Centre-west region of Burkina Faso. For this purpose, information was gathered through a literature review and focus group discussions involving government authorities at various levels, local Forest Management Groups (FMGs), technical support staff and the regional association of fuel wood wholesalers. The acquired data show that Forest Management Units (FMUs) established by the State are not clearly demarcated, and in some cases fall within several administrative units, creating difficulties in devolving responsibility for resources to specific local administrations. This problem is compounded by conflicts over decision-making power among actors, especially elected local leaders, traditional village leaders and representatives of FMGs (which were officially established to manage resources at local level within the FMUs). The central government has also retained substantial control over forest resources through its Forest Service. Thus, the FMGs have little institutional strength, and their authority is further weakened by limited local competence and a lack of transparency and robust accountability mechanisms. Hence, adjustments to the decentralization reforms are required to transfer forest management power to local levels more effectively, which should enhance access to forest resources, thereby increasing benefits for local communities.

**Dahal G. R. & Capistrano D., 2006. Forest Governance and Institutional Structure: An Ignored Dimension of Devolution Policy Process in Collective Action: The Case of Community Based Forest Management in the Philippines. *International Forestry Review*, 8(4): 337-394.**

This paper identifies strategic weaknesses in the devolution policy process in forest management and analyses the reasons behind them. Further, it establishes the relationship of devolution policy outcomes with governance and institutional structures. The field research was undertaken in the Philippines, taking six cases of community based forest management (CBFM) sites in the province of Nueva Vizcaya and Quirino and employing a qualitative technique for data collection and interpretation. The study demonstrates that the devolution policy process has two major interrelated strategic weaknesses: one is inadequate policy articulation and the other is a set of differences between policy and the complex reality of implementation. Drawing upon this analysis of strategic weaknesses in the devolution policy process in the Philippines the paper argues that the level of success of policy outcomes is dependent on the interrelation between the levels of devolution with clear policy articulation on the one hand and quality of governance and institutional structures on the other.

**Daniel W. Bromley, 2008. Resource Degradation in the African Commons: Accounting for Institutional Decay. *Environment and Development Economics*, 13: 539–563.**

The development literature has devoted considerable attention to the commons and has ignored the wider economic context of the commons. I develop a model of two kinds of agents (naïve and sophisticated) using two kinds of assets (safe and unsafe) to illustrate the possibility of resource degradation in the commons in the absence of free riding, shirking, and general theft among members of the village and its associated commons. This model makes it possible to understand that degradation of the commons arises from factors outside of the commons rather than arising from ‘perverse’ property rights and selfish behavior within the commons. This approach suggests a needed reformulation of development assistance away from prescriptions for the commons. Instead, development assistance must be refocused on the more serious challenge of institutional incoherence in the larger economy of which the village and its commons are but a part.

**David Brown, 1999. Principles and Practice of Forest Co-Management: Evidence From West-Central Africa. *European Union Tropical Forestry Paper 2. Overseas Development Institute, London.***

The principle of co-management - the involvement of local communities as well as the state in forest management - is now a major component of most internationally-supported programmes of forest sector development in the tropics, and a significant feature of forest policy and practice on a global scale. The arguments in favor of community involvement are numerous and compelling, ranging from the positive aspects of local participation (in terms of indigenous capacity and proximity to the resource) to the negative features of the alternatives (the inefficiencies of existing systems of single-purpose industrial management and the need for improved discipline in the sector). The main agenda of development assistance to forestry over the last twenty years has been to put participation firmly at the centre of tropical forest management, and this has now been achieved in very large measure. Increasingly, however, doubts are arising as to justification of the endeavor from the point of view of its likely impacts on both the livelihoods of the poor and the conservation of the forest resource. This paper reflects on some of the difficulties which the movement presently confronts, and seeks to identify pointers to improve the design of development assistance interventions. The main focus of interest is on attempts to promote community involvement in forest management in tropical moist forest areas of sub-Saharan Africa. In such societies, there are likely to be significant imbalances in power between industrial and non-industrial users, and questionable levels of political will in the key state agencies. Both of these present significant barriers to meaningful community participation. Attempting to change systems of land tenure to favor sustainable forest management may also be hazardous in such contexts, and offers no guarantee of improved access to the poor. An additional difficulty is that the assumptions made in the classical model of forest co-management about community identities and relationships may well not apply in the conditions which pertain today in many areas of tropical high forest. In the modern world of global integration, monetization of economies, growing social complexity and increasing pressure on natural resources, such areas are often highly unstable in social terms, and their population dynamics are not necessarily conducive to community solidarity and joint action. Using case studies from the high forest zones of Ghana and Cameroon, the paper reviews the ambiguities in the classical model of forest co-management, and the difficulties

which arise when attempts are made to apply the model to specific national contexts. Consideration is given to some of the solutions which have been offered to address these problems of local adaptation. The paper is particularly skeptical of attempts to recreate traditional resource management systems. These tend to assume the existence of effective 'traditional' leadership roles, with a basic commonality of purpose between leaders and followers. In neither case study situation are such assumptions upheld with confidence. In Ghana, the interests which divide traditional leaders from their followers may be at least as important as those which bind them together. In many parts of Cameroon, the very notion of meaningful traditional leadership is in doubt. Varying levels of social heterogeneity in the two contexts (with increasing immigration and admixing of populations) also militate against the coalescence of community forces around traditional leadership, particularly where this has an important ethnic or tribal component.

**Debnarayan Sarker, 2009. Joint Forest Management: Critical Issues. Commentary. *Economic & Political Weekly*, 44 (04):15-17.**

The Joint Forest Management circular that took the National Forest Policy (1988) as its basis for people's involvement in the development and protection of forests, issued more than 18 years ago, has failed in its attempt to utilise forest wealth to improve local livelihoods. The structure of the JFM is skewed towards the forest department and needs to be balanced with equal opportunities and rights to the participating communities.

**Elinor Strom, 1999. Self-Governance and Forest Resources. *Occasional Paper No. 20*, CIFOR. Bogor Indonesia.**

Forest resources share attributes with many other resource systems that make difficult their governance and management in a sustainable, efficient and equitable manner. Destruction or degradation of forest resources is most likely to occur in open-access forests where those involved, or external authorities, have not established effective governance. Conventional theories applied to forest resources presumed that forest users themselves were incapable of organizing to overcome the temptations to overharvest. Extensive empirical research, however, has challenged this theory and illustrated the many ways that forest users themselves have devised rules that regulate harvesting patterns so as to ensure the sustainability of forest resources over time. There is now a large body of literature analyzing common-pool resources such as many fisheries, irrigation systems and rangelands. A growing consensus exists in this literature concerning the attributes of common-pool resources and of resource users that enhance the probability that self-organization will occur. Many of these attributes seem also to help predict when forest users will self-organize. Forest users are more likely to devise their own rules when they use a forest that is starting to deteriorate but has not substantially disappeared, when some forest products provide early warning concerning forest conditions, when forest products are predictably available, and when the forest is sufficiently small that users can develop accurate knowledge of conditions. Self-organization is more likely to occur when forest resources are highly salient to users, when users have a common understanding of the problems they face, when users have a low discount rate, when users trust one another, when users have autonomy to make some of their own rules, and when users have prior organizational experience. These attributes of forests and of the user community affect the benefits and costs of organising to protect and

enhance forest resources. When users create organizations consistent with a set of design principles, they are likely to be able to sustain their own institutional arrangements over a long period of time. This growing consensus about the attributes of users and resources has been applied in the design of policies intended to enhance the participation of local users in the governance and management of common-pool resources, including many forests. Supporting further research especially studies of forests and their users over time is an important foundation for even more effective public policies in the future.

**Ellen Winberg, 2010. Participatory Forest Management in Ethiopia, Practices and Experiences. Food and Agriculture Organization Sub Regional Office for Eastern Africa (SFE), Addis Ababa.**

Deforestation and the resulting environmental degradation is a major problem in the Federal Democratic Republic of Ethiopia and a key factor challenging food security, community livelihood and sustainable development. Between 1955 and 1979, over 77 percent of the country's forested area disappeared and it continues to lose 8 percent of its remaining forests annually. Participatory Forest Management (PFM) is a mechanism to protect forests and enhance the livelihoods of communities who use and benefit from them in the process. PFM was first introduced to Ethiopia thirteen years ago but the approach is expanding to cover more and more hectares of forest across the country. This report is the result of a survey of ten PFM actors in Ethiopia including stakeholders in the Federal Government of Ethiopia, regional governments, woreda offices, international development agencies and international as well as national NGOs. The largest pockets of remaining natural forests of Ethiopia are located in the south of Oromiya and Southern Nations Nationalities and Peoples (SNNP) regions and the majority of PFM intervention sites are located in these areas. A smaller number of recently introduced sites are located in Amhara in northern Ethiopia. The components that are reported to have been most important for successes in the different intervention areas are: o Collaboration, involvement, continuous follow-up and support of relevant regional and local government sectors. Comprehensive and unified understanding within project staff at all levels including training of all field practitioners. o Making use of and strengthening already present traditional systems; repeatedly consulting the community; communicating and building consensus with local elders, politicians and religious leaders and recognizing traditional knowledge and customary rights. Linking income generation to forest management as well as improving market access for forest products. Enabling exchange of experiences between farmers and communities at different PFM sites can have positive impacts on neighboring communities. It often leads to farmers copying the methods that are introduced in the PFM areas, such as farming spices in their home gardens for income generation. What became clear throughout the writing of this report was that for PFM approaches and sustainability of these interventions rely on self-financing mechanisms being put in place.

**Elizabeth J. Z. Robinson & Razack B. Lokina, 2012. Efficiency, enforcement and revenue tradeoffs in participatory forest management: an example from Tanzania. *Environment and Development Economics*, 17 (01): 1 – 20.**

Where joint forest management has been introduced into Tanzania, 'volunteer' patrollers take responsibility for enforcing restrictions over the harvesting of forest resources, often



receiving as an incentive a share of the collected fine revenue. Using an optimal enforcement model, we explore how that share, and whether villagers have alternative sources of forest products, determines the effort patrollers put into enforcement and whether they choose to take a bribe rather than honestly reporting the illegal collection of forest resources. Without funds for paying and monitoring patrollers, policy makers face tradeoffs over illegal extraction, forest protection and revenue generation through fine collection.

**Gibbon H., Mbithi D., Mugo E. N. & Phiri M., 2005. Forest And Woodland Management In East And Central Africa: Emerging Models for Improvement in Livelihoods and Natural Resource Management in Kenya and Zambia. *International Forestry Review*, 7 (3): 193-207.**

Participatory Forest Management is a new strategy for the Forest Departments of Kenya and Zambia. Over the last five years or so, an increasing number of small project initiatives have been supported in both countries to test this model. Progress has been slowed by a lack of policy and legal frameworks, as well as management reluctance to take responsibility for new ideas and ways of engaging with multiple stakeholders. The authors argue that both of these governments as well as the international donors need to collaborate to develop suitable systems for monitoring and assessing progress towards improvements in resource utilization and livelihoods.

**Girma Amente<sup>1</sup>, Juergen Huss & Timm Tennigkeit, 2006. Forest Regeneration Without Planting: The Case of Community Managed Forests in the Bale Mountains of Ethiopia. *Journal of The Drylands*, 1(1): 26-34.**

The participatory forest conservation approach adopted by the forest dwellers associations, hereafter referred to as user groups, in Adaba-Dodola forest priority area has substantially reduced illegal utilization and further degradation of the forests. However, the forests were already degraded before they were handed over to the user groups due to illegal logging. Therefore, to make the conservation efforts of the user groups more beneficial there is a need to improve the production potential of the forests. The present study assessed the potential of the forests to be transformed into semi-natural productive forests based on potential crop tree focused management. A diagnostic survey conducted in the year 2003 in the forests managed by the three user groups revealed that more than 30 % of the total area had a sufficient number of potential crop trees per hectare to start the transformation process. In this area forest rehabilitation seems to be feasible without replanting. However, a rotating grazing system has to be introduced to enable the establishment of highly palatable species like *Hagenia abyssinica* (Bruce) JF Gmel.

**Golam Rasul , Gopal B. Thapa & Madhav B. Karki, 2011. Comparative Analysis of Evolution of Participatory Forest Management Institutions in South Asia. *Society & Natural Resources: An International Journal*, 24 (12): 1322-1334.**

In pursuit of sustainable forest conservation, Bangladesh, Bhutan, India, and Nepal have promoted participatory forest management (PFM) approaches such as community forestry, joint forest management, and social forestry. This study assessed these approaches based on policy and legal frameworks, organizational arrangements, and decentralization of

authority, which are considered the fundamental requirements for the success of PFM. The findings of the analysis revealed that although there is a tendency among all four countries moving toward PFM, their features and fundamentals vary considerably from one country to another. Overall, community forestry in Nepal appeared to be a robust participatory system, while the social forestry of Bangladesh a highly centralized approach is deemed very weak. The community forestry approach in Bhutan and joint forest management in India fall between these two extremes. Broad policy recommendations are outlined for promotion of genuine PFM.

**Grazia Borrini-Feyerabend, 1996. Collaborative Management of Protected Areas: Tailoring the Approach to the Context. IUCN , The World Conservation Union.**

The term ‘collaborative management’ of protected areas refers to a partnership by which various stakeholders agree on sharing among themselves the management functions, rights and responsibilities for a territory or set of resources under protected status. The stakeholders primarily include the agency in charge and various associations of local residents and resource users, but can also involve non-governmental organizations, local administrations, traditional authorities, research institutions, businesses, and others. This paper addresses conservation professionals - in particular governmental agency staff - interested in pursuing the collaborative management option. It offers a broad definition of the approach and provides a number of examples of how it has been specifically tailored to different contexts. General assumptions, consequences, benefits, costs and potential draw-backs of collaborative management are reviewed. A process by which an agency in charge of a protected area can pursue the approach is illustrated. The paper ends by posing a number of questions on the future of collaborative management as a viable and effective option in protected areas.

**Hersilia Fonseca, 2004. Community Forests Equity, Use and Conservation. World Rain Forest Movement.**

As we all know, the conservation of the world’s forests requires the adoption of a series of measures to change the current model of destruction, among which the empowerment of local communities to manage their own forests. In most of the countries of the world, there are many examples of appropriate forest management, in which environmentally sustainable use is assured while benefiting local communities. This type of management is generically known as “community-based forest management,” although it adopts different modalities in accordance with the socio-environmental diversity of the places where it is developed. This publication (also available in Spanish and French) aims at supporting and promoting this type of approach. The book is divided into two sections: the first one, presents a series of analytical article on the subject, and the second one consists of a selection of articles based on experiences of community forest management from different countries of the world.

**Habtemariam Kassa., Campbell B., Sandewall M., Kebede M., Tesfaye Y., Dessie G., Seifu A., Tadessee M., Garedew E. & Sandewall K., 2009. Building Future Scenarios and Uncovering Persisting Challenges of Participatory Forest Management in Chilimo Forest, Central Ethiopia. *Journal of Environmental Management*, 90: 1004–1013.**

We examined the changes in forest status and people's livelihoods through building future scenarios for Chilimo Forest in Central Ethiopia where participatory forest management (PFM) is being implemented. Participatory methods were employed to collect data, and a dynamic modeling technique was applied to explore trends over time. By integrating the more quantitative model outputs with qualitative insights, information on forests and livelihoods was summarized and returned to users, both to inform them and get feedback. A scenario of open access without PFM provides higher income benefits in the short term but not over the longer term, as compared to a scenario with PFM. Follow up meetings were organized with national decision makers to explore the possibility of new provisions in the national forest proclamation related to joint community–state ownership of forests. Project implementers must constantly work towards improving short term incentives from PFM, as these may be insufficient to garner support for PFM. Other necessary elements for PFM to succeed include: ensuring active participation of the communities in the process, and, clarifying and harmonizing the rules and regulations at different levels.

**Keywords:** Chilimo Forest, Communities, Conflicts, Conservation, Ethiopia, Livelihoods, Modeling Participatory forest management, Rules and regulations

**Isla Grundy, Jane Turpie, Pamela Jagger, Ed Witkowski Isabelle Guambe, Daniel Semwayo & Anastelle Solomon, 2000. Special Section: Land Use Options in Dry Tropical Woodland Ecosystems in Zimbabwe Implications of Co-Management for Benefits from Natural Resources for Rural Households in North-Western Zimbabwe. *Ecological Economics*, 33: 369–381.**

Addressing issues of resource management in sub-Saharan Africa has prompted the consideration of joint management policies that incorporate the needs of several stakeholder groups. This study examines the short and long-term use of natural resources in north-western Zimbabwe in a complex ecological–economic setting using a simulation model. Land and resource ownership in the model is divided between communal lands, which are managed by local inhabitants, and State Forest, which is managed by the Forestry Commission. Three different resource users rely on the stock of resources that the woodlands and grasslands (dambos) produce: the Zimbabwe Forestry Commission, communal land residents and illegal occupants of the State Forest. Net benefits to each of the three user groups are estimated under four different management scenarios, two of which advocate for the expulsion of illegal forest dwellers from the State Forest, and two of which involve a degree of joint management of the State Forest by the Forestry Commission and inhabitants neighboring the forest. If the status quo is maintained, or if access by local people to the forest is severely limited, forest quality will decline due to the impacts of increased fires (which are limited when livestock are in abundance). Eviction of the forest dwellers results in a serious loss of benefits for that stakeholder group, but does not result in a significant increase of benefits for other stakeholder groups. The economic impacts of

the different management scenarios are not very different because of the low values of the forest resources. Compared to the status quo, co-management provides for slightly greater net benefits, but the transaction costs associated with the establishment of co-management may be too high to justify this option.

**Jesse C. Ribot, 2002. *Democratic Decentralization of Natural Resources: Institutionalizing Popular Participation*. World Resources Institute, Washington D.C.**

In order to increase environmental management efficiency and improve equity and justice for local people, many environmentalists have advocated participatory and community-based natural resource management (CBNRM). Democratic decentralization is a promising means of institutionalizing and scaling up the popular participation that makes CBNRM effective. However, most current “decentralization” reforms are characterized by insufficient transfer of powers to local institutions, under tight central-government oversight. Often, these local institutions do not represent and are not accountable to local communities. Nonetheless, some lessons and recommendations can be derived from the limited decentralization experiments that have taken place in various locations. Decentralization requires both power transfers and accountable representation. To identify appropriate and sufficient powers to transfer, principles of power distribution, called environmental subsidiarity principles, would be of great use. Such principles could be developed to guide the division of decision-making, rule-making, implementation, enforcement, and dispute resolution powers among levels of government and among institutions at each level. Security of power transfers also matters. Local representatives remain accountable and subject to central authorities when their powers can be given and taken powers are empty. Most decentralization reforms only establish one or the other. A partial explanation is that many central government agents fear, and therefore block, decentralization. By preventing transfers of meaningful powers to local democratic bodies, or transferring them to local agents who are only accountable to central government, environmental agencies and other line ministries prevent decentralizations from moving forward. To date, the potential benefits of decentralization remain unrealized because government discourse has not resulted in the enactment of necessary laws, or where decentralization laws do exist, they have not been implemented.

**John M. Cohen, 1980. *Participation’s Place in Rural Development: Seeking Clarity through Specificity*. *World Development*, 8 (3): 213–235.**

Over the past few years, development specialists have expressed increasing concern **over** the lack of progress in altering the plight of the rural poor. Towards this end they are shifting from the capital-investment growth models of the 1960s to the more people-centered basic needs approaches that are increasingly dominating development thinking in the 1970s. In the process, they are turning to a number of related development strategies, one of the most important and least understood of which ‘popular participation’ is. Increasing numbers of studies and activities are being undertaken to bolster government and donor capacity to promote participation in development programs. Yet, with all these activities the disturbing fact is that there is little agreement on what participation is or on its basic dimensions. This article seeks to provide some order to the emergence of participatory concerns in the development literature, and to offer a carefully elaborated framework that clarifies the notion of ‘rural-development participation’ and make it applicable to total-development projects.

**John Robertson & Michael J. Lawes, 2005. User Perceptions of Conservation and Participatory Management of Igxalingenwa Forest, South Africa. *Environmental Conservation*, 32 (1): 64–75.**

New forest policies in South Africa seek to reconcile conservation and development objectives by devolving some responsibility for forest management from the state to local communities. Community participation in forest management aims to protect forest-based subsistence livelihoods by incorporating the interests of resource users, while simultaneously diffusing threats to biodiversity by managing resource use. To date, participatory forest management (PFM) has had mixed success in South Africa because the transfer of rights to users has not accompanied changes in policy. A questionnaire survey of 60 households (43%) revealed the attitudes of users toward current management and conservation options for igxalingenwa forest. Users chose participatory forest management (52%) over community (25%) or state-dominated forest management (2%) structures. User choice was motivated by the desire to secure rights of access to, and ensure equitable benefit from, a dwindling resource base, rather than the conservation of these resources to sustain future yields. Users were unwilling to reduce resource use and compromise usufruct rights to achieve conservation goals, even to improve the availability of the resource stock. Current user needs compromise biodiversity conservation goals, and users regard state conservation practices as protectionist and obstructing their rights of access to resources. While the National Forests Act of 1998 seeks to conserve resources by limiting access to them and is based on principles of sustainable use, it is nevertheless perceived to offer few incentives to users to participate in forest management and conservation. Ideally, an institutional and legal framework that allocates user rights and managerial responsibilities to households is required, but clearly suitable alternatives to forest products are also vital for successful management. Greater trust between the provincial parks authority and users is needed, but is complicated by weak traditional leadership and poor community representation. Ultimately, users preferred PFM because, while recognizing that harvest rates are unsustainable, user dependence upon forest resources and weak traditional leadership means they can protect usufruct rights only by participation. Changes to any of these factors may create demands for a new management system. PFM allows the greatest flexibility for responding to changes in demands as well as the environment.

**John R. Petheram, Peter Stephen & Don Gilmour, 2004. Collaborative forest management: a review. *Australian Forestry*, 67 (2):137–146.**

The term collaborative forest management (CFM) is adopted in this review because it has become popular internationally as a generic descriptor of a range of participatory approaches involving some form of co-management between government forest agencies and other stakeholders. It seems likely that Australia will go down its own track towards CFM, at least in some forest areas and communities. But as Africa has learned from Asia, the development of CFM in Australia could be vastly aided by heeding the wealth of experience of CFM from Asia, Africa, Europe and the Americas. This paper outlines the 'drivers', trends and extent of various types of community-based forest management worldwide. The terminology of participation in resource management is covered, as are concepts of stakeholder power and accommodation of multiple interests, and the need for acceptance of action learning and 'emergence' in the collaboration process. A generic example of a 'start-up' process for collaborative management is presented, although the importance of developing locally

appropriate approaches to CFM is emphasised. Brief reference is made to Australia's first CFM initiative, in the Wombat State Forest in Victoria, which prompted the writing of this review.

**Keeley, James & Scoones, Ian, 2003. Knowledge, Power and Politics: the Environmental Policymaking Process in Ethiopia. *The Journal of Modern African Studies*, 38 (01): 89-120.**

Policy discourses urging environmental rehabilitation, and rapid agricultural intensification for food self-sufficiency are firmly entrenched in Ethiopia. This paper examines the actor-networks and key policy spaces associated with the establishment of these discourses, taking natural resource management policies, and institutionalisation of the SG-2000 extension programme as case studies. An emergent, and potentially challenging, participatory natural resource management discourse is also identified. Contrasting the regions of Tigray and the Southern Nations, Nationalities and Peoples' Region (SNNPR), the paper concludes by arguing that, with decentralisation, differences between regional administrative and political cultures are key to policy processes, affecting the degree to which central policies reflect local concerns.

**Kendra McSweeney, 2002. Who Is "Forest-Dependent"? Capturing Local Variation in Forest-Product Sale, Eastern Honduras. *The Professional Geographer*, 54 (2):158-174.**

How researchers describe groups living within or near the world's tropical rain forests has important implications for how and why these groups are targeted for assistance by conservation and development organizations. This article explores how data about market behavior can be used to assess one aspect of forest peoples' livelihoods: their "dependence" on forest resources as a source of market income. With the intent of revealing the importance of methodology to how we describe forest peoples' livelihoods, I draw from a multiyear survey of market activity among the Tawahka Sumu of Honduras and distinguish nested measures of the Tawahkas' engagement in forest-product sale. Results indicate that whether or not the Tawahka - or any forest group—can be considered financially "dependent" on forest resources depends on the spatial and temporal scales at which data are aggregated. As a group, the Tawahka earned 18 percent of total market income from forest-product sale, but their group profile masked a high degree of heterogeneity at the village and household level. Similarly, multiyear data indicated that while group-level generalizations adhere from year to year, they belie considerable change in households' market behavior across years. I discuss three ways in which the findings are relevant to the theory and practice of conservation and development in the humid tropics. I emphasize the importance of spatial scale in interventions, how market-oriented conservation schemes can benefit from a broader conceptualization of the economic context in which forest-product sale occurs, and how longitudinal analysis can reveal the dynamism of forest peoples' livelihoods.

**Liz Alden Wily, 2002. The Political Economy of Community Forestry in Africa - Getting the Power Relations Right. *Forests, Trees and People Newsletter* No. 46.**

Asian and particularly South Asian developments in community forestry have received a great deal of publicity over the years, including in this Newsletter. Thousands of foresters around the world now know something about community forestry in Nepal and joint forest management in India. However, the rest of the world has not been sleeping. Indeed, as this Newsletter has also illustrated, countries in other continents have also begun to adopt community based approaches to forest management. Africa is such a case. Below Liz Alden Wily, a well-known facilitator in the sector, provides an overview of community forestry on the continent. She shows the startling extent of action in Africa and the depth accruing in its evolution. These initiatives include tackling issues of forest tenure often avoided elsewhere and placing much less restriction upon the kind of forests where community management may be applied. At the same time, she warns that use of community based forest management as a route to forest conservation and livelihood support is - like Asia - still being hampered in many countries by inadequate attention to the fact that rural populations cannot adopt guardianship roles whole heartedly without gaining an equivalent degree of jurisdiction over the resource. Basic needs strategies that over-focus upon the boosting of immediate incomes without addressing structural inequities in the ownership and control of forests have not been helpful, she argues. All too many communities remain in subordinate positions as beneficiaries of forest developments, not shareholders. There are signs that this is changing as more programmes adopt- and communities demand - the basic power sharing that is essential to genuine democratization of forest governance. More communities are getting involved not as forest users who need to help to protect the forest in order to secure access rights or other benefits but as forest managers in their own right.

**Luca Tacconi, 2007. Decentralization, Forests And Livelihoods: Theory and Narrative. *Global Environmental Change*, 17: 338–348.**

This paper discusses the theory of decentralized forest management, the associated narrative and the underlying hypotheses. That discussion informs the assessment of whether decentralization can lead to forest conservation. The paper argues that the ideal model of democratic decentralization described in the literature is unlikely to be implemented given the governance constraints present in many tropical forest countries. Even if that model could be implemented, it is shown that decentralization cannot be expected to necessarily lead to forest conservation. The policies required to complement the current decentralization model are discussed, including financial incentives and monitoring and evaluation mechanisms.

**Madhushree Sekher, 2001. Organized participatory resource management: insights from community forestry practices in India. *Forest Policy and Economics*, 3: 137-154.**

The paper examines, on the basis of a field study, the process of organized participatory resource management. Drawing insights from the community forestry practices in India being carried out under the country's Joint Forest Management efforts, the paper explores how different local organizations affect participatory management of common-pool resources ŽCPRs. Founded in the ideas of 'interdependency' and 'new institutionalism', the analysis is on the lines of Elinor Ostrom's 'design principles' and the 'institutional

analysis and development framework' developed by her and colleagues at the Workshop in Political Theory and Policy Analysis, Indiana University, to study renewable natural resource problems, particularly in developing countries. Attributing individual choice within collective-action strategies for CPR management to the incentives they face, the framework suggests that the participatory strategies are conditioned by three factors \_ the attributes of the goods Ž resource., the attributes of the user-group, and the attributes of the institutional arrangements. The analysis in this paper is, however, confined to the third attribute. Based on the user's perspective, a comparative analysis of three broad categories of local organizations operating in three villages is made, namely a non-governmental people's organization Ž NGPO., a government-engineered people's organization Ž GEPO., and an indigenous participatory strategy Ž traditional management regime.. A review of the participatory resource management strategies in three study villages provided useful insights into organized participation and the role of different collective-choice arrangements in CPR management. The paper argues that, depending on the process rules are made and interests internalized, different organized participatory systems create restraints, provide opportunities and confer legitimacy differently. At the same time, the paper acknowledges that, the study being a once-off exercise with a limited sample, its purpose is not to make any generalization about local organizations in the process of participatory resource management. Rather, the objective is to provide broad organizational guidelines for development initiatives requiring community involvement.

**Keywords:** Common-pool resources CPRs, Participatory resource management, Organized participation, Local organizations, Regulatory decision-making

**Mark Appiah, 2001. Co-Partnership in Forest Management: The Gwira-Banso Joint Forest management Project in Ghana. Department of Forest Ecology, Tropical Silviculture Unit,. University of Helsinki Finland.**

The involvement of local communities, as well as the private sector and the government in forest management is now an important principle of tropical forestry policy and practice and a major component of most international forestry aid programmes. This paper present an analysis on the Joint Forest Management Project initiated by two timber companies (Ghana Prime wood Products Ltd and Dalhoff Larsen & Horneman) in collaboration with local people in Gwira-Banso of Ghana. Conditions required for enhancing responsibility for and commitment to local forest management, and for an effective local participatory process were also analyzed. The study began with the premise that incentives and good communication will enhance participation in joint forest management. The assumption was valid and the results from the survey showed that five broad issues prioritized by respondents to be essential for co-partnership in forest management are communication, financial support, tree planting, multiple land use and benefit sharing. The Project enjoys a great deal of support from the local community, but a number of factors make the continued support of local people a challenging task, including questions of immediate livelihood sources and tenure arrangements. Although this participatory forest management has been implemented over a relatively short period, there is evidence that government and private sectors can successfully involve local people in sustainable management of the forests.



**Mbuvi M. T. E. & Musyoki J. K., 2013. Impacts of Participatory Forest Management on Community Livelihoods: A Case Study of Dida Community Adjacent to Arabuko-Sokoke Forest in Kilifi County, Kenya. *World Journal of Agricultural Sciences*, 1(2): 044-055.**

Forest Management (PFM) process was piloted in Arabuko Sokoke Forest (ASF) Dida beat in 1997 as an alternative forest management approach. This was necessitated by national outcry over forest resource degradation, clamour for democratization and need for better forest governance. The motivation for introducing PFM were as diverse as were the stakeholders: for KFS and other government departments' it was forest protection and biodiversity conservation with communities being motivated by anticipated opportunity to access benefits and participate in forest management. Non-Governmental Organizations were motivated by pioneering PFM introduction in Kenya and community poverty alleviation. The objective of this study was to assess community perceived impacts of PFM on community livelihoods and forest management. PRA tools and household questionnaire were used for the survey of 40 randomly selected households. The study has shown that PFM can contribute to better forest management. About 87.5% of respondents perceived that the forest condition had improved since 1995. PFM contributes to improved livelihoods as indicated by 64% of the respondents in the PFM villages of Dida who perceived that household well-being overall improved between 1995 and 2005 compared to Vimburuni village (non PFM village) in which only 31% of respondents indicated improved wellbeing.

**Mukamuri B.B., Campbell B.M. & Kowero G.S., 2003. Local Organisations and Natural Resource Management in the Face of Economic Hardships: A Case Study from Zimbabwe. CIFOR, Bogor, Indonesia.**

In this study, participatory rural appraisal tools were employed in three smallholder farming areas of Zimbabwe to investigate perceptions about organizations, and the factors driving organizational change. In 1991 Zimbabwe embarked on the Economic Structural Adjustment Programme (ESAP) that encompassed wide-ranging economic reforms. Local people in the study areas linked many of the current hardships to ESAP and to the drought of 1991/92. The economic hardships were seen as the reason for the collapse of community endeavors and the increasing move away from the extended family. The reform measures have also negatively impacted on the state organizations operating in the rural areas, including those related to agriculture and natural resource management. Traditional institutions have eroded, but it is suggested that they still remain the focus for management of natural resources.

**Peter J. Balint & Judith Mashinya, 2005. The Decline Of A Model Community-Based Conservation Project: Governance, Capacity, and Devolution in Mahenye, Zimbabwe. *Geoforum*, 37: 805–815.**

This paper reports the results of our research, conducted from June to August 2004, on the community-based conservation project in Mahenye, Zimbabwe. Previous studies have described this project as a model example of Zimbabwe's CAMPFIRE program. We explore the project's recent performance within the context of the country's post-2000 political and economic crisis and address the implications of our findings for arguments supporting devolution of authority for natural resource management to the community level. These

issues are related in that calls for devolution are at least partly contingent on the demonstrated capacity of local institutions to manage projects in the community interest despite difficult circumstances. In our research, we found that outcomes in Mahenye have deteriorated sharply from conditions described in earlier studies. We found further that local failures of leadership combined with the withdrawal of outside agencies responsible for oversight and assistance may be more to blame for this decline than the ongoing national turmoil. Our results suggest that even in apparently successful conservation and development projects, local participatory decision-making institutions are fragile and require continuing external support. Consequently, we argue for caution in promoting full devolution of authority to the community level without safeguards to maintain good governance and adequate capacity.

**Ryan Plummer & John Fitzgibbon, 2004. Co-Management of Natural Resources: A Proposed Framework. *Environmental Management*, 33 (6): 876–885.**

Co-management acknowledges pragmatic development and progression of institutional choice theories in natural resource management. This innovative concept embraces a pluralistic management approach based on the principle of subsidiarity and creates opportunities for the reconciliation of competitive property claims. This article reviews definitions of co-management, distinguishes it from other property rights regimes, and develops an organizational structure of the major elements involved. Synthesis of both experiences and literature leads to the development of a conceptual framework. Co-management is structured in terms of context, components, and linking mechanisms. In concert, these elements offer insight into the practice of co-management, address the shortcomings of institutional theories, and respond to critical issues raised in related literature. The framework contributes to natural resource management by acting as a means of identification and evaluation for such arrangements, as well as a systematic guide for future inquiries.

**Sarah South wold-Llewellyn, 2006. Devolution of Forest Management: A Cautionary Case of Pukhtun Jirgas in Dispute Settlements. *Human Ecology*, 34(5): 637-653.**

Devolution of natural resource management is a widely claimed aim in policy discourse. The Government of Pakistan is undertaking devolution of Provincial Government, including the Provincial Forest Departments. In historical and current practice, forest management has been devolved to local, community-based jirgas. Jirgas achieve some of the aims claimed by devolution which often fail in community-based management organizations. They represent the interests of different asset-based groups and ensure use rights of all for subsistence. However, the internal logic on which they work is based on different principles than those envisaged by policymakers. A case study of Pukhtun agro-pastoralists in the Malak and Division, North-West Frontier Province, Pakistan, illustrates the jirga's role in forest management and questions some of the assumptions on which community-based management is founded.

**Vyamana V.G., 2009. Participatory Forest Management in the Eastern Arc Mountains of Tanzania: Who Benefits? *International Forestry Review*, 11(2): 239-253**

Participatory forest management (PFM) is being promoted throughout Tanzania as a means of achieving conservation and improving livelihoods. This paper presents the results of a study in nine villages in the Eastern Arc Mountains to investigate the impacts of two institutional forms of PFM Joint Forest Management (JFM) and Community-Based Forest Management (CBFM) on the livelihoods of different well-being groups within communities. PFM was found to provide a new, though small, source of community-level income that was used to improve community physical capital. Household incomes from PFM forests generally increased slightly for most groups. However, technical and administrative obstacles prevented the poorest from taking full advantage of the benefits of forests under CBFM, while benefits from JFM-related income-generating activities were captured by village elites. Overall the results suggest that PFM implementation in Tanzania is improving forest conservation but not realizing its potential to contribute to reducing poverty and social exclusion and, in the case of CBFM, may even be increasing the gap between rich and poor.

**White Sarah C., 1996. 'De-Politicizing Development: the Uses and Abuses of Participation'. *Development in Practice*, 6 (1): 6 - 15.**

Participation must be seen as political. There are always tensions underlying issues such as who is involved, how, and on whose terms. While participation has the potential to challenge patterns of dominance, it may also be the means through which existing power relations are entrenched and reproduced. The arenas in which people perceive their interests and judge whether they can express them are not neutral. Participation may take place for a whole range of un-free reasons. It is important to see participation as a dynamic process, and to understand that its own form and function can become a focus for struggle.

**Yemiru Tesfaye, Roos A., Campbell B.M. & Bohlin F., 2010. Forest Incomes and Poverty Alleviation under Participatory Forest Management in the Bale Highlands, Southern Ethiopia. *International Forestry Review*, 12(1):66-77.**

There is an increasing interest in understanding the role forest products and forest resource management in rural livelihoods and poverty reduction strategies. This study investigates the contribution of forest resources to the livelihoods of rural households under a participatory management arrangement in southern Ethiopia. Data were collected through key informant interviews, group discussion, and household surveys from a total of 350 households. Income data were collected in four separate seasons at intervals of three months. The result indicates that forest products are the most important sources of income contributing to 34% and 53% of household per capita income and per capita cash income, respectively. Forest income also helps 20% of the population to remain above the poverty line. Forest income reduces inequality (Gini coefficient) by 15.5%. In general, the result confirms the importance of forest income in poverty alleviation and as safety nets in times of income crisis.

## 4.2. Analysis of PFM, Success Factors, Challenges, and Scaling up PFM

**Adcharaporn Pagdee, Yeon-Su Kim & Daugherty P. J., 2006. What Makes Community Forest Management Successful: A Meta-Study from Community Forests Throughout the World. *Society and Natural Resources*, 19:33–52.**

Thirty-one articles on community forestry, encompassing 69 case studies worldwide, were reviewed for systematic data synthesis and hypothesis testing. The meta-study identifies 43 independent variables ranging from internal attributes of the community and resources to external factors. Variables with significant influence on the success of community forestry are tenure security, clear ownership, congruence between biophysical and socioeconomic boundaries of the resources, effective enforcement of rules and regulations, monitoring, sanctioning, strong leadership with capable local organization, expectation of benefits, common interests among community members, and local authority. These variables illustrate community– forest relationships, community ability to organize and continue collective activities, and protection of benefits, rights, and responsibilities in common resource management.

**Agrawal A. & Ashwini Chhatre, 2005. Explaining Success on the Commons: Community Forest Governance in the Indian Himalaya. *Development*, 34 (1): 149–166.**

In the past two decades, scholarship on resource use and management has emphasized the key role of institutions, communities, and socio-economic factors. Although much of this writing acknowledges the importance of a large number of different causal variables and processes, knowledge about the magnitude, relative contribution, and even direction of influence of different causal processes on resource management outcomes is still poor at best. This paper addresses existing gaps in theory and knowledge by conducting a context-sensitive statistical analysis of 95 cases of decentralized, community-based, forest governance in Himachal Pradesh, and showing how a range of causal influences shape forest conditions in diverse ecological and institutional settings in the Indian Himalaya. In focusing attention on a large number of cases, but drawing on findings from case studies to motivate our analysis and choice of causal influences, our study seeks to combine the strengths of single case-oriented approaches and larger-N studies, and thereby contributes to a more thorough understanding of effective resource governance.

**Ambika P. Gautam, 2007. Group Size, Heterogeneity and Collective Action Outcomes: Evidence from Community Forestry in Nepal. *International Journal of Sustainable Development & World Ecology*, 14(6): 574-583.**

In the context of ongoing theoretical debate on the role of group size and heterogeneity in affecting collective action outcomes, this study analyzed associations of group size, and intra-group heterogeneities arising from ethnic, educational and livelihood-related differences with conditions of selected forests managed (formally or informally) by local user groups in the middle hills of Nepal. Four biological variables, basal area of trees, density of trees, density of saplings and richness of plant species, were chosen to represent the

condition of the forests. The findings show significant differences in biological condition of the forests managed by different size forest user groups and levels of ethnic, educational and livelihood-related heterogeneities. These differences, however, are inconsistent across the dependent variables representing forest condition, indicating that they were not necessarily caused by the size of the user groups or the group heterogeneities, but could be the result of other factors, such as the history of forest land use and degradation, composition of tree species and institutional arrangements governing the forests.

**Ambika P. Gautam & Ganesh P. Shivakoti, 2005. Conditions for Successful Local Collective Action in Forestry: Some Evidence from the Hills of Nepal. *Society & Natural Resources*, 18:153–171.**

In the context of an ongoing debate on the type of institutions or tenurial arrangements that are appropriate for the sustainable management of common pool resources (CPRs), this article examines the role played by local institutions in determining the conditions of two forests located in the Middle Hills of Nepal. The institutional robustness of the forests' governance systems is evaluated using Ostrom's (1990) design principles that characterize the configuration of rules devised and used by long-enduring CPR institutions. The findings show that the two forests are different in level of historical degradation as well as present condition, and these differences are generally explained by the structural characteristics of the local institutions governing the forests. The analysis indicates that Ostrom's design principles are useful for analyzing institutional robustness of local forest governance systems. However, some of the principles need modification or expansion if they are to be prescribed for forestry situations.

**Amy R. Poteete & Elinor Ostrom, 2004. Heterogeneity, Group Size and Collective Action: The Role of Institutions in Forest Management. *Development and Change*, 35(3): 435–461.**

Collective action for sustainable management among resource-dependent populations has important policy implications. Despite considerable progress in identifying factors that affect the prospects for collective action, no consensus exists about the role played by heterogeneity and size of group. The debate continues in part because of a lack of uniform conceptualization of these factors, the existence of non-linear relationships, and the mediating role played by institutions. This article draws on research by scholars in the International Forestry Resources and Institutions (IFRI) research network which demonstrates that some forms of heterogeneity do not negatively affect some forms of collective action. More importantly, IFRI research draws out the interrelations among group size, heterogeneity, and institutions. Institutions can affect the level of heterogeneity or compensate for it. Group size appears to have a non-linear relationship to at least some forms of collective action. Moreover, group size may be as much an indicator of institutional success as a precondition for such success.

**Blomley Tom, 2013. Lessons Learned from Community Forestry in Africa and Their Relevance for REDD+. Lessons Learned from Community Forestry in Africa and their Relevance for REDD+, USAID-supported Forest Carbon, Markets and Communities (FCMC) Program. Washington D.C., USA.**

The United States Agency for International Development (USAID)-supported Forest Carbon, Markets and Communities (FCMC) Program commissioned this review of lessons learned from community forestry in Africa. This review analyzes experiences and key lessons learned over three decades following the introduction of legal and policy reforms supporting community management of forests. It presents some key lessons from community forestry that are highly relevant for REDD+ (Reducing Emissions from Deforestation and Forest Degradation). Key findings were: (i) Empowerment of Communities: Community forestry is most successful where empowerment of communities is strongest, especially in terms of: 1) simple and practical procedures and guidelines for legalization of community tenure rights; 2) local community definition of forest management areas; 3) legally recognized community-level management entities; 4) community establishment of community forest management rules governing access and use; and 5) inclusion of marginalized groups that hold a stake in the resource. To date, however, in most African countries, the delegation of rights to communities is incomplete, discretionary or limited in scope. (ii) Governance and Stakeholder Engagement: Effective community-level institutions are required to develop and implement rules governing access and use of forest resources, and to ensure that costs and benefits of forest management are shared equitably among local forest users. Community institutions are most effective when built on existing structures or when communities are given strong leeway in defining them. It is important to carefully consider vertical (upward, as well as downward) accountability mechanisms, appropriate scale and linkages to existing formal and traditional structures. (iii) Benefits and Incentives: Community forestry is more successful where donor and/or government objectives coincide with community objectives. This is especially true when the benefits and incentives for communities are: clear, tangible and defined in national laws and policies; greater than the transaction and management costs associated with community forestry; and equitably distributed between national and local level stakeholders, as well as within participating communities. Overall, the benefits accrued by communities have been limited, especially where externally-initiated community forestry has focused on conservation. (iv) Capacity building: Successes have been noted in building the capacities of community forestry members and foresters to support community forestry, in terms of not only skills, but also legitimacy and social capital. Local forest managers need skills and knowledge required for community forestry. These include technical aspects of sustainable forest management, forest monitoring, forest tenure mapping, record keeping (including finances), and general skills, such as leadership, governance, communication and planning. (v) Scaling up: Scaling up is possible where governments take strong ownership, donor support is sustained, and community forestry generates concrete benefits to communities. Other than Tanzania, Gambia, Cameroon and Namibia, few African countries have moved beyond a portfolio of donor-funded community forestry pilot projects to national programs anchored and supported by government institutions. Devolution of forest revenues from government to community-level is being heavily contested by powerful actors with vested interests within or connected to government. (vi) Sustainability: Evidence exists of improved forest condition in community managed forests, as compared with state-managed or open-access forests. Reduced harvests in sustainably managed community forests, however, are often offset by increased harvests in adjacent, non-managed areas,

resulting in little net gain at a landscape level. Initiatives based on traditional beliefs, values and systems have a high potential for success, as do those with significant benefits and revenues. But limited financial returns at the local level threaten to undermine incentives for long-term management. Increased demand for conversion to both large and small-scale agriculture is increasing the opportunity costs of community forestry.

**Blomley T. & Ramadhani H., 2006. Going to scale with Participatory Forest Management: Early Lessons from Tanzania. *International Forestry Review*, 8(1):93-100.**

The paper provides an overview of experiences in Tanzania to date in 'scaling up' Participatory Forest Management (PFM) from what has until recently been a 'project-driven' approach to one that is mainstreamed and embedded within national and local government institutions. It highlights the valuable role that projects have played in influencing policy, developing new models and tools, but also some of the pitfalls of the project approach, particularly with regard to local expectations, the lack of sustainability and failure to integrate within local institutions and systems. In addition, the paper assesses the degree to which different models of Participatory Forest Management (PFM) have delivered on their two main policy objectives – sustainable forest management and improved rural livelihoods. The paper outlines some of the enabling factors as well as constraints to further dissemination and scaling-up of PFM in Tanzania – looking at political, institutional, social and economic dimensions.

**Brenda J. Crook & Eugene Decker, 2005. Factors Affecting Community-Based Natural Resource Use Programs in Southern Africa, Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, CO, USA.**

Interviews of 50 persons with knowledge of and/or experience with community-based natural resource management programs were conducted in late 1995 and early 1996 in southern Africa, to determine factors affecting the success of programs. An analysis of the qualitative research identified the following as major factors in successful programs: benefits acquired by local people, community control of the resources and programs, local organization in place, independence from outside funding and interference, and low human population to resource ratio. Conversely, the lack of similar factors was considered reasons for program fragility. In particular, government control and interference had undesirable consequences.

**Eric A. Coleman, 2009. 'Institutional Factors Affecting Biophysical Outcomes in Forest Management'. *Journal of Policy Analysis and Management*, 28 (1): 122-146.**

Although there is considerable interest in the impact of diverse policies affecting the biophysical outcomes in forests, gaining a substantial sample over time of forests under different institutional arrangements has been difficult. This article analyzes data from 46 forests located in six countries over time. In forests where policies have been adopted for conservation, active monitoring and sanctioning by locals is associated with positive forest conditions. Forests that allow user group harvesting, perhaps counterintuitively, are also shown to be associated with positive forest conditions. However, conditions in community-managed forests are not statistically different from government- or privately managed

forests. This implies that local communities can play an important role in achieving positive forest conditions but that full management responsibilities need not be given to achieve these results.

**Eva-Maria Nordström, Carlos Romero, Ljusk Ola Eriksson, & Karin O'hman, 2009. Aggregation of Preferences in Participatory Forest Planning with Multiple Criteria: An Application to the Urban Forest in Lycksele, Sweden. *Canadian Journal of Forestry Research*, 39: 1979–1992.**

A promising approach for participatory forest management planning is the combination of multiple-criteria decision-making and group decision making. A crucial part of the participatory multiple-criteria decision-making process is the aggregation of individual stakeholder preferences into a collective preference. In this study, an approach based on the determination of cardinal compromise consensus was applied to a real case of participatory forest planning. Consensus matrices for four different social groups were established from stakeholder preferences in the form of pairwise comparisons of different sets of criteria. Criteria weights were obtained for each social group and used to determine rankings of 12 forest management plans. The rankings of the social groups were aggregated to determine consensus solutions for the choice of the best forest management plan from a collective perspective. In the procedure, control parameters and a distance metric were employed to find solutions that balance the points of view of the majority and the minority. This approach makes it possible to aggregate preferences of different stakeholders and produces a range of different solutions. Furthermore, certain values of the control parameters and the distance metric generate solutions that are promising to present in a participatory situation where stakeholders have very differing preferences.

**Gopal Naik, 2009. Joint Forest Management Factors Influencing Household Participation. *Economic and Political Weekly*, 32 (48): 3084-3089.**

Forest departments in various states have made efforts to manage forests jointly with the local community in selected areas in order to prevent current rate of degradation of forests and ensure their regeneration. The theoretical framework used in this paper suggests that the extent of participation in JFM activities is dependent on the expected levels and variations in the marginal profit to labour from JFM and alternative enterprises, co-variance of their profit, expected share of households in the profit from JFM, risk awareness of the households, interest rate prevailing in the village and total labour available with the households. The two case studies provide empirical support to the conclusions drawn from the theoretical framework.

**Guillermo A. Mendozaa & Ravi Prabhu, 2005. Combining Participatory Modeling and Multi-Criteria Analysis for Community-Based Forest Management. *Forest Ecology and Management*, 207:145–156.**

Participatory approaches to forest management have gained wide acceptance and have also become the primary guiding principle in the management of natural resources worldwide. Despite their widespread popularity, participatory methods developed so far have often been criticized as lacking in rigor and in need of better structuring and analytical capabilities. This paper proposes and combines two approaches, namely multi-



criteria analysis (MCA) and participatory modeling. MCA offers an analytical environment where multiple goals, objectives, and perspectives can be accommodated and analyzed collectively and holistically. Such framework is deemed appropriate under a community-based forest management (CBFM) setting that is typically characterized by plurality of opinions and interests. Participatory modeling, on the other hand, is a general framework that subscribes to the principles of participatory action research, where direct participation of local communities is deemed crucial to the success of any management strategy. To ensure that the modeling process is participatory, the modeling environment, model formulation, and model development must be transparent and within the grasp of local participants. This paper describes how these two approaches can be integrated in a decision support system. The integration of the two approaches takes advantage of the analytical capabilities of MCA and the open and collaborative nature of participatory modeling. Applications of these two approaches as standalone models are briefly described. A more detailed case study describing the integration of the two approaches is also described.

**Heltberg R., 2001. 'Determinants and Impact of Local Institutions for Common Resource Management'. *Environment and Development Economics*, 6: 183-208.**

In this article, local institutions for forest conservation and management are analysed. The discussion is based on data from 37 villages and 180 households randomly sampled from a protected area in Rajasthan, India. Local management institutions are described, factors affecting inter-village differences in management institutions and collective action are analysed in a logit model, and the impact of institutions and other variables on common resource dependency and forest outcomes is tested using instrumental variable regression. Village population size has a positive effect and prior institutional experience a negative effect on the probability of collective action. It is concluded that efforts at improving forest management should not be confined to the poorest farmers. Large landowners are heavily involved in degrading use practices, especially when resources have good market potential. Local management institutions play a positive role in the area, but their impact appears insufficient to safeguard forests and commons from continued degradation. Conservation policies should target win-win options through interventions aimed at improving technologies for private and common lands as well as institutional changes.

**Herry Purnomo, Guillermo A. Mendozac, Ravi Prabhu & Yurdi Yasmi. 2005. Developing Multi-Stakeholder Forest Management Scenarios: A Multi-Agent System Simulation Approach Applied in Indonesia. *Forest Policy and Economics*, 7: 475– 491.**

Participatory approaches to development in general and natural resource management in particular are now a widely accepted management strategy. Multi-agent system (MAS), a computer-based tool, offers a promising approach for multistakeholder management systems such as the case involving community-managed resources. MAS provides a framework where stakeholders' (or agents) individual actions, behaviors and rational decisions can be analyzed in the context of the other stakeholders' actions and decisions. This robust approach offers a convenient analytical framework that can be used to simulate agents' actions, reactions and interactions. The approach also provides an environment where strategies or multi-stakeholder forest management scenarios can be developed and analyzed. This paper describes a MAS model developed for a forest management

unit located in East Kalimantan, Indonesia. Results and experience gained from the case study suggest that MAS is a suitable approach for developing multi-stakeholder forest management strategies.

**Irmeli Mustalahti & Iben Nathan, 2009. Review article: Constructing and sustaining Participatory Forest Management: Lessons from Tanzania, Mozambique, Laos and Vietnam. *Folia Forestalia Polonica*, 51(1): 66–76.**

The paper introduces an illustrative model, the ‘house model’, which contains a number of key elements for constructing and sustaining people’s participation in forest management. The model is used as a tool for analysing four donor supported forestry projects in Tanzania, Mozambique, Laos and Vietnam. The study shows that the two core elements for sustaining participation in forest management, regardless of land tenure or forest management model, are: (a) attitude: local people in the specific context see themselves as responsible for the local resources and; (b) access: local people gain secured access to information and benefits from the resources.

**Jafari R. Kideghesho, Eivin Røskoft & Bjørn P. Kaltenborn, 2006. Factors influencing conservation attitudes of local people in Western Serengeti, Tanzania. *Biodivers Conservation*, 16 :2213–2230.**

Attitudinal studies are increasingly being adopted as tools for evaluating public understanding, acceptance and the impact of conservation interventions. The findings of these studies have been useful in guiding the policy interventions. Many factors affect conservation attitudes positively or negatively. The factors inspiring positive attitudes are likely to enhance the conservation objectives while those inducing negative attitudes may detrimentally undermine these objectives. The magnitude of the resultant effects of each particular factor is determined by the historical, political, ecological, socio-cultural and economic conditions and this may call for different management interventions. In this study we examined how conservation attitudes in western Serengeti are shaped by the following factors: level of conflicts with protected areas; wildlife imposed constraints (inadequate pasture, water, diseases, loss of livestock during migration, theft and depredation); participation in the community based project; and socio-demographic factors (age, education level, wealth, immigration, gender and household size). The results indicated that the level of conflicts, participation in the community based project, inadequate pasture, lack of water, diseases, wealth and education were important in shaping peoples’ attitudes. However, in a stepwise linear regression analysis, 59% of the variation in peoples’ attitudes was explained by three variables i.e., conflict level with protected areas, lack of water and participation in the community based project. In addition to these variables, level of education also contributed in explaining 51% of the variation in people’s attitude regarding the status of the game reserves. Five variables (lack of water, level of education, inadequate pasture, participation in the community based project and diseases) explained 12% of the variation in people’s attitude towards Serengeti National Park. The paper discusses the implications for conservation of these results and recommends some measures to realise effective conservation of wildlife resources.

**Jagannadha R. Matta & Janaki R.R. Alavalapati, 2005. Perceptions of Collective Action and its Success in Community Based Natural Resource Management: An Empirical Analysis. *Forest Policy and Economics*, 9: 274– 284.**

Community based natural resource management (CBNRM) has received considerable attention in recent years and is being actively encouraged across the world as a successful strategy in promoting natural resource governance. Its efficacy in the field, however, is highly variable. The present study, based on an empirical analysis of the Joint Forest Management program in Tamil Nadu, India, explores the variation in the perceptions of collective action among community members, and analyzes the factors influencing perceptions of its performance. The results underline the need for a shared understanding of the collective action among community members for the joint venture's success and sustainability. Further, the analysis highlights the role of costs and benefits entailed in collective action in influencing the perceptions of its performance. The authors suggest careful consideration of differences in community members' understanding of the collective action and its impacts, before and during the implementation of CBNRM strategies.

**Jeff Dayton-Johnson, 2000. Determinants of Collective Action on the Local Commons: A Model with Evidence from Mexico. *Journal of Development Economics*, 62: 181–208.**

I develop a model of cooperation in small irrigation systems. I give conditions under which an equalizing redistribution of wealth increases the level of equilibrium cooperation, but also show that some redistributions that increase inequality can also increase cooperation. The distributive rule, a combination of arrangements for maintenance-cost sharing and water allocation, also affects the cooperation level. I estimate statistical models of cooperation for three maintenance indicators using field data from a study of Mexican irrigation societies. Social heterogeneity and landholding inequality are significantly associated with lower maintenance. Distributive rules that allocate water proportionally to landholding size likewise reduce maintenance.

**Kendra McSweeney, 2002. Who is “Forest-Dependent”? Capturing Local Variation in Forest-Product Sale, Eastern Honduras. *The Professional Geographer*, 54(2),:158–174.**

How researchers describe groups living within or near the world's tropical rain forests has important implications for how and why these groups are targeted for assistance by conservation and development organizations. This article explores how data about market behavior can be used to assess one aspect of forest peoples' livelihoods: their “dependence” on forest resources as a source of market income. With the intent of revealing the importance of methodology to how we describe forest peoples' livelihoods, I draw from a multiyear survey of market activity among the Tawahka Sumu of Honduras and distinguish nested measures of the Tawahkas' engagement in forest-product sale. Results indicate that whether or not the Tawahka or any forest group can be considered financially “dependent” on forest resources depends on the spatial and temporal scales at which data are aggregated. As a group, the Tawahka earned 18 percent of total market income from forest-product sale, but their group profile masked a high degree of heterogeneity at the village and household

level. Similarly, multiyear data indicated that while group-level generalizations adhere from year to year, they belie considerable change in households' market behavior across years. I discuss three ways in which the findings are relevant to the theory and practice of conservation and development in the humid tropics. I emphasize the importance of spatial scale in interventions, how market-oriented conservation schemes can benefit from a broader conceptualization of the economic context in which forest-product sale occurs, and how longitudinal analysis can reveal the dynamism of forest peoples' livelihoods.

**Kojo Sebastian Amanor, 2004. *Natural and Cultural Assets and Participatory Forest Management in West Africa. Working papers series no. 75, University of Ghana.***

Participatory forest management is now an established principle in most donor-supported forestry programs in West Africa. It became institutionalized during the 1980s as part of a movement towards decentralization and devolution of state enterprises management under structural adjustment programs. Most nation states have implemented forest sector administrative reforms that give greater roles to communities in forest management and recognize the importance of building partnerships between communities and forest departments (Brown 1999). The idea that community participation is central to effective natural resource management has been recognized in a number of international environmental conventions. It was given a prominent place in the 1992 Rio Earth Summit and the 1994 UN Convention to Combat Desertification. It was embraced in 1997 by the United Nations Intergovernmental Panel on Forests Proposals for Action, which called for the establishment of participatory mechanisms to involve all interested parties, including local communities and indigenous people, in policy development and implementation. Most West African states have initiated decentralization programs, with devolution of natural resource management as an important component. Most national forestry services in the region now recognize the importance of community forestry, collaborative forestry, or joint forest management and have developed a critique of previous practices based on exclusionary top-down approaches. Nevertheless, participatory forest management is still generally conceptualized within a techno-centric, top-down framework. The goal is to get rural communities to participate in the programs of global and national agencies, rather than to create a platform where rural people can make their own inputs into natural resource policy. The main concerns driving participatory forest management are rooted in neoliberal economic philosophy: the need to make forestry management more efficient and to involve communities in lowering the transaction costs of management. Equity concerns have focused largely on promoting a trickle down of minor benefits from the state to communities from the devolution of management functions. They do not get to grips with redressing the past state appropriation of forest resources for the benefit of industry at the expense of rural dwellers. They do not restore rights in forest resources to rural producers. Community forestry is typically conceptualized within a framework of ecological crisis. The crisis is blamed on inappropriate local or community natural resource management strategies, overpopulation, poverty, and inappropriate agricultural technologies used by peasant farmers. The objective of community participation is to introduce more efficient regulation and to prevent degradation by rural producers by imposing community natural resource management structures in areas where there was open access. Participation empowers community organizations to control the use of natural resources by the local population. But this framework examines neither the distortion of forestry policies by industry, nor the sources

of alienation of rural people from these policies. Crisis narratives have long been used as rhetorical devices to justify external interventions to control natural resources (Leach and Mearns 1996). Paradoxically, just as colonialism justified state appropriation through crisis narratives on the incapacity of the peasantry to manage forestry resources, community forestry now justifies the need for participation and community regulation by resorting to the same narratives. In both cases there is little attempt to understand the human imprint on nature, including the positive interactions between rural people and forests, and to build new initiatives based upon this history. This chapter explores the ways in which concepts of 'community' and 'environmental crisis' are constructed and implemented in contemporary forest policy in West Africa and the implications of these policies for the relationships among people, their production, and the environment. It argues that many West African communities have interacted with the environment in ways that have enhanced the natural resource base. A forestry strategy rooted in a conception of building natural assets – rather than in protecting a threatened and ostensibly pristine nature from human intervention, as characterizes much environmental thinking – can meet the objectives of reducing poverty and protecting the environment. This alternative approach would address the alienation of the rural poor from mainstream environmental policies and would be a step in the direction of harmonizing popular aspirations with forestry policy.

**Mark J. Baker, 1998. The Effect of Community Structure on Social Forestry Outcomes: Insights from Chota Nagpur, India. Mountain Research and Development, 18(1): 51-62.**

Social forestry integrates rural people with forest management in an attempt to improve rural welfare and reverse environmental degradation. Social forestry depends on people, yet the ability to assess opportunities for it is primarily based on technical criteria. Uniform social forestry programs are implemented in communities with different social characteristics without a clear understanding of the effects of those characteristics on people's actions and the outcomes of the program. Based on survey research among eighteen villages in the hilly Chota Nagpur Plateau, southeastern Bihar, India, this paper uses theories of collective action and common property resource management to investigate the relationship between social differentiation, local institutional capacity and wealth distribution, and the likelihood of success of private or community-based social forestry strategies. The results provide the basis for distinguishing among communities according to the probable effectiveness of different forms of social forestry, as well as for determining appropriate roles for external organizations interested in promoting social forestry. Additionally, the paper includes discussion of other factors such as local leadership, land and tree tenure, relations with external institutions, and ecological variation which affect social forestry outcomes.

**Melissa Leach, Robin Mearns & Ian Scoones, 1999. Environmental Entitlements: Dynamics and Institutions in Community-Based Natural Resource Management, Institute of Development Studies, Brighton, UK. World Development, 27(2): 225-247.**

While community-based natural resource management (CBNRM) now attracts widespread international attention, its practical implementation frequently falls short of expectations. This paper contributes to emerging critiques by focusing on the implications of intracommunity dynamics and ecological heterogeneity. It builds a conceptual framework highlighting the

central role of institutions in regularized patterns of behavior between individuals and groups in society in mediating environment- society relationships. Grounded in an extended form of entitlements analysis, the framework explores how differently positioned social actors command environmental goods and services that are instrumental to their well-being. Further insights are drawn from analyses of social difference; "new", dynamic ecology; new institutional economics; structuration theory, and landscape history. The theoretical argument is illustrated with case material from India, South Africa and Ghana.

**Pascaline Coulibaly-Lingani, 2011. Appraisal of the Participatory Forest Management Program in Southern Burkina Faso. Ph.D. thesis, Swedish University of Agricultural Sciences, Alnarp.**

In many developing countries there has been a paradigm shift in forest conservation and management strategies, away from State-centred control towards community based schemes, with twin goals of fostering sustainable forest management and reducing poverty. In Burkina Faso, various policy reforms have been introduced and attempts have been made to devolve use and management rights to local communities since the 1980s. However, it remains questionable whether communities' participation has yielded the intended improvements in livelihood and good governance. With the aims of providing a platform for developing strategies that promote sustainable forest management, the studies in this thesis is based upon examining the participatory forest management program (PFM) in southern Burkina Faso in terms of people's access to forest products, members' participation, their perceptions of the program, and challenges associated with early stages of political decentralization. Quantitative and qualitative data were gathered through household surveys, focus group discussions and literature reviews. The results show that factors related to decision-making, forest conservation and economic benefits are the most important determinants of participation. Further, the determinants of access to forest resources differed among households, thus local management institutions need to take these variations into account to ensure that the livelihood needs of the poor are met. Despite the decentralization policy in force in the country since 1992, the State Forest Service is still heavily involved in the decision making process. This considerably limits the active participation of local people. The results also show that, to some extent, participation in forest management activities is influenced by gender, household size, land tenure status, marital status, and forest legislation and implementation of forest laws and regulations. The performance of the PFM groups was found to vary, depending on their proximity to roads and market. Members' perceptions of the PFM seem to focus on their ability to generate income to support their livelihood, while less emphasis is placed on forest conservation. To enhance the outcome of the forest management program, the following strategies could be considered: securing user rights and empowering forest users by promoting the direct involvement of vulnerable and marginalized groups (women and migrants), increasing participation incentives, and enforcing the decentralization measures after addressing the challenges to enhance good governance and ensure equitable benefit-sharing.

**Pascaline Coulibaly-Lingani, Muluaem Tigabu, Patrice Savadogo, Per-Christer Oden & Jean-Marie Ouadba, 2009. Determinants of Access to Forest Products in Southern Burkina Faso. *Forest Policy and Economics*, 11:516–524.**

There is an increasing understanding that forests and the forestry sector are key elements in poverty reduction strategies in Africa. However, issues of equity between various forest users are becoming a major challenge to environmental development, forest management and poverty reduction. This paper presents an analysis of household representatives' socio-economic determinants and other constraints on accessing forest products, based on data collected through a questionnaire survey of 1865 respondents in seven districts of the Sissili province, southern Burkina Faso. Three logistic regression models were developed to examine determinants of access to the forest for collecting fuel wood, grazing livestock and collecting non-timber forest products (NTFPs). The results showed that access to forest products is associated with individual characteristics. Age, ethnicity, occupation and sources of income were significant determinants of access to all types of forest products. Access to the forest for grazing livestock was further influenced by gender and household size, while access to NTFPs was influenced by gender, household size and education level of the respondents. The formal forest law that precludes grazing in the forest, and customary rules and regulations pertaining to land tenure, were reported to be serious constraints to forest access for women and migrant people. Understanding the factors influencing access to products from commonly-owned forest resources could form the basis for developing, modifying and targeting policy instruments that promote equitable access. Policies should particularly encourage the direct involvement of vulnerable and marginalized groups (women and migrants) in forest management activities.

**Priya Shyamsundar & Rucha Ghate, 2011. 'Rights, Responsibilities and Resources: Examining Community Forestry in South Asia', SANDEE Working Papers, ISSN 1893-1891; WP 59–11. South Asian Network for Development and Environmental Economics (SANDEE), Kathmandu, Nepal.**

This paper seeks to understand whether decentralized management of forests can reduce forest loss in developing countries. In South Asia, large-scale experiments in decentralization -- Joint Forest Management in India and community forestry in Nepal, in particular - have changed the relationship between forests, the forest departments and rural households. However, have these institutional changes lead to a decline in forest degradation? Have they empowered households with stronger access rights and contributed to household well being? These are important questions to examine because rural households depend on forests to meet numerous subsistence needs. The emerging evidence suggests that community forest management may indeed be contributing to improved forest health. However, the impacts on household well-being are less carefully studied and seem to be far more varied. The paper suggests that clarity over rights, local monitoring and recognition of differences in intra-community needs are issues that require policy support if community forestry is to meet both livelihood and forest conservation expectations.

**Salla Rantala, Renee Bullock, Mwillla A. Mbegu & Laura A. German, 2012. Community-Based Forest Management: What Scope for Conservation and Livelihood Co-Benefits? Experience from the East Usambara Mountains, Tanzania. *Journal of Sustainable Forestry*, 31:777–797.**

The Tanzanian Community-Based Forest Management policy is based on the assumption that formalized forest tenure by village communities results in increased incentives for sustainable forest management. We compared the policy expectations to village forest management practices in northeastern Tanzania. Findings suggest that the practices follow policy in terms of increased security of rights, but exclusionary management of village forests precludes livelihood benefits while costs are unevenly distributed. Management appears effective at the village scale, but concerted efforts are likely to be needed to increase its long-term and landscape-level sustainability, and to create more significant incentives for the communities involved.

**Sandker M., Campbell B. M., Ruiz-Pérez M., Sayer J. A., Cowling R., Kassa H. & Knight A. T., 2010. The Role of Participatory Modeling in Landscape Approaches to Reconcile Conservation and Development. *Ecology and Society*, 15 (2):13.**

Conservation organizations are increasingly turning to landscape approaches to achieve a balance between conservation and development goals. We use six case studies in Africa and Asia to explore the role of participatory modeling with stakeholders as one of the steps towards implementing a landscape approach. The modeling was enthusiastically embraced by some stakeholders and led to impact in some cases. Different stakeholders valued the modeling exercise differently. Noteworthy was the difference between those stakeholders connected to the policy process and scientists; the presence of the former in the modeling activities is key to achieving policy impacts, and the latter were most critical of participatory modeling. Valued aspects of the modeling included stimulating cross-sector strategic thinking, and helping participants to confront the real drivers of change and to recognize trade-offs. The modeling was generally considered to be successful in building shared understanding of issues. This understanding was gained mainly in the discussions held in the process of building the model rather than in the model outputs. The model itself reflects but a few of the main elements of the usually rich discussions that preceded its finalization. Problems emerged when models became too complex. Key lessons for participatory modeling are the need for good facilitation in order to maintain a balance between “models as stories” and technical modeling, and the importance of inviting the appropriate stakeholders to achieve impact.

**Singh K., 1991. ‘People’s Participation In Managing Common Pool Natural Resources: Lessons of Success in India’, Presented at the Second Annual Conference of the International Association for the Study of Common Property (IASCP). Winnipeg, Manitoba, September 26-29.**

This paper presents a critical review and analysis of five selected successful cases of common pool natural resources management in India and, based on the analysis done, identifies major determinants of people’s participation in development and management of common pool natural resources. The term, people’s participation, is used to mean the act



of partaking by local people in all stages of common pool natural resources development and management programmes right from designing of various resource development and conservation structures through monitoring and evaluation of their performance and impact. The case study method of research was used to explore the major determinants of people's participation. The findings of the research are generalised to the theory of collective action as developed by Mancur Olson (1971) and James M. Buchanan and Gordon Tullock (1965). The five success stories selected for the study were: the Parwara Van (Forest) Panchayat in Uttar Pradesh, the Arabari Experiment in joint forest management in West Bengal, the Ralegan-Siddhi project in micro-watershed development in Maharashtra, the Sukhomajri project in micro-watershed development in Haryana, and the Mohini Water Co-operative in Gujarat. The case study revealed that the major determinants of people's participation in development and management of common pool natural resources were: substantial excess of expected private benefits from participation over the expected private costs of participation; high stakes of local people in the resource(s), organisation of local people in small groups; honest and good local leadership, existence and enforcement by the people involved of rules for regulation of resource use and for fair and equitable distribution of benefits from collective action; legal back up of the rules; involvement of non-governmental organisations in organising, educating, training, and motivating the people; and willingness and ability of government to provide needed financial and technical support.

**Sirisha C. Naidu, 2009. Heterogeneity and Collective Management: Evidence from Common Forests in Himachal Pradesh, India. *World Development*, 37(3):676–686.**

This paper conducts a statistical investigation into the impact of differences in economic benefits, wealth, and social classes within the community on collective management of forests. There are two key results. First, social parochialism is not a pre-requisite for collective management of forests. Moderate levels of social diversity are associated with low collective management, but at high levels of social diversity, collective management is high. Second, moderate wealth heterogeneity is beneficial; however, at high levels and in the presence of benefit heterogeneity, it decreases collective management. Similarly, benefit heterogeneity reduces collective management if wealth heterogeneity also exists. These results run counter to the dominant understanding of heterogeneity but may be seen as alternate explanations under a specific socioeconomic context.

**Sushil Kumar & Shashi Kant, 2005. Bureaucracy and new management paradigms: modeling foresters' perceptions regarding community-based forest management in India. *Forest Policy and Economics*, 77: 651–669.**

Foresters' perceptions (from Andhra Pradesh (AP), Haryana (HR), Himachal Pradesh (HP), and West Bengal (WB), states of India) about incongruity between forest departments' bureaucracy and acceptability of community based forest management (CBFM) are examined. Structural equation modeling is used, and variations in incongruity are explored across the four states and the two management levels. We construe organizational bureaucracy comprising of hierarchical rigidity, centralization of powers, non-participatory decision making, and organizational rigidity, and acceptability of CBFM being composed of structural acceptability, cultural acceptability, and organizational support. The analyses reveal variation in the degree of incongruity across the states—highest in HP, lowest in WB,

and in middle for AP and HR, but no variation across management levels. The loadings of four conceptual components of organizational bureaucracy are invariant across the four states, but the loadings of three components of acceptability of CBFM systems vary. Organizational structure has the highest influence on acceptability of CBFM systems in HP and the lowest in WB; support mechanisms have an almost uniform impact in WB, HR and HP states, and lowest impact in AP; and organizational culture has the highest impact in HR and HP, lower impact in AP, and no impact in WB. These differences suggest that the uniform organizational reforms, across states, pursued by the Government of India may prove counterproductive.

**Terefe Degeti, 2003. 'Factors Affecting People's Participation in Participatory Forest Management: The Case of IFMP Adaba-Dodola in Bale Zone of Oromia Region', M.A Thesis, Addis Ababa University School of Graduate Studies Regional and Local Development Studies, Addis Ababa.**

Forest is one of the most essential kinds of resources that human beings and other animals depend on. It regulates environmental and ecological changes in which soil, water, climate, rainfall etc. are in the good existence in sustainable condition. Whether it is private or public property, forest is the nationally and globally mutual treasure. The major causes for deforestation of Adaba-Dodola Priority Forest Area are the expansion of agricultural farm, the commercialization of forest product almost by the whole community living inside and outside it. As a remedy, the IFMP started its operation as a pilot project with the intention of adopting the collaborative management between the community and the government, where the community takes part in the conservation process so that the authority and ownership right are permanently transferred to some identified members of community living within the forest. The study was conducted on Adaba-Dodola Forest Priority Area, from February to May 2002. The general objective of this Thesis is to identify the major factors affecting people's participation in participatory forest management of Adaba-Dodola pilot project. Primary data are collected by face-to-face interview from sample population of WAJIB members using research instrument. Information was also gathered from district agriculture office and IFMP staffs for the purpose of getting preliminary idea but the response does not incorporated in the findings report. The interview covered 90 informants, which comprise about 20 percent out of the total WAJIB population size. Purposive, multi-stage stratified and systematic sampling methods have been employed in sample selection process. It is found out that people positively perceive the WAJIB approach of PFM due to the fact that they proved there is a positive change in forest conservation, empowerment and accountability devolved upon them. Moreover, the WAJIB members are strongly participating in the forest management in idea sharing, planning, decision-making and controlling. This happened as a result of the privileges of ownership and use right granted to them by the agreement made with the regional government. The benefits they derive or expect to derive are also the driving force for such active WAJIBs' community participation. Moreover, awareness creation made about the gloomy side of deforestation, and the chance of the community to be displaced from the forest region by government force for the loss of forest stock, the homogeneity of the people living within the forest, and decision making power devolved towards the community (applying bottom-up approach) are some of the major encouraging factors in forest management. On the other hand, in contrast to some research findings, which were carried-out in other area, land tenure; income difference and traditional or cultural value do not have impact on both participation and forest management activity. This

reveals that the variables that affect people's participation are based on regional specific attributes. Some of the factors that discourage participation are conflict/potential conflict/arising between those WAJIB members who are granted the use right and non-WAJIB members of the community who are excluded from use right over the forest. Furthermore, the fear of losing their farm land, lack of incentives, weak legal actions taken on illegal users and doubt on project continuity are some of the hindrances mentioned by the informants. Most of such variables are directly or indirectly related to securing forest right.

**Thomas S., 2006. Analyzing Community-Based Forestry: Local, Political and Agrarian Perspectives. *Forest Policy and Economics*, 8: 339– 349.**

This article serves as a substantive introduction to the special issue on community-based forestry. It situates the articles contained in this issue in relation to existing research on the social relationships and practices constituting forestry on the ground. Three perspectives on local forest relations, two well established and one emergent, are identified. The local perspective accords analytical priority to micro-level processes and emphasizes local factors as the primary influences on local forest relations. The political perspective emphasizes the contested nature of property in forest, linking local contestations to the effects of larger political forces, in particular states. The third, emergent perspective is agrarian, situating local forest relations at the intersection of local-level processes and larger economic and political forces. This article reviews examples of research employing these perspectives, discusses the papers in this volume with an eye on their relations with the agrarian perspective, and links the agrarian perspective to current concerns in forest policy.

**Victoria R. Napier, George M. Branch & Jean M. Harris, 2005. Evaluating Conditions for Successful Co-Management of Subsistence Fisheries in Kwazulu-Natal, South Africa. *Environmental Conservation*, 32 (2): 165–177.**

Conditions important for the success of co-management have repeatedly been identified, but their relative influence has not been quantitatively evaluated. To investigate the implementation of co-management in 11 subsistence fisheries within seven rural communities in KwaZulu-Natal, South Africa, perceptions of the responsible authorities and the fishing communities were surveyed. Of 16 conditions often considered important for the success of co-management, only nine were correlated with perceived success, the most strongly correlated being (1) benefits of co-management must exceed costs of participation, (2) training and empowerment, and (3) existence of a long-term 'champion' to drive the process. The perceptions of the authorities concurred with those of the communities with regards to the attainment of conditions, but views on the success of co-management differed significantly owing to disagreements that were specific to three particular fisheries. Both groups agreed that co-management is a viable improvement on top-down authoritarian imposition of regulations. However, it takes time to become effective; perceived success was directly correlated with how long individual programmes had been operating. Failure to devolve power from national government to local institutions, and delays in awarding subsistence permits, remain the major stumbling blocks to full realization of co-management.

**Wietze Lise, 2000. Factors Influencing People's Participation in Forest Management in India. *Ecological Economics*, 34: 379–392.**

Forests used to be an important source of revenue for the government of India, which is no longer the case because of large-scale deforestation. Proper forest management is needed to regenerate degraded forests, yet the government is powerless when people refuse to participate. However, there might be conditions that are more conducive for people's participation in forest management and this paper draws lessons from practical settings in which people do participate. Participation was initiated by government employees, a local leader, or through a strong community. A comparative analysis between three institutional settings in different states of India demonstrates the importance of empowering people in managing forests. There is a clear role for the state, which is to facilitate the people and to motivate their participation. The related fieldwork was carried out in about ten villages per state. On average 13 households were interviewed in each village. This led to a data set that is analysed in this paper with two techniques. A factor analysis is performed on ten to 12 participatory indicators of each household. In each institutional setting, social indicators turn out to be the main consideration in participation. Economic indicators follow as the second most important consideration. A regression analysis is carried out using the primary data. The main conclusion is that a high dependence on the forest and good forest quality enhances voluntary people's participation.

**Wollenberg E., Merino L., Agrawal A. & Ostrom E., 2007. Fourteen Years Of Monitoring Community-Managed Forests: Learning from IFRI's Experience. *International Forestry Review*, 9 (2): 670-684.**

Although community managed forests constitute a significant proportion of the worlds' forests, there is little information about their condition or how they are managed. The International Forestry Resources and Institutions (IFRI) network is a research programme established in 1992 to collect interdisciplinary information about forest sustainability and governance. IFRI is unique in terms of the large number of small-scale sites monitored (more than 350 communities and 9000 forest plots) for more than a decade, under the guidance of strong central leadership, a well defined research framework, relative autonomy of network members, and a strong inward focus. These features have enabled IFRI to have particular impacts on new knowledge, policy and local communities, and capacity building. Lessons about how to further strengthen, extend and sustain these impacts include developing more robust agreement about measures of forest sustainability, building network members' capacities to conduct comparative analysis, ensuring the database meets the needs of multiple users and expanding the membership and outreach of the network.

**Yemiru Tesfaye, Anders Roos & Folke Bohlin, 2012. Attitudes of Local People Towards Collective Action For Forest Management: The Case of Participatory Forest Management in Dodola Area in the Bale Mountains, Southern Ethiopia, *Biodivers Conservation*, 21: 245–265.**

The theory of planned behaviour was applied to study the attitude and intention of households towards participating in collective forest management (tree planting) activity. Households were randomly selected from 22 forest user groups. The results indicate that

the success of planting activities in terms of survival rate of seedlings has a strong effect in motivating households to participate in planting. Although households in general show a positive attitude and intention to participate in tree planting, there were significant differences among households on the basis of socio-economic characteristics. Dependence on crop income, possession of bigger farmlands and better physical assets, and higher education level are positively related to intention to participate in planting activity. On the other hand, dependence on forest income is negatively related to attitude and intention. A continuous exchange of ideas and information between user groups and the government counterparts that provide technical support and advice is recommended.

### **4.3. Livelihoods, Collective Forest Management and Impacts under Participatory Forest Management**

**Aklilu Ameha, 2013. Conservation and Livelihood Impacts of Decentralized Forest Governance in Ethiopia. Ph.D. Thesis, Department of Food and Resource Economics, University of Copenhagen.**

Policy reforms over the past three decades have transformed the institutional conditions for natural resource governance in most developing countries. Among such reforms is decentralized management of forests to various actors in the hope to halt tropical deforestation by ensuring tenure security and more responsible forest governance. This dissertation focuses on a specific form of forest decentralization, namely participatory forest management (PFM). PFM emerged in developing countries in response to primarily deforestation and forest degradation and the recognition that many state governments do not have the resources to enforce forest management laws. Subsequently, the participation of the local community in forest management and the importance of forests for rural livelihoods became an additional key factor. Despite the theoretical advantages of PFM, few studies holistically documented its effects on livelihoods, forest condition, and institutional dynamics. The key research questions in this PhD study are what have been the impacts of PFM on livelihood, forest governance and forest conditions in Ethiopia, and what are the post project PFM impacts? The PhD study approaches these questions by disentangling outcomes that can be attributed to PFM rather than other factors through quasi-experimental designs. The significance of the conducted study lays in its holistic assessment of the theoretically expected outcomes of PFM. Research locations were dispersed across the Oromia and Southern Nations and Nationalities People's Regional states of (SNNPRS) Ethiopia. Both quantitative and qualitative data collection methods were employed in the study. The post project PFM outcome assessment (paper I) shows that in all five pioneer PFM sites the state of the forest is perceived to have improved with the introduction of PFM, something which centralized management failed to achieve. However, weak legal and technical support from local authorities after external support ended reduced the institutional effectiveness of forest user groups (FUGs) to assert their rights. The livelihood impact study (Paper II) shows that PFM affects livelihoods both negatively and positively, depending on the institutional arrangement that either grants subsistence use only or both subsistence use and cash income from forest. After controlling for confounding factors, FUG households in Dodola, where commercial wood marketing is allowed, increased their livestock assets and earned an equivalent amount of income compared with non-FUG households. In contrast,

in Chilimo, total income and expenditure for FUG households decreased compared with non-FUG households; this is attributed to the restricted forest access rules introduced with PFM. The third paper looks into socio-economic and bio-physical outcomes of commercial timber harvest regulation in the Dodola PFM site. It shows how changes in forest access rights have influenced the way timber harvest is conducted. FUGs marketed 90% of timber, unofficially 'violating' the top-down defined harvesting rules, but without reducing the overall sustainable supply of products from the forest. We analysed the difference in tree density between forests under participatory and government management in 23,046 ha of forest (paper IV). The results show that after controlling for confounding effects of topographical and structural variables, the densities of trees in forest under participatory management were higher than those in forest under government management. The dissertation argues that the PFM programme in Ethiopia actually contributes to forest conservation compared with other types of management regimes. However, conservation is also challenged mainly by lack of support from the authorities to the FUGs. The study confirms the theoretical claim that rules imposed from above are not followed, and that commercialization of timber and forest conservation can go side by side in decentralized forest management. Though various pilot projects have gained valuable experiences, the current PFM expansions remain based on the discretion of the individual donors and NGOs with a model where only subsistence level incentives are made available to members. The Ethiopian PFM scaling-up programmes focus to a large degree on linking PFM with additional incentives likely to emerge from global initiatives, such as Reduction of Emissions from Deforestation and Forest degradation (REDD+). However, the implications of REDD+ programmes for PFM efficiency and equity are not yet clear. Therefore, the study suggests the Ethiopian PFM programmes need to address the institutional weaknesses identified in this study before engaging with other objectives.

**Aklilu Ameha, Oystein Juul Nielsen & Helle Overgard Larsen, 2014. Impacts of Access And Benefit Sharing On Livelihoods And Forest: Case of Participatory Forest Management In Ethiopia. *Ecological Economics*, 97: 162–171.**

The introduction of participatory forest management (PFM) may involve the exclusion of previous forest users from accessing forest resources. This is the case for PFM in the two Ethiopian pioneer sites, Dodola and Chilimo that represent two distinct PFM approaches in Ethiopia. This paper analyses how PFM, after controlling pre-PFM differences, affects members of forest user groups (FUGs) and non-members' total annual incomes, forest incomes, expenditures and livestock asset holdings. Income and asset data were collected from 635 randomly selected households. Data were analysed using propensity score matching models. Results show that in Dodola, where commercial timber harvest is allowed, the introduction of PFM means that FUGs have higher livestock assets and forest income than non-members. The average total income and the expenditure for members and non members, however, were not significantly different. In Chilimo site, the result is the opposite the introduction of PFM means that FUG members have lower total incomes and assets than non-members. Based on our findings we recommend that the PFM scaling up approaches in Ethiopia, which currently allow FUGs only subsistence use from forest resources, need to be revised.

**Alfonso Peter Castro & Erik Nielsen, 2001. Indigenous people and co-management: implications for conflict management. *Environmental Science & Policy*, 4:229–239.**

Co-management agreements among indigenous people, state agencies, and other stakeholders offer substantial promise as a way of dealing with natural resource conflicts in a participatory and equitable manner. However, experience shows that co-management regimes can set into motion new conflicts or cause old ones to escalate. In practice the result may not be power sharing but rather a strengthening of the state's control over resource policy, management, and allocation. Instead of contributing to local empowerment, such arrangements may further marginalize communities and resource users. We use case material, primarily from northern Canada and South Asia, to explore the pervasive role of conflict in generating, shaping, and influencing the performance of co-management regimes. The paper analyzes the divergent interests and motives of state agencies in planning and implementing co-management arrangements. It highlights the cultural, political, and legal obstacles encountered by indigenous people and other rural communities in trying to negotiate co-management arrangements. We also explore the conflicts that can arise in co-management regimes where local participation in decision making is very limited. General lessons and recommendations are drawn from our analysis.

**Ambrose-Oji B., 2003. The Contribution of NTFPS to the Livelihoods of the 'Forest Poor': Evidence from the Tropical Forest Zone of South-West Cameroon. *International Forestry Review*, 5(2): 106-118.**

Many claims have been made concerning the use of NTFPs as part of development and conservation strategies. Important amongst these is that because NTFPs play an important part in household incomes they can be used to raise the perceived value of forests and thus provide incentives for more sustainable use of the forest estate. However, migrant communities living around forest margins have often been perceived as groups of people most likely to take advantage of the free goods provided by forests in a way that degrades the forest environment as short term benefits are maximised over long-term sustainability. Empirical evidence from the forest zone of south-west Cameroon suggests that for many migrant communities NTFPs are not a significant part (no more than 6%) of household total income and that poorer groups seek diverse livelihood strategies that are not predicated on natural resource use. Whilst richer groups may continue to rely on sources of income from the forest and NTFPs may make up to 15% of household income, for rich and poor alike the value derived from NTFPs is generated by secondary forest and forest fallow rather than less disturbed forest that has been the focus of conservation interest. The view is put forward that forest managers and international donors interested in conservation and development need to reassess the potential contribution of NTFPs in poverty alleviation strategies, and acknowledge that forest conservation priorities of local communities require policies and management systems focused on 'sustainable systems for production of livelihood benefits' rather than protectionist approaches to areas traditionally defined as valuable forest. Indigenous forests and savannas, along with plantation forests, offer numerous benefits to rural communities and society at large. Yet, the role of forests and forestry in contributing to sustainable livelihoods and poverty alleviation are widely debated. However, much of the debate pertains to lessons from the humid tropics, with little consideration of the widespread dry forests and savannas. It concludes that a large proportion of the population makes use of forests and the resources from them. These are vital components of local livelihoods, which

probably prevent people from slipping into deeper poverty. Moreover, for a measurable proportion, engagement in informal forest activities, as well as the formal forestry sector, has resulted in them being able to move out of poverty. Additionally, the generally dry nature of forests in South Africa, coupled with the high unemployment rate, limit the extent of alternative locally based livelihood options, thereby magnifying the contributions from forests and forest products.

**Arild A. & Sven W., 2003. Exploring The Forest: Poverty Link: Key Concepts, Issues and Research Implications, *CIFOR Occasional Paper No. 40*. Center For International Forestry Research. Bogor, Indonesia**

They distinguished three main benefits category, firstly, Non timber forest products serve subsistence needs, may have important gap filling or safety nets functions and sometime. Thirdly, ecological service provides regular cash incomes. Secondly, timber has not traditionally been very pro-poor but the current trends of increased local ownership of non timber forests growing tree commercialization and small scale wood processing could modify that practice. Thirdly, ecological services payments are emerging rapidly but it is uncertain how much the poor will benefit. In conclusion they proposed the following promising research topics: assessing current forest-based benefits to the poor, exploring emerging market opportunities, and evaluating cross-cutting institutional and extra sectoral issues.

**Arnold J.E.M. & Bird P., 1999. Forests and the Poverty-Environment Nexus. Prepared for the UNDP/EC Expert Workshop on Poverty and the Environment, Brussels, Belgium.**

Linkages between the rural poor and the forest resources they draw upon are complex. In using and managing forests to maintain flows of material and environmental inputs into their livelihood systems, people often transform the resource. While pressures of poverty can mean that this leads to deforestation, it is incorrect to assume that this will necessarily happen. The existence of multiple categories of user, with different and often competing interests, can mean that developing equitable and effective systems of participatory control and management of forests can be difficult. In particular, the needs of the poor to have continued access to forests to sustain subsistence and coping livelihood strategies, are likely to conflict with the interests of the wealthier and industry in privatizing forest product flows in order to exploit market opportunities. Four main areas of recommendation are discussed in the paper. One argues for a livelihoods approach to identifying constraints faced by the poor and priorities for action. A second stresses the need to strengthen governance systems, to enable the poor who draw on forests to do so equitably within systems characterized by multiple uses and multiple stakeholders. A third focuses on bringing about necessary policy reforms to underpin more equitable and sustainable forest use and management, and on strengthening mechanisms to implement and enforce such reforms. The fourth emphasises the importance of promoting partnerships among those with interests in sustainable forest management, at both the policy and local governance levels, in order to advance such changes (Arnold and Bird, 1999).



**Arnold M. & Townson I., 1998. Assessing the Potential of Forest Product Activities to Contribute to Rural Incomes in Africa, *Natural Resource Perspectives, Number 37*. Overseas development Institute.**

Large numbers of rural households in Africa continue to generate some of their income from forest product activities. However, much of this involvement is in labor intensive low return activities that help to provide the poor with an income safety net, but which decline once better alternatives become available. Expansion of forest product activities is likely to be concentrated on a limited number of products and services for which demand grows with rural and urban development. However, until recently information about actual production, trade in and demand for, products produced at a household and small enterprise level has been mostly situation specific and restricted to a particular point in time. According to the authors, most forest product activities are engaged in part-time, by farm households that cannot raise enough to be food self-sufficient year round. In the areas surveyed, about two-thirds of the activities involved just a single person. A forest product based activity usually constitutes just one activity within an agricultural household. In conclusion, they underlined that Entry into other forest product activities in contrast, is likely to be in response to growing demand and is likely to form part of the strategy of more dynamic households. Managing 'forest' resources to meet rural household income needs should therefore take account of the different roles they play in the strategies of different categories of household. It also needs to respond to the fact that, as a consequence, demand for some forest products will be declining while for others it will be growing.

**Ashley C., & Maxwell S., 2001. Theme issue: Rethinking Rural Development. *Development Policy Review, 19(4): 395–425*.**

A number of studies clearly indicate that forest products make a difference to the welfare of the most marginalized sectors of the community, delivering a range of financial and nonfinancial benefits. Although only in limited instances was the trade able to boost household incomes to any significant extent, it nevertheless played a critical role in (a) providing additional options for income generation in the context of few opportunities, (b) allowing households to diversify and supplement their income base, (c) providing a safety net for those facing shock and hardship, (d) reducing reliance on other safety nets such as inter household transfers and state welfare, and (e) meeting specific cash needs such as school fees. Thus, together with the less tangible benefits of self-reliance, identity and respect, new skills and social networks, flexibility, and often a more dignified way of earning a living than some of the alternatives for low skilled people. Few could argue that the natural product trade does not have a positive impact on the wellbeing of the individuals and households involved. This is particularly so when the alternative is demoralizing joblessness and greater vulnerability. Producers' own comments and perspectives regarding the benefits of the trade as well as the measurable proportion entering the trade by choice are clear (Ashley & Maxwell, 2001).

**Ashwini Chhatre & Arun Agrawal, 2008. Forest Commons and Local Enforcement. *PNAS, 105:(36)*.**

This article examines the relationship between local enforcement and forests used as commons. It uses a unique multi country dataset, created over the past 15 years by the

International Forestry Resources and Institutions Research Program. Drawing on original enforcement and forest commons data from 9 countries, we find that higher levels of local enforcement have a strong and positive but complex relationship to the probability of forest regeneration. This relationship holds even when the influence of a number of other factors such as user group size, subsistence, and commercial importance of forests, size of forest, and collective action for forest improvement activities is taken into account. Although several of the above factors have a statistically significant relationship to changes in the condition of forest commons, differences in levels of local enforcement strongly moderate their link with forest commons outcomes. The research, using data from diverse political, social, and ecological contexts, shows both the importance of enforcement to forest commons and some of the limits of forest governance through commons arrangements.

**Bahuguna V.K., 2000. Forests in the Economy of the Rural Poor: An Estimation of the Dependency Level. Royal Swedish Academy of Sciences. *Ambio*: 29 (3).126-129.**

The rural people in India, particularly the tribals and poor, depend on forest resources for meeting their energy needs, forest products, and for employment. This paper gives details of one estimation of dependency of people on forests in villages in the Madhya Pradesh, Orissa, and Gujarat states of India. Benefits derived by the people were reflected as a percentage of the total income of the household. The dependency on forests varies from 37% to 76% in these villages. This kind of assessment would create a data base and provide indicators of sustainable forest management, especially for an understanding of the intricacies of Joint Forest Management. This information can be very useful in deriving the overall contribution of the forestry sector in the national economy and thus help the planners, administrators and foresters in evolving better management practices.

**Belcher B. M., 2005. Forest Product Markets, Forests and Poverty Reduction. *International Forestry Review*, 7(2): 82-89.**

There is a new and increasing emphasis on poverty alleviation and livelihoods improvement in forestry, representing both a challenge and an opportunity. This paper briefly reviews the evolution of the 'livelihoods' issue, analyzes the concept of 'poverty alleviation' and discusses means by which forestry can contribute to livelihoods improvement. It focuses on the contributions of forest products and markets, questioning the typical timber vs non-timber dichotomy. The role and the potential of a forest product is determined more by the socio-economic and environmental context of the production, processing and marketing system than by the physical characteristics of the product itself. This is important as new opportunities arise through increased control of resources by local people and new markets for forest products. Helping achieve poverty alleviation through forestry requires protecting poverty mitigation functions, enhancing income and employment options, and taking advantage of opportunities to build and strengthen local institutions through policies and project-level interventions.

**Bhim Adhikari, Frances Williams & Jon C. Lovett, 2007. Local Benefits from Community Forests in the Middle Hills of Nepal. *Forest Policy and Economics*, 9: 464– 478.**

Community forestry has been in existence for about 20 years in Nepal, but there are few observations on changes in resource use since its inception. This study aims to investigate how farmers affected by community forestry have adapted to its introduction and whether their livelihood options have changed in response to changes in forest accessibility and forest product availability. A total of 309 households were interviewed in eight forest user groups in the middle hills of Nepal and results on reported changes in forest product collection and livestock numbers analysed. Reported forest product collection has increased since the introduction of community forestry, while livestock numbers have decreased. The main findings of the study are that, despite controlled access to the forest, collection rates have increased slightly in the majority of income groups and households. The number of trees on private land has increased, while the size of livestock herds has decreased. As long as the farmers can continue to adapt without adversely affecting their livelihoods they will support this forestry management system leading to an increased chance of the long term success of common property forest management in Nepal.

**Bognetteau E., Abebe Haile & Wiersum K.F., 2007. Linking Forests and People: A Potential for Sustainable Development of the Southwest Ethiopian Highlands. In Ensermu Kelbessa and Camille De Stoop (ed.). *Participatory Forest Management (PFM), Biodiversity and Livelihoods in Africa. Proceedings of the International Conference. March 19-21, 2007, Addis Ababa, Ethiopia.***

The local communities in the southwest highlands of Ethiopia are highly dependent on the forest resources for their livelihoods. Over time they have developed various ways of using and managing these forests in order to meet their needs for a range of non-timber forest products for household use and income generation. However, pressures on the forest resources have been increasing mainly as a result of population growth (both from natural increase and due to extensive settlement schemes), but also due to inappropriate agricultural investment projects. The deforestation and forest degradation not only threaten the ecological functions of the forests, but also impact on the livelihoods of local communities. There is an urgent need to stimulate both forest conservation and livelihood improvements in this region. As the forests harbour several important non-timber forest products, these could offer a good contribution to the livelihood development of local people. This paper describes the strategy and initial results of the NTFP Research and Development Project in southwest Ethiopia for stimulating non-timber forest production as a means towards economic advancement. First, the paper describes the characteristics of the project area and explains the project strategy. Within the project area, a highland forest area and a coffee forest area are distinguished which vary not only with respect to forest composition but also in terms of the degree of deforestation and development of anthropogenic agroforest types. In both areas NTFPs provide an important contribution to the local livelihoods, notably honey in the highland zone and coffee in the coffee forest zone. Secondly, the paper discusses the integrated approach followed by the project in order to stimulate NTFP production. This consists of improvements in participatory forest management and the production and marketing of commercial NTFPs, combined with local institutional development and capacity building. The approach focuses on technical, economic and sociopolitical elements. The project activities

are then reviewed, explaining how they are based on the principles of building on the local knowledge, skills and institutions, while responding to the ambitions, needs and challenges of the communities. Specific attention is given to i) location-specific approaches, ii) the interdependence of technical activities concerning improved production and processing of NTFPs, market linkage development and sustainable forest use and management, and iii) the stimulation of participation and collaboration by various stakeholder groups, through CBO development, training of local officials and policy dialogue. Finally, conclusions are drawn from the experience to date by application of the project strategy.

**Brooke Ann Zanetell & Barbara A. Knuth, 2004. Participation Rhetoric or Community-Based Management Reality? Influences on Willingness to Participate in a Venezuelan Freshwater Fishery. *World Development*, 32(5): 793–807.**

Community-based management (CBM) has progressed from the conceptual fringe to the dialogical heart of environmental management. Despite its rhetorical popularity, limited quantitative data exist on factors influencing local involvement. A quantitative survey of three Venezuelan fishing villages resulted in a predictive model of willingness to participate in CBM. Sense of community and fishery dependence was significant positive influences. High level of concern about the current and future state of the fishery correlated with an unwillingness to participate, indicating a defeatist attitude about perceived insurmountable problems. We explore sense of community, defeatist attitudes, and education in CBM project formulation and implementation.

**Byron N. & Arnold M., 1999. What Futures for the People of the Tropical Forests? *World Development*, 27(5): 789-805.**

The importance of forest products to households living in or near forests has been increasingly recognized. Estimates of numbers of people who in some way rely on forests, for survival or livelihoods, vary widely. Yet numbers alone do not reveal the forests' importance to diverse users. A typology that recognizes the varied relationships of people to forests and forest products permits assessment of the impacts of economic, cultural, and social changes. Understanding these relationships is crucial for institutions to adapt to changing patterns of demand, use, and supply, and to support both "forest dependent" and "forest-related" peoples.

**Campbell B. M., Clarke J. M., Luckert M., Matose F., Musvoto C. & Scoones I., 1995. Local Level Economic Evaluation of Savanna Woodland Resources: Village Cases from Zimbabwe. *Hidden Harvest Project Research Series 3*. International Institute for Environment and Development, London.**

There are two common difficulties in estimating forest income. First, data collection is costly because of the large numbers of diverse forest products, the irregularity or unpredictability of their collection, and their geographical dispersion. Second, as forest communities tend to be remote and far from markets, there is a higher likelihood that the value of many products will be based on a mixture of market exchange value, the value of monetary transfer, barter value, use value, or social values (Campbell et al. 1995). There is no simple way to sum the values of products along one dimension or to provide monetary values for comparison with other studies.

**Cavendish W., 2000. Empirical Regularities in the Poverty-Environment Relationship of Rural Households: Evidence from Zimbabwe. *World Development*, 28(11): 1979-2003.**

Analysis of rural households and environmental resources is beset by inadequate data, especially in Africa. Using purpose-collected panel data from Zimbabwe, we demonstrate seven empirical regularities in the rural poverty-environment relationship. Most important, environmental resources make a significant contribution to average rural incomes. Poorer households also depend heavily on these resources, which contribute c.40% to their incomes. Richer households, however, use greater quantities of environmental resources in total. Finally, considerable differentiation exists in the economic characteristics of environmental goods. These results demonstrate the considerable economic significance of environmental resources to rural households. Surveys which ignore them miscalculate rural incomes and welfare (William C.2000).

**Chasca Twyman, 2000. Participatory Conservation? Community-Based Natural Resource Management in Botswana. *The Geographical Journal*, 166 (4):323-335.**

This paper examines the complexities of participatory conservation through a case Study of the process of participation in a government funded community-based natural resource management programme in Western Botswana. The paper argues that different stakeholders have very different views on the levels of participation taking place in particular projects. Furthermore local people find it difficult to voice their concerns about the environment and issues of sustainability given the power relations involved in this 'participatory process. The paper questions the accountability and motivation of the different stakeholders involved in participatory projects and suggests that implicit in the policy implementation process are mechanisms which constrain empowerment and dictate the forms of participatory conservation which can emerge. The paper concludes by reviewing the case study in the light of new policy developments in Botswana.

**Clark C. Gibson, John T. Williams & Elinor Ostrom, 2005. Local Enforcement and Better Forests. *World Development*, 33 (2): 273–284.**

Current studies of local resource management examine many factors thought to be associated with good resource conditions. Despite the number of studies and the importance of such resources to millions of people worldwide, a lack of theory and hypothesis testing beyond the case level limits the lessons empirical studies offer. We argue that regular monitoring and sanctioning of rules, rule enforcement is a necessary condition for successful resource management. We test our theory using data regarding 178 user groups and by pairing rule enforcement with other important factors: social capital, formal organization, and dependence on forest products.

**Coad L., Campbell Miles A. & Humphries L. K., 2008. The Costs and Benefits of Protected Areas for Local Livelihoods: a Review of the Current Literature. Working Paper. UNEP World Conservation Monitoring Centre, Cambridge, U.K.**

Protected areas could play a significant role in the implementation of schemes to reduce emissions from deforestation and degradation (REDD) in developing countries, through either the strengthening of the existing protected area network, or designation of new areas. Many rural poor people rely on forest resources, and may experience positive or negative changes to their livelihoods as a result of REDD. This review aims to assess the livelihood implications of the existing protected area network in order to inform future REDD policy. The costs and benefits of individual protected areas for community livelihoods have been well documented. Costs can range from displacement of local communities to crop damage by wildlife, and sometimes include restricted access to resources and changes in land tenure. Benefits can include direct revenue from environmental protection, and the maintenance of ecosystem services such as watershed protection. The nature of these costs and benefits depends largely upon the protected area's status and governance, as well as its history of use. The net livelihood impacts of protected areas are less easy to discern, as there is a lack of standardised assessment methodologies. The effect on livelihoods of differing governance types within and between IUCN protected area management categories is rarely assessed in the literature, and requires further research. However, general patterns can be observed. The livelihood impacts of protected areas vary with protected area status, management strategies and community involvement in governance. Strictly protected areas with top-down management structures (generally associated with IUCN management categories I-II) can result in major livelihood costs and cause conflict between local communities and protected area management. Community management schemes, and protected area management allowing sustainable use of forest resources (more often associated with IUCN management categories V-VI), can provide tangible benefits. However, significant costs can still be incurred by communities if management and institutional capacity is lacking, and issues of governance and tenure are not resolved (Coad et al 2008).

**Delacote P., 2007. Agricultural Expansion, Forest Products As Safety Nets, And Deforestation. *Environment and Development Economics*, 12: 235–249.**

According to Philippe D. 2007, two safety nets that has been used were the diversification strategy and the coping strategy. With both strategies, crop risk reduction, lower risk aversion and larger population increase tropical deforestation. Forest profitability always tends to increase the forest cover in the diversification case. Conversely, considering the coping strategy, two opposite effects determine the impact of forest profitability on the forest cover: a portfolio effect and an insurance effect. Finally, the household is better off and deforests less when using the diversification strategy instead of the coping strategy (Philippe D. 2007).

**Dev O. P., Yadav N. P., Springate-Baginski O. & Soussan J., 2003. Community Forest Management in the Middle Hills of Nepal: The Changing Context. *Journal of Forest and Livelihood*, 3(1).**

This paper outlines the policy context and resource base for community forestry in Nepal. Drawing on a study of 11 Forest User Groups (FUGs) in the Middle hills region, the paper examines the process of FUG formation and post-formation support. The implementation process of community forestry demands rapid institutional change at Department of Forests (DoF) and village level, and changes in working relationships between these levels. The DoF's main responsibilities in the Middle hills are changing from the traditional role of forest policing and protection, and moving towards FUG facilitation. However, the limited capacity of the DoF has become the key constraint to implementation of community forestry, and finding a solution may involve re-organizing the DoF support role. As new priorities emerge in FUGs (relating to community development for instance) involving multiple support agencies is becoming increasingly necessary.

**Feldman A. Lo´Pez- Mora, J. & Taylor, J. E., 2007. Does Natural Resource Extraction Mitigate Poverty and Inequality? Evidence from Rural Mexico and a Lacandona Rainforest Community. *Environment and Development Economics*, 12: 251–269.**

Similarly, according to research findings of Aljendro et al. 2007, entitled “Does natural resource extraction mitigate poverty and inequality? Evidence from rural Mexico and a Lacandona Rainforest Community revealed that poverty can be reduced in the short-run by programs that raise the price that households receive. In the long run, however, sustained price increases could lead to overexploitation of the resource, leaving everyone worse off. The biological relationship between extraction and the resource base, the incentives and disincentives that this creates for future extraction, and the institutional setting surrounding price increases will jointly determine whether this seemingly perverse outcome occurs. Both long- and short-run considerations should be weighed carefully when assessing the potential to promote the green marketing of other natural resources as a poverty alleviation and forest conservation tool.

**Fisher R. J., 2007. Participatory Forest Management, Sustainable Livelihoods and Poverty Reduction: Experiences from Community Forestry in Asia. In Ensermu Kelbessa and Camille De Stoop (ed.). *Participatory Forest Management (PFM), Biodiversity and Livelihoods in Africa. Proceedings of the International Conference. March 19-21, Addis Ababa, Ethiopia.***

Since the late 1970s and early 1980s, community forestry (under a variety of different names) has emerged as an important approach to forest management in many Asian countries. At first community forestry was supported mostly as a policy option to achieve better forest management and protection. Increasingly, however, it has been advocated as a means to support sustainable rural livelihoods and, more recently, as a potential contributor to poverty reduction. This paper reviews experiences from a number of Asian countries (focusing on Nepal, India and the Lao PDR) in terms of the progress of community forestry in achieving livelihood and poverty reduction goals. It argues that the achievements have been uneven, although there are promising signs. The main focus of community forestry in terms of

livelihoods has been on the promotion of non-timber forest products. The paper argues that, while this has made useful contributions in some cases, the potential for larger contributions has been limited by the reluctance of forest departments to transfer meaningful control of valuable resources (including timber) to communities.

**Getachew Mamo, Espen S. & Pål V., 2007. Economic Dependence on Forest Resources: A case from Dendi District, Ethiopia. *Forest Policy and Economics*, 9: 916–927.**

Using a case from Dendi District, Ethiopia Getachew et al., 2007 examine variation in dependence on forest resources among rural households and the income equalizing effects of such resources. Their findings revealed that forest resources have an important income-equalizing potential among the rural households. They concluded that reduced access to forest resources would greatly affect the welfare of the rural population and increase wealth differentiation among rural households in the study area.

**Gibbon H., Mbithi D., Mugo E. N., & M. Phiri, 2005. Forest and Woodland Management in East and Central Africa: Emerging Models for Improvement in Livelihoods and Natural Resource Management in Kenya and Zambia. *International Forestry Review*, 7(3):193-207.**

Participatory Forest Management is a new strategy for the Forest Departments of Kenya and Zambia. Over the last five years or so, an increasing number of small project initiatives have been supported in both countries to test this model. Progress has been slowed by a lack of policy and legal frameworks, as well as management reluctance to take responsibility for new ideas and ways of engaging with multiple stakeholders. The authors argue that both of these governments as well as the international donors need to collaborate to develop suitable systems for monitoring and assessing progress towards improvements in resource utilisation and livelihoods.

**Gobeze T., Bekele M., Lemenih M. & Kassa H., 2009. ‘Participatory Forest Management and its Impacts on Livelihoods and Forest Status: The Case of Bonga Forest in Ethiopia’, *International Forestry Review*, 11 (3):346-358.**

The forest resources in Ethiopia have suffered decades of mismanagement due mainly to loosely defined property relations over these resources. As one of the solutions, Participatory Forest Management (PFM) scheme was introduced during the early 1990s by some NGOs. Nearly two decades of experience now exists in the country. However systematic assessments of the performance of the scheme are scanty. This study reports the experience from Bonga PFM project, which is one of the oldest pilot sites. Forest inventory and socio-economic survey were conducted to collect data. The study was conducted during a transition from NGO - Community to State - Community based management of the PFM project. PFM is shown to have positive impacts both on the state of the forest and living condition of participant households at least within the project life time. Forest conditions such as seedling and sapling densities improved. PFM also (i) promoted awareness about forest, (ii) capacitated locals to form new institutional arrangement that increased their participation in forest management, helped to reduce open access and assisted a regulated forest use, and (iii) contributed towards social equity in terms of gender and minority ethnic groups.



When accompanied with complementary non-forest based livelihood activities, PFM helped to diversify income sources, increase household income level, and build household assets. This reduced dependence of communities on forests for livelihoods. A challenge threatening the sustainability of the PFM program in Ethiopia is the weak government support for the scheme. PFM is still far from being mainstreamed in the forest management system of the country. Thus, it will be appropriate to assess how the PFM programs would perform few years after the support of the NGOs terminates.

**Gubbi S. & MacMillan D. C., 2008. Can Non-Timber Forest Products Solve Livelihood Problems? A Case Study From Periyar Tiger Reserve, India. *Oryx*, 42(2): 222–228.**

According to the study made in Indian Tiger Reserves (Sanjay G. and Douglas C. M., 2008), they examined whether NTFP collection can solve livelihood problems by analyzing revenues obtained from various NTFP species, estimating the economic returns to collectors from various social backgrounds, and exploring the attitudes of collectors towards their profession. Their findings suggest that the lowest daily revenues were earned by part-time collectors with low socio-economic status such as migrants, forest-dwellers or those without access to agricultural land. Most collectors (82%) did not wish to continue harvesting NTFPs if alternative livelihoods from agriculture could be provided, and none wanted their children to be NTFP collectors. In conclusion they stated that with respect to social justice, poverty alleviation and environmental sustainability, the role of NTFP collection in sustainable development is questionable.

**Hill L. & Shields D., 1998. Incentives for Joint Forest Management in India: Analytical methods and Case Studies. The World Bank, Washington D.C.**

The study examines the economic and financial incentives for various groups of forest users in India, to participate in Joint Forest Management (JFM) arrangements that is the management of forest resources by government forest departments and local communities. An analytical method is developed and applied to two case studies of communities managing a mixed teak forest system and as a coppice forest system. The analytical results show that: (i) Economic returns to JFM are considerable in both forest systems; (ii) There is an increase in revenues from the forest to the communities but a theoretical loss to forest departments; (iii) Income flows into the communities increase significantly though in the sal coppice system this is partially offset by declining income from collection of non-timber forest products (NTFPs); (iv) The benefits of JFM are not always distributed equally, which may result in collectors of firewood and some NTFPs losing, even though overall gains are sufficient to compensate losers. The realization of benefits is dependent on an enabling environment consisting of complex institutional and social conditions in particular the representativeness and functioning of the village forest committee, the regulatory framework and sharing arrangements and the regional economic and marketing context. The method needs to be more widely tested in a variety of social and environmental conditions and the results from these two case studies can only be extrapolated with caution. Nevertheless they point to significant economic and financial benefits to communities and the need for specific measures to safeguard the interests of those who may lose as a result of unequal distribution of the benefits.

**Isla Grundy, Jane Turpie, Pamela Jagger, Ed Witkowski, Isabelle Guambe, Daniel Semwayo, & Anastelle Solomon, 2000. Implications of Co-Management For Benefits From Natural Resources For Rural Households In North-Western Zimbabwe. *Ecological Economics*, 33: 369–381.**

Addressing issues of resource management in sub-Saharan Africa has prompted the consideration of joint management policies that incorporate the needs of several stakeholder groups. This study examines the short and long-term use of natural resources in north-western Zimbabwe in a complex ecological–economic setting using a simulation model. Land and resource ownership in the model is divided between communal lands, which are managed by local inhabitants, and State Forest, which is managed by the Forestry Commission. Three different resource users rely on the stock of resources that the woodlands and grasslands (dambos) produce: the Zimbabwe Forestry Commission, communal land residents and illegal occupants of the State Forest. Net benefits to each of the three user groups are estimated under four different management scenarios, two of which advocate for the expulsion of illegal forest dwellers from the State Forest, and two of which involve a degree of joint management of the State Forest by the Forestry Commission and inhabitants neighbouring the forest. If the status quo is maintained, or if access by local people to the forest is severely limited, forest quality will decline due to the impacts of increased fires (which are limited when livestock are in abundance). Eviction of the forest dwellers results in a serious loss of benefits for that stakeholder group, but does not result in a significant increase of benefits for other stakeholder groups. The economic impacts of the different management scenarios are not very different because of the low values of the forest resources. Compared to the status quo, co-management provides for slightly greater net benefits, but the transaction costs associated with the establishment of co-management may be too high to justify this option.

**Jagger P. & Pender J., 2003. The Role of Trees for Sustainable Management of Less-Favored Lands: The Case of Eucalyptus in Ethiopia. *Forest Policy and Economics*, 5: 83–95.**

In northern Ethiopia, eucalyptus is the most commonly observed tree species in community and household woodlots. In an environment suffering from biomass and water shortages, erosion and land degradation, fast growing and resilient eucalyptus perform better than most indigenous tree species. Smallholders show a clear preference for eucalyptus poles, which are useful for farm implements and constructing dwellings and fences. In addition, the sale of eucalyptus poles and products has the potential to raise farm incomes, reduce poverty, increase food security and diversify smallholder-farming systems in less-favored areas of Tigray. Despite the potential for eucalyptus to improve rural livelihoods, in 1997 the regional government of Tigray imposed a ban on eucalyptus tree planting on farmlands. The ban was precipitated by concerns about the potential negative environmental externalities associated with eucalyptus, and the desire to reserve farmland for crop production. However, the regional government promotes the planting of eucalyptus in community woodlots, and has recently begun to allow private planting of eucalyptus on community wasteland and steep hillsides. In this paper, we review the ecological debate surrounding the planting of eucalyptus trees. In addition, the economic factors that influence smallholders to invest in tree production are considered. Ex ante benefit–cost analysis based on community and village level survey data from Tigray illustrates that planting eucalyptus yields high rates of

return, well above 20% in most circumstances. The effect of variable harvest rates, and the potential costs of decreased crop production when eucalyptus trees are planted on or near farmlands are considered relative to our base case scenario. Based upon the review of the ecological and economic impacts of eucalyptus, we conclude that a policy option favoring the allocation of wastelands for private tree planting offers the greatest opportunity for rural smallholders.

**Jean-Marie Baland, Pranab Bardhan, Sanghamitra Das Dilip Mookherjee. Forests to the People: Decentralization and Forest Degradation in the Indian Himalayas. *World Development*, 38(11): 1642–1656.**

This paper assesses degradation of forests managed by local communities (Van Panchayats (VPs)), relative to state protected and open access forests in the Indian state of Uttaranchal. It is based on ground-level ecological measures of forest quality (including canopy cover, biomass, lopping, and regeneration) in forest areas adjoining a random sample of villages, and controls for unobserved village heterogeneity, possible endogeneity of management regimes and cross-forest spillovers. Controlling for these factors, VP forests are found to be 20–30% less lopped, and similar on other dimensions. The lopping differences are greater the longer the forest has been under a VP.

**John Robertson And Michael J . Lawes, 2005. User Perceptions Of Conservation and Participatory Management of Gxalingenwa Forest. South Africa. *Environmental Conservation*, 32 (1): 64–75.**

New forest policies in South Africa seek to reconcile conservation and development objectives by devolving some responsibility for forest management from the state to local communities. Community participation in forest management aims to protect forest-based subsistence livelihoods by incorporating the interests of resource users, while simultaneously diffusing threats to biodiversity by managing resource use. To date, participatory forest management (PFM) has had mixed success in South Africa because the transfer of rights to users has not accompanied changes in policy. A questionnaire survey of 60 households (43%) revealed the attitudes of users toward current management and conservation options for iGxalingenwa forest. Users chose participatory forest management (52%) over community (25%) or state-dominated forest management (2%) structures. User choice was motivated by the desire to secure rights of access to, and ensure equitable benefit from, a dwindling resource base, rather than the conservation of these resources to sustain future yields. Users were unwilling to reduce resource use and compromise usufruct rights to achieve conservation goals, even to improve the availability of the resource stock. Current user needs compromise biodiversity conservation goals, and users regard state conservation practices as protectionist and obstructing their rights of access to resources. While the National Forests Act of 1998 seeks to conserve resources by limiting access to them and is based on principles of sustainable use, it is nevertheless perceived to offer few incentives to users to participate in forest management and conservation. Ideally, an institutional and legal framework that allocates user rights and managerial responsibilities to households is required, but clearly suitable alternatives to forest products are also vital for successful management. Greater trust between the provincial parks authority and users is needed, but is complicated by weak traditional leadership and poor community representation. Ultimately, users preferred PFM because, while recognizing that harvest rates are unsustainable, user

dependence upon forest resources and weak traditional leadership means they can protect usufruct rights only by participation. Changes to any of these factors may create demands for a new management system. PFM allows the greatest flexibility for responding to changes in demands as well as the environment.

**Kendra McSweeney, 2002. Who Is “Forest-Dependent”? Capturing Local Variation in Forest-Product Sale, Eastern Honduras. *The Professional Geographer*, 54(2):158–174.**

How researchers describe groups living within or near the world's tropical rain forests has important implications for how and why these groups are targeted for assistance by conservation and development organizations. This article explores how data about market behavior can be used to assess one aspect of forest peoples' livelihoods: their “dependence” on forest resources as a source of market income. With the intent of revealing the importance of methodology to how we describe forest peoples' livelihoods, I draw from a multiyear survey of market activity among the Tawahka Sumu of Honduras and distinguish nested measures of the Tawahkas' engagement in forest-product sale. Results indicate that whether or not the Tawahka or any forest group can be considered financially “dependent” on forest resources depends on the spatial and temporal scales at which data are aggregated. As a group, the Tawahka earned 18 percent of total market income from forest-product sale, but their group profile masked a high degree of heterogeneity at the village and household level. Similarly, multiyear data indicated that while group-level generalizations adhere from year to year, they belie considerable change in households' market behavior across years. I discuss three ways in which the findings are relevant to the theory and practice of conservation and development in the humid tropics. I emphasize the importance of spatial scale in interventions, how market-oriented conservation schemes can benefit from a broader conceptualization of the economic context in which forest-product sale occurs, and how longitudinal analysis can reveal the dynamism of forest peoples' livelihoods.

**Kerstin Pfliegner, 2010. ‘The Impacts of Joint Forest Management on Forest Condition, Livelihoods and Governance: Case studies from Morogoro Region in Tanzania’, Thesis submitted to the University of East Anglia, U.K. for the degree of Doctor of Philosophy, University of East Anglia, School of Development Studies Faculty of Social Sciences.**

This study of six lower altitude Eastern Arc forest and miombo woodland reserves around the Uluguru Mountains in Tanzania investigates the impacts of Joint Forest Management (JFM) on forest quality, household livelihoods and forest governance. In terms of forest quality, comparative analysis of 659 forest plots showed significant signs of improved forest quality in the three forests jointly managed between communities and state, compared to the three forests under sole state management (control group). This was measured through an increased frequency of trees, poles and withies, as well as seedling coverage and canopy density. There were significantly less incidences of fire in the JFM forests compared to the control group. In terms of livelihoods and resource access, JFM essentially provides preferential forest access to village leaders and forestry committee members, at the expense of the rest of the community. For village families who own land, this causes a greater reliance on their home gardens and farms, as well as diversion in the extraction of

forest products to areas not covered by the JFM regime. For poor families with limited land, forest closure due to JFM limits their ability to maintain diversified livelihoods. The local forest committees do not follow good governance principles in regard to record keeping and information sharing with villagers. The disjuncture between externally created village forest committees and established village governance bodies prevents accountability and transparency with regard to forestry matters, allowing those who benefit to reinforce a regime that keeps them in control and avoids them being questioned. In summary JFM has led neither to improved livelihood opportunities for the majority of villagers nor improved forest governance.

**Khanal K. P., 2007. Participatory Forestry and its Contribution to the Livelihood of Rural Poor. In Ensermu Kelbessa and Camille De Stoop (ed.). Participatory Forest Management (PFM), Biodiversity and Livelihoods in Africa. Proceedings of the International Conference. March 19-21, 2007, Addis Ababa, Ethiopia.**

This paper presents the development of decentralized forest policy adopted in Nepal and multi-stakeholder participation in programme planning, monitoring and evaluation of forest resource management. The Community Forestry Programme is one of the successful programmes in Nepal and so far approximately 15,000 Forest User Groups (CFUGs) are formed now managing about 1.2 million ha of national forests with significant contribution to the livelihoods of the poor. The Leasehold Forestry (LHF) programme aims to rehabilitate degraded national forest through reforestation by small groups of rural poor. A package programme including farming of annual crops and animal husbandry is provided to support the livelihood of the beneficiaries. A large block of productive forest of the plain area in Nepal is managed collaboratively by the local government and users in well-defined roles and responsibilities, and benefit sharing mechanisms. The government also involves groups of poor women in public land agro-forestry practice, which is demonstrating substantial contribution to the livelihoods of these groups. With these forest management modalities the forest user groups in Nepal are moving forward to make the forestry sector development in Nepal self-reliant at a local level thereby contributing to poverty.

**Macqueen D.J., 2008. Forest Connect: Reducing Poverty and Deforestation Through Support to Community Forest Enterprises. *International Forestry Review*,10(4): 670-675.**

International commitments to reduce poverty and curb deforestation echo many national programmes and policies. But how do you achieve both together? The overlap between areas of persistent poverty and high deforestation often coincides with traditional models of state forest ownership in which large-scale industrial logging concessions or agricultural clearance are superimposed on pre-existing forest and land rights claims of varying validity. Widespread informality, resource conflicts and forest degradation often result. But there are also increasing numbers of more positive stories - sustainable community forest enterprises overcoming multiple dimensions of poverty. Secure forest rights, strong social organisation, appropriate business models and well designed support have enabled many communities to deliver on both social and environmental fronts. This paper highlights lessons learned,

policy and institutional gaps that remain, and the formation of a new alliance, Forest Connect, to address those gaps.

**Mahapatra A. K, Albers H. J. & Robinson E.J.Z., 2005. The Impact of NTFP Sales on Rural Households' Cash Income in India's Dry Deciduous Forest. *Environmental Management*, 35 (3): 258–265.**

In recent years, researchers and policy makers have recognized that nontimber forest products (NTFPs) extracted from forests by rural people can make a significant contribution to their well-being and to the local economy. This study presents and discusses data that describe the contribution of NTFPs to cash income in the dry deciduous forests of Orissa and Jharkhand, India. In its focus on cash income, this study sheds light on how the sale of NTFPs and products that use NTFPs as inputs contribute to the rural economy. From analysis of a unique data set that was collected over the course of a year, the study finds that the contribution of NTFPs to cash income varies across ecological settings, seasons, income level, and caste. Such variation should inform where and when to apply NTFP forest access and management policies.

**Mbuvi M. T. E. & Musyoki J. K., 2013. Impacts of Participatory Forest Management on Community Livelihoods: A Case Study of Dida Community Adjacent to Arabuko-Sokoke Forest in Kilifi County, Kenya. *World Journal of Agricultural Sciences*, 1 (2): 044-055.**

Participatory Forest Management (PFM) process was piloted in Arabuko Sokoke Forest (ASF) Dida beat in 1997 as an alternative forest management approach. This was necessitated by national outcry over forest resource degradation, clamour for democratization and need for better forest governance. The motivation for introducing PFM were as diverse as were the stakeholders: for KFS and other government departments' it was forest protection and biodiversity conservation with communities being motivated by anticipated opportunity to access benefits and participate in forest management. Non-Governmental Organizations were motivated by pioneering PFM introduction in Kenya and community poverty alleviation. The objective of this study was to assess community perceived impacts of PFM on community livelihoods and forest management. PRA tools and household questionnaire were used for the survey of 40 randomly selected households. The study has shown that PFM can contribute to better forest management. About 87.5% of respondents perceived that the forest condition had improved since 1995. PFM contributes to improved livelihoods as indicated by 64% of the respondents in the PFM villages of Dida who perceived that household well-being overall improved between 1995 and 2005 compared to Vimburuni village (non PFM village) in which only 31% of respondents indicated improved wellbeing.

**McSweeney K., 2002. Who Is "Forest-Dependent"? Capturing Local Variation in Forest-Product Sale, Eastern Honduras. *The Professional Geographer*, 54(2): 158–174.**

How researchers describe groups living within or near the world's tropical rain forests has important implications for how and why these groups are targeted for assistance by conservation and development organizations. This article explores how data about market

behavior can be used to assess one aspect of forest peoples' livelihoods: their "dependence" on forest resources as a source of market income. With the intent of revealing the importance of methodology to how we describe forest peoples' livelihoods, I draw from a multiyear survey of market activity among the Tawahka Sumu of Honduras and distinguish nested measures of the Tawahkas' engagement in forest-product sale. Results indicate that whether or not the Tawahka—or any forest group—can be considered financially "dependent" on forest resources depends on the spatial and temporal scales at which data are aggregated. As a group, the Tawahka earned 18 percent of total market income from forest-product sale, but their group profile masked a high degree of heterogeneity at the village and household level. Similarly, multiyear data indicated that while group-level generalizations adhere from year to year, they belie considerable change in households' market behavior across years. I discuss three ways in which the findings are relevant to the theory and practice of conservation and development in the humid tropics. I emphasize the importance of spatial scale in interventions, how market-oriented conservation schemes can benefit from a broader conceptualization of the economic context in which forest-product sale occurs, and how longitudinal analysis can reveal the dynamism of forest peoples' livelihoods.

**Michael C. Gavin & Gregory J. Anderson, 2006. Socioeconomic Predictors of Forest Use Values in The Peruvian Amazon: A Potential Tool for Biodiversity Conservation. *Ecological Economics*, 60 (4): 752 – 762.**

Conservation is a crisis discipline requiring rapid action with limited funds. This study examines the potential of socioeconomic variables to predict forest use values. If natural resource use can be predicted from socioeconomic data, conservation planners could rapidly identify and focus conservation programs on the sectors of local populations that most intensively utilize local flora and fauna. Families in three communities in the northern Peruvian Amazon were surveyed over a 6-month period. Data were collected on use of flora and fauna from six locally determined use categories (food, medicine and poisons, wood, weavings, adornments, and "other") in forest types of three age classes (fallow fields—very young forests, young secondary forests, and old secondary forests). Forest use values were the dependant variables calculated in \$/ha/year. Socioeconomic variables included: age, education, family size, residence time, land worked, land owned, number of fishing nets, chickens, pigs, cows, and/or mules owned (all proxies for productive assets), and level of ecological knowledge (ability of informants to correctly identify forest species and answer basic questions about their biology). Ordinary least square multiple regressions were run independently for each forest type. Regressions were also run separately for the two most valuable use categories, food and wood. Low R<sup>2</sup> adjusted values (all <0.3) reflect the difficulty in predicting human behavior due to confounding variables and complex interactions. Residence time and a household's community of residence were the most significant predictors of forest use values. Households in Vista Alegre, the community with the highest density of people and smallest landholdings per household, extracted the highest value of forest products per hectare. The longer a family stayed in any community the higher the value of forest goods they extracted. If families that lived in an area longest are the most intensive extractors of forest products, they should be a major focus for conservation programming. In addition, the higher value of products extracted from forests by some families may make them more open to strategies seeking to protect long-term viability of the resources they utilize. The importance of residence time also indicates that

planners need to account for changes in the resource use patterns of stakeholders over time (Michael, et al 2006).

**Mirjam A.F., Rose T. & Wiersum K.F., 2003. Paper Presented at GIZ/CIFOR International Conference on Livelihoods and Biodiversity 19-23 May 2003, Bonn.**

In the past capacity, of Non timber forest products (NTFP) to contribute to tropical forest conservation and poverty alleviation was regarded as very promising. Recent studies have made clear, however, that the alleged commercialization-conservation/ development link in NTFP debate needs reconsideration. Although some NTFPS do play a role in rural livelihood strategies and can contribute to sustained forested landscapes in various tropical landscape areas, there is no uniform pictures as regards the actual importance of NTFPS to rural livelihoods (Mirijam A.F., et al.2003.). According to Charlie S. and Sheona S. 2007, the value of NTFP to rural households is manifested through a daily net function which represents a cost saving to the families involved and to the state, as well as through an emergency net, which serves as an insurance in times of misfortune, such as drought, disease, and unexpected economic hardship. Ad hoc trade in NTFPs is a common emergency net, which in some instances evolves into a permanent way of life. Financial returns from trade are variable, depending on resource type and hours worked, but are typically low. Despite the small cash incomes from trade, they provide an important contribution that complements the diverse livelihood strategies within a household, especially for the poorer sectors of rural society. Moreover, there are non-financial benefits of NTFP trade that are commonly overlooked.

**Monica Fisher, 2004. Household Welfare and Forest Dependence in Southern Malawi. *Environment and Development Economics*, 9: 135–154.**

This paper examines the role forests play in alleviating poverty in rural Malawi. Data from three villages in southern Malawi indicate high levels of forest dependence. Gini decomposition shows that access to forest income reduced measured income inequality at the study sites. Tobit analysis of the determinants of reliance on low-return and high-return forest activities indicates that asset-poor households are more reliant on forest activities compared with the better off; reliance on high-return activities is conditioned also by availability of adult male labor and location. Taken together, the study's findings suggest that forests prevent poverty by supplementing income, and may also help to improve the living standards of households that are able to enter into high-return forest occupations. Policy implications are discussed (Fisher, 2004).

**Neumann R. & Hirsch E., 2000. Commercialization of Non-Timber Forest Products: Review and Analysis of Research. Center for International Forestry Research, Bogor, Indonesia.**

In recent years, a renewed interest in NTFPs as tools to promote socially equitable and environmentally sustainable economic development put into context. This interest is evident not only in the rapidly growing volume of literature, but in the number of government and private interventions directed at this sector, particularly in tropical forests. Much of this investment is based on the premise that improving prices for producers, adding value locally



through increasing post-harvest processing and improving local organizations, can lead to long-term economic and political gains for these groups. Some also argue that these kinds of interventions can lead to forest conservation. And yet, understanding of the true role and potential of forest product development to contribute to human development or conservation, based as it is on untested theory and scattered and inconsistent case-based research, remains limited (Neumann and Hirsch 2000). The hypothesis that people benefit from the forest, and would conserve it if they controlled it, may not hold when alternative land uses provide higher benefits than forests. This condition is common given that agriculture is the leading cause of deforestation.

**Nitin D. Rai & Christopher Uhl F., 2004. Forest Product Use, Conservation and Livelihoods: The Case of Uppage Fruit Harvest in the Western Ghats, India. *Conservation & Society*, 2 (2):289-313.**

The harvest and sale of non-timber forest products (NTFP) by local communities has been suggested as a possible solution to the often observed conflict between forest use and forest conservation. Recent studies have, however, suggested that the economic rewards might not be constant, and that ecological effects of harvest might be higher than previously believed. In India trade in NTFP has a long history, but few studies have explored both the ecological and socio-economic aspects of harvest. We report here the results of a socio-economic and ecological study on the harvest of fruits from the rainforest tree uppage (*Garcinia gummigutta*), which occurs in the tropical forests of the Western Ghats. We studied the characteristics of uppage fruit harvest, socio-economic factors that influence harvest, and the ecological effect of fruit harvest under differing tenurial regimes. Our findings suggest that dependence on NTFP harvest by local communities might be problematic due to market instability, patchy resource distribution, inequitable access to forest resources within the village and lack of security of tenure (Natin et al. 2004).

**Oyono P.R., 2007. Is Decentralization in Natural Resource Management Leading to Livelihoods Improvement and Sustainability? Evidence from Central Africa. In Ensermu Kelbessa and Camille De Stoop (ed.). *Participatory Forest Management (PFM), Biodiversity and Livelihoods in Africa. Proceedings of the International Conference. March 19-21, 2007, Addis Ababa, Ethiopia.***

Since 1990, Central African States have made profound natural resource policy reforms. One of the main orientations of these reforms is known today as the 'decentralization' of forest management processes within a long lasting context of 'complex political ecology'. This essay examines the effects of this policy change on livelihoods and forest sustainability. It shows that contrary to what was planned by policy-makers and what was expounded by several theorists, decentralization in forest management and related financial benefits is not yet synonymous with the improvement of livelihoods, poverty reduction, and environmental sustainability. On the ground, there are, by and large, very few positive socio-economic outcomes. In conclusion, the author proposes some enabling conditions for an effective link between decentralization and improved livelihood.

**Paul Matiku, Mireri Caleb & Ogot Callistus, 2013. The Impact of Participatory Forest Management on Local Community Livelihoods in the ArabukoSokoke Forest, Kenya. *Conservation and Society*, 11(2): 112-129.**

This study examines the impact of participatory forest management (PFM) on forest adjacent household livelihoods in the Arabuko.Sokoke forest in Kenya. It compares the impacts on households near PFM forests (PFM zones) with those near forests with no participatory management (non.PFM zones). The study questions were: does conservation of the Arabuko.Sokoke forest result in net household incomes?; does PFM increase net household benefits?; and are household benefits uniformly distributed within the 5 km PFM intervention zone? The hypotheses tested were: forest conservation benefits exceed forest conservation costs; PFM zones have higher household benefits than non PFM zones; and benefits and costs reduce with distance from forest edge. In the year 2009, we collected data on household benefits and costs in PFM and non PFM zones. Data were collected along 10 km transects at 1 km intervals, sampling 600 households up to 5 km away from the forest. The results show varied household dependence on the Arabuko-Sokoke forest. The forest benefits exceed costs in PFM zones but the forest is a cost in non PFM zones, and costs and benefits reduce with distance from forest edge. The study concludes that, though not cheap, PFM is a tool that can help the Arabuko-Sokoke forest win the support of the adjacent local communities.

**Paumgarten F., 2005. The Role of Non-Timber Forest Products as Safety-Nets: A Review of Evidence With a Focus on South Africa. *Geo Journal*, 64: 189–197.**

Poor, rural communities are vulnerable to adversity. To secure their livelihoods, people adopt multiple livelihood strategies, including using non-timber forest products (NTFPs). NTFPs have been identified as important to rural livelihoods, as an alternative land-use option as well as in fulfilling an important safety-net function although empirical evidence on the latter's strength is limited. Whilst NTFPs may contribute towards alleviating poverty, this safety-net function needs more critical and quantitative investigation. This includes the establishment of an applicable definition so this function can be communicated to policy makers and taken into account in national poverty alleviation strategies and, in attempts to promote resource-conserving behavior by highlighting the value of natural resources (including NTFPs) compared to alternative land-use options. Poverty in rural households is complex and households are vulnerable to a range of shocks. During adversity households can turn to a range of possible safety-nets. What determines the use of NTFPs as a safety-net, how this safety-net function manifests and the strength of this function is poorly understood and there is need for further investigation (Fiona, 2003).

**Penjani Kamanga, Paul Vedeld & Espen Sjaastad, 2009. Forest incomes and rural livelihoods in Chiradzuru District, Malawi. *Ecological Economics*, 68: 613-624.**

This paper examines forest income among rural dwellers in one of Malawi's most densely populated districts, Chiradzulu. 160 households were interviewed in two sites, only 20 km apart, purposely selected on the basis of access to a forest reserve. People are extremely poor, with 97% having incomes of less than 1 USD/day. Forest income constitutes around 15% of total income; only non-farm income (47%) and agriculture (28%) rank higher. The

poorest segment depends more on forest income than the least poor group, but the medium income group exhibits the highest dependence. Fuelwood constitutes the major source of such income followed by fodder. The incomes mainly support current consumption. People with better access to the forest reserve have higher total income, forest income, and relative forest income. As revealed through a Gini-coefficient analysis, forest resources have an important income equalizing effect across rural households. A particular group of resource poor farmers (8.1% of sample), with little access to agricultural land and a high representation of female heads, derives an average of 65% of their income from the forest. An important policy lesson is that restricting people's access to forest resources can have substantial effects on household livelihoods and welfare, and would serve to increase income inequalities in the area. Livelihood researchers should now recognize the substantial income from forest resources.

**Penjani K., Paul V. & Espen S., 2008. Forest Incomes and Rural Livelihoods in Chiradzulu District, Malawi. *Ecological Economics*, 68: 613 – 624.**

According to Pejani K. et al 2008, study conducted on forest incomes and rural livelihoods in Chiradzulu District, Malawi, examines forest income among rural dwellers in one of Malawi's most densely populated districts, Chiradzulu. As revealed through a Gini-coefficient analysis, forest resources have an important income equalizing effect across rural households. A particular group of resource poor farmers (8.1% of sample), with little access to agricultural land and a high representation of female heads, derives an average of 65% of their income from the forest. An important policy lesson is that restricting people's access to forest resources can have substantial effects on household livelihoods and welfare, and would serve to increase income inequalities in the area. Livelihood researchers should now recognize the substantial income from forest resources.

**Rabindra Nath Chakraborty, 2001. Stability and Outcomes of Common Property Institutions in Forestry: Evidence from the Terai Region of Nepal. *Ecological Economics*, 36:341–353.**

The purpose of this paper is to explore the conditions for success of local common property institutions in forestry. The analysis is based on a case study of the Terai (lowlands) region of Nepal. Common property institutions were found to be stable despite the presence of inequality, ethnic heterogeneity, and migration into the region. This is due to the fact that these institutions build upon established systems of authority in the villages, include monitoring and enforcement mechanisms, and benefit from a supportive legal environment. As far as outcomes are concerned, common property serves well to protect forests locally; however, many village residents resort to exploiting forests managed under state property. The impact of common property on poverty alleviation is ambiguous.

**Rasmus Heltberg, 2001. Determinants and Impact of Local Institutions for Common Resource Management. *Environment and Development Economics*, 6:183–208.**

In this article, local institutions for forest conservation and management are analysed. The discussion is based on data from 37 villages and 180 households randomly sampled from a protected area in Rajasthan, India. Local management institutions are described,

factors affecting inter-village differences in management institutions and collective action are analysed in a logit model, and the impact of institutions and other variables on common resource dependency and forest outcomes is tested using instrumental variable regression. Village population size has a positive effect and prior institutional experience a negative effect on the probability of collective action. It is concluded that efforts at improving forest management should not be confined to the poorest farmers. Large landowners are heavily involved in degrading use practices, especially when resources have good market potential. Local management institutions play a positive role in the area, but their impact appears insufficient to safeguard forests and commons from continued degradation. Conservation policies should target win–win options through interventions aimed at improving technologies for private and common lands as well as institutional changes.

**Reddy S. R. C. & Chakravarty S. P., 1999. Forest Dependence and Income Distribution in a Subsistence Economy: Evidence from India. *World Development*, 27(7): 1141-1149.**

We examine an area of northern India where forestry acts to ameliorate the incidence of poverty and destitution, though it does not otherwise contribute significantly to the reduction of income inequality. The poor would be doubly disadvantaged without common property access to forest products. Conservation measures entailing curtailment in the right to common access pose a dilemma. This issue is explored here.

**Roe D., Nelson, F., Sandbrook, C., 2009. ‘Community management of natural resources in Africa: Impacts, Experiences and Future Directions’. *Natural Resource Issues No. 18*, International Institute for Environment and Development, London.**

Across sub-Saharan Africa, natural resources remain central to rural people’s livelihoods. Local norms and customs shape people’s everyday forms of resource use. In contrast, the commercial uses of natural resources often remain highly centralized, conditioned by government policies of the colonial and post-colonial eras. During the past several decades, there has been a shift from this predominantly centralized natural resource management towards more devolved models known very broadly as Community-Based Natural Resource Management (CBNRM). CBNRM models work to strengthen locally accountable institutions for natural resource use and management, enabling local groups of people to make better decisions about the use of land and resources. Because it involves the transfer of authority over natural resources to local communities, including of potentially valuable resources such as wildlife and timber, CBNRM is often about major institutional reforms and fundamental changes in power. This pan-African review of the impacts, challenges, and future directions of CBNRM highlights the diverse range of forms of community involvement in natural resource management that have emerged across the continent during the past twenty years. CBNRM means different things to different actors in different places across sub-Saharan Africa. In much of western and central Africa, CBNRM is interpreted by government authorities, donor agencies, and NGOs as benefit-sharing or outreach between national parks and adjacent communities. In such instances communities are not empowered as authorized local resource managers but are involved principally as passive recipients of benefits controlled elsewhere. This form of outreach and benefit-sharing is also a characteristic of some protected area management in East African countries. In Southern Africa, CBNRM

is most clearly defined in terms of the devolution of rights to make management decisions, and capture benefits, in relation to resources located on communal lands. In all instances CBNRM involves some degree of co-management of resources between central authorities, local government, and local communities which share rights and responsibilities through diverse institutional arrangements. The various forms of CBNRM and their many locally-specific adaptations have greatly diversified approaches to natural resource governance in sub-Saharan Africa. Some notable ecological, economic, and institutional achievements have been documented.

**Sanjay Kumar, 2002. Does “Participation” in Common Pool Resource Management Help the Poor? A Social cost–Benefit Analysis of Joint Forest Management in Jharkhand, India. *World Development*, 30 (5): 763–782.**

Joint Forest Management (JFM) has succeeded in halting forest degradation in India, but its poverty reduction objective has not fully been evaluated previously. This paper compares JFM forests and government-managed forests to assess their respective net social benefits to different groups of local villagers. It shows that the JFM regime reflects the social preference of the rural non poor, and that the poor are net losers over a 40-year time horizon. Future plans for JFM need to include suitable compensatory mechanisms to reduce the poverty of the poorest within a village.

**Schreckenber K. & Luttrell C., 2009. Participatory Forest Management: A Route To Poverty Reduction?. *International Forestry Review*, 11(2): 221-238.**

This paper presents the results of a three-year action research project, which investigated the impacts of participatory forest management (PFM) on poverty. Beginning with an analysis of over 30 cases reported in the literature, the project went on to undertake field research in Kenya, Tanzania and Nepal, three countries representing very different stages in and approaches to the implementation of PFM. PFM typically provides a new decision-making forum and may reroute previously direct household benefits to the user group or community level. Regardless of PFM model, the research shows that the key to providing rural people with a sustainable and equitably distributed stream of net benefits is to adopt poverty reduction as a stated objective, allow for both subsistence and commercial use of forest products, design appropriate PFM institutions, introduce transparent and equitable means of benefit-sharing, and provide sufficient support during establishment of PFM initiatives.

**Shackleton C. M., Shackleton S. E., Buiten E. & Bird N., 2007. The Importance of Dry Woodlands and Forests in Rural Livelihoods and Poverty Alleviation in South Africa. *Forest Policy and Economics*, 9: 558– 577.**

Indigenous forests and savannas, along with plantation forests, offer numerous benefits to rural communities and society at large. Yet, the role of forests and forestry in contributing to sustainable livelihoods and poverty alleviation are widely debated. However, much of the debate pertains to lessons from the humid tropics, with little consideration of the widespread dry forests and savannas. This paper considers the role of dry forest types, including savannas, using South Africa as a case example. It concludes that a large

proportion of the population makes use of forests and the resources from them. These are vital components of local livelihoods, which probably prevent people from slipping into deeper poverty. Moreover, for a measurable proportion, engagement in informal forest activities, as well as the formal forestry sector, has resulted in them being able to move out of poverty. Additionally, the generally dry nature of forests in South Africa, coupled with the high unemployment rate, limit the extent of alternative locally based livelihood options, thereby magnifying the contributions from forests and forest products. The depressing effects of widespread HIV/AIDS on labour availability, economic activities and livelihoods has exacerbated peoples' dependence on forest products(Charlie M.S.et al, 2007).

**Sherbinin A., Leah K. Wey V., McSweeney K., Aggarwal R., Barbieri A., Henry S., Hunter L. M., Twine W. & Walker R., 2007. Rural Household Demographics, Livelihoods and the Environment. *Global Environmental Change*, 18: 38–53.**

This paper reviews and synthesizes findings from scholarly work on linkages among rural household demographics, livelihoods and the environment. Using the livelihood approach as an organizing framework, we examine evidence on the multiple pathways linking environmental variables and the following demographic variables: fertility, migration, morbidity and mortality, and lifecycles. Although the review draws on studies from the entire developing world, we find the majority of micro level studies have been conducted in either marginal (mountainous or arid) or frontier environments, especially Amazonia. Though the linkages are mediated by many complex and often context-specific factors, there is strong evidence that dependence on natural resources intensifies when households lose human and social capital through adult morbidity and mortality, and qualified evidence for the influence of environmental factors on household decision-making regarding fertility and migration. Two decades of research on lifecycles and land cover change at the farm level have yielded a number of insights about how households make use of different land-use and natural resource management strategies at different stages. A thread running throughout the review is the importance of managing risk through livelihood diversification, ensuring future income security, and culture-specific norms regarding appropriate and desirable activities and demographic responses. Recommendations for future research are provided (Sherbinin et al, 2007).

**Sisitka H. L. & Shackleton C., 2008. Links between the Local Trade in Natural Products, Livelihoods and Poverty Alleviation in a Semi-arid Region of South Africa. *World Development*, 36(3): 505–526.**

Can the local commercialization of natural products contribute to reduced poverty and vulnerability? Commentary on this issue is mixed, with some observers being quite optimistic, while others hold a counterview. This paper explores the poverty alleviation potential of four products traded in Bushbuckridge, South Africa traditional brooms, reed mats, woodcraft, and “marula” beer. While key in enhancing the livelihood security of the poorest households, these products were unlikely to provide a route out of poverty for most, although there were exceptions. Incomes often surpassed local wage rates, and some producers obtained returns equivalent to the minimum wage. Non-financial benefits such as the opportunity to work from home were highly rated, and the trade was found to represent a range of livelihood strategies both within and across products (HeilaL.S and Charlie S.

2008).

**Subhrendu K. Pattanayak & Erin O. Sills, 2001. Do Tropical Forests Provide Natural Insurance? The Microeconomics of Non-Timber Forest Product Collection in the Brazilian Amazon. *Journal of Land Economics*, 77 (4): 595- 612.**

Tropical forests may contribute to the well-being of local people by providing a form of ‘‘natural insurance.’’ We draw on microeconomic theory to conceptualize a model relating agricultural risks to collection of non-timber forest products. Forest collection trips are positively correlated with both agricultural shocks and expected agricultural risks in an event-count model of survey data from the Brazilian Amazon. This suggests that households rely on forests to mitigate agricultural risk. Forest product collection may be less important to households with other consumption-smoothing options, but its importance is not restricted to the poorest households.

**Sudhakara Reddy B., Jyoti K. Parikh & Srinivasan P.V., 1999. Plantation Programmes Through People’s Participation: a Case Study from India. *Biomass and Bioenergy*, 17: 257-271.**

This paper provides a framework for analysing land regeneration programmes combining financial, economic and environmental aspects as applied to a wood plantation programme undertaken by a Tree Grower’s Cooperative Society (TGCS) established by the National Tree Growers’ Cooperative Federation (NTGCF), Anand, India. Mallanahally TGCS, situated in the southern part of Karnataka state in India was selected and a survey was carried out. Benefit-cost ratios and internal rate of return are worked out for various situations. The paper also examines the role of cooperatives in managing plantation activities and assesses the distributional aspects of the benefits of the plantations. The survey elicited information on the villagers’ perceptions regarding benefits from and barriers to implementation of plantation programmes. It is shown here that despite apparently unequal distribution of benefits, the present arrangements preserve cooperation as each of the stakeholders derive positive benefits

**Sunderlin W. D., Dewi S., Puntodewo A., Müller D., Angelsen A. & Epprecht, M., 2008. Why Forests Are Important for Global Poverty Alleviation: a Spatial Explanation. *Ecology and Society*, 13(2): 24.**

Forests have been declared important for the well-being of the poor because of the kinds of goods and services that they provide. We asked whether forests are important for the poor not only because of the kinds of goods and services they provide, but also because they tend to be located where the poor are. We conducted a spatial analysis to ascertain the degree of spatial association between poverty and in seven countries: Brazil, Honduras, Malawi, Mozambique, Uganda, Indonesia, and Vietnam. For most of these countries, there was a significant positive correlation between high natural forest cover and high poverty rate (the percentage of the population that is poor) and between high forest cover and low poverty density (the number of poor per unit area). We explain the findings and discuss policy implications and topics for future research.

**Takasaki Y., Barham B.L. & Coomes O.T., 2004. Risk Coping Strategies in Tropical Forests: Floods, Illnesses, and Resource Extraction. *Environment and Development Economics*, 9: 203–224.**

This paper examines coping strategies in response to covariate flood shocks and idiosyncratic health shocks among riverine peasant households in the Amazonian tropical forests. An assessment of coping strategies reveals that although precautionary savings (food stock and livestock) are important for both types of shocks, ex post labor supply responses in the form of upland cropping and resource extraction (fishing and non-timber forest product gathering) are more common to cope with the flood shock depending on local environments. A bivariate probit model examines what factors shape households' adoption decisions of gathering and fishing as a coping strategy. The analysis reveals an important insurance role of non-timber forest product gathering for the asset poor who have limited options for coping with flood risk.

**Tanvir Ali, Munir Ahmad, Babar Shahbaz & Abid Suleri, 2007. Impact of Participatory Forest Management on Vulnerability and Livelihood Assets of Forest-Dependent Communities in Northern Pakistan. *International Journal of Sustainable Development & World Ecology*, 14: 211–223.**

During the past two decades, several (donor-funded) participatory forest management projects were implemented in the forest-rich North-West Frontier Province (NWFP) of Pakistan, but these projects could not reduce the high rate of deforestation in the province. In 1996 the Asian Development Bank funded the Forestry Sector Project (FSP) in NWFP, which has institutionalized the participatory forest management system in the province. Forests are important natural capital and an essential part of the daily lives of the people who live in and around them. It was therefore considered imperative to analyze the impact of the participatory forest management model introduced by the FSP through a livelihoods lens, and to assess the contribution to livelihood sustainability made by the participatory approach. The findings of the study may be applied to similar situations in Third World settings. People of similar socio-economic and ecological zones may learn lessons for accelerating the process of sustainable natural resource management in their areas. The results showed that the participatory forest management system introduced by the FSP has had a definite impact on increasing the natural and social assets of forest dwellers and reducing vulnerability to their livelihoods. But the project did not address most of the factors of vulnerability and the elites that dominated the newly created institutions. It is suggested that the available livelihood assets, diverse factors of vulnerability and livelihood strategies of the local communities should be analyzed before the implementation of such mega-projects.

**Tanvir Ali, Munir Ahmada, Babar Shahbaza, Abid Sulerib Tanvir Alia, Munir Ahmada, Babar Shahbaza & Abid Sulerib, 2007. Impact of Participatory Forest Management on Financial Assets of Rural Communities in Northwest Pakistan. *Ecological Economics*, 63: 588 – 593.**

The system of participatory (or joint) forest management was commenced in the North West Frontier Province (NWFP) of Pakistan in 1996 through Asian Development Bank's funded



project. These forest reforms seek to initiate the process of eliminating the main causes of forest depletion through participation of local communities. Nevertheless, despite decades of the donor's interventions the deforestation rate in NWFP is still alarming. In this paper we have attempted to analyze the participatory forest management in Northwest Pakistan through livelihood lenses. More specifically this paper explores the impact of joint forest management initiatives on financial assets and livelihood strategies of local people. The overall results indicated that majority of the respondents were not dependent on the natural resources for their cash income rather they had adopted diverse non-natural resource based activities such as migration, labour etc. The results also indicated that the main priorities of the local people were financial and food security; where as the NWFP model of joint forest management gives more emphasis on forest protection and regeneration. Although the joint forest management enhanced the social assets of the local communities yet the omission of immediate financial benefits from the institutional changes in the forestry sector of NWFP was a barrier in motivating the local people in forest protection and was one of the main issues hindering the effectiveness of the forest reforms process.

**Tapan Kumar Nath & Makoto Inoue, 2010. Impacts of Participatory Forestry on Livelihoods of Ethnic People: Experience from Bangladesh. *Society and Natural Resources: an International Journal*, 23:1093-1107.**

As a strategy of social development, the Bangladeshi government has attached the highest priority to participatory forestry (PF) since the early 1980s. In this article, we examine the impacts of PF on livelihoods of ethnic people, drawing empirical data from three villages involved in two PF projects. The projects have varying impacts on livelihoods of participating villagers. Disparities in income and forest conditions in the study villages were traced to factors including forest production technologies (agroforestry), the top-down approach of project management, failure to create awareness about project benefits, and the inability of project staff members to organize planters. Findings also indicate that PF projects are not sufficient to conserve and develop forests without assuring people's basic needs food security and regular income sources. Meeting the diversified needs of people necessitates a longterm integrated plan that focuses on sustainable management of land, water, and other resources with a coordinated approach.

**Thorkil Casse & Anders Milhøj, 2009. 'Local Forest Management and Forest Conservation: Friends or Strangers?'. Paper presented at 8<sup>th</sup> International Conference of the European Society for Ecological Economics: Transformation, Innovation and Adaption for Sustainability, Ljubljana, Slovenia.**

The paper is a meta-study of local forest management experiences in developing countries drawn from a review of original 100 + articles (after screening the sample includes 55 papers). The existing literature does not address the issue of the impact of transfer of management of forest resources on the forest stock/forest area. Other meta-studies include different definitions of success (not only the forest stock) or lump together various management types (local management forests, private forests, and sacred forests). We found no systematic correlation between presence of local forest management and forest conditions. If anything, the enforcement of local rules is the closest variable to correlate with the forest condition variables. One explanation could be that community forestry will not work in a vacuum, as

one could believe that a minimum requirement is probably the presence of a government legal structure, which exists in India and Nepal, but not in many other countries.

**Tom Blomley, Kerstin Pflieger, Jaconia Isango, Eliakimu Zahabu, Antje Ahrends & Neil Burgess, 2008. Seeing the Wood for the Trees: An Assessment of the Impact of Participatory Forest Management on Forest Condition in Tanzania. *Fauna & Flora International Oryx*, 42(3): 380–391.**

Over the past 15 years the Tanzanian government has promoted participatory forest management (both joint forest management and community-based forest management) as a major strategy for managing natural forests for sustainable use and conservation. Such management is currently either operational or in the process of being established in 3.6 million ha of forest land and in 800 villages. Data from three case studies of forests managed using participatory and non-participatory forest management approaches suggest that community involvement in forest management is correlated with improving forest condition. In our first case study we demonstrate increasing basal area and volume of trees per ha over time in miombo woodland and coastal forest habitats under participatory forest management compared with similar forests under state or open access management. In our second case study three coastal forest and sub-montane Eastern Arc forests under participatory forest management show a greater number of trees per ha, and mean height and diameter of trees compared to three otherwise similar forests under state management. In our third case study levels of cutting in coastal forest and Eastern Arc forests declined over time since initiation in participatory forest management sites. We conclude that participatory forest management is showing signs of delivering impact in terms of improved forest condition in Tanzanian forests but that further assessments need to be made to verify these initial findings

**Tonen R., M.A.F., & Wiersum K.F., 2003. The Importance of Non Timber Forest Products for Forest Based Livelihoods-An Evolving Research Agenda. Paper Presented at the GTZ/CIFOR International Conference on Livelihoods and Biodiversity, 19-23 May 2003, Bonn.**

In the past, the capacity of non timber forest products (NTFP) to contribute to tropical forest conservation and poverty alleviation was regarded as very promising. Recent studies have made it clear, however, that the alleged commercialization-conservation/ development link in the NTFP needs reconsideration. Although some NTFPS do play a role in rural livelihoods strategies and can contribute to sustained forested landscapes in various tropical forest areas, there is no uniform picture as regards the actual importance of NTFPs to rural livelihoods (Rose A. et al. 2003).

**UNDP, 1999. Forest Management to Support Sustainable Livelihoods. United Nations, New York.**

Forests are dynamic productive systems when managed sustainably. However, the unsustainable use of forests, while perhaps generating some short-term gain, eventually decreases their contribution to national and local economies, and thus to the possibility of sustainable development. Of the multitude of benefits that forests provide, usually only

timber and a few other forest products enter markets. Because of this severe economic distortion, the record on sustainable forest management (SFM) is not good. There are few working examples of sustainable forest management; deforestation and unsustainable land use continue on a massive scale. The poor, who rely upon forests for water, energy, food, medicine, and shelter, are disproportionately affected by the destruction of forest resources. Consequently, any long-term strategy to address issues of rural poverty should stress the importance of sustainable forest management and forest conservation as key elements. It is clear that narrow forest policies alone cannot have an effect on all the forces determining the use or misuse of forest resources. They are very closely bound with policies and actions aimed at sustainable livelihoods, poverty eradication, and food security. Achieving cross-sectoral integration and a holistic, comprehensive approach to forest issues is a key challenge. The present forest situation cries out for better national and international efforts to promote sustainable forest management and to shift private sector investments from unsustainable to sustainable practices. In principle, instruments for this exist or are being developed through various national and international processes and initiatives. In practice, the forestry sector still suffers from a fragmented approach and the many interventions do not add up to comprehensive strategies for the sustainable development and management of forest resources (UNDP 1999).

**UNEP. 2008. The Costs and Benefits of Forest Protected Areas for Local Livelihoods: a Review Of The Current Literature Working Paper, Revised 21st May 2008, The United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC).**

Protected areas could play a significant role in the implementation of schemes to reduce emissions from deforestation and degradation (REDD) in developing countries, through either the strengthening of the existing protected area network, or designation of new areas. Many rural poor people rely on forest resources, and may experience positive or negative changes to their livelihoods as a result of REDD. This review aims to assess the livelihood implications of the existing protected area network in order to inform future REDD policy. The costs and benefits of individual protected areas for community livelihoods have been well documented. Costs can range from displacement of local communities to crop damage by wildlife, and sometimes include restricted access to resources and changes in land tenure. Benefits can include direct revenue from environmental protection, and the maintenance of ecosystem services such as watershed protection. The nature of these costs and benefits depends largely upon the protected area's status and governance, as well as its history of use. The net livelihood impacts of protected areas are less easy to discern, as there is a lack of standardised assessment methodologies. The effect on livelihoods of differing governance types within and between IUCN protected area management categories is rarely assessed in the literature, and requires further research. However, general patterns can be observed. The livelihood impacts of protected areas vary with protected area status, management strategies and community involvement in governance. Strictly protected areas with top-down management structures (generally associated with IUCN management categories I-II) can result in major livelihood costs and cause conflict between local communities and protected area management. Community management schemes, and protected area management allowing sustainable use of forest resources (more often associated with IUCN management categories V-VI), can provide tangible benefits. However, significant costs

can still be incurred by communities if management and institutional capacity is lacking, and issues of governance and tenure are not resolved. Inequitable distribution of livelihood costs and benefits is an obvious problem that is often yet to be adequately addressed in protected area management. These issues need careful consideration as REDD policy develops. An analysis of livelihood costs and benefits in existing forest carbon markets has identified issues similar to those for protected areas; including lack of established tenure and the inequitable distribution of resources, particularly affecting the landless members of society. Involving local communities in the planning and implementation of REDD, and ensuring that financial or other benefits are shared, is likely to result in a more sustainable solution to deforestation than are less participative strategies

**Vyamana V.G., 2009. Participatory Forest Management in the Eastern Arc Mountains of Tanzania: Who Benefits?. *International Forestry Review*, 11(2):239-253.**

Participatory forest management (PFM) is being promoted throughout Tanzania as a means of achieving conservation and improving livelihoods. This paper presents the results of a study in nine villages in the Eastern Arc Mountains to investigate the impacts of two institutional forms of PFM – Joint Forest Management (JFM) and Community-Based Forest Management (CBFM) – on the livelihoods of different well-being groups within communities. PFM was found to provide a new, though small, source of community-level income that was used to improve community physical capital. Household incomes from PFM forests generally increased slightly for most groups. However, technical and administrative obstacles prevented the poorest from taking full advantage of the benefits of forests under CBFM, while benefits from JFM-related income-generating activities were captured by village elites. Overall the results suggest that PFM implementation in Tanzania is improving forest conservation but not realising its potential to contribute to reducing poverty and social exclusion and, in the case of CBFM, may even be increasing the gap between rich and poor.

**Wollenberg A., 2000. Methods for Estimating Forest Income and their Challenges. *Society and Natural Resources*, 13: 777-795.**

Income measures are increasingly used as an indicator of the well-being of forest villagers, their use of forest products, and even the value of a forest. The methods for estimating income are often underreported, however, and little analysis is available of the methods required to measure income. Ten case studies are examined to demonstrate methods in use for quantifying household income. Ten cases are used to investigate techniques for overcoming two common methodological obstacles: (1) the cost of collecting data about many, diverse and distant sources of income from the forest, and (2) the difficulty of aggregating the monetary values of products. The strengths and weaknesses of the techniques are discussed to help researchers identify methods appropriate to their needs. The article concludes that (1) costs are most effectively reduced where the number of products studied is limited and methods based on indirect observation are used; (2) aggregating the monetary value of a mix of market and subsistence products requires sensitivity to the limitations of the methods; and (3) addressing the diversity of values that forest products provide to people might provide a more accurate estimation of income (Wollenburg, 2000).

**Wunder S., 2001. "Poverty Alleviation and Tropical Forests: What Scope for Synergies?" Draft. Paper Presented at the Biodiversity for Poverty Alleviation Workshop, Nairobi, Kenya, May 12–14, 2000. Center for International Forestry Research (CIFOR), Bogor, Indonesia.**

Forest services are particularly important for the poorest of the rural poor, and this fact alone provides a powerful reason to protect forests and the stream of services that they provide to poor rural dwellers. Then, while acknowledging that forests are of immediate importance to the rural poor, some analysts do not believe that forests have the ability to lift the rural poor out of poverty. They point to the fact that, as rural household income increases, the proportion coming from forest service's decreases sharply. A general conclusion is that, in most settings, natural forests tend to have little comparative advantage for the large-scale alleviation of poverty, especially compared to their great land use competitor, agriculture (Wunder, 2001).



## 5. PLANTATION FOREST MANAGEMENT



### **COMPILED BY**

Alemu Gezahegne, Berihun Tefera, Bitew Shibabaw, Teshome Tesema, Wubalem Tadesse and Habtemariam Kassa

## 5.1. Plantation and Livelihoods

**Abebe Mekoya, Simon J. Oosting, Salvador Fernandez-Rivera & Akke J. Van der Zijpp, 2008. Farmers' Perceptions About Exotic Multipurpose Fodder Trees and Constraints to Their Adoption. *Agroforestry Systems*, 73:141–153.**

Many organizations in Ethiopia have for many years promoted exotic multipurpose fodder trees (EMPFT) for livestock feed and soil improvement. Despite the apparent benefits, the number of farmers planting these trees was low. The objectives were to elucidate farmers' perceptions about their use value, management practices and constraints to adoption in three districts representing annual (one wheat-based and one teff-based) and perennial (coffee-based) crop-livestock systems in the Ethiopian highlands. Data were collected from 235 farm households. Most farmers (95.3%) had awareness of EMPFTs and the principal information sources were development agents (75.3%). Over half of the farmers were motivated to plant EMPFTs for feed value. Motivation for other purposes depended on cropping system, vegetation cover and availability of alternative local fodder trees in the area. Farmers had positive perceptions about EMPFTs for their feed value and contribution to soil conservation. Current adopters had a mean number of 587 (SE  $\pm$  84) EMPFTs per farm. Major constraints to adoption of EMPFTs were agronomic problems, low multipurpose value, and land shortage. Majority of farmers (89.8%) were interested to either continue or begin fodder tree development. Of the interested respondents, 44.5% preferred local fodder trees whereas 55.5% preferred EMPFTs. We conclude that farmers are aware of use values of EMPFTs while perceived constraints suggest that introduction of EMPFTs need consideration of farmers multiple criteria, but also awareness of feeding fodder trees and resource availability. Moreover, current development approaches have to recognize the importance of involving the end-users at all stages through participatory approaches to enhance adoption.

**Allen J.A., 1990. Homestead Tree Planting in Two Rural Swazi Communities. *Agroforestry Systems*, 11:11-22.**

Tree planting practices were investigated on a total of 95 homesteads in two communities in rural Swaziland. Information was also collected on socioeconomic characteristics of the homesteads. In both the study areas, Sigombeni and Bhekinkhosi, there was considerable variation amongst individual homesteads in size, relative wealth (as indicated by cattle and motor vehicle ownership), and amount and types of trees planted. Eighty-five percent of all homesteads in Sigombeni and 73 percent in Bhekinkhosi had planted at least one tree. Common forms of planting included small woodlots, fruit trees, and ornamentals. Virtually all the woodlots consisted of two introduced wattle species (*Acacia mearnsii* and *A. decurrens*). The most commonly planted fruit trees were avocados, bananas, and peaches. No complex or labor-intensive agroforestry practices (such as maize/leucaena intercropping) were observed. There was some evidence that the poorest and newest homesteads were the least likely to have planted any trees and that the richest homesteads were the most likely to have planted woodlots. The results indicate that forestry research and extension efforts should take into account homestead characteristics, and strive to offer a range of tree planting options that vary in input requirements, labor needs, and complexity.



**Alemu Mekonnen, 2009. Tenure Security, Resource Endowments, and Tree Growing: Evidence from the Amhara Region of Ethiopia. *Land Economics*, 85: 292–307.**

We analyze roles of tenure insecurity and household endowments in explaining tree growing in Ethiopia, where farmers cannot sell or mortgage land and factor markets are imperfect. Unlike most other studies, we use panel data and examine determinants of the decision and intensity of tree growing. Unlike other studies, we compare the decision to keep trees and the decision to plant in the recent past. The results suggest that land-tenure insecurity influences the decision to grow trees but not the number of trees households grow. Household endowments, time, and location also explain tree growing by farmers.

**Alemu Mekonnen, 2000. Valuation of Community Forestry in Ethiopia: a Contingent Valuation Study of Rural Households. *Environment and Development Economics*, 5 : 289–308.**

Community forestry projects in Ethiopia have been implemented using the top-down approach, which may have contributed to the failure of most of these projects. The so-called community plantations practically belonged to the government and the labour contribution of the local communities in the establishment of the plantations was mainly in exchange for wages. In this paper, we use the contingent valuation method to examine the determinants of the value of community forestry in rural Ethiopia and its feasibility, when the plantations are established, managed, and used by the communities themselves. The value elicitation format used is discrete question with open-ended follow-up which is closer to the market scenario our respondents are familiar with compared, for example, with the single discrete choice format. Unlike most other studies, we use a tobit model with sample selection in the empirical analysis of the bid function to correct for the effect of excluding invalid responses (protest zeros, outliers and missing bids) from the analysis. The analysis of the bid function shows that household size, household income, distance of homestead to proposed place of plantation, number of trees owned and sex of household head are significant variables that explain willingness to pay. We also find that there are significant differences in willingness-to-pay across sites. It is hoped that this study contributes to the limited empirical literature on community forestry in developing countries by indicating some of the conditions under which community plantations will be acceptable and feasible.

**Alemu Mekonnen & Randall Bluffstone, 2008. Is There a Link between Common Property Forest Management and Private Tree Growing? Evidence of Behavioral Effects from Highland Ethiopia. *Environment for Development Discussion Paper Series, Efd DP 08-29.***

This paper attempts to analyze the correlates of (1) aggregated and disaggregated indices of common property forest management (CPFM) as perceived by households, and (2) the decision to grow trees and the number of trees grown with the objective of looking at the effect of CPFM. We used data collected in 2007 from a sample of rural households in the Amhara region of Ethiopia. While the CPFM indices we used varied across households, the overall CPFM index and its two sub-indices (management tools and institutional characteristics) showed a generally low level of management. We observed significant differences in the nature of management of community forests across sites, mainly driven

by population size, population density, and size of forests. The results also showed that the overall management of community forests, as reflected by the overall CPFM index and its two sub-indices, had a positive association with the decision to grow trees on-farm as well as the number of trees grown. These results suggest that households that perceive a more strict management are more likely to grow trees on their farm and that those which do grow trees grow more trees. A strong correlation between the different CPFM indices suggests that households perceived the components of CPFM as being similar and hence these components were, in this case, indistinguishable.

**Amy C. Osorio, 2002. Incentives to Plant Trees in Tigray Ethiopia: Interactions of Public Microdams and Health. MSc Thesis. Faculty of the Virginia Polytechnic Institute and State University College of Natural Resources, Department of Forestry.**

Governments of developing countries face the dual tasks of increasing agricultural productivity and ensuring sustainability of resources. The government of Ethiopia initiated a major rural development program in Tigray, Ethiopia ten years ago, called SAERT (Sustainable Agricultural and Environmental Rehabilitation), to change the decline in agricultural productivity and reverse local forest degradation. SAERT targets water resource development through the construction of regional public microdams, intended to bring irrigated agriculture to surrounding villages and improve household income. Through SAERT, villagers can choose to plant trees on public microdam sites, protected and monitored by the surrounding villages. Unfortunately, microdams may cause potentially serious side effects to human populations through water-borne illnesses such as malaria and schistosomiasis. This paper examines incentives for villagers in Tigray to plant trees for private use, in both villages with and without access to regional public microdams. In addition, we investigate the importance of health factors on the household decision to plant trees on household and public land.

**Arega Bazezew, Woldeamlak Bewket & Melanie Nicolau, 2013. Rural Households' Livelihood Assets, Strategies and Outcomes in Drought-Prone Areas of the Amhara Region, Ethiopia: Case Study in Lay Gaint District. *African Journal of Agricultural Research*, 8: 5716-5727.**

This study examines rural livelihood strategies and food security outcomes in the drought-prone Amhara Region of Ethiopia by focusing on Lay Gaint district as a case study site. Questionnaire survey, key informants interview and focus group discussions were employed to collect primary data. A total of 210 households were covered by the questionnaire survey, and the questionnaire covered issues related to household level asset ownership, crop and livestock production and engagement in non-farm and off-farm income sources in a mix of closed and open-ended questions. Both qualitative and quantitative methods were used for data analysis and the later included descriptive statistics and regression modeling. A major finding is that despite the low level of productivity related to local environmental constraints, rural livelihoods remain undiversified with small scale rain-fed agriculture providing the primary source of livelihood for the large majority of sample households (~93% of respondents). Only about 25% of respondents participated in some form of non-farm or off-farm activities, but with only little contributions to their total annual incomes. The use of yield-enhancing agricultural inputs such as chemical fertilizers and improved seeds was

extremely low, and this was attributed to the severe land degradation and rainfall variability in the area. Food insecurity is a chronic problem in that, on average, households in the study area consume from own production for only about six months. Improving food security of rural households in the study area requires integrated development interventions aimed at improved natural resources management and diversification of livelihood strategies including interventions to create non-farm employment opportunities.

**Andersson C., Mekonnen A.& Stage J., 2009. Impacts of the Productive Safety Net Program in Ethiopia on Livestock and Tree Holdings of Rural Households. Environment for Development. Discussion Paper Series EfD DP 09-05.**

We evaluated the impacts of the Ethiopian Productive Safety Net Program (PSNP) on rural households' holdings of livestock and forest assets including trees. Using panel data, we applied both regression analysis and propensity score matching. We found no indication that participation in PSNP induces households to disinvest in livestock or trees. In fact, households that participated in the program increased the number of trees planted, but there was no increase in their livestock holdings. We found no evidence that the PSNP protects livestock in times of shock. Shocks appear to lead households to disinvest in livestock, but not in trees. Our results suggest that there is increased forestry activity as a result of PSNP, and that improved credit access encourages households to increase their livestock holdings.

**Biruk Ketsela, 2012. The Contribution of Eucalyptus Woodlots to the Livelihoods of Small Scale Farmers in Tropical and Subtropical Countries with Special Reference to the Ethiopian Highlands. M.Sc. thesis, Swedish University of Agricultural Sciences, Uppsala.**

Different eucalyptus species have an ability to grow in a wide range of ecological conditions and are found almost all over the world, mostly in tropical and subtropical countries. Small scale farmers in least developing countries plant eucalyptus widely compared to other tree species. Hence, the aim of this study was to contribute to the pros and cons of eucalyptus in different regions. Eucalypts have several important qualities for the smallholders; they are easy to establish even on degraded land and easy to manage, and have few natural enemies, a wide ecological range, good survival, high growth rate, many important uses and a reliable source of cash income. The use of eucalypt is environmentally controversial; it is difficult to prove that the genus has particular negative effects compared to other common fast growing plantation species. It was further found that eucalypts have specific economic advantages for the smallholders; a stable and accessible market even in remote areas, produce high value particularly on small densely planted woodlots and give an early return on investment compared to other plantation species resulting in a more even cash flow. Thus, eucalyptus hold obvious potentials to contribute to poverty alleviate among smallholders.

**Keywords:** *Eucalyptus*, Small-holder, Environment, Cash flow, Wood-lots, Tropics, Undergrowth

**Camilla Andersson, Alemu Mekonnen & Jesper Stage, 2009. Impacts of the Productive Safety Net Program in Ethiopia on Livestock and Tree Holdings of Rural Households Environment for Development. Discussion Paper Series, Efd DP 09-05.**

We evaluated the impacts of the Ethiopian Productive Safety Net Program (PSNP) on rural households' holdings of livestock and forest assets including trees. Using panel data, we applied both regression analysis and propensity score matching. We found no indication that participation in PSNP induces households to disinvest in livestock or trees. In fact, households that participated in the program increased the number of trees planted, but there was no increase in their livestock holdings. We found no evidence that the PSNP protects livestock in times of shock. Shocks appear to lead households to disinvest in livestock, but not in trees. Our results suggest that there is increased forestry activity as a result of PSNP, and that improved credit access encourages households to increase their livestock holdings.

**Cellier G.A., 1999. Small-scale planted forests in Zululand, South Africa: an Opportunity for Appropriate Development. New Forests, 18: 45–57.**

Forestry in South Africa is sharply divided between commercially driven private enterprise which controls 1.3 million ha of plantation forests, and government and nongovernment organizations which promote a variety of social forestry programs. One area of crossover is that of small-scale (1–2 ha) commercial woodlots being promoted by private timber companies as an additional source of fiber for their pulpmills, but grown and managed by individual farmers. Inputs, such as plants and fertilizers, as well as expertise in the form of extension foresters, are provided by the company, whereas the farmers supply the land and the labor. The company guarantees to buy the timber at the time of harvest. Under such arrangements, the risk is spread between the farmers and the company; the farmers assume most of the risks of production, and the company takes on the marketing risks. The possibilities for appropriate and sustainable development do exist under such a program, but issues involving both ecological and social sustainability must be addressed. This paper suggests that four key characteristics are needed to achieve appropriate development in Zululand. These characteristics are participation, flexibility, empowerment, and commitment. When compared to the current arrangement, the company would have to make a fundamental paradigm shift to achieve these goals. However, the long-term support of the farmers, and ultimately more fiber in the mills, would be the reward.

**Cynthia S. S., Robert W., Wood T., Charles H., 2002. Tree Planting by Small Producers in the Tropics: A Comparative Study of Brazil and Panama. Agroforestry Systems, 56 (2): 89-105.**

Forest regrowth is a notable phenomenon across the tropical forest latitudes. Such reforestation takes place in the wake of land abandonment, occurs cyclically in a rotational agricultural system, and may result from the deliberate planting of trees by farmers. Although less extensive than successional forest regeneration, tree planting by small farmers can have potentially important environmental impacts at both the site and global scale. This paper examines tree-planting efforts by small farmers in the tropical frontier regions of Panama and Brazil in order to gauge the magnitude of reforestation activities, and to identify

factors that influence these efforts. This paper discusses the environmental regulations, forestry law, and tenure institutions in both countries, and performs a comparative analysis of reforestation efforts with information derived from household surveys ( $n = 356$ ) and in-depth tree planting interviews ( $n = 35$ ). Results from logistic regression are also presented. Our results show that tree planting occurs more frequently in Panama, which we attribute to greater external support in the provisioning of extension and materials and strong market incentives. We suggest that the proximity of the study sites to Panama City facilitates external support and market drivers. Finally, our results suggest that land tenure security is an influential determinant of reforestation activities in both countries.

**Dewees P.A., 1993. Trees, Land, and Labor: World Bank Environment Paper Number 4. The World Bank, Washington D.C.**

Smallholder tree cultivation and management is a common form of land-use in high-potential areas of Kenya. Some practices, such as the planting of trees on field boundaries, are strongly embedded in customary notions of land and tree tenure. Others, such as the planting of black wattle (*Acacia mearnsii*) woodlots, are more recent innovations, introduced to produce commodities for domestic and export markets. This study explores the economic dimensions of tree growing in Kenya, using land use studies and the results from a household survey in the upper coffee/lower tea zone of Murang'a District. The household survey was designed to explore the hypothesis that tree growing complements formal employment as a strategy for overcoming poorly operating factor markets and helps to ease land-use constraints imposed by labor migration. Tree planting is favored because of its low capital and recurrent costs and when farmers are unable to plant other more resource-intensive crops. The survey focused on households which currently maintain a black wattle woodlot and on households which operate parcels which were used for growing black wattle in 1967 but which have since been cleared and are being used for growing something else. The survey showed that the households now growing woodlots operate larger parcels, are headed by older persons, and have fewer resident, and more non-resident, members than other households in the survey. Logistic regression (logit) modeling explored causal relationships, suggesting woodlots are indeed more likely to be established as households age and as family labor becomes scarce, and that woodlot clearance takes place when labor is more available to cultivate the holding. Woodlot-growing parcels are also at a lower altitude and are more steeply sloping than other parcels. This illustrates the impact of other related factors in the enterprise choice decision, e.g., higher costs of production and greater erosion risks on steeper slopes. Also, tea performs best at the higher altitudes in the survey area and is the preferred alternative. From a policy perspective, it is critically important that efforts to introduce tree planting innovations are put into a context which more accurately reflects farmer ability and knowledge. This study emphasizes that, even when it is recognized that smallholders have the knowledge and ability to plant trees, temporal changes in land use may be undertaken quite independently of the usual understanding about why smallholders plant trees, which is predominantly oriented around perceived demands for fuel, fodder, and food. Even broader objectives related to environmental protection or agricultural sustainability fail to capture the full dimensions of land-use choice: households which establish woodlots do so in part partly because of changing supplies of and demands for income and for household labor. Because of this, policies with regard to rural afforestation may be incompatible with other policy objectives with regard to rural

employment generation and land use. If structural constraints to the operation of rural land markets, for instance, are removed, it could be anticipated that the incentive to establish or maintain woodlots would be reduced.

**Emtage N., Herbohn J. & Harrison S., 2007. Rural Household Diversity and the Implications for Small-scale Forestry Development in Leyte Province, the Philippines. Proceedings: International Conference on Poverty Reduction and Forests, Bangkok, September 2007**

This paper reports the results from a study of the social and economic factors affecting the development of smallholder forestry in Leyte Province. More than 50% of all households in rural areas of the Philippines have cash incomes that are below the national poverty threshold and the forest resources of the nation continue to be degraded. Agricultural activity by poor rural households is blamed for causing much of the past and present damage to forest resources. Community forestry and agrarian reform programs have been developed as a means to address the links between forest degradation and poverty by granting households limited access to Government-owned forest lands. Reviews of these programs have suggested the need to better understand rural households and their diversity as a means to improve the design, implementation, and monitoring of forestry and other development programs in rural areas. The study used a literature review, focus groups, household surveys, and workshops to assess pathways to forestry development for smallholders in the Philippines. Cluster analysis was applied to survey data on group households that have similar attitudes to forestry development. Subsequent analyses of the groups' livelihood assets and income levels revealed patterns of relationships between households' socio-economic circumstances, their attitudes to forestry, and forestry activities. Overall the study found few rural households are engaged in growing and selling timber and other forest products, with the poorest households least involved in community forestry programs and growing timber. Households reported reducing their use of public forest areas for a variety of reasons including the loss of timber resources in these areas. Many households acknowledge the need for rehabilitation of public forest areas but other development issues are rated as more urgent. The authors describe the variations in possible impacts of policy and program reforms on the different types of households. They conclude that all the households are being critically constrained in the development of forestry activities by institutional factors including uncertain or unsupportive land tenure arrangements, poorly developed timber markets, plus a general lack of land and financial capital.

**Fortmann L., Antinori C. & Nabane N., 1997. Fruits of Their Labors: Gender, Property rights, and Tree Planting in two Zimbabwe Villages. *Rural Sociology*, 62 (3) : 295-314.**

An analysis of tree planting by women and men in two Zimbabwe villages demonstrates that women are significantly less likely than men to plant trees on homestead land where the security of their duration of tenure is uncertain due to the likelihood of change in marital status. However, men and women are equally likely to plant trees in community woodlots where the duration of their tenure is secure if they remain village residents. These findings demonstrate the importance of attention to gendered security of tenure at the sub-household level.

**Fu Y., Brookfield H., Guo H., Chen J., Chen A. & Cui J., 2009. Smallholder Rubber Plantation Expansion and Its Impact on Local Livelihoods, Land Use and Agrobiodiversity, A Case Study from Daka, Xishuangbanna, Southwestern China. *International Journal of Sustainable Development & World Ecology*, 16(1): 22-29.**

Crop inventory, botanical surveys, and questionnaire investigations of 60% of households in Daka from 1998 to 2004 (a Hani nationality village in the mountainous region of Xishuangbanna) were undertaken. We focused on virtual extinction of agrobiodiversity in smallholder rubber plantations, which have improved smallholder livelihoods but have affected land-use strategies. Income per capita has increased from US\$128.3 in 1998 to US\$561.7 in 2004 because of an increase of income from rubber from US\$75.8 in 1998 to US\$451.4 in 2004. The number of cultivated upland rice varieties decreased from seven in 2001 to one in 2004 because of a sharp increase in rubber price after 2002. Rubber plantations increased from 17.7 ha in 1998 to 82.2 ha in 2004, while swidden fields decreased from 20.4 ha in 1998 to 12.7 ha in 2004. It appears that traditional upland rice production and number of varieties is being seriously eroded by encroachment from rubber plantation. Stabilization of agrobiodiversity loss is necessity while still improving the rural economy.

**Getahun Haile, Mulugeta Lemenhi, Fisseha Itanna & Feyera Senbeta, 2014. Impacts of Land Uses Changes on Soil Fertility, Carbon and Nitrogen Stock under Smallholder Farmers in Central Highlands of Ethiopia: Implication for Sustainable Agricultural Landscape Management around Butajira Area. *New York Science Journal*, 7(2):27-44.**

Landuses/land cover changes from natural forests to farmland, open grazing and eucalyptus woodlots, and subsequent changes in soil physical and chemical properties are widespread in Highlands of Ethiopia. Thus, assessing land use-induced changes in soil properties are essential for addressing the issues of agricultural landscape sustainability. The aim of this study was to examine the impacts of land use/land cover changes on soil properties, SOC and TN stock around Butajira area, Southern Ethiopia. The types of land uses considered on this study were: enset, cereal farms, grazing land, and *Eucalyptus camaldulensis* woodlots. Seven households having all the above mentioned land uses adjacent to each other were selected. For the purpose of this study, the selected household and land use types were considered as replication and treatments, respectively. 28 soil pits were dug i.e. one soil pit was dug at each land uses hence a total of eighty four soil samples were collected at three depths, namely 0-15cm, 15-30cm, and 30-45cm for chemical analysis. In addition, similar undisturbed soil samples were collected from same pits but opposite sides for soil bulk density and moisture content determination. Standard soil analytical procedures were followed in carrying out soil analysis. The results of the present study showed that land use changes induced significant differences on soil properties as reflected by the changes in bulk density, MC, pH, OC, TN, available P, OC and TN stocks. Soil bulk density was significantly higher in the cereal farms as compared to enset farms reflecting compaction of soil due to intensive tillage in cereal farms. Soil MC was significantly lowest under Eucalyptus woodlots compared to enset. Moreover, soil pH was lowest in woodlots and cereal lands as compared to other land uses. Soil under enset farms had higher OC, TN, available P, carbon and nitrogen stock as compared to other land uses. OC and total N stocks were shown a trend of enset farm > eucalyptus woodlots > grazing land > cereal land within 0-45 cm. Lowest OC and TN under cereal land showed the severity of land

degradation under this land use utilization, where as the higher soil nutrients, OC and TN under enset soils suggesting the importance of this land use utilization for addressing soil nutrient and carbon depletion. Besides, woodlots and grazing land had higher OC, TN, SOC and TN stock as compared to cereal lands. Therefore, future restoration of soil should focus on strategies that improving the soil nutrient and carbon storage under cereal land for enhancing sustainable agricultural landscape management, thereby improving the livelihood of agrarian community. However, fast growing nature of eucalyptus species may negatively affects soil reaction and moisture. Planting eucalyptus also negatively affects the crop yield of adjacent farm lands due to root competition and shading effects. Thus, current strategies of planting fast growing eucalyptus woodlots in response to scarcity of forest products and economic benefits, should be considered the negative impacts on soil and crop yields of neighboring farmlands. Hence, there is a need to develop proper land use policy and sustainable soil management and cropping practices to combat the on ongoing soil degradation in the study area.

**Keywords:** Land use, Soil physical and chemical properties, Soil degradation, Ethiopia

**Godoy R.A., 1992. Determinants of Smallholder Commercial Tree Cultivation. *World Development*, 20 (5): 713-725.**

This article contains a discussion of how output prices, tenure, information, credit, technology, government policies, and labor availability affect smallholder commercial tree cultivation. Output prices play the key role in smallholder commercial tree cultivation, even in the face of insecure tenure. Output prices, however, are a necessary but not a sufficient condition to induce smallholders to undertake commercial fuelwood cultivation.

**Haileab Zegeye, 2010. Environmental and Socio-Economic Implications of Eucalyptus in Ethiopia. In: Gil, L., Wubalem Tadesse, Tolosana, E. And López, R. (Eds.), *Proceedings of the Conference on Eucalyptus Species Management, History, Status and Trends in Ethiopia*, Pp. 184-205. Ethiopian Institute of Agricultural Research, Addis Ababa.**

Eucalyptus is one of the exotic tree species in Ethiopia. It has been once associated with the Ethiopian environment and economy. It is one of the most successful trees; it adapts to a variety of environments. Eucalyptus is often considered to have undesirable ecological qualities such as depletion of soil water and nutrients, aggressive competition for resources with native flora, unsuitability for erosion control, production of allelopathic chemicals that suppress the growth of other plants and provision of inadequate food and habitat for wildlife. On the other hand, Eucalyptus provides multiple environmental and socio-economic benefits. It is useful for provision of wood and other products thereby reducing the pressure on the natural forests, conservation of soil and water, rehabilitation of degraded lands, fostering the regeneration of native woody species, provision of food and habitat for wildlife, drainage of swampy areas, mitigation of climate change and provision of amenity. The benefits of Eucalyptus are far greater than the negative impacts. The negative impacts are mainly because of the poor management rather than its biological characteristics. Eucalyptus has been found to be efficient water user. In fact, it is fast growing and thereby consumes more nutrients from the soil. Applying appropriate silviculture and management on Eucalyptus



planting will enhance the utilization of this important tree for maintaining and/or restoring the environment and solving socio-economic problems in Ethiopia and elsewhere. It appears that there are no profound reasons not to continue Eucalyptus planting in Ethiopia.

**Keywords:** Allelopathic effects, Environmental and socio-economic importance, Eucalyptus, Exotic species, Plantations

**Hansen J D, Luckert M K., Minae S. & Place F., 2005. Tree Planting Under Customary Tenure Systems in Malawi: Impacts of Marriage and Inheritance Patterns. *Agricultural Systems*, 84 (1): 99-118.**

Debates about land tenure throughout Africa, and in Malawi in particular, are central to development strategies. Marriage and inheritance patterns are important aspects of tenure that influence how individuals acquire land and trees thereon. Accordingly, such patterns may influence the management of natural resources, such as trees. Along these lines, policy makers in Malawi have been suggesting that uxori-local marriage, where the man resides in the woman's village upon marriage, discourages tree planting. In this study we investigate how marriage and inheritance patterns affect tree-planting behaviour by gender in two villages. Results show that tree planting by men may indeed be dissuaded by uxori-local marriage patterns. Furthermore, tree planting by married women is not necessarily promoted under uxori-local patterns. Rather, a high incidence of non-married women appears to be associated with increased tree planting by women.

**Holding C., Carsan S. & Njuguna P., 2006. Smallholder Timber and Firewood Marketing in the Coffee and Cotton/Tobacco Zones of Eastern Mount Kenya. ICRAF, Nairobi.**

Recent analysis on tree management by farmers has moved away from the needs based and conservation approaches that dominated much of the earlier work, and instead examines tree management in terms of farmer livelihood strategies and the dynamics of rural change. Trees in farming systems are most usefully seen in the context of farm household livelihood decision making and strategies. In Kenya, there is a tradition of agroforestry in the country, with the planting and retention of a variety of multi-purpose trees on farms. As long ago as 1994 the Kenya Forest Masterplan advised: closer linkages between industry and farm tree growers that could provide the rural population with increased earnings from sales of wood and other industrial raw material and from the various steps in tree product harvesting, transport and processing. Kenya is not alone in this situation, and with the decline in commodity prices of farmers' principal cash crops e.g. coffee, farmers are increasingly viewing trees, wood products and timber as a viable alternative cash generating farm enterprise. This paper presents the results of two surveys designed to better understand the dynamics of timber harvesting and marketing at farm level conducted in the area of Eastern Mount Kenya. A household survey combined rural household sampling and interview techniques, farm walks, focus groups and key informant interviews to ascertain the decision making of landowners (householders/farmers). Concurrently on the same farms, a biomass survey was conducted to gain quantitative data on: stems, volumes, principal use, planting niches, diameter and age classes. 42.5% of farmers surveyed engaged in commercial marketing of tree products. Of those farmers engaged in selling trees, the numbers of trees (and concomitant volume calculations) sold from farms were found to be twice as many as

those used for domestic purposes. There are however serious knowledge gaps towards farmers participating equitably in the timber and firewood markets. Often external actors with better market networks gather the greater benefits from trees on farms. Conclusions indicate that on-farm timber has the potential to contribute to the regional wood industry and small-holders livelihoods in the area surveyed.

**Herbohn J. L. & Harrison S.R., 2005. Potential Economic Impact of Improving Returns to Smallholder Tree Farmers in Leyte: A Cost Benefit Analysis of ACIAR Project ASEM/2003/052. *Annals of Tropical Research*, 27(1): 105-114.**

This paper presents the results of a cost-benefit analysis of the likely impact of research project ASEM/2003/052 *Improving financial returns to smallholder tree farmers in the Philippines* – funded by the Australian Centre for International Agricultural Research. Three main categories of project benefits are identified which coincide with short, medium and long-term outcomes, namely (1) increased returns to existing tree farmers from increased volume and higher quality of merchantable timber combined with higher stumpage prices flowing from improved market access (estimated to have a net present value of A\$ 1.9 M), (2) increased returns to existing tree farmers from subsequent tree rotations due to increased volume and higher quality of merchantable timber from better management and higher prices (estimated NPV of A\$ 1.22 M), and (3) expansion of the timber plantation area due to the higher returns available as a result of project outputs (estimated NPV of A\$ 7.79 M). These estimated net present values suggest that the research project is a highly rewarding investment in economic terms.

**Hocking D., Hocking A., Islam K., 1996. Trees on farms in Bangladesh 3: farmers' species preferences for homestead trees, survival of new tree planting, and main causes of tree death. *Agroforestry Systems*, 33 (3) : 231-247.**

This third paper follows 2 previous papers with slightly different titles published in this journal (Hocking, D.; Islam, K. *ibid* 25 (1994) 193-216; 31 (1995) 39-57). They report results from the Village and Farm Forestry Project (VFFP), a development programme for rural Bangladesh organized to support the planting of trees on homesteads and crop fields, which started in 1986. The earlier papers covered the crop (paddy) fields, and this one covers the homesteads. The most common trees on farm homesteads were bamboo (several species), jackfruit (*Artocarpus heterophyllus*), mango (*Mangifera indica*), betelnut (*Areca catechu*), and jujube (*Zizyphus jujube* [*Ziziphus mauritiana*]) in all the agroecological zones studied. There were regional differences in the less common species. Species for new homestead planting were chosen mainly by women and tended to include indigenous fruit trees and a few exotics of high timber value. Choices were later influenced by new experience with exotic tree species and by perceptions from secondary information sources. Farmer managed action research was used to test the survival and performance of new trees planted under the VFFP. The main factors influencing tree survival were the role of women in selection of species and planting site, the degree of personal attention paid to aftercare by the owner, and the quality and size of the planting stock. Biophysical factors and agroecological zones were unimportant. The main recorded causes of tree mortality were, in order of importance: damage by livestock, pests or diseases; physical damage

by people (mainly children playing); and drought. Cause of death could not be attributed in about 35% of cases, suggesting that the recorded causes should be treated with caution.

**Hyde W.F. & Köhlin G., 2000. Social forestry reconsidered. *Silva Fennica*, 34(3): 285–314.**

This paper reviews the expectations for forestry's contribution to rural development and for its special contributions to the most disadvantaged, to women and the landless users of the forest commons. A growing literature challenges some of these expectations; in particular, certain expectations about cultural differences and physical stocks as explanatory factors for patterns of household behavior. This literature could also be used to support a call for sharper definitions of deforestation, improved indicators of the effects of forest resources on the rural poor, and improved design of forest policy interventions. Our paper reviews the literature, suggests some unifying themes, and identifies the critical issues that remain unanswered. The primary contention arising from this literature is that households follow systematic patterns of economic behavior in their consumption and production of forest resources, and that policy interventions in social forestry should be analyzed with regard to markets, policies, and institutions. Markets for forest resources generally exist in some form – although they may be thin. Successful forestry projects and policies require careful identification of the target populations and careful estimation of market and market-related effects on the household behavior of these populations. Institutional structures that assure secure rights for scarce forest resources are uniquely important in a forest environment often characterized by open access resources and weak government administration. Social and community forestry, improved stoves, improved strains of multi-purpose trees, and even private commercial forest operations can all improve local welfare, but only where scarcity is correctly identified and the appropriate institutions are in place. An increasing number of observations of afforestation from developing countries around the world is evidence that forestry activities do satisfy these conditions in selective important cases. The critical point for policy is to identify the characteristics of these successful cases that are predictive of other cases where new forestry activities can be welfare enhancing.

**Jagger P., Pender J. & Gebremedhin B., 2003. Woodlot Devolution in Northern Ethiopia: Opportunities for Empowerment, Smallholder Income Diversification and Sustainable Land Management. IFPRI. *Environment and Production Technology Division Discussion Paper No. 107*.**

This paper explores the patterns and determinants of empowerment, income generation, and environmental sustainability under varying degrees of woodlot management in Tigray, Ethiopia. Our analysis is based upon a survey of 120 collectively managed woodlots, devolved to varying degrees, and 66 households that have recently received small plots of community land for tree planting. We find that more devolved woodlot management empowers resource users by providing greater autonomy regarding the management of woodlots, and in particular the ability to make decisions about the harvest of woodlot products. Our economic analysis indicates that grass is by far the most important product being harvested from woodlots. There has been very limited harvesting of higher value products such as poles and fuelwood, which are in very short supply in the region. Labor inputs declined, and average annual net benefits improved as woodlots were more

devolved, indicating that devolved woodlots are more economically efficient. Woodlots were generally perceived to be associated with positive changes in environmental conditions such as the slowing of erosion and gully formation, and the maintenance of biodiversity. However, greater environmental benefits were associated with less devolved woodlots. This study highlights the trade-offs inherent in varying levels of woodlot management. Though woodlots are perceived to provide significant environmental functions, restrictions regarding harvesting high value products are limiting the potential for smallholder income diversification and empowerment, two critical components of poverty alleviation in Ethiopia.

**Jagger P., & Gebremedhin B., 2005. Trading Off Environmental Sustainability for Empowerment and Income: Woodlot Devolution in Northern Ethiopia. *World Development*, 33(9): 1491–1510.**

This paper explores local empowerment, income generation opportunities, and environmental sustainability under varying scales of woodlot management in Ethiopia. We find that more devolved woodlot management empowers resource users, providing greater decision-making autonomy regarding harvesting and management. Our economic analysis indicates that there has been limited harvesting of high value products such as poles and fuelwood. Labor inputs declined, tree survival rates increased, and average annual net benefits improved as woodlot management was devolved, indicating improved efficiency with more localized management. Environmental sustainability was associated with less devolved woodlot management. This study highlights the tradeoffs inherent in devolution reforms.

**Kahurananga J., Alemayehu Y., Tadesse S. & Bekele T., 1993. Informal Surveys to Assess Social Forestry at Dibandiba and Aleta Wendo, Ethiopia. *Agroforestry Systems*, 24: 57-80.**

Two surveys were carried out at Dibandiba, a semi-arid site in central Ethiopia, and Aleta Wendo, a sub-humid site in southern Ethiopia, to assess farmers' attitudes toward and perceptions of tree planting, levels of social forestry and uses of tree products. At Dibandiba, farmers planted mostly *Eucalyptus camaldulensis* trees, exclusively on homesteads and *Acacia albida* was left on farmland. Trees were planted mainly for construction (32%), fuelwood (29%), shade (11%) and cash (11%). Major (85%) uses were fencing, fuelwood, construction and plough handles. Dung was the major source of fuel (56%). At Aleta Wendo, planting consisted of *Eucalyptus globulus* mostly on private woodlots and homesteads, of *Milletia ferruginea* and *Cordia abyssinica* on farms, and of *Euphorbia abyssinica* on fences and boundaries. Avocado and pears were also planted. The uses were the same as at Dibandiba. Major constraints were lack of seedlings and shortage of land at both sites, plus shortage of water at Dibandiba. Also, a review of information obtained from previous surveys on household composition and income, farm holding, cropping pattern, livestock composition and the use of labour was made.

**Kihiyo V. B. M. S., 1996. Economic Evaluation of Rural Woodlots in a Developing Country: Tanzania. *Journal of Environmental Management*, 46: 271–279.**

Rural areas in developing countries use wood as their main source of energy. Previously, wood has been obtained free from natural forests and woodlands. The pressure of increased demand through population growth, and the fact that natural trees take longer to grow, has made this resource scarce. Thus, raising trees in woodlots has been adopted as the solution to its shortage in the wild. However, growing trees in woodlots will inevitably require resources in terms of capital, land and manpower. Economic evaluation becomes necessary to ascertain that these resources are used economically. This paper dwells on some of the salient features of the economic evaluation of woodlots, such as interest rates, shadow prices of factors of production, social opportunity, cost of capital and sensitivity analysis of such woodlots in a developing country such as Tanzania.

**Koku J.E., 2002. Tree Planting, Local Knowledge and Species Preference in the South Tongu District of Ghana: Some Perspectives. *Geo Journal*, 57: 227–239.**

This paper explores the link between local knowledge and tree species preference in the South Tongu District of Ghana. It is based on a field study that observed, *inter alia*, that even though Neem is not commonly promoted in Ghanaian afforestation programmes, it is highly popular in the area. Local farmers' preferences for tree species are governed by several factors— suitability to local climate, availability and access to markets, perceived economic value and availability of wood fuel dependent enterprises. The survey further demonstrates that local knowledge is incorporated into decision-making regarding adaptation of farming practices to changing rainfall patterns; and also plays a role in influencing specie preference. Some likely implications, which these may have on conservation policy and planning in the study area, are also explained.

**Kooten G. C. van, 2000. Economic Dynamics of Tree Planting for Carbon Uptake on Marginal Agricultural Lands. *Canadian Journal of Agricultural Economics*, 48 (1): 51-65.**

As a result of the 1997 Kyoto Protocol, afforestation of agricultural lands can be expected to take on an important role in the CO<sub>2</sub> emissions reduction policy arsenal of some countries. To date, identification of suitable (marginal) agricultural lands has been left mainly to foresters, but their criteria fail to take into account economic nuances. In this study, an optimal control model is used to determine the optimal level of afforestation in western Canada (the Peace River region of British Columbia and all of Alberta). The results indicate that, while planting fast-growing trees (hybrid poplars) for carbon uptake on marginal agricultural land may be important, the path dynamics matter in determining whether Canada can rely on afforestation to meet its obligations under Kyoto.

**Locatelli B. & Pedroni L., 2006. Will Simplified Modalities and Procedures Make More Small Scale Forestry Projects Viable Under the Clean Development Mechanism?. *Mitigation and Adaptation Strategies for Global Change*, 11: 621–643.**

Simplified modalities and procedures (M&P) are expected to increase the viability of

smallscale project activities under the Clean Development Mechanism (CDM). A small-scale afforestation or reforestation (AR) project is defined as a project removing less than 8 kilotons of carbon dioxide equivalent (CO<sub>2</sub>e) per year. Depending on the project type and the method for measuring scale, 8 kilotons of CO<sub>2</sub>e per year correspond to highly diverse areas, possibly ranging from 200 to 6000 ha. Using a model to calculate the minimum project scale above which the CDM is a positive financial incentive for eligible AR project activities, the paper analyzes whether a reduction of transaction costs under simplified M&P will be a sufficient incentive to motivate small-scale participation in the CDM. Model results show that, even under optimistic assumptions on carbon market conditions and transaction costs, small-scale project activities will not benefit from simplified M&P. Results also show that project activities removing more than 8 kilotons of CO<sub>2</sub>e per year and registered as small-scale would be the ones that could benefit the most from simplified M&P. It is concluded that the participation of small-scale project activities to the CDM requires more than simplified M&P, the price of expiring Certified Emission Reductions being one of the most critical parameters.

**Logomo O.E., 2009. Community Perception on Farm Trees and Adjacent Natural Forests Status Under Participatory Forest Management: Dodola Distract, West Arsi Zone, Ethiopia, Msc Thesis. Wondo Genet College of Forestry and Natural Resources, Hawassa University.**

Understanding of community perception is of paramount importance in natural resources management. This study attempts to investigate the local community perception with temporal changes of on- farm trees and adjacent natural forest at present under participatory management, and its contribution to livelihoods. The study was conducted in Dodola district, Oromia Regional State, Ethiopia. From the district two representative PAs namely Bura chale and Barisa were selected by stratified purposive sampling procedure based on presence of on farm trees and their access to natural forest since these factors were believed to affect the contribution of on- farm trees and PFM to livelihoods. From each PAs two villages of WAJIB and Non-WAJIB were selected. Households were then selected using random sampling from the study population using WAJIB member and PAs record lists. Formal survey was conducted on 120 households that makeup at least 6% of the households under the total population of study area. Following this forest inventory was made at Sokora and Mararo-Urgo WAJIB forest applying systematic sampling design using transects lines. Nine plots were laid in each site and inventory data from the two sites were integrated and computed for number of stems per hectare, basal area (m<sup>2</sup>/ha), forest structure and regeneration status. Based on the wealth categories data were collected from a total of 72 plots of 0.5ha sizes which were laid out in the crop fields and homegarden of WAJIB and Non- WAJIB. SPSS and EXCEL were used for data analysis; the result showed that the studied community has relatively better perception for the WAJIB forest management and on-farm trees as well as their contributions to livelihood. WAJIB promote forest awareness among the local people, enable them to regulate forest access, empower local community for decision making. Forest and On-farm trees contribute to the livelihoods about 21% and 6% for WAJIB and Non-WAJIB, respectively. With regard to forest and on-farm trees conservation, better tree species richness as well as seedling and sapling densities were observed in the forest under PFM. While, declining on-farm trees were observed for the different time scales. Therefore, in-depth studies will be needed to

mitigate declining trend of wood resources with increasing crop cultivation at different times. In addition it needs mechanism of coping with as the basic issues in developing extension strategy of on-farm trees development and the natural forest conservation of the study area.

**Long A.J. & Nair R.P.K., 1999. Trees Outside Forests: Agro-, Community and Urban Forestry. *New Forests*, 17: 145–174.**

Planted forests are often considered to consist of tree plantings at a scale large enough to satisfy such objectives as commercial production of timber and fiber, protection of watersheds, and preservation of natural habitats. However, trees are planted also at greatly reduced scales in agroforestry systems or as community woodlots to provide a mixture of products and services to resident households, local communities, and regional cultures. Agroforestry systems represent a major form of small-scale tree planting, where trees are grown in purposeful combinations with agricultural crops and/or livestock in order to take advantage of tree-crop interactions, and thereby enhance crop production, diversify farm output, stabilize or improve soils, or ameliorate harsh environmental conditions. Some important examples of these systems in tropical countries include homegardens, alley cropping, improved fallows, intercropped trees for shade and fodder production, and trees planted in hedgerows and along fence lines. Throughout the tropics, there is a large variety of indigenous practices and species mixtures that represent adaptations of these systems to meet localized needs and opportunities. Research and development programs have supported the expansion and refinement of many of these systems during the last 20 years, but substantial constraints on tree planting still exist in the form of land-tenure practices, population pressures that relegate agroforestry practices to degraded lands, subsistence needs that prevent extended periods of tree growth, and insufficient technical information or technology dissemination. Agroforestry systems in temperate, industrialized countries include combinations of trees, pasture, and livestock; fruit or nut trees interplanted with vegetable or grain crops; windbreaks and shelterbelts; multispecies riparian buffer strips; and forest farming systems for specialty crops. Compared to the tropics, however, temperate-zone systems tend to focus on one or two high-value crops, often involve some level of mechanization, and frequently represent an opportunistic approach to improving the economic profitability of farms rather than meeting subsistence needs. In both tropical and temperate regions, agroforestry systems and community woodlots will be an important component of new sustainable agriculture and environmental protection programs. Although species diversity is an essential feature of all agroforestry systems, community forests generally involve planting only a few species in small woodlots near farms, around villages, along roads, and as riparian buffers. Provincial or state governments and the local populace are often involved in landownership and plantation establishment. Major objectives of these forests are production of fuelwood for local consumption and of other tree products for market; soil stabilization, reclamation, or improvement; and protection of water quality. As with many other planted forests, the number of species widely used in community forests has been relatively small, with the genera *Eucalyptus*, *Pinus*, and *Acacia* providing the bulk of the species. Major issues with these “planted forests” focus on rights for use of the products, tending responsibilities once trees are established, protection until trees are large enough for their designated use, increasing interest in using “native” species, and greater community involvement in planning and management. Trees planted along streets and waterways, or as woodlots in parks and other public places, represent

a major group of planted forests in many urban and periurban landscapes. In addition to providing many of the same environmental services that agroforests and community forests do, these urban plantings have unique aesthetic and recreational value. For much of the world's ever-increasing urban population, these may be the only tangible reference points for understanding planted forests. These relatively little-recognized forms of planted forests – planted trees, to be more appropriate – are now receiving much greater attention. There are, however, some serious technical and socio-politico-institutional constraints to their development as more widely adopted systems in both tropical and temperate regions.

**Mahapatra A.K. & Mitchell C. P., 2001. Classifying Tree Planters and Non-Planters in a Subsistence Farming System Using a Discriminant Analytical Approach. *Agroforestry Systems*, 52: 41–52.**

Since the 1970s tree planting has been promoted to meet the multipurpose needs of subsistence farmers and to arrest deforestation in many developing countries. Financial support and extension systems were developed as tree growing outside the forest became more important. The limited success of the forest extension approaches used in the 1980s has been attributed to the failure to ascertain householders' priorities and attitudes to tree growing. Although the broader theoretical paradigm of factors influencing householders' planting of trees has been discussed household and regional level analyses are rare. This study used discriminant analysis to assess the extent to which social and economic factors affect smallholder farmer tree planting in Orissa, eastern India. The validity of the predictive model to define the different groups was tested by assessing the accuracy of classification. The significance of the factors was probed using the identified variables in the discriminant functions developed for smallholder farmers in the coastal and inland zones of Orissa. The results contradicted some common assumptions that only large landowners with a substantial income are innovators. The likelihood of adopting agroforestry is dependent on the progressive attitude of farmers, membership of village organisations, their wealth status and, more importantly, their perceived risk concerning agricultural production. This approach enables tree planters and non-planters to be characterized and hence give better targeting of planning and social forestry programmes.

**Matthies B.D. & Karimov A.A., 2014. Financial Drivers of Land Use Decisions: The Case of Smallholder Woodlots in Amhara, Ethiopia. *Land Use Policy*, 41: 474–483.**

A household survey on the financial drivers of woodlot production was conducted in the Lake Tana watershed of Amhara State, Ethiopia. Analysis of smallholder *Eucalyptus globulus* Labill. production reveals that converting uneroded over eroded croplands leads to significantly higher financial returns. Returns were also significantly higher for rotation intervals closer to the optimal economic rotation and for higher planting densities. Most woodlots had positive financial returns. The presence of negative financial returns for some households demonstrates that positive ecological externalities, a lack of economies of scale and/or myopic behavior are potentially important factors in land use decision-making. Wood utilization decisions were shown to impact the potential financial returns of households. Smallholders' activities demonstrate that eucalyptus is an imperfect substitute for agricultural production on surplus crop land. A third of respondents indicated they had intentionally chosen to convert uneroded croplands to achieve higher returns. Smallholders



faced constraints in bargaining over price and access to markets. Future land use policies should address marketing constraints and unsustainable land use activities. Harvesting soil from natural forests and the conversion of productive surplus cropland to woodlot production both present long-term sustainability challenges. This study demonstrates the importance of considering economic and social incentives when creating land use policies for smallholder's woodlot production.

**Mekonnen A., 2000. Valuation of Community Forestry in Ethiopia: a Contingent Valuation Study of Rural Households. *Environment and Development Economics*, 5: 289–308.**

Community forestry projects in Ethiopia have been implemented using the top-down approach, which may have contributed to the failure of most of these projects. The so-called community plantations practically belonged to the government and the labour contribution of the local communities in the establishment of the plantations was mainly in exchange for wages. In this paper, we use the contingent valuation method to examine the determinants of the value of community forestry in rural Ethiopia and its feasibility, when the plantations are established, managed, and used by the communities themselves. The value elicitation format used is discrete question with open-ended follow-up which is closer to the market scenario our respondents are familiar with compared, for example, with the single discrete choice format. Unlike most other studies, we use a tobit model with sample selection in the empirical analysis of the bid function to correct for the effect of excluding invalid responses (protest zeros, outliers and missing bids) from the analysis. The analysis of the bid function shows that household size, household income, distance of homestead to proposed place of plantation, number of trees owned and sex of household head are significant variables that explain willingness to pay. We also find that there are significant differences in willingness-to-pay across sites. It is hoped that this study contributes to the limited empirical literature on community forestry in developing countries by indicating some of the conditions under which community plantations will be acceptable and feasible.

**Mekonnen A., 2009. Tenure Security, Resource Endowments, and Tree Growing: Evidence from the Amhara Region of Ethiopia. *Land Economics*, 85 (2): 292–307.**

We analyze roles of tenure insecurity and household endowments in explaining tree growing in Ethiopia, where farmers cannot sell or mortgage land and factor markets are imperfect. Unlike most other studies, we use panel data and examine determinants of the decision and intensity of tree growing. Unlike other studies, we compare the decision to keep trees and the decision to plant in the recent past. The results suggest that land-tenure insecurity influences the decision to grow trees but not the number of trees households grow. Household endowments, time, and location also explain tree growing by farmers.

**Muhammed N., Koike N.M., Haque F. & Miah D., 2008. Quantitative Assessment of People-Oriented Forestry in Bangladesh: A Case Study in the Tangail Forest Division. *Journal of Environmental Management*, 88: 83–92.**

Forests represent more than just a livelihood to many people in developing countries. In Bangladesh, for example, overwhelming poverty and socio-economic pressures have resulted in an unstable situation where intensive pressure on forest resources is having increasingly negative consequences for the population. Some studies have evaluated the benefits of people-oriented forestry activities from an investment, as well as a participant, point of view. In the study area located in the Tangail Forest Division, a total of 11,854 ha of woodlot, 2704 ha of agroforestry and 945km of strip plantations have been raised in a benefit-sharing program that is inclusive of land encroachers and other economically disadvantaged people. Since 2000–2001, a total of 3716 ha of woodlot, 890 ha of agroforestry and 163km of strip plantations have been harvested to the benefit of 6326 individuals. Investment analysis indicates that woodlot plantation is not financially viable but agroforestry is the most profitable. These results were somewhat unexpected since initial analysis suggested that the woodlot plantation profit would be greater than, or at least equal to, that of the agroforestry plantation if the number of planted seedlings per unit area was taken into account. The per unit area net present value (NPV) was highest in the agroforestry plantation (\$1662) and negative in the woodlot plantation (−\$397). The benefit cost ratio (BCR) was also highest in the agroforestry plantation (1.64) and lowest in the woodlot plantation (0.86). This study also showed that some individuals who were formally classified as encroachers have now become vital stakeholders. On average, participants received \$800, \$1866 and \$1327 over the course of 13 years from strip, agroforestry and woodlot plantations, respectively. Average annual return per participant was \$62, \$144 and \$102, respectively, which was in addition to each individual's yearly income. This added income is a significant contribution to monetary resources and improves socio-economic conditions at a grass roots level. Overall then this program can be considered a financial success as a plantation raising strategy. However, despite this financial progress, the program cannot be considered a true form of participatory people-oriented forestry because it shows serious deviations from the original concept or model for participatory people-oriented forestry that is outlined in the project document. These discrepancies are especially notable with regard to (i) beneficiary selection, (ii) gender equity, (iii) professional attitude and corruption, (iv) funding and (v) program approach. However, other countries faced with similar challenges of forest overuse and degradation may adopt this practice for achieving self-reliance and environmental stability.

**Mulugeta Lemenih, 2010. Growing Eucalypt by Smallholder Farmers in Ethiopia. In: Gil, L., Wubalem Tadesse, Tolosana, E. and López, R. (Eds.), Proceedings of the Conference on Eucalyptus Species Management, History, Status and Trends in Ethiopia, pp. 184-205. Ethiopian Institute of Agricultural Research, Addis Ababa.**

The genus *Eucalyptus* predominates tree-planting practices among smallholder farmers in Ethiopia. The genus is introduced to the country over a century ago, but it is showing an alarming expansion throughout rural Ethiopia in recent decades. Eucalypt is preferred over other species due to a number of merits that address the need of the farmers. Most farmers describe it as 'life saviour', 'safety net,' or 'tree bank' as it is converted easily and quickly to cash whenever needed. Despite the alleged ecological demerits, which farmers are also well aware of, expansion is on going and justified until the current wood and income shortage of smallholder farmers will subside. Eucalypt growers claim that there is no equally productive, adaptive, and demandable species to replace or substitute it. Farmers

are confining perceived environmental impacts by developing locally adaptive stand management techniques such as trenching and site selection. From farmers perspective benefits from growing eucalypt far outweigh ecological costs from its impacts. Under current market condition, Eucalypt growing provides far better return on investment than any alternative land uses. The growing scarcity of wood products from natural sources on the one hand, and the need to satisfy household wood and cash needs on the other are the major drivers of planting eucalypt. Eucalypt is contributing to private forest development, supporting households to becoming wood self-sufficient and provide considerable cash income. Indeed, Eucalypt is a great asset that is contributing to rural development and poverty reduction in Ethiopia. Therefore, making decisions about eucalypt on the basis of perceived ecological impacts only is not advisable, rather the choices of poor households and the economic impacts that the plant is bringing on their welfare is equally important and justified to consider.

**Keywords:** Ecological impacts, Eucalypt, Farm forest, Income, Profitability, Perception, Wood products.

**Nawir A.A., Kassa H., Sandewall M., Dore D., Campbell B., Ohlsson, B. & Bekele M., 2007. Stimulating Smallholder Tree Planting – Lessons from Africa and Asia. *Unasylva*, 58: 53-58.**

From 1990 to 2005 the area of tropical forest plantations increased from 69 million to 93 million hectares (FAO, 2006). Small-scale forest plantations provide a range of benefits to rural communities, including fuelwood, fodder and wood for building and everyday uses, as well as environmental and amenity benefits. Yet small-scale producers and poor households still reap only a small portion of the commercial benefits from plantation-derived wood and processed wood products, even though plantations in developing countries produce billions of dollars worth of these products annually. This article describes some different schemes through which smallholders participate in establishing and managing productive plantations. These reflect a continuum from management by tree growers themselves to private corporate initiatives, with government-initiated collaborative management in between. For each of these schemes, the article identifies key incentives – defined as “payments or services that increase the comparative advantage of forest plantations over other land use options and thus stimulate investments in plantation establishment and management”(Enters, Durst and Brown, 2003) – that can promote smallholder involvement in tree planting, although the strategies of course vary according to the country and the local conditions. The article highlights the importance of supportive policies and legislation, and clear, secure forest land tenure and management rights as enabling conditions for sustainable development of smallholder plantations.

**Nibbering J W., 1999. Tree Planting on Deforested Farmlands, Sewu Hills, Java, Indonesia: Impact Of Economic and Institutional Changes. *Agroforestry Systems*, 46 (1): 65-82.**

The paper analyses how farmers in the Sewu Hills, a limestone hill complex in Java, were led to grow trees on their holdings. In the past, the area had been notorious for its deforestation, soil erosion and poverty. An historical analysis of change in land use in the area bears out

a number of factors that were conducive to the change to tree planting: increased crop productivity, depletion of forest resources, better marketing opportunities for tree products, greater security of the trees, and increased non-agricultural employment opportunities. Tree planting campaigns launched by the government provided the population with important incentives, establishing a critical mass of farmers adopting tree growing. Trees and their products have diversified, buffered and expanded household economies in the Sewu Hills. However, it remains to be seen whether the system can withstand the economic and social pressures the area is facing today. The findings show that an historical, multi-level analysis of land use adds considerably to cross-sectional studies in understanding what causes farmers to grow trees on their fields.

**Obidzinski K. & Dermawan A., 2010. Smallholder Timber Plantation Development in Indonesia: What Is Preventing Progress?. *International Forestry Review*,12(4): 339-348.**

This paper evaluates a community timber plantation programme in Indonesia called HTR (*Hutan Tanaman Rakyat*, community timber plantation). Launched in 2006, the programme seeks to establish over 5 million hectares of new plantations by 2016. Government authorities have offered a range of incentives including low interest loans, assistance with the acquisition of land, streamlined application procedures and simplified reporting on operations. Nearly four years later only a small fraction of the intended plantations have been established. Review of the policy content, incentives offered and financial profitability assumptions indicate significant policy design flaws and shortcomings in implementation. The policy also runs the risk of encouraging illegal forestry activities. We identify five policy adjustments that can potentially increase the success of the programme in the areas of financial feasibility, legal certainty, and transparency in land allocation and financing.

**Osorio A.C., 2002. Incentives to Plant Trees in Tigray Ethiopia: Interactions of Public Microdams and Health: M.Sc. Thesis . Faculty of the Virginia Polytechnic Institute and State University College of Natural Resources, Department of Forestry.**

Governments of developing countries face the dual tasks of increasing agricultural productivity and ensuring sustainability of resources. The government of Ethiopia initiated a major rural development program in Tigray, Ethiopia ten years ago, called SAERT (Sustainable Agricultural and Environmental Rehabilitation), to change the decline in agricultural productivity and reverse local forest degradation. SAERT targets water resource development through the construction of regional public microdams, intended to bring irrigated agriculture to surrounding villages and improve household income. Through SAERT, villagers can choose to plant trees on public microdam sites, protected and monitored by the surrounding villages. Unfortunately, microdams may cause potentially serious side effects to human populations through water-borne illnesses such as malaria and schistosomiasis. This paper examines incentives for villagers in Tigray to plant trees for private use, in both villages with and without access to regional public microdams. In addition, we investigate the importance of health factors on the household decision to plant trees on household and public land.

**Pohjonen V., 1988. Energy Forestry and Use of Biomass fuels in Ethiopia. Paper Presented in the International Seminar on “Strategies and Means off Development: South and North” held in Nurmes, Finland on 4th – 7th August, 1988. 11 p.**

Energy from biomass counts over 90 per cent of the energy use in Ethiopia. Since the indigenous forests have largely been cut, fuelwood is no more sufficient. Substitute fuels cow dung and crop residues must have been taken in use. Decimating of natural forests is going on at rate of 100,000 – 200,000 ha/a, which is 10 times above the re-establishment of new forests by planting. To reduce the harmful effects of overcutting the forests for fuel, and of using cow dung and crop residues as substitute fuels, establishment of fuelwood plantations is needed. Energy forestry with eucalypts is known since 1895 to the dwellers of the central highlands where rainfall is high enough for tree planting. The biggest fuelwood plantations, 19,800 ha planted before the 1975 land reform, grow in the green belt of Addis ababa. Additional fuelwood plantations of about 14,000 ha have been established with funding from international organizations. The total area of fuelwood plantations in Ethiopia is about 100,000 ha. *Eucalyptus globulus* is the main species grown for fuel. Although some doubts of the ecological suitability of eucalypts for plantations exist, the advantages of high production, coppicing and the non-palatability of the leaves for cattle outweigh the disadvantages of low erosion control and high demand for water and nutrients.

**Putzel L., Cronkleton P., Larson A., Pinedo-Vasquez M., Salazar O. & Sears R., 2013. Peruvian Smallholder Production and Marketing of Bolaina (*Guazuma Crinita*), A Fast-Growing Amazonian Timber Species: Call for a pro-livelihoods policy environment. CIFOR Brief No. 23, August 2013.**

i) In Amazonia, certain native fast-growing timber species perform well in local smallholder management systems; (ii) Fast-growing timber from second-growth forests and fallows is an important source of income for local producers; (iii) Bolaina (*Guazuma crinita*) timber has an established national market. The species is well suited to sustainable smallholder forest management and timber production, processing and marketing; (iv) Opportunities for farmers who are also small-scale forest managers to improve their livelihoods by producing and selling timber are limited by the lack of a supportive legal framework; (v) Policies and regulations on timber harvesting and trade should facilitate markets for timber sustainably produced in smallholder forests.

**Randall Bluffstone, Mahmud Yesuf, Bilisuma Bushie & Demessie Damite, 2008. Rural Livelihoods, Poverty, and the Millennium Development Goals: Evidence from Ethiopian Survey Data. Environment for Development, Discussion Paper Series.**

This paper provides an in-depth look at some of the key development issues facing households in Ethiopia, in the context of the Millennium Development Goals (MDG). Using household survey data from 2000, 2002, and 2005, we found that Ethiopia is making progress toward some vital MDG goals, but household incomes are shockingly low and hugely varied. Assets could potentially help smooth consumption when incomes vary, but because land is owned by the government, it cannot serve as a true, functioning asset. The current property rights structure excessively limits households' options.

**Rocheleau D. & Edmunds D., 1997. Women, Men and Trees: Gender, Power and Property in Forest and Agrarian Landscapes. *World Development*, 25 (8): 1351-1371.**

This paper proposes a revision of the concept of property commonly associated with land in analyzing the gender dimensions of tree tenure. Unlike two-dimensional maps of land ownership, tree tenure is characterized by nested and overlapping rights, which are products of social and ecological diversity as well as the complex connections between various groups of people and resources. Such complexity implies that approaches to improving equity using concepts of property based on land may be too simplistic. Rather than incorporating both women and trees into existing property frameworks, we argue that a more appropriate approach would begin by recognizing legal and theoretical ways of looking at property that reflect the realities and aspirations of women and men as well as the complexity and diversity of rural landscapes. Through a selective review of the literature, particularly in Africa, and illustrative case studies based on our fieldwork, we explore the “gendered” nature of resource use and access with respect to trees and forests, and examine distinct strategies to address gender inequalities therein. A review of the theoretical and historical background of land tenure illustrates the limitations of “two-dimensional” maps associated with land tenure in delineating boundaries of nested bundles of rights and management of trees and forests by different actors. The introduction of gender adds another dimension to the analysis of the multidimensional niches in the rural landscape defined by space, time, specific plants products, and uses. Gender is a complicating factor due to the unequal power relationships between men and women in most societies. These power relationships, however, are subject to change. Rather than adopting an artificial dichotomy between “haves” and “have nots” (usually linked with men and women, respectively, in discussions of land tenure), we argue that gendered domains in tree tenure may be both complementary and negotiable. If resource tenure regimes are negotiable, they can be affected by changes in power relations between men and women. This idea has important policy implications. In many discussions of tenure, rights are often assumed to be exogenous or externally determined. The negotiability of tenure rights gives policy makers and communities another lever with which to promote a more equitable distribution of rights to the management and use of natural resources.

**Rogers E., Malimbwi R.E, Zahabu E., Katani J. & Mugasha W., 2010. Improving Smallholder Livelihoods Through Woodlots Management for Adaptation to Climate Variability & Change in Makete District, Tanzania.**

A study on improving smallholder livelihoods through woodlots management as an adaptation measure to climate change variability and change measure was conducted in Makete Districts, Tanzania. Tree planting programme in most part of the country has been advocated for decades but adoption to these activities still is not promising to most part of the country. In contrary, people in Makete do not need sensitization regarding tree planting. They already know the importance of trees as they contribute highly to the economy of individuals and to the District at large. Previously people in Makete Districts depended their income through agricultural products such as maize, white flour, potatoes and *pareto*. Later due to climate variability and change, the crops production fell tremendously. As a result food security and the wellbeing of rural people of Makete were threatened. Responding to this situation which is a consequence of climate change, local people of Makete District have established tree woodlots as an alternative source of household income. This is

essentially a climate variability & change adaptation strategy. Makete rural area is among the Southern highlands of Tanzania reported to have successful woodlots. These areas are well afforested with trees especially of cypress, pines, eucalyptus and wattle. The woodlots range from 0.25 to 3 hectares. Unfortunately there was little information the contribution of individual woodlots to the income of smallholders, poverty alleviation as a whole and how the benefits are distributed to all stakeholders involved in the industry. It was therefore not clear how much woodlot management was contributing to climate change adaptation. Much as the communities were harvesting and getting income from their woodlots, their management practices including marketing strategies were far from being sound. Therefore this study assessed management practices of smallholder woodlots and marketing of timber and documents effective climate variability & change adaptation in Makete district. The silvicultural management practices investigated through questionnaire included: sources of planting material, site selection, choice of species to grow in a specified area, transplanting, tending activities, harvesting and markets for the woodlot products. By utilizing the indigenous knowledge and that of scientists a guideline on best practices for woodlot management was produced as an outstanding output of this study. In the identification of existing marketing channels and practices for softwood timber from smallholder's woodlots, three marketing channels were identified. These were: Farmers selling immature stands to middlemen who manage the woodlots to maturity and then extract timber which they sell to final market destinations of Makambako, Njombe, Dar es salaam and Mbeya; Farmers selling mature stands or round logs to middlemen who convert them to sawn timber and lastly; Farmers themselves converting their mature or immature stands to lumber and sell them to middlemen or to the final destination. The last option is more profitable to farmers and therefore recommended. It was also recommended that farmers form credit associations e.g. *Mang'oto Tree Growers Association* from which they can borrow money while keeping their immature woodlots as collaterals and repay when they sell mature timber. This will reduce the loss caused by selling immature timber. The district authorities support this recommendation and promised to facilitate.

**Rist L., Feintrenie L. & Levang P., 2010. The Livelihood Impacts of Oil Palm: Smallholders In Indonesia. *Biodiversity and Conservation*, 19 (4): 1009-1024.**

The biodiversity and climate consequences of oil palm (*Elaeis guineensis*) expansion across South East Asia have received considerable attention. The human side of the issue, highlighted with reports of negative livelihood outcomes and rights abuses by oil palm companies, has also led to controversy. Oil palm related conflicts have been widely documented in Indonesia yet uptake by farmers has also been extensive. An assessment of the livelihood impacts of oil palm development, including sources of conflict, is needed to shed light on the apparent contradiction between these reports and the evident enthusiasm of farmers to join the oil palm craze thereby informing future expansion. We assessed the impact of oil palm development on the economic wellbeing of rural farmers in Indonesia. We found that many smallholders have benefited substantially from the higher returns to land and labour afforded by oil palm but district authorities and smallholder cooperatives play key roles in the realisation of benefits. Conflicts between communities and companies have resulted almost entirely from lack of transparency, the absence of free, prior, and informed consent and unequal benefit sharing, and have been exacerbated by the absence of clear land rights. We make specific recommendations to improve the present situation

and foster the establishment of smallholder friendly production regimes. Oil palm expansion in Indonesia is set to continue. If environmental standards can be raised and policy interventions targeted at the broader social impacts of land development this expansion may be achieved to the significant benefit of large numbers of rural smallholders.

**Rudel T.K., 2009. Tree Farms: Driving Forces and Regional Patterns in the Global Expansion of Forest Plantations. *Land Use Policy*, 26: 545–550.**

People have planted trees in rural places with increasing frequency during the past two decades, but the circumstances in which they plant and the social forces inducing them to plant remain unclear. While forests that produce wood for industrial uses comprise an increasing number of the plantations, most of the growth has occurred in Asia where plantations that produce wood for local consumption remain important. Explanations for these trends take economic, political, and human ecological forms. Growth in urban and global markets for forest products, coupled with rural to urban migration, may spur the conversion of fields into tree farms. Government programs also stimulate tree planting. These programs occur frequently in nations with high population densities. Quantitative, cross-national analyses suggest that these forces combine in regionally distinctive ways to promote the expansion of forest plantations. In Africa and Asia plantations have expanded most rapidly in nations with densely populated rural districts, rural to urban migration, and government policies that promote tree planting. In the Americas and Oceania plantations have expanded rapidly in countries with relatively stable rural populations, low densities, and extensive tracts of land in pasture. If, as anticipated, the growing concern with global warming spurs further expansion in forest plantations in an effort to sequester carbon, questions about their social and ecological effects should become more pressing.

**Sisay Feleke, 2010. Essential Oil Yield from Leaves of *Eucalyptus grandis* and *Eucalyptus saligna* and their Commercial Applications; in Gil L., Tadesse W., Tolosana E. & Lopez R. (Eds.). *Eucalyptus Species Management, History, Status and Trends in Ethiopia. Proceedings from the Congress Held in Addis Ababa, September 15<sup>th</sup> – 17<sup>th</sup>, 2010.***

Over 50 eucalyptus species were introduced to Ethiopia for various purposes especially for fuel wood and construction. Additionally they have industrial uses in the production of particle and fiberboards, which are the main and major raw material consuming part of these species. The eucalyptus species are rich with essential oils, which are used in pharmaceutical, perfumery, and various industries. The use of eucalyptus oil for pharmaceutical industry depends on the oil chemical composition and the species as well, oils rich with cineol greater than 80% and in perfumery industry the oil to be rich with citronellal. In Ethiopia, by hydrodistillation mechanism, the essential oil produced at pilot scale from *Eucalyptus globulus* and *Eucalyptus citrodora* are used in the detergent factories. The oil production from these species made from waste or felled big trees. The production of essential oils from biological material depends on the extraction techniques, plant species, and geographical location, age of materials (maturity), parts of the plant, season, and climatic factors. The constituents of the oils are mainly monoterpene and sesquiterpene hydrocarbons, oxygenated compounds derived from these hydrocarbons (alcohols, aldehydes, esters, ethers, ketones, phenols, and oxides). In the production of



eucalyptus oil the major raw material is leaf and therefore the biomass production of the leaf per hectare to be maximized.

**Keywords:** Essential oil, Eucalyptus, Monoterpens

**Shackleton C. M., Paumgarten F. & Cocks M.L., 2008. Household Attributes Promote Diversity of Tree Holdings in Rural Areas, South Africa. *Agroforestry Systems*, 72:221–230**

Trees within the homestead area provide many functions to rural households. However, within the semi-arid regions of southern Africa, there has been only limited examination of the correlates between the socio-economic attributes of rural households and the density, species richness and types of trees they keep. This paper reports on a multivariate analysis of household attributes in relation to homestead tree holdings from six rural villages in South Africa. In terms of density of trees per household, gender of the household head was the only significant correlate, with female-headed households having significantly fewer trees than their male-headed counterparts. This was especially so for the density of indigenous trees. With respect to species richness, a number of interrelated correlates were identified through Principle Components Analysis, the most prominent ones being relative wealth, village location, homestead size and gender. Most species were common between both male- and female-headed households, although there were differences between them for six of the species held by at least five percent of households. However, the differences were not related to species uses or income generation potential. These results indicate that support programs should be conscious of the differential needs and responses of households according to their different characteristics and circumstances.

**Shively G. E., 1999. Prices and Tree Planting on Hillside Farms in Palawan. *World Development*, 27(6): 937-949.**

This paper investigates determinants of tree-planting decisions on low-income farms in the Philippines. The analysis quantifies the extent to which agricultural prices, price uncertainty, and farm-species characteristics help to explain mango planting decisions on hillside farms. Regression analysis is applied to data on tree planting for 1981±94. Results indicate tree planting is positively correlated with mango prices and negatively correlated with prices of competing crops. Relative price uncertainty and farm size also play important roles in explaining tree-planting patterns. Implications for policies to encourage tree planting are discussed.

**Simmons C.S., Walker R.T. & Wood C.H., 2002. Tree planting by Small Producers in the Tropics: A Comparative Study of Brazil and Panama. *Agroforestry Systems*, 56: 89–105.**

Forest regrowth is a notable phenomenon across the tropical forest latitudes. Such reforestation takes place in the wake of land abandonment, occurs cyclically in a rotational agricultural system, and may result from the deliberate planting of trees by farmers. Although less extensive than successional forest regeneration, tree planting by small farmers can have potentially important environmental impacts at both the site and global scale. This

paper examines tree-planting efforts by small farmers in the tropical frontier regions of Panama and Brazil in order to gauge the magnitude of reforestation activities, and to identify factors that influence these efforts. This paper discusses the environmental regulations, forestry law, and tenure institutions in both countries, and performs a comparative analysis of reforestation efforts with information derived from household surveys (n = 356) and in-depth tree planting interviews (n = 35). Results from logistic regression are also presented. Our results show that tree planting occurs more frequently in Panama, which we attribute to greater external support in the provisioning of extension and materials and strong market incentives. We suggest that the proximity of the study sites to Panama City facilitates external support and market drivers. Finally, our results suggest that land tenure security is an influential determinant of reforestation activities in both countries.

**Skutsch M., 1983. Why People do not Plant Trees? The Socioeconomic Impacts of Existing Woodfuel Programs: Village Case Studies, Tanzania. Energy in Developing Countries Series. Resources for the Future / Washington, D.C. Discussion Paper D-73P**

The aim of this research was to evaluate the impact of Tanzania's policy of village afforestation. In particular, it examines the motivations that lie behind the decision of a village to adopt forestry, and the social and economic reasons for the many failures. A parallel study by Dr. A. B. Tamu is investigating the policy itself and its interpretation by those responsible for implementing it. Eighteen villages were taken as case studies, including some which had not started social forestry, some which had but failed, and some which have been successful. Many hypothetical causes of the failure of social forestry were examined. The main findings were: (1) shortage of firewood is not merely an incentive to start a woodlot, but also to succeeding with it; (2) skills in planting and caring for young trees are widespread; (3) the style of forestry extension work tends to encourage the starting of woodlots but not their planning and expansion; (4) the transport of seedlings to the villages at the appropriate time is a greater constraint than their actual production at the nurseries; and (5) the communal aspects of organizing social forestry projects lead to more difficulties than the physical aspects of silviculture.

**Tekalign Simeneh, 2013. Value chain Analysis Of Eucalyptus From Small Woodlots in Ethiopia: The case of West Gojjam Zone, Mecha District. M.Sc. Thesis, the Faculty of Environmental Sciences, Technische Universität Dresden.**

This paper discusses the value chain of eucalyptus based products from small woodlots of Ethiopian. A case study was made of two *Kebelles* of Mecha district in West Gojjam zone of Amhara National Regional State. The main objectives were to identify the actors involved, map the marketing chain and assess the value added share and distribution; and identify main factors affecting the eucalyptus value chain. A total of 84 respondents; 54 growers, 28 traders and 2 exporters were selected and interviewed. Qualitative and quantitative data were also obtained from interviews with key informants, personal observations and group discussions. According to the survey results farmers, village traders, urban traders, transporters, exporters, consumers and the governmental institutions were the major eucalyptus value chain actors. These actors were able to increase their margin through different value addition activities. Processing and transportation activities increased growers' profit margin by 16%, while the village traders' profit margin involved in buying of standing

trees were 22% which was 9% greater than those involved in processed eucalyptus poles. Similarly, urban traders who bought eucalyptus poles from village traders and sold it at Gonder, Metema, Humera and Shire have got a profit margin of 14%, 28%, 34% and 31% (before tax) respectively. On the other hand the average profit margin before tax of exporters was about 23%. Lack of policy and institutional support, lack of cooperation among actors and the existing poor taxation system were the main limiting factors of eucalyptus business development in the study area.

**Keywords:** Eucalyptus based product, Profit margin, Value added distribution, Value chain, Woodlots.

**Yoseph Melka, Tsegaye Bekele & Jürgen Bausch. Factors Influencing Leaf Oil Yield of Eucalyptus and Corymbia Species Growing in Ethiopia.**

Sources of variation in essential oil yields of myrtaceae family growing in Ethiopia were examined. The volatile leaf oils were analyzed from twenty mature trees growing in the arboretum of Wondo Genet. Further investigations were made on samples from managed stands of three prominent oil bearing species (*C. citriodora*, *E. globulus*, and *E. camaldulensis*) to understand the effects of different influencing factors on oil yield. The mean leaf oil yield of the studied species ranged from 0.20 to 5.23 % (dry weight bases). Seven out of the twenty species examined contained leaf oil below 1%, six species between 1% and 2%, three species between 2% and 3% and only four species have shown oil yield values above 3%. The mean oil yield at subgenus level varied significantly in the order of *Corymbia* (2.64%), *Symphomyrtus* (1.82%), and *Monocalyptus* (0.79%). The result showed that, genotype is the most influential factors in determining leaf oil yield of the genera *Eucalyptus* and *Corymbia*. The influence of the season on leaf oil yield appeared to be species specific and no distinct seasonal trend of oil yield was evident from this study. Oil yield from *C. citriodora* found to be higher during summer followed by autumn and spring with lowest yield during winter. In the case of *E. globulus*, autumn appeared to provide the highest oil yield followed by summer and spring with the lowest yield recorded during winter. Oil yield from *E. camaldulensis* was higher in winter followed by spring and summer with lowest yield occurred in autumn. Leaf oil yield from juvenile leaf samples (0.49 - 4.08 %, dry weight) was higher than the corresponding mature leaves (0.77- 4.51%). The effect of leaf type was markedly significant in the case of *E. camaldulensis* than *E. globulus* and *C. citriodora*. Enriching the findings with further chemical analysis would provide a better insight on the impacts of the influencing factors in determining the overall oil production of myrtaceae family both in terms of quantity and in terms of quality.

**Keywords:** Leaf oil yield, Season, Species, Subgenera, Variation, Volatile

**Zelalem Getahun, Pradeep Poddar & Omprakash Sahu, 2014. The Influence of Physical and Mechanical Properties on Quality of Wood Produced From Pinus Patula Tree Grown at Arsi Forest. *Advanced Research Journal of Plant and Animal Sciences*, 2: 032-041.**

The main objective of the study was to investigate the physical and mechanical properties of *Pinus patula*. For this study, 28 years old *pinus patula* stand was used along the tree

height from three portions, namely bottom, middle, top. Six trees were harvested and lumber used for testing were produced in Arsi Forest Enterprise mobile sawmill. A total of 336 samples free from visible defects were produced from three log positions of *Pinus patula*, each for modulus of elasticity, modulus of rupture, compression parallel to the grain, and impacts bending of dry and green and 84 samples of shrinkage were tested. For this experiment, variable of physical properties like basic density, initial moisture content and shrinkage were evaluated. The result showed that tree height had significant ( $p < 0.05$ ) effects on basic density and insignificant effects on initial moisture content and tangential and radial shrinkage. Basic density, initial moisture content and radial shrinkage shows decreasing trend from bottom to top log, but tangential shrinkage increase from bottom to top log. Similarly, the result indicated that highly significant ( $p < 0.01$ ) in all mechanical properties except specific impact resistance of green sample. The result of specific impact resistance of green sample was significant ( $p < 0.05$ ). The value of mechanical properties decreases from bottom to top log in all tests of green and dry samples. Generally, tree positions influence the physical and mechanical properties of wood.

**Keywords:** Density, Compression, Elasticity, Moistures, Resistance

## 5.2. Plantation for Diversity and Rehabilitation of Degraded Land

**Abraham Abiyu, Mulugeta Lemenih, Georg Gratzner, Raf Aerts, Demel Teketay & Gerhard Glatzel, 2011. Status of Native Woody Species Diversity and Soil Characteristics in an Exclosure and in Plantations of *Eucalyptus globulus* and *Cupressus lusitanica* in Northern Ethiopia. *Mountain Research and Development*, 31(2):144-152.**

Exclusion of grazing animals and tree plantations are 2 methods that have been used for restoration of degraded lands in tropical semiarid areas. These 2 options can foster secondary forest succession by improving soil conditions, attracting seed-dispersal agents, and modifying microclimate for understory growth. We compared native woody plant diversity and soil chemical and physical attributes under exclosure and on *Eucalyptus globulus* (EGP) and *Cupressus lusitanica* (CLP) plantations. Vegetation data were collected by an inventory of stands with circular plots of 5.64 m radius, and soil samples were collected from the 4 corners and center of 20 x 20 m plots. As a result, 15 native woody plant species belonging to 13 families were recorded. Importance value index (IVI), Shannon-Wiener, Simpson's diversity, and species richness were higher in the exclosure, followed by EGP and CLP. Contents of soil organic carbon and total nitrogen showed significance difference and were highest in the exclosure, followed by CLP, EGP, and grazing land. Although the difference was not significant, an increasing trend was observed for cation exchange capacity and  $K^+$ . Bulk density was highest on the grazing land, followed by EGP, CLP, and exclosure. Our results suggest that degraded land reclamation can be achieved with plantation of rapidly growing tree species as well as exclosure. However, native woody species diversity and improved soil attributes are better achieved with exclosure. Exclosures can be established interspersed strategically with single- or mixed-species plantations to facilitate restoration of native vegetation. However, it is important to conduct further research on the comparative

advantage of enrichment planting of exclosures with preferred tree species or exclosures interspersed within blocks of plantation.

**Keywords:** Restoration, Regeneration, Succession, Woody species, Soil attributes, Afromontane, Ethiopia.

**Ahiback A.J., 1995. Mobilizing Rural People in Tanzania to Tree Planting: Why and How. *Ambio*, 24 (5):304-310.**

Most developing countries suffer from growing population pressure on soil and trees. Unless action is taken soon, there will not be enough arable land to feed future populations, nor there enough fuelwood. As these countries have poor economies but many people, action needs to be based on people's creativity and energy through mass movement. The major prerequisites are technology, resources, institutions, and motivation. In Tanzania, simple tree-planting technology (within farming systems), human resources (creativity and energy), and suitable supporting institutions (village authorities) are in place. The urgent task is motivation and mobilization. In the choice of a mobilization approach, essential aspects to consider are the magnitude and urgency of the required efforts. The approach suggested is a combination of encouragement, coercion and trust. Coercion with trust will provide the short-cut to action required to win the race against time. While tree planting is compulsory, people are trusted to decide where, what and how to plant, thus easing the chronic shortage of extension staff. The present conventional community-forestry efforts, backed by the Tanzania Forestry Action Plan, will lend support to the mass movement required.

**Bewket W., 2003. Household Level Tree Planting and its Implications for Environmental Management in the Northwestern Highlands of Ethiopia: A Case Study in the Chemoga Watershed, Blue Nile Basin. *Land Degradation and Development*, 14: 377–388.**

The unsustainable exploitation and destruction of forests is a serious environmental concern in the developing countries of Africa. One of its main driving forces is the growing population causing a growing demand for fuelwood. In Ethiopia, as in many developing countries, there is a heavy dependence on and a growing demand for fuelwood. This dependence has been contributing to a widescale deforestation, as stated in various reports. Contrary to these reports, a study in the Chemoga watershed found a slightly increased forest cover during the past four decades, which was ascribed to households' tree planting practices. The objective of this study was to examine household level tree planting activities in reference to biofuel consumption patterns in four sample villages in the watershed. The results indicate that fuelwood and cattle dung accounted for nearly 100 per cent of the domestic energy consumption, with cattle dung contributing 34 per cent of the total. Fuelwood and dung combined, per capita biofuel consumption was estimated at 511 kg yr/year, but with variations between the villages and socio-economic groups. Supply appears to have influenced the quantity of biofuels used. The scarcity of wood for fuel and other uses has forced households to plant trees. This has contributed to the increased forest cover of the watershed at the present as compared to that four decades ago. Number of trees planted showed variation between the villages and socio-economic groups, which is attributable to physical and human factors. In promoting tree planting, agroforesters and environmental management planners should therefore take into account local level biophysical and socio-

economic realities. This agroforestry practice is a good short-term solution to the problem of fuelwood shortage, and also has many positive implications for environmental management and agricultural production. Thus, it has to be encouraged. Spatially aggregated, local level agroforestry practices contribute positively towards global ecosystem health.

**Keywords:** Air temperature; Canopy closure percent; Leaf area index; Soil temperature; Soil moisture; Colonizing woody species

**Carnus Jean-Michel, Parrotta John, Brockerhoff Ekehard, Arbez Michel, Jactel Hervé, Kremer Antoine, Lamb David, O'Hara Kevin & Walters Bradley, 2006. Planted Forests and Biodiversity. *Journal of Forestry*, 104 (2): 65-77.**

Expansion of planted forests and intensification of their management has raised concerns among forest managers and the public over the implications of these trends for sustainable production and conservation of forest biological diversity. We review the current state of knowledge on the impacts of plantation forestry on genetic and species diversity at different spatial scales and discuss the economic and ecological implications of biodiversity management within plantation stands and landscapes. Managing plantations to produce goods such as timber while also enhancing ecological services such as biodiversity involves trade-offs, which can be made only with a clear understanding of the ecological context of plantations in the broader landscape and agreement among stakeholders on the desired balance of goods and ecological services from plantations.

**Keywords:** Biological Diversity; Conservation Biology; Landscape Management; Planted Forests; Stand Management

**Coert J. & Geldenhuys, 1998. Native Forest Regeneration in Pine and Eucalypt Plantations in Northern Province, South Africa. *Forest Ecology and management*, 99 (1-2):101-115.**

Commercial plantations in South Africa have been established mainly in grasslands adjacent to native forest which occur as small, scattered patches, restricted to valleys and scarps by regular fires in the adjacent fire-prone grasslands. Understorey vegetation was sampled in plantation stands of different age of *Pinus patula*, and old stands of *P. elliottii*, *P. taeda* and *Eucalyptus saligna*, growing on the forest margin. The study was done in two areas in Northern Province, South Africa (23°S to 25°S, and 30°E to 31°E): Woodbush-De Hoek along the Eastern Escarpment, and Entabeni on Soutpansberg mountains. The area receives 1200 to 1900 mm rain per annum, mainly during summer. Two hypotheses were tested: understorey colonisation by native plant species is strongly influenced by the overhead plantation species; and abundance and diversity of indigenous woody and herbaceous species increase with increasing stand age. A total of 170 species were recorded on 62 plots of 78.5 m<sup>2</sup> each, and included all major growth forms present in the surrounding forest, except epiphytes. Trees were represented by 62 species, but only 18% of these occurred in more than 10% of the plots. Seventy-two percent of the 95 tree, shrub and climber species are animal-dispersed but only 22% of the animal-dispersed species occur in more than 10% of the plots. Mean clean bole length of the plantation stand gave the best regression coefficients with species richness, stem density, mean DBH and mean height of the woody regeneration, all of which increased with stand age. There

was no clear pattern in understorey species composition among the different plantation species. Site factors such as substrate (geology) and temperature (altitude and radiation index) had a strong correlation with species composition and density of understorey vegetation. The results do demonstrate a useful successional process which could be used to achieve specific management objectives at relatively low costs. Potential applications of this succession process are manipulation of tree stands (commercial plantations or invader plants) to restore native forest biodiversity, control of understorey weeds in commercial plantations, and growing of useful crops under tree canopies.

**Keywords:** Afforestation, Eucalyptus, Evergreen forest, Pinus, Restoration, Succession

**Desalegn Tadele & Masresha Fetene, 2013. Photosynthetic Responses of Seedlings of two Indigenous Plants inside Exotic Tree Plantations and adjacent Natural Forest in Munessa–Shashemene Forest, Southern Ethiopia. *Ethiopian Journal of Science*, 5(2): 3-14.**

The potential role of exotic tree plantations in facilitating successional processes on degraded areas was evaluated in southern Ethiopia, Munessa-Shashemene forest, by examining photosynthetic responses of *Bersama abyssinica* Fres. And *Croton macrostachyus* Del. seedlings naturally grown inside plantations of *Eucalyptus saligna* and *Pinus patula* and adjacent natural forest. Photosynthetic responses of the seedlings were recorded using modulated photosynthesis yield analyzer, Mini-PAM. Analysis of fluorescence parameters in the leaves showed no significant differences in the level of dark-adapted and light-adapted fluorescence yield ( $F_v/F_m$  and  $\Delta F/F_m$ , respectively) among seedlings grown inside plantations and adjacent natural forest indicating similar photosynthetic performance. The light response curves of electron transport rate (ETR), light-adapted fluorescence yield ( $\Delta F/F_m$ ) and non-photochemical quenching (NPQ) showed similar light saturation behavior among the seedlings grown inside plantations and natural forest and suggested a shade-adapted behavior of *Bersama abyssinica* as compared to *Croton macrostachyus*. The results suggest the role of exotic tree plantations in facilitating restoration processes on degraded areas by improving light conditions for photosynthesis.

**Desalegn Tadele & Masresha Fetene, 2013. Tree Plantations and adjacent Natural Forest in Munessa–Shashemene Forest, Southern Ethiopia. *Ethiopian Journal of Science*, 2: 3-14.**

The potential role of exotic tree plantations in facilitating successional processes on degraded areas was evaluated in southern Ethiopia, Munessa-Shashemene forest, by examining photosynthetic responses of *Bersama abyssinica* Fres. And *Croton macrostachyus* Del. seedlings naturally grown inside plantations of *Eucalyptus saligna* and *Pinus patula* and adjacent natural forest. Photosynthetic responses of the seedlings were recorded using modulated photosynthesis yield analyzer, Mini-PAM. Analysis of fluorescence parameters in the leaves showed no significant differences in the level of dark-adapted and light-adapted fluorescence yield ( $F_v/F_m$  and  $\Delta F/F_m$ , respectively) among seedlings grown inside plantations and adjacent natural forest indicating similar photosynthetic performance. The light response curves of electron transport rate (ETR), light-adapted fluorescence yield ( $\Delta F/F_m$ ) and non-photochemical quenching (NPQ) showed similar light saturation behavior

among the seedlings grown inside plantations and natural forest and suggested a shade-adapted behavior of *Bersama abyssinica* as compared to *Croton macrostachyus*. The results suggest the role of exotic tree plantations in facilitating restoration processes on degraded areas by improving light conditions for photosynthesis.

**Keywords:** Chlorophyll fluorescence, Light response curves, PS II, Restoration, Ethiopia.

**Eshetu Yirdaw, 2002. Restoration of the Native Woody-Species Diversity, Using Plantation Species as Foster Trees, in the Degraded Highlands of Ethiopia. Ph.D. Thesis, Faculty of Agriculture and Forestry, University of Helsinki, Finland.**

The potential of fast-growing forest plantation species to enhance the recruitment, establishment and succession of native woody species in the degraded Ethiopian highlands was studied. The naturally-regenerated woody species diversity and ground layer vegetation cover were studied in plantations of *Eucalyptus globulus*, *Pinus patula*, *Cupressus lusitanica*, *Grevillea robusta*, and *Juniperus procera*, and in surrounding natural forests in Wondo Genet, Menagesha and Chancho, Ethiopia. Furthermore, the canopy photosynthetic photon flux density transmittance of these five forest plantation species and the growth of native *Podocarpus falcatus* seedlings in canopy gaps of plantations were investigated. In addition, to understand the germination ecology and consequently the recruitment of native tree species, the germination response of *Cordia africana*, *Juniperus procera*, *Acacia abyssinica*, and *Faidherbia albida* seeds to red to far-red ratios and temperature were studied. At Wondo Genet, a total of 53 naturally regenerated tree and shrub species belonging to 31 families were recorded in the understory of the plantations; important indigenous timber species were also represented. Trees accounted for 72% of all naturally regenerated woody plant species. In eucalypt plantations at Menagesha and Chancho, a total of 22 and 20 woody species belonging to 18 and 17 families were found and, out of these, trees accounted for 68 and 55%, respectively. About 77 and 83% of the woody species found in the adjacent natural forest were also represented in the understory of plantations at Wondo Genet and the eucalypt plantation at Menagesha, respectively. However, the relative abundance of species in the plantations and the adjacent natural forest varied considerably. The understory woody plant density in plantations was up to 8,325 stems/hectare. There was no significant variation in understory woody species richness among plantations. The herbaceous ground cover percentage in *G. robusta* and *P. patula* stands was considerably higher than that observed in *C. lusitanica* and *J. procera* stands. Woody species richness and abundance at Menagesha were on the average 2.4 times and 5.7 times higher, respectively, than the corresponding values at Chancho, and these differences were significant. This result demonstrated the crucial role of the remnants of small patches of natural forests, as a source of diaspores for the restoration of the woody species diversity in degraded areas of the Ethiopian highlands. Canopies of *E. globulus*, *P. patula* and *G. robusta* transmitted about three times as much photosynthetic photon flux density as *J. procera* or *C. lusitanica* plantations. In contrast to *J. procera* and *C. lusitanica*, *E. globulus* and *G. robusta* had relatively open crowns, higher crown-bases and lower leaf area indices, and, as a result, their canopies had a higher photosynthetic photon flux density transmittance percentage as well as higher below-canopy red/far-red ratio and temperature. The mean height and root-collar diameter of *P. falcatus* seedlings decreased steadily from gap centre towards gap edge and further to the plantation understory. As the gap size decreased from 668 m<sup>2</sup> to 449 m<sup>2</sup>, the height and root-collar diameter of *P. falcatus* seedlings decreased by 27% and



19%, respectively. In general, opening of gaps in plantations of heavy-shading tree species seems to increase the herbaceous layer groundcover, enhance the colonisation and growth of native woody species and, consequently, may also increase the floral diversity of mono-specific plantations. Germination of *Cordia africana* seeds was strongly inhibited at low R/FR and increased as the temperature increased from 15 to 30°C. It appears that *C. africana* has evolved a light quality sensing mechanism that prevents seed germination beneath leaf canopies. R/FR, temperature, and their interaction significantly affected germination of *J. procera*. The effect of R/FR on germination of *J. procera* was most pronounced, and the highest germination probability was recorded at 20°C. Seeds of this species displayed a complex dormancy mechanism and germinated only within a narrow range of temperatures and R/FR. The germination probability of *F. albida* seeds increased with rising temperature (from 15 to 30°C), but there was no significant effect of light. Neither R/FR, temperature, nor their interaction had a significant effect on the germination of *A. abyssinica* seeds. The density of naturally-regenerated woody plants in plantations was over three times the usual planting density in Ethiopia, indicating a high potential of forest plantations for restoring the natural forest ecosystems on degraded lands at a comparatively low cost. In order to fully re-establish the diverse and economically valuable natural forest, complementary measures such as enrichment planting of missing primary forest species may be required. The small isolated remnant natural forests are the only native woody species refuges left in many parts of the highlands, and they are also the only source of diaspores. Therefore, the linkage between plantations and natural forests should be realised and hence the conservation of these natural stands should be given high priority. Although there is a lack of quantifiable practical standards for biodiversity evaluation, natural forest stands near a restoration site can initially provide baseline data for the evaluation of the extent and rate of woody plant recruitment and establishment in plantations.

**Keywords:** Afromontane forests, Degraded lands, Plantations, Natural regeneration, Natural succession, Restoration, Woody species diversity, Ethiopia

**Farley K.A., Jobba E.G. & Jackson R.B., 2005. Effects of Afforestation on Water Yield: A Global Synthesis with Implications for Policy. *Global Change Biology*,11: 1565–1576.**

Carbon sequestration programs, including afforestation and reforestation, are gaining attention globally and will alter many ecosystem processes, including water yield. Some previous analyses have addressed deforestation and water yield, while the effects of afforestation on water yield have been considered for some regions. However, to our knowledge no systematic global analysis of the effects of afforestation on water yield has been undertaken. To assess and predict these effects globally, we analyzed 26 catchment data sets with 504 observations, including annual runoff and low flow. We examined changes in the context of several variables, including original vegetation type, plantation species, plantation age, and mean annual precipitation (MAP). All of these variables should be useful for understanding and modeling the effects of afforestation on water yield. We found that annual runoff was reduced on average by 44% (3%) and 31% (2%) when grasslands and shrublands were afforested, respectively. Eucalypts had a larger impact than other tree species in afforested grasslands (P50.002), reducing runoff (90) by 75% (10%), compared with a 40% (3%) average decrease with pines. Runoff losses increased significantly with

plantation age for at least 20 years after planting, whether expressed as absolute changes (mm) or as a proportion of predicted runoff (%) (Po0.001). For grasslands, absolute reductions in annual runoff were greatest at wetter sites, but proportional reductions were significantly larger in drier sites (Po0.01 and Po0.001, respectively). Afforestation effects on low flow were similar to those on total annual flow, but proportional reductions were even larger for low flow (Po0.001). These results clearly demonstrate that reductions in runoff can be expected following afforestation of grasslands and shrublands and may be most severe in drier regions. Our results suggest that, in a region where natural runoff is less than 10% of MAP, afforestation should result in a complete loss of runoff; where natural runoff is 30% of precipitation, it will likely be cut by half or more when trees are planted. The possibility that afforestation could cause or intensify water shortages in many locations is a tradeoff that should be explicitly addressed in carbon sequestration programs.

**Fekadu Debushe, 2008. Impact of *Eucalyptus Globulus* Labill. (Myrtaceae) Plantation on the Regeneration of Woody Species at Entoto Mountain, Addis Ababa, Ethiopia. M.Sc. Thesis, Addis Ababa University.**

This study was carried out at Entoto Mountain Eucalyptus plantation, about 10 km north of the center of Addis Ababa, to assess the impact of *Eucalyptus globulus* Labill. plantation on the naturally regenerated woody species. Sixty plots of 400 m<sup>2</sup> (20 m X 20m) size were established along a transect lines at every 300 m distance between them. Transects were laid in north–south directions at 500 m distance from each other. Seedlings, herbaceous species and soil samples were collected from five sub-plots (4 m<sup>2</sup>) within each major plot. A total of 68 plant species belonging to 55 genera and 32 families were identified. Asteraceae (8 species) was the most dominant family. Out of a total of 68 plant species, 41 of them were naturally regenerated woody species recorded in Entoto E. globulus plantation. They represented 33 genera and 25 families. For the analysis of vegetation diversity, woody species density and soil environmental factors, the individual E. globulus plantation stands were used to classify the plots into three categories. These are C1 (plots with less than 154 E. globulus stands), C2 (plots consists of 154 to 199 E. globulus stands) and C3 (plots with greater than 199 E. globulus stands). Twenty plots were identified for each category. There was significance difference ( $P < 0.05$ ) in the species diversity ( $H'$ ) between C1 and C2, as well as C1 and C3 while there was no significant difference between C2 and C3. The species richness was also significantly different ( $P < 0.05$ ) among the three categories of E. globulus plantations. The species diversity and species richness increased with the decrease in E. globulus plantation and vice versa. Sorenson similarity index showed highest similarity between C1 and C2 while C2 and C3 showed relatively weak similarity. The density of naturally regenerated woody species showed a decreasing trend with the increase in the density of E. globulus plantation and vice versa. Therefore, the density of E. globulus plantation was negatively correlated with density of naturally regenerated woody species. The study on vegetation and population structure showed that the density of tree species was high at the lower DBH class levels and there was good regeneration status. Density of naturally regenerated woody species greater than 2.5 cm DBH (cal.932.1 ha<sup>-1</sup>), height, frequency, basal area and the respective IVI values for naturally regenerated woody species were also calculated. There was no significant difference between the three categories of E. globulus plantations in their major soil nutrient contents.

**Feyera Senbeta & Demel Teketay, 2001. Regeneration of Indigenous Woody Species under the Canopies of Tree Plantations in Central Ethiopia. *Tropical Ecology*, 42(2): 175-185.**

The hypothesis that tree plantations may foster the regeneration of native woody species, was tested through studies of understory floristic composition, height-class distribution of naturally regenerated seedlings and saplings of indigenous woody species, and soil seed banks in the native and exotic tree plantations in Central Ethiopia. A total of 70 plots, having 10 x 10 m area each, were studied in six monoculture plantation stands of four exotic species, i.e. *Cupressus lusitanica* (2 stands of different age), *Eucalyptus globulus*, *Pinus patula*, *P. radiata* and *Juniperus procera*, an indigenous coniferous species. Ages of the plantations ranged between 14 and 42 years. Soil seed bank analysis was also undertaken from soil samples collected in each of the 70 plots to examine the similarity between the soil seed flora and aboveground vegetation. Vegetation diversity was assessed through analyses of floristic composition, species richness and abundance. A total of 37 naturally regenerated indigenous woody species were recorded beneath all plantation stands, with densities ranging between 1630 and 18270 individuals ha<sup>-1</sup>. There was considerable variation among plantation stands/species with respect to the density of naturally regenerated native woody species. Generally, seedling populations were the most abundant components of the regeneration in most of the plantation stands, forming 85% of the total regeneration count. A total of 68 plant species represented by 53 herbs, eight woody species and seven grasses were recorded in the soil seed bank from all stands. Similarity between the soil seed banks and aboveground flora (both seedlings and larger plants) was very low implying that the role of soil seed banks in the regeneration is low and dispersal of seeds from the adjacent natural forest plays an important role in the process. These results support the concept that forest plantations can foster the regeneration of native woody species and increase biodiversity in the plantation stands, if seed sources are available in the vicinity of the plantations.

**Feyera Senbeta, Demel Teketay & Bert-Åke Näslund, 2002. Native Woody Species Regeneration in Exotic Tree Plantations at Munessa-Shashemene Forest, Southern Ethiopia. *New Forests*, 24 (2): 131-145.**

Regeneration of native woody species was studied in the plantations and the adjacent natural forest at Munessa-Shashemene Forest Project Area, Ethiopia. The aim of the study was to test the hypothesis that tree plantations foster regeneration of native woody species. A total of 60 plots, having 10 × 10 m area each, were studied in monoculture plantations of 4 exotic species (*Cupressus lusitanica*, *Eucalyptus globulus*, *E. saligna*, *Pinus patula*) and an adjacent natural forest. Ages of the plantations ranged between 9 and 28 years. Soil seed bank analysis was also undertaken from soil samples collected in each of the 60 plots to examine the similarity between the soil seed flora and aboveground vegetation. A total of 56 naturally regenerated woody species were recorded beneath all plantation stands with densities ranging between 2300 and 18650 individuals / ha in different stands. There was a significant difference among plantation stands with regard to understorey density (standard deviation: 4836 ± 1341). Vegetation diversity was assessed through analyses of floristic composition, species richness and abundance. Generally, seedling populations were the most abundant components of the regeneration in most of the plantation stands, forming 68 % of the total regeneration count in all stands. A total of 77 plant species represented by

44 herbs, 13 woody species, 8 grasses and 12 unidentified species were recorded in the soil seed bank from all stands. Similarity between the soil seed bank and aboveground flora was very low implying that the role of soil seed banks is negligible rather dispersal plays an important role in the process of regeneration. These results support the concept that forest plantations can foster the regeneration of native woody species, thereby increasing biological diversity, provided that there are seed sources in the vicinity of the plantations

**Feyera Senbeta, Erwin Beck & Ulrich Lüttge, 2002. Exotic Trees as Nurse-Trees for the Regeneration of Natural Tropical Forests. *Trees*, 16 (4-5): 245-249**

It is a widely held view that plantations of exotic tree species in the tropics are harmful to the environment. Arguments are collected here from experience in tropical countries, showing that the canopies of exotic trees can exert protective functions and have a nurse effect for the regeneration of natural forest. This counterbalances the opinion that exotic tree plantations generally are detrimental.

**Getachew Tesfaye & Abiyot Berhanu, 2006. Regeneration of Indigenous Woody Species in the Understorey of Exotic Tree Species Plantations in Southwestern Ethiopia. *Ethiopian Journal of biological Sciences*, 5 (1): 31-43.**

Regeneration of native woody species in the understorey of exotic plantations and in the adjacent natural forest of a moist montane forest ecosystem was investigated. The objectives of the study were to assess whether exotic plantations in the moist montane forest ecosystem of Ethiopia foster regeneration of native woody species and the effect of plantation density on their regeneration. Quadrats of 10 m × 10 m size were established for the study of population structure and densities of woody species along parallel transect lines within the different plantation stands at every 100 m distance between them. For seedlings, 2 m × 2 m subplots were established within the larger 100 m<sup>2</sup> quadrats. Plant population structure and regeneration status were assessed in arbitrarily defined height classes based on frequency distribution of individuals in each height class. A total of 40 woody plant species belonging to 23 families were regenerated. The highest number of species was recorded for *Eucalyptus camaldulensis* followed by *Grevillea robusta* plantation stand. Similarly, highest density was recorded for the *Eucalyptus camaldulensis* plantation stand. The *Grevillea robusta* stand showed the highest Shannon diversity followed by the *Eucalyptus camaldulensis* plantation stand. Sorenson similarity index showed highest similarity between *Casuarina equisetifolia* and *Grevillea robusta* stands. The natural forest and the *Eucalyptus camaldulensis* plantation stands showed an inverse J-shape population structure. This implies that the population is composed of numerous individuals at the seedling stage, some individuals at the intermediate height classes and few individuals of mature trees, and hence indicates healthy regeneration. The study revealed that native woody species could successfully become established under the canopies of exotic plantations of moist montane forest ecosystem of Ethiopia, but with considerable variation in abundance and diversity of the regenerating species.

**Gordon J.E., Hawthorne W.D., Sandoval G. & Barrance A.J., 2003. Trees and Farming in the Dry Zone of Southern Honduras II: The Potential for Tree Diversity Conservation. *Agroforestry Systems*, 59: 107–117.**

The potential of the dry zone agro-ecosystem of southern Honduras to contribute to the conservation of Mesoamerican dry forest tree diversity is evaluated. Four rural communities containing eight land uses were surveyed using rapid botanical sampling resulting in the identification of 241 tree and shrub species. As a result of ordination analysis, it is concluded that the land uses are relatively similar in their species composition, particularly maize fields, *milpas*), fallows, pastures and woodlots, because of the predominance of natural regeneration. Therefore all land uses might contribute to local tree diversity conservation. Those land uses in which planting also contributes to diversity, home gardens, *solares*) and orchards, are more distinct; however the tree species found there are widespread and often exotics and thus not the usual focus of conservation measures. Across the landscape the total complement of species considered a global priority for biodiversity conservation is very low and therefore this agro-ecosystem does not represent a good place in which to implement dry forest tree diversity conservation programmes. Instead its value is likely to be in the contribution that tree diversity makes to rural livelihoods. Particular consideration is given to *Swietenia humilis* Zucc, small leaved mahogany, and its status as a threatened species is questioned because of its abundance within this landscape and its wide distribution.

**Grundy I.M., Campbell B.M., Balebereho M., Cunliffe R., Tafangenyasha C., Fergusson R. & Parry D., 1993. Availability and Use of Trees in Mutanda Resettlement Area, Zimbabwe. *Forest Ecology and Management*, 56: 243-266.**

This study quantifies current wood supply and consumption, and investigates the effect of wood use on wood supply and the current uses of wood. More than one-third of the study area was miombo woodland, supporting about 20 t ha<sup>-1</sup> of woody biomass, and 10% of the area was mopane, supporting over 60 t ha<sup>-1</sup>. The remaining area, cultivated lands and wooded grasslands, supported little woody biomass. Cultivation has been the chief source of deforestation, with dramatic reductions in overall woody cover since 1981 when the area was first resettled. Wood harvesting has a much more local effect on woodland structure, its impact being limited to within 300 m of a village. The dominant species of the woodland are used for fuel wood, but householders are more selective of species for wood for construction and other household requirements. The majority of farmers leave indigenous trees, predominantly fruit-bearing species, in cultivated lands. Tree-planting activities are directed towards exotic fruit trees. Total fuel wood consumption is estimated at nearly 7 t per household per year. The average household contains over 15 t of wood in building structures, which require approximately 2 t year<sup>-1</sup> to maintain. These are high values compared with other studies of the small-scale farming sector and reflect the abundance of the wood resource. Simple calculations of wood supply and consumption indicate that these high levels are within the sustainable yields of the remaining woodland, if legal limits to the size of arable lands are enforced. This study adds to the growing literature which indicates that the 'wood crisis' has been overstated.

**Guzman P., Gil L. & Tadesse W., 2013. Variation in Growth Traits and Survival of Landraces of *Eucalyptus globulus* Labill. in the Ethiopian Highlands. *Forest Systems*, 22(3), 401-407.**

Aim of study: *Eucalyptus globulus* Labill. is the most planted tree species in the Ethiopian highlands due to its potential to satisfy the increasing wood demand of the population. The objectives of this study are to assess the variation in growth traits and survival among *E. globulus* landraces and clones and to evaluate correlations between growth traits on saplings established in the field. The study was performed in the central highlands of Ethiopia. A landrace trial with Ethiopian seedlings and Spanish cuttings (Sancho and Tinto clones) of *E. globulus* was carried out. Root collar diameter, height and survival were evaluated on saplings one year after out planted in the field. The Spanish landrace showed an improved field performance with 35% higher root collar diameter, 35% taller saplings and 27% higher survival rates as compared to the Ethiopian plants. Sancho clone attained 10% higher root collar diameter than Tinto clone. Strong positive correlation between root collar diameter and height for all saplings was observed ( $r = 0.8785$ ). The present study can be considered as a starting point to implement a breeding program for *E. globulus*, which is nowadays of great importance in Ethiopia. The introduction of a new Spanish landrace may contribute to broadening the genetic base of this species in Ethiopia. Further tree breeding efforts with *E. globulus* should be undertaken to raise such genetic base and to increase the productivity of eucalypt plantations in the Ethiopian highlands.

**Keywords:** Clone, Rural development, Tree breeding.

**Hua-Feng Wang, María Vanessa Lencinas, Cynthia Ross Friedman, Xiao-Ke Wang & Jiang-Xiao Qiu, 2011. Understory Plant Diversity Assessment of Eucalyptus Plantations Over Three Vegetation Types in Yunnan, China. *New Forests*, 42 (1): 101-116.**

Biodiversity in managed plantations has become an important issue for long-term sustainability of ecosystems. The environmental effects of plantations comprised of fast-growing introduced trees have been vigorously debated. On one hand, monocultures have been said to exhaust resources, resulting in decreased biodiversity. Conversely, it has been stated that monocultures may favor regeneration of undergrowth plants from surrounding forests, increasing biodiversity. In order to clarify the effects of planting Eucalyptus trees on species composition, diversity, and functional type of understory vegetation in Yunnan province, a field trial was implemented to compare Eucalyptus plantations (EPs) with two other local current vegetation types (secondary evergreen forests (SEs), and abandoned farmlands (AFs)). Each vegetation type was sampled in each of three elevational ranges (low = 1,000–1,400 meters above sea level (m.a.s.l), medium = 1,400–1,800 m.a.s.l, and high = 1,800–2,200 masl). Sample sites within each elevational range had similar environmental characteristics (slope, aspect, etc.). Thus, we sampled three vegetation types at each of three sites at each of three elevations for a total of 27 plots. We calculated relative abundance and importance value of species and diversity indexes to evaluate differences among local current vegetation types and elevational ranges, employing multivariate ordination analyses and other methods such as Analyses of Variance (ANOVA) and Indicator Species Analysis. We found that fast growing introduced Eucalyptus plantations led to reduced plant diversity in the study area, and that rare or threatened species were recorded almost exclusively in the

SE plots, being essentially absent from the EP and AF plots. The understory plant diversity did not correlate with the altitude gradient significantly. Eucalyptus plantations (EPs) have a simpler community structure than that of either secondary evergreen forests (SEs; similar to natural state) or abandoned farmlands (AFs). No variable significantly explained variation of the understory shrub layer, but soil moisture-holding capacity and overstory coverage were significant in explaining variation of the understory herb layer, suggesting that the study of soil physical properties is necessary for better understanding of their importance in Eucalyptus plantations and other local current vegetation types.

**Keywords:** Understory, Eucalyptus plantation, Secondary evergreen forests, Abandoned farmland, Plant diversity, Assessment, Industry Sectors, Materials & Steel

**Jagger P. & Pender J., 2003. The Role of Trees for Sustainable Management of Less-Favored Lands: The Case of Eucalyptus in Ethiopia. Forest Policy and Economics, 5: 83–95.**

In northern Ethiopia, eucalyptus is the most commonly observed tree species in community and household woodlots. In an environment suffering from biomass and water shortages, erosion and land degradation, fast growing and resilient eucalyptus perform better than most indigenous tree species. Smallholders show a clear preference for eucalyptus poles, which are useful for farm implements and constructing dwellings and fences. In addition, the sale of eucalyptus poles and products has the potential to raise farm incomes, reduce poverty, increase food security and diversify smallholder-farming systems in less-favored areas of Tigray. Despite the potential for eucalyptus to improve rural livelihoods, in 1997 the regional government of Tigray imposed a ban on eucalyptus tree planting on farmlands. The ban was precipitated by concerns about the potential negative environmental externalities associated with eucalyptus, and the desire to reserve farmland for crop production. However, the regional government promotes the planting of eucalyptus in community woodlots, and has recently begun to allow private planting of eucalyptus on community wasteland and steep hillsides. In this paper, we review the ecological debate surrounding the planting of eucalyptus trees. In addition, the economic factors that influence smallholders to invest in tree production are considered. Ex ante benefit–cost analysis based on community and village level survey data from Tigray illustrates that planting eucalyptus yields high rates of return, well above 20% in most circumstances. The effect of variable harvest rates and the potential costs of decreased crop production, when eucalyptus trees are planted on or near farmlands are considered relative to our base case scenario. Based upon the review of the ecological and economic impacts of eucalyptus, we conclude that a policy option favoring the allocation of wastelands for private tree planting offers the greatest opportunity for rural smallholders.

**Keywords:** Afforestation; Ethiopia; Eucalyptus; Less-favored lands; Policy options; Rate of return

**Jiregna Gindaba, Andrey Rozanov & Legesse Negash, 2005. Photosynthetic Gas Exchange, Growth and Biomass Allocation of Two *Eucalyptus* and Three Indigenous Tree Species of Ethiopia Under Moisture Deficit. *Forest Ecology and Management*, 205: 127-138.**

The effects of water deficit on growth, biomass allocation and gas exchange of *Cordia africana* Lam., *Croton macrostachyus* Del., *Eucalyptus camaldulensis* Dehnh, *Eucalyptus globulus* Labill. and *Millettia ferruginea* (Hochst.) Baker seedlings were studied under glasshouse conditions for 104 days. Plants were subjected to four watering regimes, viz. control (well-watered), mild-, moderate- or severe-water-deficit conditions corresponding to 25, 50, or 75% of the control moisture level, respectively. Well-watered plants produced about 4–6 times higher biomass compared to severely water deficient plants. All species had comparable biomass production under sufficient water or mild water deficit. However, the eucalypts produced more biomass than the deciduous species under severe water deficit. *C. africana* and *C. macrostachyus* invested more biomass to root unlike the other species. Increased water supply increased biomass allocation to leaves in *M. ferruginea* and the eucalypts whereas it increased biomass allocation to roots in *C. macrostachyus*. Water deficit reduced predawn and midday leaf water potentials in all the studied species with large decline at the midday in the eucalypts. Water deficit had marked effect on leaf relative water content (RWC) in *C. macrostachyus* and *C. africana* in which severely stressed plants had greatly reduced RWC than the controls during both predawn and midday. *M. ferruginea* maintained high predawn and midday RWC under all treatment conditions. Both stomatal conductances and photosynthetic rates declined in response to increasing water stress, however, the reductions followed different patterns for the different species. Water losses from *C. macrostachyus* and *C. africana* leaves were about 2–3 times those of *E. camaldulensis* and *E. globulus* across all the treatments. Water stress reduced whole plant water use efficiencies ( $WUE_{WL}$ ) from  $5 \pm 0.9$  to  $2 \pm 0.6$  g dry mass  $kg^{-1}$  water depending on the species.  $WUE_{WL}$  of *C. africana* and *C. macrostachyus* were lower compared to the other species in all treatments. *M. ferruginea* showed superior water stress avoidance as evidenced by its high tissue water potential, RWC and photosynthetic rate under severe water deficit

**Keywords:** Relative water content, Stomatal conductance, Transpiration, Water potential, Water use efficiency

**Leakemariam Berhe, 2009. Volume and Implicit Taper Functions For *Cupressus Lusitanica* and *Pinus Patula* Tree Plantations in Ethiopia. *Ethiopian Journal of Environmental Studies and Management*, 2:12-28.**

Data from *Cupressus lusitanica* and *Pinus patula* were used to develop total and exponential form merchantable volume models, and implicit taper functions. The exponential form merchantable volume model to a specified top diameter limit showed marked improvement compared with the unbounded non exponential form merchantable volume model of Burkhart (1977). Implicit taper functions derived from the exponential form merchantable volume models were found superior to taper functions obtained from the non-exponential merchantable volume models. In general, these models are essential management tools for the plantation of the species and in particular provide stock volume estimates by end use type.



**Keywords:** *C. lusitanica*, Merchantable volume models, Taper functions, Total tree volumemodels, *P. patula*.

**Mehari A. Tesfaye, Andrés Bravo-Oviedo, Felipe Bravo, Berhane Kidane, Kassahun Bekele & Demissew Sertse, 2014. Selection of Tree Species and Soil Management for Simultaneous Fuelwood Production and Soil Rehabilitation in the Ethiopian Central Highlands. Land Degradation & Development. DOI: 10.1002/ldr.2268.**

In the Ethiopian Central Highlands, a serious soil degradation occurs while fuelwood demand is high. This study consists of an evaluation of seven tree species for fuelwood and soil restoration under three soil management options: control, manure and manure + mulch, in degraded highlands of Ethiopia. The experimental design was a split-plot, species as the main plot and treatment as subplot, with three replicates. Survival count, height and root collar diameter growth measurements were measured annually until 48 months. Biomass production for fuelwood was inferred at the end of the experiment. Before and after the experiment, soil parameters (pH, organic carbon, N, P, K and cation exchange capacity) were measured to test changes in soil condition because of species plantation. A mixed model and repeated analysis of variance was performed. *Grevillea robusta* A. Cunn. ex R. Br. showed maximum survival (100%), followed by *H. abyssinica* (Bruce) J.F.Gmel. (93.52%); while the lowest survival rate was recorded for *A. decurrens* Willd. (57.41%). *Hagenia abyssinica* (Bruce) J.F.Gmel. and *Chamaecytisus palmensis* (Christ.) Hutch showed the lowest growth rates but both species showed the highest soil condition improvement. *E. globulus* Labill. and Acacia species presented the highest growth rates and biomass although Eucalyptus depleted soil nitrogen. *Hagenia abyssinica* (Bruce) J. F.Gmel. is recommended for soil rehabilitation, whereas *Grevillea robusta* A. Cunn. ex R. Br. can be used for simultaneous fuel wood production and soil rehabilitation. An ecological based study on *E. globulus*' Labill. effects in Central Highlands is recommended before recommendation for large scale fuel wood plantations.

**Mulugeta Lemenih, 2006. Expediting Ecological Restoration with the Help of Foster Tree Plantations in Ethiopia. Journal of the Drylands, 1(1): 72-84.**

The biophysical degradation of land and its formidable impediment to sustainable rural and economic development in Ethiopia has been discussed for several decades. What is required is to develop and implement scientific solutions to the problem. Obviously, in a country like Ethiopia, where vast degraded ecosystems and a rapidly growing human population occur, and where still all livelihood and economic development emerge from agriculture and biological resources, the restoration of the productive capacity of the degraded ecosystems will have a valid and crucial role to bring about sustainable development. A key question, however, is how to successfully and quickly restore the degraded landscapes in the country. An ecological management tool that is receiving considerable attention in recent years for enhancing ecological restoration in the tropics is the use of tree plantations as foster ecosystem. Reforestation of heavily degraded lands with fast growing tree species has been shown to expedite the recovery of soil fertility as well as the rehabilitation of a diverse native flora and fauna faster than sites that are left bare or unplanted. In this paper information is collected by reviewing primary literature. Ample evidence is presented from wide geographical areas, both from outside and from inside Ethiopia, to substantiate this

potential of tree plantations. It is also known that several factors related to the design and management of plantation forests affect their usefulness in restoration ecology. These issues that require special attention in using tree plantations in restoration ecology are discussed in detail. The paper concludes that, supported with sound silvicultural management, tree plantations can be employed as one effective method capable of reversing soil, biomass and biodiversity degradation, while providing diverse socio-economic services.

**Keywords:** Biodiversity, Soil restoration, Vegetation restoration, Exotic species, Indigenous species

**Mulugeta Lemenih, Taye Gidyelwa & Demel Teketay, 2004. Effects of Canopy Cover and Understory Environment of Tree Plantations on Richness, Density and Size of Colonizing Woody Species in Southern Ethiopia. *Forest Ecology and Management*, 194 (1-3):1-10.**

To assess the effects of canopy characteristics and associated understory environmental factors of tree plantations on native woody species colonization, we measured canopy closure percent (CCP), leaf area index (LAI), understory air and soil temperatures as well as soil moisture in two broadleaved and two coniferous plantations in southern Ethiopia. The plantation species were *Cordia africana* (indigenous and broadleaved), *Eucalyptus saligna* (exotic and broadleaved), *Cupressus lusitanica* (exotic and coniferous) and *Pinus patula* (exotic and coniferous). The broadleaved species had significantly lower CCP ( $P < 0.001$ ), LAI ( $P < 0.001$ ), higher understory air temperature ( $P < 0.001$ ), soil temperature ( $P < 0.001$ ) as well as higher diurnal temperature fluctuations than the conifers. These characteristics were accompanied with significantly higher species richness ( $P < 0.05$ ) and density ( $P < 0.01$ ) of colonizing woody species (CWS) under the broadleaved species than the conifers. *Cupressus lusitanica*, the species with the densest canopy (CCP  $\frac{1}{4}$  2%), had the lowest significant understory air and soil temperatures, species richness and density of CWS. On the other hand, *Pinus patula*, a relatively open canopy conifer, had intermediate CCP, LAI, air and soil temperatures between the broadleaved species and *Cupressus lusitanica*, but had comparable species richness, density, DBH and heights of CWS with those of the broadleaved species. These results suggest a relationship between plantation canopy characteristics and richness, density and sizes of woody species colonizing under the plantation canopies. Accordingly, we propose that stands of plantation species with open canopies could enhance more native woody recolonization than stands of plantation species with dense canopies at the study site.

**Mulugeta Lemenih & Demel Teketay, 2005. Effect of Prior Land Use on the Recolonization of Native Woody Species Under Plantation Forests in the Highlands of Ethiopia. *Forest Ecology and Management*, 218 (1-3): 60-73.**

Effect of prior land use on the recolonization of native woody species in plantation forests was investigated by assessing naturally regenerating flora (NRF) and soil seed banks (SSB) in plantation forests established on abandoned farmland and cleared natural forest sites in southern highlands of Ethiopia. *Eucalyptus saligna* and *Cupressus lusitanica*, two of the most widely planted tree species in the highlands of Ethiopia, were considered in the plantation treatments. About 66 plant species were recorded in the NRF and 55 plant species

germinated from the soil samples collected for SSB analysis. Seedlings from the SSB were dominantly herbs, which accounted for 75% of the identified species germinated from the SSB, and native woody species accounted only for 10%. On the contrary, in the NRF native woody species were slightly more dominant (49%) than the herbs (45%). There was high species similarity between the NRF beneath the plantations and the standing vegetation in the adjacent natural forest. On the contrary there was very low similarity between the seedlings emerged from the SSB and the standing vegetation in the adjacent natural forest. Effect of prior land use was apparently stronger on the species composition of the SSB than the species richness of NRF under the plantations. The results also showed that overstorey plantation species had stronger influence on the species richness of NRF rather than the pre-plantation land use history. As the SSB of the plantation sites lacked viable seed reserves for most of the naturally regenerating woody plants recorded underneath the plantations of both sites, it was assumed that seed dispersal from the adjacent natural forest has played major role in the recolonization process. From these results it could be shown that establishment of plantation forests either on abandoned farmland or directly on degraded natural forest sites can create comparable enabling environment for the recovery of the native forest flora, even if SSB are devoid of viable seeds of woody species, provided that there is a natural forest in the vicinity to donate seeds.

**Keywords:** Biodiversity, *Cupressus lusitanica*, *Eucalyptus saligna*, Natural regeneration, Restoration, Seed dispersal, Soil seed bank, Repeated cultivation

**Mulugeta Lemenih & Demel Teketay, 2004. Restoration of Native Forest Flora in the Degraded Highlands of Ethiopia: Constraints and Opportunities. *SINET: Ethiopian Journal of Science*, 27 (1):75-90.**

Wide spread deforestation and subsequent degradation is severely threatening the natural forest resources in Ethiopia. What is imperatively and urgently needed today is ecological restoration. In order for ecological restoration to be successful and cost effective, critical analyses of possible constraints and available opportunities are crucial. Such Knowledge increases our understandings of ecosystem responses and a more reasonable prediction of where and why restoration efforts will be difficult or possible. These understandings will also improve the decision-support systems for the kind of restoration strategies or tools to apply and what kind of management techniques to follow. Available literature indicated that scarcity or complete absence of viable soil seed banks under natural environments and in environments affected by humans, such as abandoned farmlands, poor seed rain/dispersal and site impoverishment would be severe limitations to ecological restoration in the country. On the other hand, land abandonment due to marginalization followed by the establishment of plantation forests as foster crops are opportunities that could be utilized for rapid and productive restoration of the vast degraded ecosystems in the country. Nevertheless, successful utilities of these management options certainly demand conservation of the remnant natural forests to serve as propagule donors. Hence, conservation of the scattered remnant forests in the country is the major prerequisite for successful future restoration ventures.

**Keywords:** Land degradation, Seedling bank, Seed rain, Soil seed bank, Tree plantations

**Pohjonen V. & Pukkala T., 1990. *Eucalyptus globulus* in Ethiopian Forestry. *Forest Ecology and Management*, 36: 19-31.**

*Eucalyptus globulus* Labill. has been planted as the main tree species in the central highlands of Ethiopia since 1895. The success of the 100 000 ha planted so far is based on the adaptability of *E. globulus* to the highland climate and soil conditions, its vigorous coppicing and non-palatability for livestock, and its suitability for fuel and small construction poles. The mean annual growth of *E. globulus* in fuelwood plantations varies between 10 and 30 m<sup>3</sup> / ha/year. Other equally productive fuelwood species have not been identified for the Ethiopian highlands. Despite alleged ecological demerits, like high consumption of water, additional planting of *E. globulus* is justified until the current fuelwood shortage is eliminated. In the long run, parts of Ethiopian *Eucalyptus* plantations may naturally alter in composition into stands of indigenous highland species, e.g. *Juniperus procera*, *Podocarpus gracilior* and *Olea africana*.

**Shiferaw Alem & Jindrich Pavlis, 2012. Native Woody Plants Diversity and Density under *Eucalyptus camaldulensis* Plantation, in Gibie Valley, South Western Ethiopia. *Open Journal of Forestry*,2(4): 232-239.**

The aim of the study was to assess the impact of *E. camaldulensis* plantation established in a semi-arid area on native woody plants diversity and density. Nested quadrant plot design, having an area of 15 m × 15 m used to collect data. Totally, 37 species at the plantation and 30 species at the native woodland, belonging to 24 families, identified. Species diversity (*H'*) was 1.57 at the plantation and 2.09 at the woodland forest. As for density of understory woody plants (height ≥ 1 m) the plantation forest harbored 6, 604 stems/ha while the native woodland had 7347 stems/ha. Seedling density (height < 1 m) at the native woodland and at the plantation there were 11,436 stems/ha and 8865 stems/ha, respectively. The similarity of woody species composition between the woodland forest and the plantation was low. However, in terms of autochthonous tree seed bank availability, authentic hypothesis seems to prove that if clear-cut patches replanted by introduced species that do not exceed 5 ha, they still significantly favour original forest regeneration and composition in a semi-arid area and surprisingly favors the regeneration of *Do-donaea angustifolia* and other native species important for soil conservation, timber, bee forage and medicinal use.

**Keywords:** *Eucalyptus camaldulensis*; Plantation; Diversity; Natural Regeneration; Semi-Arid; Woodland

**Shiferaw Alem & Tadesse Woldemariam, 2009. A Comparative Assessment on Regeneration Status of Indigenous Woody Plants in *Eucalyptus grandis* Plantation and Adjacent Natural Forest. *Journal of Forestry Research*, 20: 31-36.**

Diversity, density and species composition of naturally regenerated woody plants under *Eucalyptus grandis* plantation and the adjacent natural forest were investigated and compared. Twenty plots, with an area of 20 m × 20 m for each, were established in both of *E. grandis* plantation and adjacent natural forest, independently. In each plot, species name, abundance, diameter and height were recorded. Numbers of seedling were collected in five sub-plots (4 m<sup>2</sup>) within each major plot. A total of 46 species in the plantation, and 52 species in the natural forest, which belongs to 36 families were recorded. The diversity of

species ( $H'$ ) is 2.19 in the plantation and 2.74 in the natural forest. The density of understory woody plant was 3842 stems/ha in the plantation and 4122 stems/ha in the natural forest. The densities of seedlings in the natural forest and the plantation were 8101 stems/ha and 4151 stems/ha, respectively. High similarity of woody species composition was found between the natural forest and the plantation. The *E. grandis* plantation was found favoring the regeneration and growth of *Millitia ferruginia* and *Coffea arabica* in a much better way than other underneath woody species.

**Shiferaw Alem, Jindrich Pavlis, Josef Urban & Jiri Kucera, 2015. Pure and Mixed Plantations of *Eucalyptus camaldulensis* and *Cupressus lusitanica*: Their Growth Interactions and Effect on Diversity and Density of Undergrowth Woody Plants in Relation to Light. *Open Journal of Forestry*, 5: 375-386.**

Published results on the growth interactions of non-nitrogen fixing mixed plantations species, and their impact on the regeneration of woody plants are scant. This paper addresses the growth interactions of pure and mixed plantations of *Eucalyptus camaldulensis* and *Cupressus lusitanica* and their impact on the regeneration of woody plants in relation with light. Data on the regenerated woody plants, individual characteristics of the plantation species and light reaching under the canopies were collected using sample plots ( $n = 4$ ) with a size of 20 m  $\times$  20 m for each plantation type. The result showed that, *E. camaldulensis* was suppressing the growth of *C. lusitanica* while its growth was favored when it was mixed with *C. lusitanica* ( $p < 0.05$ ). There were no significant differences between the pure and mixed plantations in their diversity and density of undergrowth woody plants ( $p > 0.05$ ). Density of plantation trees were found not having a significant relationship with diversity of species ( $p = 0.801$ ). There was a significant but not direct relationship between light reached in the understory of the canopies and diversity of species in the plantations ( $p = 0.027$ ). Overall, the result indicated that both the pure and the mixed plantations were favoring the recruitment of woody plants.

**Keywords:** Diversity, Growth, Light, Mixed Plantation, Pure Plantation, Woody Plants

**Tougiani A., Guero C. & Rinaudo T., 2009. Community Mobilisation for Improved Livelihoods through Tree Crop Management in Niger. *Geo Journal*, 74:377–389.**

Effective natural resource management requires interrelated technical practices and social arrangements that are appropriate to a region's biophysical characteristics and that address protection and sustainable management of resources. This is illustrated from our experience in the Republic of Niger, West Africa. In 1980 barren plains, infertile soils, drought, dust storms, severe fodder shortages, and agricultural pest outbreaks were normal occurrences in Niger's rural regions. In general, despite large investments of time and funding, conventional reforestation efforts had little impact. However by 2008 over five million hectares of once barren land had been transformed through wide adoption of an agroforestry method known as 'Farmer Managed Natural Regeneration' (FMNR), introduced in 1983. In the Aguié Department, the practice of FMNR was formalized through the Desert Community Initiative (DCI), addressing interrelated technical and social issues in resource management. New governance structures, which include marginalized groups, implement monitoring and enforcement systems enabling communities to manage land and

regenerating trees. These, together with technical solutions that build on local knowledge and skills and use previously undervalued indigenous tree species, have generated a sustainable fuel-wood market for the first time. Increased linkage and compatibility between institutions at local and national levels and strengthened social capital have been crucial to these impacts. Food security and community resilience to drought have been markedly enhanced and local incomes have increased. The experience provides important lessons for approaches to addressing environmental degradation and poverty in other semi-arid areas and facilitating the spread and adoption of new agroforestry systems.

**Scott D.F & Lesch W., 1997. Stream Flow Responses to Afforestation with *Eucalyptus grandis* and *Pinus patula* and to Felling in the Mokobulaan Experimental Catchments, South Africa. *Journal of Hydrology*, 199 (1997): 360-377.**

The reductions in stream flow following the afforestation of grassland with *Eucalyptus grandis* and *Pinus patula* in the Mokobulaan research catchments on the Mpumalanga escarpment, and the subsequent response in stream flow to clear-felling of the eucalypts are presented. Afforestation with eucalypts of an entire catchment with a virgin annual runoff of 236 mm, caused a statistically significant decrease in stream flow in the third year after planting and the stream dried up completely in the ninth year after planting. The eucalypts were clear felled when 16 years old but full perennial stream flow did not return until five years later. Afforestation with pines of an entire catchment with a virgin annual runoff of 217 mm, produced a significant decrease in stream flow in the fourth year after planting and caused the stream to dry up completely in the twelfth year after planting. The drying up of the streams was not altogether surprising as the annual runoff was lower than the expected reductions owing to complete afforestation. The delayed return of stream flow in the clear felled catchment is surprising though, and is attributed to the desiccation of deep, soil-water stores by the eucalypts. These stores had to be replenished before the streams could return to normal behaviour.

**Siyanbola W.O., Adesina F. A., Pellemo D. A., Oketola F. O., Ojo L. O. & Adegbulugbe A. O., 2002. Towards Global Climate Change Mitigation: Assessment of an Afforestation Option for Nigeria. *The Environmentalist*, 22: 83–92.**

This paper assesses the potential of an intensive afforestation program as a measure of reducing the atmospheric concentration of carbon in Nigeria. The results presented are based on the recently completed Nigerian Country Studies Program on Climate Change Mitigation. A comprehensive mitigation analysis process (COMAP) model was employed to carry out detailed cost/benefit evaluation of the mitigation option. The end-use based scenario adopted was considered the most appropriate strategy to sustainably implement the mitigation option in Nigeria. The analyses showed that the country could significantly reduce net carbon emission while at the same time meet all her essential domestic wood needs, if approximately  $7.5 \times 10^6$  ha of wasteland could be committed to an afforestation program over the 40 year period of projection. The initial cost of establishing such forest plantations, taking cognisance of the opportunity cost of land averaged at about US\$500/ha, or in carbon terms, a unit cost of about \$13 per tonne of carbon. In terms of carbon flow, if all the end-product based plantations considered (*i.e.* fuelwood, poles, pulpwood, sawlogs and veneer) were fully established and maintained, it was estimated that by the year 2030,

the total carbon stored in the afforested land would be about  $638_0 \times 10^6$  t of carbon with an annual incremental rate of  $16_0 \times 10^6$  t of carbon. Other economic indicators (*i.e.* net present value of benefits, present value of costs and benefit for reduced atmospheric carbon) when evaluated showed that the afforestation option could be economically viable even when the investment capital was discounted at rates ranging from 9 to 33 percent for different wood products. It should be noted, however that implementation of such a program would require huge sums of money and a high degree of commitment on the part of Federal, State and Local governments if the associated financial, social and environmental benefits were to be derived.

**Tesfaye Hunde, Dawit Mamushet, Dagne Duguma, Belachew Gizachew & Demel Teketay, 2002. Growth and form of Provenances of *Eucalyptus saligna* at Wondo Genet, southern Ethiopia. *Australian Forestry*, 66: 213–216.**

A trial testing 10 provenances from across the natural range of *Eucalyptus saligna* and a local land race was established at Wondo Genet, southern Ethiopia. Eight years after planting, survival, tree height, diameter at breast height over bark, stem form, number of forks, height to the first fork, number of branches, branch diameter and branch angle were assessed. Volume per hectare was also calculated. Survival ranged between 36% (a provenance from 87 km north of Windsor, NSW) and 79% (Consuelo Tableland, Queensland), and differences were significant ( $P < 0.05$ ). Among morphological characteristics, only the number of branches showed significant variation ( $P < 0.05$ ), with the greatest number (12.4) being recorded for the Bulahdelah, NSW, provenance and the least (8.5) for the Clyde River, NSW, provenance. Major growth and morphological parameters (tree height, diameter, volume and stem form) did not differ significantly. The overall volume production (mean annual increment  $26.4 \text{ m}^3\text{ha}^{-1}$ ) was well above the minimum acceptable growth observed on good sites elsewhere. Differences between provenances were small and mostly not significant, and no pattern of geographic variation was detected. Given the acceptable mean annual increment, those provenances represented by an adequate number of parent trees could be maintained for further selection and breeding, and to maintain genetic diversity of the species in Ethiopia.

**Keywords:** Provenance trials; Growth; Stem form; Habit; *Eucalyptus saligna*; Ethiopia

**Thacher T., Lee D.R. & Schelhas J.W., 1997. Farmer Participation in Reforestation Incentive Programs in Costa Rica. *Agro forestry Systems*, 35: 269-289.**

Reforestation programs are a common policy response among developing country governments in the tropics attempting to deal with environmental and economic problems caused by widespread deforestation. The objective of this paper is to examine participation by small and medium-sized farms in two reforestation programs undertaken in recent years by one country, Costa Rica, which has been at the forefront of developing country environmental protection efforts. Analysis of a survey of 243 program participants and non-participants shows that farm households participating in reforestation programs had generally larger farm sizes, were dedicated to low labor-intensive, land-extensive agricultural activities, faced significant family on-farm labor constraints, were more heavily dependent on off-farm income sources, and had more extensive contact with local extension efforts.

Logistic regression is employed to econometrically identify demographic, economic, and land use determinants of farm household participation in reforestation programs; the implications of these findings are analyzed. The limitations of reforestation programs, especially with regard to management factors and quality of reforested plots, are reviewed. Implications for improving the efficiency of reforestation programs and the merits of other policy alternatives are also discussed.

**Torres A.B., Marchant R., Lovett J.C., Smart J.C.R. & Tipper R., 2010. Analysis of the Carbon Sequestration Costs of Afforestation and Reforestation/Agroforestry Practices and the Use of Cost Curves to Evaluate Their Potential for Implementation of Climate Change Mitigation. *Ecological Economics*, 69: 469–477.**

Carbon sequestration in forest sinks is an important strategy to remove greenhouse gases and to mitigate climate change; however its implementation has been limited under the Clean Development Mechanism of the Kyoto Protocol which has not created the incentives for widespread implementation. The objective of this paper is to analyze the sequestration costs of agroforestry afforestation and reforestation projects (ARPs) following a partial market equilibrium using average cost curves and economic break even analysis to identify the supply costs. The modelling done in this work contrasts the voluntary and clean development mechanism transaction costs. Data is based on the voluntary project, Scolel Té, being implemented in Mexico. Cost curves are developed for seven different sequestration options considering transaction and implementation costs; information from agricultural production in Chiapas Mexico is used to integrate opportunity costs of two agroforestry practices suggesting that sequestration costs may follow a “U” shape, with an initial reduction due to economies of scale and a subsequent increase caused by high opportunity costs. The widespread implementation of agroforestry options not requiring complete land conversion (e.g. living fences and coffee under shade) might be cost effective strategies not generating high opportunity costs. Results also suggest that payments in the early years of the project and lower transaction costs favour the development of ARPs in the voluntary market especially in marginal rural areas with high discount rates.

**Torres-Lezama A., Vilanova A. & Ramórez-Angulo A., 2009. Guiding Principles for Small-Scale Forestry in a Watershed of the Venezuelan Andes: Constraints and Opportunities. *Small-scale Forestry*, 8:77–93**

In the Venezuelan Andes, some small-scale forest plantations have become an important resource basis for forest management. In this paper, the forestry management progress in the Mucuju’n river watershed is analyzed. Constraints and opportunities for sustainable management within national policies, local regulations, environmental features and social benefits are also examined. Plantation assessment, and biophysical, legal and socioeconomic information, are used for guiding small-scale forestry practices in this watershed, with emphasis on the main principles of landscape management. These plantations have become an important part of the socio-ecological landscapes with potential for wood production—in the context of low intensity and low environmental impact environmental services and amenity—because of the two protected areas within the watershed. Current forest stand conditions, however, reflect that management requires



improvement. Furthermore, the analysis suggests that improvement of local livelihoods may be achieved with a small-scale forestry approach, taking properly into account the basic criteria of social involvement and management of planted forests, while maintaining ecosystem services including biodiversity and water supply.

**Tirhas Mebrahtu, 2009. Understanding Local Forest Management Institutions and Their Role in Conserving Woody Species Biodiversity: A Case Study of Alamata Woreda, Southern Tigray, Northern Ethiopia: M.Sc. Thesis. Mekele University, Mekele.**

Even though many communities in Tigray have developed their own institutions and methods of environmental management that enjoy great local legitimacy, the interventions by government and numerous projects in the name of development and environmental protection have generally failed to recognize this. Hence, a study on understanding the local forest management institutions and their role in conserving biodiversity of woody plants were carried out in Alamata woreda, southern zone of Tigray Region, Northern Ethiopia. This study attempted to compare vegetation composition of three communal forests with adjacent free grazing lands. Investigation of vegetation parameters was undertaken from 84 plots with size of 20m x 20m laid systematically along transect lines. Data from group discussion and 120 household surveys was also collected in order to understand their institutional arrangements and the perception of the local community towards communal forests. A total of 30 species of woody plants of trees were recorded in the three communal forests and six in the three free grazing lands. Comparing the diversity of woody species of trees, all the 3 communal forests are significantly different ( $P < 0.01$ ) from the free grazing lands. The local forest management institutions in the three study sites had clear boundary of forests, defined users, use rules, monitoring procedures, sanctions and conflict-resolution mechanisms among users. Ninety five of the respondents prefer the communal forests to continue under the control of the local people. All of the informants are happy about the way local institutions manage the communal forests. In addition, all agree with the rules and penalties. The Pearson chi-square test reveals that the educational level, age, sex, wealth, oxen possession and occupation of the respondents and their attitude and VI perception towards the communal forests are not significant at  $p < 0.05$ . However, the survey proved that there is difference among the female household heads and male household heads in their participation in the meetings of the forest management.

**Turbull J.H., 1999. Eucalypt plantations. *New Forests*, 17: 37–52.**

This paper reviews the historical development of the use of the eucalypt over 200 years, from its curiosity status in the botanical gardens of Europe to its extensive use as a fuelwood for the wood-burning locomotives of the national railway systems, and then to its more recent use as a major source of biomass for paper pulp, fiberboard, industrial charcoal, and fuelwood. Ecological and biological aspects of the genus *Eucalyptus* have made it successful as an exotic in industrial monocultures and as a multipurpose tree of benefit to small landholders. Social, policy, and economic aspects of growing *Eucalyptus* are examined, as are prospects for using the eucalypt in the twenty-first century as an industrial plantation tree and as a component of farming systems in the rural landscape.

**Urgessa K., 2003. Perceptions of Forest Cover and Tree Planting and Ownership in Jimma Zone, Ethiopia. *Unasyiva*, 54 (213): 18-22.**

A study was conducted in six districts of the Jimma Zone of southwestern Ethiopia during 1991-95 to identify the people's awareness of changes in forest cover and attitudes towards tree planting and ownership. The results revealed that a significantly large proportion of the respondents perceived the forest cover in these areas as rapidly declining, mainly as a result of the shifting cultivation widely practiced. The farmers were found to be very interested in tree planting and were in favour of private ownership of trees and forests, and gave less care and attention to previously planted communal trees or woodlots.

**van Wyk G, Pepler D., Kindeya Gebrehiwot, Aerts R. & Muys B., 2006. The Potential and Risks of Using Exotics for the Rehabilitation of Ethiopian Dryland Forests. *Journal of the Drylands*, 1(2):148-157.**

Climax tree species normally would fulfill the ultimate function at the end of the succession chain when land is rehabilitated. In the natural forest such trees would eventually be the veterans of the primary forest that usually replace pioneer trees of the secondary forests. Exotic trees, when used for plantations, usually fill the role of pioneers because they capture a degraded site easily. Such capturing of the site would depend on the site conditions as well as the adaptation of the species being used. Once the species grow well, it may be a deliberate decision not to replace such pioneers with climax forest species, the reason being the useful role that exotic species could play in the economy of the region concerned. However, there also may be risks involved in using exotic species in such an interrupted succession chain. Case studies from South Africa are discussed to, firstly, illustrate the potential of exotics, especially eucalypts, in providing much needed timber while also protecting the natural forest. These species, when genetically improved, can reach yields of more than 20 m<sup>3</sup>ha<sup>-1</sup>year<sup>-1</sup>, even under relatively dry conditions. Secondly, the risk of using exotics, such as eucalypts and Australian *Acacias*, e.g. in terms of water use, uncontrolled spread and destruction of local biodiversity, is discussed and examples are given of management procedures to manage the risks. Finally, some suggestions are proposed on strategies to be followed for the use of exotics in the Ethiopian highlands, especially on the questions how much, where and how to use them. It is pointed out that, with sufficient control, including spatial planning, policy and legislation, exotic species could play an important role in filling economic and social demands that need not be in conflict with environmental objectives.

**Keywords:** Invasive species, Biodiversity, Risk assessment, Replacement forest, Landscape planning.

**Walsh P. G., Barton C. V. M., Montagu K. D., 2003. Macquarie Catchment Pilot Project, New South Wales, Australia: A Cost-Effective, Market-Based Approach To Reducing Salinity Through Tree Planting. *Unasyiva*, 54 (212): 37-39.**

This paper describes the Macquarie catchment pilot project established in New South Wales, Australia to halt dryland salinity and secure irrigation-quality water. In line with this pilot project, an irrigators' group at the Macquarie valley has offered a financial incentive to State Forests of New South Wales to establish forests on private land in critical recharge areas in the upper reaches of the Macquarie river catchment.

**Zegeye H., 2010. Environmental and socio-economic implications of Eucalyptus in Ethiopia. In: Gil, L., Wubalem Tadesse, Tolosana, E. and López, R. (Eds.), Proceedings of the Conference on Eucalyptus Species Management, History, Status and Trends in Ethiopia, pp. 184-205. Ethiopian Institute of Agricultural Research, Addis Ababa.**

*Eucalyptus* is one of the exotic tree species in Ethiopia. It has been once associated with the Ethiopian environment and economy. It is one of the most successful trees; it adapts to a variety of environments. *Eucalyptus* is often considered to have undesirable ecological qualities such as depletion of soil water and nutrients, aggressive competition for resources with native flora, unsuitability for erosion control, production of allelopathic chemicals that suppress the growth of other plants and provision of inadequate food and habitat for wildlife. On the other hand, *Eucalyptus* provides multiple environmental and socio-economic benefits. It is useful for provision of wood and other products thereby reducing the pressure on the natural forests, conservation of soil and water, rehabilitation of degraded lands, fostering the regeneration of native woody species, provision of food and habitat for wildlife, drainage of swampy areas, mitigation of climate change and provision of amenity. The benefits of *Eucalyptus* are far greater than the negative impacts. The negative impacts are mainly because of the poor management rather than its biological characteristics. *Eucalyptus* has been found to be efficient water user. In fact, it is fast growing and thereby consumes more nutrients from the soil. Applying appropriate silviculture and management on *Eucalyptus* planting will enhance the utilization of this important tree for maintaining and/or restoring the environment and solving socio-economic problems in Ethiopia and elsewhere. It appears that there are no profound reasons not to continue *Eucalyptus* planting in Ethiopia.

**Zhang D. & Owiredu E.A., 2007. Land tenure, Market, And The Establishment Of Forest Plantations In Ghana. *Forest Policy and Economics*, 9: 602– 610.**

This paper presents an empirical study on the relationship among land tenure, market incentives, and forest plantation establishment in Ghana based on a two stage selectivity model. Our results show that the total amount of land owned and/or cultivated by farmers, amount of land owned by farmers outright, and use of government extension services by the farmers have a significant positive influence on plantation establishment. In addition, lands owned outright by farmers and the prices of plantation products have a significant positive effect on silvicultural investment in plantation. These results demonstrate the potential for land market reforms and market incentives in enhancing forest plantation establishment.

**Zhang Y., Liao X., Butler B.J. & Schelhas B. J., 2009. The Increasing Importance of Small-Scale Forestry: Evidence from Family Forest Ownership Patterns in the United States. *Small-scale Forestry*, 8:1–14.**

The state-level distribution of the size of family forest holdings in the contiguous United States was examined using data collected by the USDA Forest Service in 1993 and 2003. Regressions models were used to analyze the factors influencing the mean size and structural variation among states and between the two periods. Population density, percent of the population at least 65 years of age, percent of the population residing in urban areas, per capita income, income inequality, and per capita private forestland were found to be significantly correlated with the structure of landholding size. This paper suggests that the

number and proportion of small-scale family forest owners in the United States are both increasing due to the increasing importance of non-timber amenities to forest landowners.

**Zubair M. & Garforth C., 2006. Farm Level Tree Planting in Pakistan: The Role of Farmers' Perceptions and Attitudes. *Agroforestry Systems*, 66:217–229.**

The low proportion of forested land and continuing degradation of existing forest cover are serious threats to the sustainability of forestry in Pakistan. Farm forestry has been identified as a feasible solution, particularly in the plain areas. Applying the Theory of Planned Behaviour in a survey of 124 farmers in Dera Ismail Khan district of Pakistan's North West Frontier Province showed that farmers' willingness to grow trees on their farms is a function of their attitudes towards the advantages and disadvantages of growing trees, their perception of the opinions of salient referents and factors that encourage and discourage farm level tree planting. Farmers viewed farm forestry as economically beneficial and environmentally friendly. Tree planting was perceived as increasing income, providing wood for fuel and furniture, controlling erosion and pollution and providing shade for humans and animals. Farmers saw hindrance in agricultural operations and the harbouring of insects, pests and diseases as negative impacts of tree planting; however, these were outweighed by their perceptions of positive impacts. Tree growing decisions of farmers were influenced by the opinions of family members, owners/tenants, fellow farmers and village elders. The factors that significantly predicted farm level tree planting were availability of barren land, lack of markets, lack of nurseries and damage caused by animals and humans. Farm forestry programmes are more likely to be successful if they acknowledge and address the factors which underlie farmers' reasons for planting or not planting trees.

### 5.3. Silvicultural Management, Disease and Pest in Plantations

**Arnold M. & Dewees P., 1998. Rethinking Approaches to Tree Management by Farmers. *ODI Natural Resources Perspective*. No. 25.**

This paper examines farm households' tree management strategies and proposes a framework for policy interventions. Farmers plant or retain some trees on their land nearly everywhere. Historically this component of on-farm resources has attracted little interest but practical policy measures can be identified, and differ substantially from those relevant to forestry.

**Amacher G S, Ersado L. Hyde W. F., Osorio A., 2004. Tree Planting in Tigray, Ethiopia: The Importance of Human Disease and Water Microdams. *Agroforestry Systems*, 60 (3): 211-225.**

We examine the decision to plant trees and level of tree planting for two sites, public microdam areas and household agricultural land, and two species groups in Tigray, Ethiopia. Both sites are not perfect substitutes, as they vary with respect to distance from the household and tenure security. The role of permanent pooled water irrigation microdams to tree planting is important but unknown, because water borne diseases, which may influence household income and productivity, are thought to be enhanced by the dams. We find both disease and microdams to be important predictors to tree planting. Disease seems

more important in determining whether households plant at all, and less important in the level of planting for those that do plant. For example, disease increases the probability of planting both eucalyptus and other species groups on household-own land, but households suffering from malaria plant higher-cost eucalyptus trees with lower probability at both sites, while planting of other lower-cost species increases at dam sites where other villagers can monitor the trees. We also establish a connection between planting and agricultural residues, finding a strong substitution effect on own-land. Microdam access and age are also important. Households living nearer to dam sites will plant both species groups there with higher probabilities, but the decision to plant on agricultural own-land is not affected. For older dams with more developed irrigation, households are more likely to grow crops rather than plant trees on their own land, but they plant more trees at the dam sites.

**Alemu Gezahgne, Roux J., Slippers B. & Wingfield M.J., 2004. Identification of the Causal Agent of Botryosphaeria Stem Canker in Ethiopian Eucalyptus Plantations. *South African Journal of Botany*, 70(2):241–248.**

Plantations of exotic *Eucalyptus* make up more than 30% of Ethiopia's plantations, providing fuel and construction timber to the country. Species such as *E. camaldulensis*, *E. saligna*, *E. grandis*, *E. citriodora* and *E. globulus* are most commonly planted. During a survey of *Eucalyptus* diseases in 2000 and 2001, *Botryosphaeria* stem canker was observed in most plantations. The disease symptoms included tip die-back, coppice failure and stem cankers characterised by kino exudation. The aim of this study was to identify the species responsible for *Botryosphaeria* stem canker in Ethiopia. Culture and conidial morphology, as well as DNA-based identification involving restriction fragment length polymorphisms (RFLPs) and sequencing of the Internal Transcribed Spacer regions (ITS) of the ribosomal RNA gene and the elongation factor 1-alpha (EF1-a) gene, were used to identify isolates. Pathogenicity studies were conducted in the greenhouse and under field conditions. Results showed that *Botryosphaeria parva* is responsible for *Botryosphaeria* stem canker of *Eucalyptus* in Ethiopia. This is the first report of the fungus from this country. Greenhouse and field inoculation studies showed that the Ethiopian isolates are highly virulent. Careful site species selection and breeding trials are thus needed to reduce the impact of this disease in Ethiopia.

**Alemu Gezahgne, Maria-Noel Cortinas, Michael J. Wingfield & Jolanda Roux, 2005. Characterisation of the Coniothyrium Stem Canker Pathogen on *Eucalyptus camaldulensis* in Ethiopia. *Australasian Plant Pathology*, 34: 85–90.**

During a survey of *Eucalyptus* diseases in Ethiopia, a serious stem canker disease was discovered on *E. camaldulensis* trees at several localities in the south and south-western parts of the country. The disease was characterized by the presence of discrete necrotic lesions, stem cankers, cracking of stems, production of kino pockets in the wood, as well as malformation of stems. These symptoms are similar to those caused by *Coniothyrium zuluense* in South Africa. This study identified the causal agent of the disease in Ethiopia by sequencing the ITS regions of the rRNA operon for a representative set of isolates. Sequences for the Ethiopian isolates were compared with those from authenticated isolates collected in South Africa, Thailand and Mexico, as well as with *Coniothyrium*-like isolates collected from diseased *Eucalyptus* trees in Uganda. Pathogenicity trials were also

conducted in the greenhouse to determine the virulence of Ethiopian isolates. Based on comparisons of sequence data, the pathogen causing the stem canker disease in Ethiopia was identified as *C. zuluense*. Isolates from Ethiopia, however, formed their own sub-clade, reflecting geographic isolation of the pathogen. Results, furthermore, also show that *C. zuluense* does not reside with other *Coniothyrium* spp., but rather within the genus *Mycosphaerella*. Small lesions were obtained from inoculated *Eucalyptus* trees, proving that the fungus is the cause of disease in Ethiopia. This study represents the first confirmed report of *C. zuluense* and the disease caused by it in Ethiopia and Uganda. It also shows that *C. zuluense* is closely related to species of *Mycosphaerella* and not other *Coniothyrium* spp. and that it will require a name change in future.

**Keywords:** Africa, Coelomycete, Disease, Phylogeny, Taxonomy

**Alemu Gezahgne, Roux J. & Wingfield M.J., 2002. First Report of Pink Disease on *Eucalyptus camaldulensis* in Ethiopia. *New Disease Reports*, 6 (1).**

*Eucalyptus camaldulensis* was one of the first *Eucalyptus* species to be introduced into Ethiopia, and it has been widely planted at low altitude, where warm conditions prevail. Wood from *Eucalyptus* plantations provides fuel, construction material, and other forest products to local communities. Recently, disease symptoms that resemble those of pink disease were observed on *E. camaldulensis* planted at Pawe, Benshangul Gumuz region, North Western Ethiopia. These symptoms are common on *E. camaldulensis* trees growing at this locality. The disease is characterised by branch dieback, stem canker, production of epicormic shoots, the production of pink mycelial growth on the surface of infected tissue, and eventually death of trees. Based on external symptoms, the disease on *E. camaldulensis* in Ethiopia was identified as pink disease (Ciesla *et al.*, 1996). To confirm the identity of the causal agent, the large sub unit RNA (28S) operon was sequenced and analysed using Phylogenetic Analysis Using Parsimony (PAUP 4.0). The Ethiopian isolates were compared with two reference isolates of *Erythricium salmonicolor* (CBS 810.85 and CBS 168.82). Based on sequences (AF 506709), the Ethiopian and reference *E. salmonicolor* isolates grouped together with 100% confidence level, separate from any of the other Corticiaceae (CI=0.6243; RI=0.6964). Results of the sequence data analysis thus supported our preliminary identification. Isolates of *E. salmonicolor* obtained from Ethiopia have been deposited in the culture collection of FABI, University of Pretoria. *Erythricium salmonicolor* (synonym, *Corticium salmonicolor* is a member of the Corticiaceae (Basidiomycotina, Aphyllophorales). It attacks a wide range of hosts in the tropics including *Eucalyptus* spp., coffee, rubber, cacao, tea and *Acacia* spp. (Gibson, 1975; Old *et al.*, 2000; Sharma, *et al.*, 1984). Pink disease is a serious problem of *Eucalyptus* in India and Brazil (Ciesla *et al.*, 1996). Hence, the prevalence of this disease on a widely planted *Eucalyptus* species in Ethiopia is of great concern, not only to large-scale plantation development in the country, but also to rural tree growers who plant the tree to generate income. The impact of this disease on other *Eucalyptus* spp. as well as on other exotic and indigenous tree species in Ethiopia is not known and will receive attention in the future.

**Alemu Gezahgne, Roux J., Hunter G. C. & Wingfield M. J., 2006. *Mycosphaerella* Species Associated With Leaf Disease of *Eucalyptus globulus* in Ethiopia. *Forest Pathology*, 36: 253–263.**

*Eucalyptus* spp. are among the most widely planted exotic trees in Ethiopia. Several damaging leaf pathogens are known from *Eucalyptus* spp. worldwide. Of these, *Mycosphaerella* spp. are among the most important, causing the disease known as *Mycosphaerella* leaf disease (MLD). Characteristic symptoms of MLD include leaf spot, premature defoliation, shoot and twig dieback. Recent disease surveys conducted in Ethiopian *Eucalyptus* plantations have revealed disease symptoms similar to those caused by *Mycosphaerella* spp. These symptoms were restricted to *E. globulus* trees growing in several localities in south, south western and western Ethiopia. The aim of this study was to identify the fungi associated with this disease. This was achieved by examining ascospore germination patterns, anamorph associations and sequence data from the Internal Transcribed Spacer (ITS) region of the rRNA operon, for representative isolates. Several different ascospore germination patterns were observed; suggesting that more than one species of *Mycosphaerella* is responsible for MLD on *E. globulus* in Ethiopia. Analysis of sequence data showed that three *Mycosphaerella* spp., *M. marksii*, *M. nubilosa* and *M. parva* were present. This is the first report of these three species from Ethiopia and represents a valuable basis on which to build further studies in the region.

**Belay Gebre, 2007. Evaluation of Tree Nursery Management Practices in Two Agro-Ecological Zones of Central Ethiopia. M.Sc. Thesis, Boku University of Natural Resources and Applied Life Sciences, Vienna.**

The causes of deforestation in the highland and lowland zones of central Ethiopia are the population growth that leads to an increase in the demand for agricultural and grazing lands, wood for fuel, charcoal production and construction. Settlements in the forest sites are resulted in the conversion of forest lands into agricultural and other land use systems. The deforested areas can be changed through reforestation and natural regeneration. Hence, various developmental organizations involved in the production of planting stocks of different trees and shrub species in the nurseries of lowland and highland zones of central Ethiopia. The success of producing quality stocks is not clear and known. Therefore, the evaluation of nursery stock quality of selected nurseries and tree species is important to understand the factors that exhibit success and failure, in order to improve and develop the appropriate nursery management practices for the two agro-ecological zones of central Ethiopia. Three nurseries were selected from lowland and highland zones of central Ethiopia. The selected tree species were *Acacia albida*, *Eucalyptus camaldulensis* and *Grevillea robusta* from lowland zone and *Acacia meamsii*, *Eucalyptus globulus* and *Hagenia abyssinica* from highland zone. Results showed that the tree species from lowland and highland tree nurseries responded differently to the mean shoot height, mean root length, mean root collar diameter and shoot and root dry weight. In Bushoftu and Godino nurseries, the *Eucalyptus camaldulensis* nursery stock showed significant differences in mean shoot height, mean root length and mean root collar diameter. In Bekate and Garmama the nursery stock of *Acacia meamsii* did not show significant differences in the mean root length. In Bekate, Garmama, and Menagesha nurseries the *Eucalyptus globulus* did not show significant differences in the mean root length and also in Bekate and Menagesha, the *Eucalyptus globulus* nursery stock did not show significant differences in the mean root collar diameter.

According to the tree species in the other tree nurseries significant differences ( $p < 0.05$ ) have been found for mean shoot height, mean root length and mean root collar diameter. Differences in shoot and root dry weights values have been found too. Based on the results of nursery management practices, nursery stock parameters and stock quality criteria, the growth of most of the studied tree species in Garmama nursery from the highland zone of central Ethiopia is relatively better than in other nurseries. Similarly, the studied tree species in Modjo nursery from the lowland zone of central Ethiopia have shown promising nursery stock quality as compared to the other nurseries. Based on the discussion of the analysis of the parameters for stock quality test recommendations for further research are given.

**Keywords:** Nursery management, Seedling quality, *Acacia albida*, *Acacia meamsii*, *Eucalyptus camaldulensis*, *Eucalyptus globulus*, *Grevillea robusta*, *Hagenia abyssinica*.

**Bewket W., 2003. Household Level Tree Planting and Its Implications for Environmental Management in Northwestern Highlands of Ethiopia: A Case Study in the Chemoga Watershed, Blue Nile Basin. *Land Degradation and Development*, 14: 377–388.**

The unsustainable exploitation and destruction of forests is a serious environmental concern in the developing countries of Africa. One of its main driving forces is the growing population causing a growing demand for fuelwood. In Ethiopia, as in many developing countries, there is a heavy dependence on and a growing demand for fuelwood. This dependence has been contributing to a widescale deforestation, as stated in various reports. Contrary to these reports, a study in the Chemoga watershed found a slightly increased forest cover during the past four decades, which was ascribed to households' tree planting practices. The objective of this study was to examine household level tree planting activities in reference to biofuel consumption patterns in four sample villages in the watershed. The results indicate that fuelwood and cattle dung accounted for nearly 100 per cent of the domestic energy consumption, with cattle dung contributing 34 per cent of the total. Fuelwood and dung combined, per capita biofuel consumption was estimated at 511 kg yr<sup>-1</sup>, but with variations between the villages and socio-economic groups. Supply appears to have influenced the quantity of biofuels used. The scarcity of wood for fuel and other uses has forced households to plant trees. This has contributed to the increased forest cover of the watershed at the present as compared to that four decades ago. Number of trees planted showed variation between the villages and socio-economic groups, which is attributable to physical and human factors. In promoting tree planting, agroforesters and environmental management planners should therefore take into account local level biophysical and socio-economic realities. This agroforestry practice is a good short-term solution to the problem of fuelwood shortage, and also has many positive implications for environmental management and agricultural production. Thus, it has to be encouraged. Spatially aggregated, local level agroforestry practices contribute positively towards global ecosystem health.

**Buttoud G., 2009. Drivers and Barriers to Change to Governance in Small-Scale Forestry. *Small-scale Forestry*, 8:133–141.**

The progressive introduction of new modes of governance promoted by the international dialogue on forests during the last 20 years has resulted in a concrete change of the management of the forests, with a new style of relationship between the public authority



and the local actors. The change has been considerable in some specific situations, for instance when the State plays a major role in public decisions and when the continuing economic transformation increases the importance of private estates. In both cases, small-scale forestry is especially concerned. Based on detailed examples selected in various situations where this change is significant, in western Europe (Belgium, France, Germany) and in transitioning (Kyrgyzstan, Ukraine) and developing (Marocco) countries, this special issue of the Small-scale Forestry sheds a new light on the capability of small-scale forestry to adapt to a transformation of the system of public decision-making. In most cases analysed, the barriers to adaptation, usually presented as resulting from fragmentation of the management decisions and a great number and diversity of stakeholders, also appear as drivers to change, in a global process where networks of actors are recomposed and power redistributed along a new scheme of national and regional links.

**Gezahgne A., Coetzee M. P. A., Wingfield B. D., Wingfield M. J. & Roux J., 2004. Identification of the Armillaria Root Rot Pathogen in Ethiopian Plantations. *Forest Pathology*, 34:133–145.**

Armillaria root rot is a well-known disease on a wide range of plants, world-wide. In Ethiopia, the disease has previously been reported on *Pinus* spp., *Coffea Arabica* and on various native hardwoods. The causal agent of the disease has been attributed to *Armillaria mellea*, a species now known to represent a complex of many different taxa. The aim of this study was to determine the extent of Armillaria root rot and the identity of the Armillaria sp. in Ethiopian plantations. As part of a plantation disease survey in 2000 and 2001, samples were collected in plantations at and around Munessa Shashemene, Wondo Genet, Jima, Mizan and Bedele, in south and south-western Ethiopia. Basidiocarps were collected and their morphology studied. Morphological identification was confirmed by sequencing the intergenic spacer (IGS-1) region of the ribosomal rRNA operon and comparing data with published sequences of Armillaria spp. Armillaria isolates were collected from *Acacia abyssinica*, *Pinus patula*, *Cedrela odorata* and *Cordia alliodora* trees. Sporocarps were found on stumps of native *Juniperus excels*. Basidiocarp morphology and sequence data suggested that the fungus in Ethiopia is similar to that causing disease of *Pinus* spp. in South Africa and previously identified as *A. fuscipes*. This identification was confirmed for all isolates, based on sequence data. *Armillaria fuscipes* is known to be common in southern Africa. Its widespread occurrence in Ethiopia suggests that it is also the major cause of Armillaria root rot in that country.

**Gebremedhin B., Pender J. & Tesfay G., 2003. Community Natural Resource Management: The Case of Woodlots in Northern Ethiopia. *Environment and Development Economics*, 8: 129–148.**

This paper examines the nature of community management of woodlots and investigates the determinants of collective action and its effectiveness in managing woodlots, based on a survey of 100 villages in Tigray, northern Ethiopia. Despite limited current benefits received by community members, the woodlots contribute substantially to community wealth, increasing members' willingness to provide collective effort to manage the woodlots. We find that benefits are greater and problems less on woodlots managed at the village level than those managed at a higher municipality level, and that the average intensity

of management is greater on village-managed woodlots. The factors that do significantly affect collective action include population density (higher collective labor input and lower planting density at intermediate than at low or high density), market access (less labor input, planting density and tree survival where market access is better), and presence of external organizations promoting the woodlot (reduces local effort to protect the woodlot and tree survival). The finding of an inverse U-shaped relationship between population density and collective labor input is consistent with induced innovation theory, with the increased labor/land ratio promoting collective effort to invest in resources as population density grows to a moderate level, while incentive problems may undermine collective action at high levels of population density. These findings suggest collective action may be more beneficial and more effective when managed at a more local level, when the role of external organizations is more demand-driven, and when promoted in intermediate population density communities more remote from markets. In higher population density settings and areas closer to markets, private-oriented approaches are likely to be more effective.

**Gerhardt K. & Nemarundwe N., 2006. Participatory Planting and Management of Indigenous Trees: Lessons from Chivi District, Zimbabwe. *Agriculture and Human Values*, 23: 231–243.**

This paper reports on action research that evaluated local perceptions and knowledge of indigenous tree planting and management in the Romwe catchment, Chivi District, southern Zimbabwe. The species tested were the overexploited *Azelia quanzensis*, important for timber and carvings of sculptures and utensils; *Sclerocarya birrea*, the marula tree used for wood, bark, and fruit; and *Brachystegia glaucescens*, the dominant miombo tree species, used for firewood, fiber, and fodder. Participants volunteered to plant and manage the test seeds, while a research team monitored their activities and results for 26 months. For *Azelia quanzensis*, the germination rate was 81%, and 69% of the seedlings were still alive after one year. In the case of *Sclerocarya birrea*, the germination rate was 69%, and the one-year survival rate was 50%. For *Brachystegia glaucescens*, the germination rate was only 30%, and the survival rate was 31%. The main reasons for planting were to provide shade, to serve as a windbreak, and to conserve and gain individual control over dwindling natural resources, particularly *Azelia quanzensis*. Women were generally more active and innovative than men. For instance, they searched for their own seeds or seedlings in the bush when there weren't sufficient plants. Some participants tried out various indigenous methods of pest and disease control, water conservation, and moisture retention. Group feedback sessions and informal interactions provided the opportunity to share experiences. The participants learned that indigenous trees can be purposefully planted and were not simply a gift from God. Despite the droughts and political instability of recent years, a growing number of people became involved in tree planting during 2002–2003. As a result, there is now greater awareness among the local population of dwindling resources and their future potential.

**Gupta G N., 1995. Rain-water Management for Tree Planting in the Indian Desert. *Journal of Arid Environments*, 31 (2) : 219-235.**

A field experiment was conducted at the Arid Forest Research Institute, Jodhpur, to study the influence of different systems/combinations of water harvesting ('saucers' of 1 or 1.5

m diameter, microcatchments with bunds, or ridge and furrow structures) and moisture conservation (weeding, mulching) on soil moisture storage, growth, biomass accumulation and nutrient uptake by *Azadirachta indica* (neem), *Tecomella undulata* (rohida) and *Prosopis cineraria* (khejri) seedlings planted in pits in soil mixed with FYM. After 26 months, the ridge and furrow method of water harvesting was found to be the best treatment and significantly improved the growth of all three species (height by 58, 30 and 40%, collar circumference by 73, 56 and 63%, and crown diameter by 111, 51, and 131%, respectively). Biomass accumulation by *A. indica* and *T. undulata* increased 3.8-fold and 4.6-fold and root mass 4.5-fold and 3.8-fold, respectively. The mulching treatment was beneficial to *A. indica* and weeding treatment to all the three species. Tree roots in water harvesting plots were deeper and had several times larger spread than the control. Nutrient uptake by these tree species increased several-fold as a result of the different water harvesting and moisture conservation treatments. The increase in cost of plantation due to the ridge and furrow treatment was 50%.

**Kabir Md. E. & Webb E.L., 2005. Productivity and suitability analysis of social forestry woodlot species in Dhaka Forest Division, Bangladesh. *Forest Ecology and Management*, 212: 243–252.**

Reforestation efforts in Bangladesh need information on the biophysical performance and social suitability of potential species. We investigated the biophysical and social suitability of three species, *Acacia auriculiformis* Benth (Leguminosae, Mimosaceae), *Acacia mangium* Willd., and *Eucalyptus camaldulensis* Dehnh. (Myrtaceae) in 8-year-old monoculture plantations for reforestation of woodlots in Dhaka Forest Division, Bangladesh. The prevailing site conditions of the study area were suitable for all three species. Seven regression models were tested to find the best-fit model for volume and productivity calculation of each species. A simple linear regression model as a function of height (h) and diameter at breast height (dbh), i.e.  $V = b_0 + b_1 (dbh + dbh^2 + dbh^2 \cdot h)$  was selected to compute volume and productivity for all three species. Survival, average height, productivity, and gross revenue earned from *A. mangium* were greatest, followed by *A. auriculiformis*; both were substantially higher than *E. camaldulensis*. Local people preferred *A. auriculiformis* most, followed by *A. mangium* and finally *E. camaldulensis*. However, the discrepancy between the productivity/revenue projections and local perception index suggests that there should be sufficient attention paid to both the interests and objectives of implementing agencies, as well as the needs and preferences of rural communities in selecting suitable species for future woodlot establishment in the same site. Therefore, the findings of this study serve as a benchmark for more in-depth investigation regarding preferences, and gaining an historical perspective on how a more secure market might affect local people's choice of species.

**Malmer A., Murdiyarso D., Bruijnzeel L. A. & Ilstedt U., 2010. Carbon Sequestration in Tropical Forests and Water: A Critical Look at the Basis for Commonly Used Generalizations. *Global Change Biology*, 16: 599–604.**

Tree planting in the tropics is conducted for a number of reasons including carbon sequestration, but often competes with increasingly scarce water resources. The basics of forest and water relations are frequently said to be well understood but there is a pressing need to better understand and predict the hydrological effects of land-use and climate

change in the complex and dynamic landscapes of the tropics. This will remain elusive without the empirical data required to feed hydrological process models. It is argued that the current state of knowledge is confused by too broad a use of the terms 'forest' and '(af) forestation', as well as by a bias towards using data generated mostly outside the tropics and for non-degraded soil conditions. Definitions of forest, afforestation and reforestation as used in the climate change community and their application by land and water managers need to be reconciled.

**Mekonnen A. & Bluffstone R., 2008. Is There a Link between Common Property Forest Management and Private Tree Growing? Evidence of Behavioral Effects from Highland Ethiopia Environment for Development. Discussion Paper Series October 2008. EFD DP 08-29.**

This paper attempts to analyze the correlates of (1) aggregated and disaggregated indices of common property forest management (CPFM) as perceived by households, and (2) the decision to grow trees and the number of trees grown with the objective of looking at the effect of CPFM. We used data collected in 2007 from a sample of rural households in the Amhara region of Ethiopia. While the CPFM indices we used varied across households, the overall CPFM index and its two sub-indices (management tools and institutional characteristics) showed a generally low level of management. We observed significant differences in the nature of management of community forests across sites, mainly driven by population size, population density, and size of forests. The results also showed that the overall management of community forests, as reflected by the overall CPFM index and its two sub-indices, had a positive association with the decision to grow trees on-farm as well as the number of trees grown. These results suggest that households that perceive a more strict management are more likely to grow trees on their farm and that those which do grow trees grow more trees. A strong correlation between the different CPFM indices suggests that households perceived the components of CPFM as being similar and hence these components were, in this case, indistinguishable.

**Muir K. & Casey J., 1989. Institutional Responsibility for Social Forestry in Africa: Lessons from Zimbabwe. Journal of Social Development in Africa, 4 (2): 27-37.**

Social forestry has failed in many countries in Africa because the projects have been conceived, designed and implemented by agencies with a commercial forestry orientation. Social forestry must address the needs of farmers and be incorporated in the peasant farm system, using and expanding the existing institutions which service rural development. The lack of appropriate technologies is a major constraint to the success of social forestry. Foresters should play a major role in developing appropriate species and technologies and in the management of indigenous woodlands. Existing agricultural extension agencies are better placed to implement social forestry programmes. An integrated approach to development and land use is essential to maximise growth and ensure the sustainable utilisation of natural resources. Agriculturalists should consider trees, and other indigenous flora and fauna, essential components of the farming systems they are developing.

**Negash Mamo & Hubert Sterba, 2006. Site index Functions for *Cupressus lusitanica* at Munesa Shashemene, Ethiopia. *Forest Ecology and Management*, 237(1): 429-435.**

In 25 permanent sample plots in *Cupressus lusitanica* plantations of the Munesa Shashemene Wood Industry Enterprise, in the Oromia Federal Regional State, Ethiopia, the dominant height growth was observed and site index functions fitted. The plots had been continuously observed from ages 7 (10) to 21 (18) in the Gambo–Shashemene and the Munesa growth districts, respectively. Measurements in each plot were taken 5–8 times, altogether a total of 163 observations were available. Parameterising the general Chapman–Richards function, showed that (i) no point of inflection within the range of the data was found, (ii) the growth rate parameter,  $k$ , of the model did not depend on site index, and (iii) the growth rate parameter,  $k$ , and thus the shape of the height growth curves differed significantly between the Gambo–Shashemene and Munesa growth districts. Previous site index curves for the same region fitted well for the Gambo–Shashemene district but not so for Munesa. Therefore, it is concluded that when developing and using site index functions, growth districts as a possible reason for different shapes have to be taken into account.

**Osemeobo G.J., 1987. Smallholder Farmers and Forestry Development: A Study of Rural Land Use in Bendel, Nigeria. *Agricultural Systems*, 24: 31-51.**

The supply of forest products has lagged behind the demand in Bendel State, Nigeria. This derives from unplanned growth of wood-based industries and low capital input in afforestation programmes. Another reason has to do with the general misconception that the supply of timber to wood-based industries is solely a government venture. In the face of these problems, forest regeneration efforts within the reserves could not keep pace with the rate of timber exploitation. It is on the basis of the foregoing deficiencies of wood supply that the land outside reserve boundaries forms an alternative source of timber production. The study described in this paper explored ways of integrating tree planting into the traditional farming system. Data were collected through a questionnaire survey. A sampled population of 300 rural farmers was randomly selected from 32 settlements in Bendel State. Available data indicate high prospects for wood production by the smallholder farmers. This form of land use is favoured by the land tenure system, willingness of farmers to plant trees and the long fallow periods of between 6 and 12 years. However, successful adoption of tree planting relies heavily on cost-sharing devices between government and rural farmers, virile extension services and the possibility of tree crops to generate cash flow.

**Osemeobo G.J., 1989. An Impact and Performance Evaluation of Smallholder Participation in Tree Planting, Nigeria. *Agricultural Systems*, 29: 117-135.**

Smallholder participation in afforestation in Nigeria is justified by increasing wood supply deficit from the natural forests, budgetary constraints on plantation establishment by government, high rates of forest depletion and desertification. The data collected for this study were derived through a multistage sampling procedure from farmers in Kaduna, Kano, Sokoto~Bendel and Ogun States. The sources of data were forestry records, measurement of standing timber in farms and interviews with farmers. The choice of trees among farmers was influenced by superior biological characteristics of exotics over indigenous species in terms of yield and adaptability to different soils and ecological zones and favoured by

sociocultural factors affecting land use: land tenure, cropping systems and fallow periods. The number of trees per hectare was few: 400 for Gmelina and Teak and 600 for Eucalyptus as against 1760 and 1200 trees, respectively, in monospecific plantations in public lands. Nevertheless, tree planting may transform the farming system through individual ownership of land, longer fallow periods and shorter cropping periods: the prerequisites for environmental stability. While tree farming met some domestic requirements for wood, it formed an additional source of income. The financial analysis depicts agroforestry as a desirable land use. The net present worth and internal rate of return per hectare were, respectively, :N6516 and 15% for Gmelina/ 4c5509 and 12% for Teak; and =N:3958 and 34% for Eucalyptus. The conclusion is reached that smallholder participation in tree planting seems to meet the objectives of government aimed at mobilizing the populace for tree planting on private lands to improve the environment and economic wellbeing of the rural farmers.

**Place F. & Otsuka K., 2000. The role of tenure in the management of trees at the community level: Theoretical and empirical analysis from Uganda and Malawi. CGIAR System wide Program on Property Rights and Collective Action. CAPRI WORKING PAPER NO. 9**

This paper examines the effects of tenure on tree management at a community level. First, several important conceptual issues arising from this particular meso-level focus are discussed. Second, a description of the key tenure and tree management issues in Uganda and Malawi is presented. In each case, data representing changes in land use and tree cover between the 1960–70s and 1990s are analyzed. In both countries, there has been significant conversion of land from woodlands to agriculture. Tree cover has been more or less maintained over time in Uganda but has decreased in Malawi. Lastly, the paper explores the relationships between tenure and tree management using econometric techniques. Tenure is found to be linked to land-use and tree-cover change in both countries, though it is not necessarily the most important factor (e.g., population pressure is the key driving force for land-use change). In Uganda, conversion of land was more rapid under the customary tenure system and tree cover on nonagricultural land better maintained under the mailo system. In Malawi there was more rapid land-use conversion and tree cover depletion where there were more changes to traditional tenure systems taking place.

**Pohjonen Y. & Pukkala T., 1990. *Eucalyptus globulus* in Ethiopian Forestry. *Forest Ecology and Management*, 36: 19-31.**

*Eucalyptus globulus* Labill. has been planted as the main tree species in the central highlands of Ethiopia since 1895. The success of the 100 000 ha planted so far is based on the adaptability of *E. globulus* to the highland climate and soil conditions, its vigorous coppicing and non-palatability for livestock, and its suitability for fuel and small construction poles. The mean annual growth of *E. globulus* in fuelwood plantations varies between 10 and 30 m<sup>3</sup> ha<sup>-1</sup> year<sup>-1</sup>. Other equally productive fuelwood species have not been identified for the Ethiopian highlands. Despite alleged ecological demerits, like high consumption of water, additional planting of *E. globulus* is justified until the current fuelwood shortage is eliminated. In the long run, parts of Ethiopian *Eucalyptus* plantations may naturally alter in composition into stands of indigenous highland species, e.g. *Juniperus procera*, *Podocarpus gracilior* and *Olea africana*.

**Price L. & Campbell B., 1998. Household tree holdings: A case study in Mutoko communal area, Zimbabwe. *Agroforestry Systems*, 39: 205–210.**

Tree holdings at homesteads and in homefields were investigated for two villages in Zimbabwe. Of the households, 90% owned at least one exotic tree. Trees were concentrated at homesteads and conserved indigenous trees tended to be edible fruit trees. Female heads of households (divorcees and widows) had fewer trees than households headed by men. Households with longer period of residence at a site had increased the proportion of indigenous fruit trees compared to non-fruit trees. Wealth status showed no relationship to tree holdings. The considerable tree planting and tree conservation activity around homesteads and in home fields has the effect of replacing non-fruit indigenous trees with exotic and indigenous fruit trees. Agroforestry research, extension and development should focus more on current practices, concentrate more on trees that farmers favour (such as fruit trees) and take into account differences among households.

**Subramanian P.A, Abraha Gebrekidan & Kebede Nigussie, 2012. Yield, Contents and Chemical Composition Variations in the Essential Oils of Different *Eucalyptus globulus* Trees from Tigray, Northern Ethiopia. *Journal of Pharmaceutical and Biomedical Sciences*, 17 (17).**

Eucalyptus trees are available abundantly in the Tigray Region, Ethiopia. The investigation has been carried out to find the feasibility for the extraction of medicinal quality eucalyptus oil in this area. A survey in this Region showed that Hagereselam, Korem and Maychew are the potential areas to collect the samples. The species has been identified as *Eucalyptus globulus* in all the highlands of Tigray Region. Hydro-distillation method was employed for the extraction of oil. The oil extracted in the sample area has been analyzed to have 1.4602 - 1.4623 refractive index value, 0.918 - 0.919 specific gravity (sp.gr.), +9 - +10 optical rotation and negative for phellandrene test that satisfy the standards stipulated by British Pharmacopeia. The percentage oil content in the *Eucalyptus globulus* has been found to be in the range 0.8 - 2.0% w/w (% dry weight) depending upon the dryness of the leaves. The essential oils were analyzed by GC/MS where the composition of the ten commonly found compounds in the oils are as follows: 1,8-cineole (66.28 - 75.36%), cis-ocimen (15.92 - 21.33%),  $\alpha$ -terpineol acetate (2.70 - 3.39%),  $\alpha$ -terpineol (1.51 - 2.26%), aromadendrene (0.69 - 2.85%), globulol (0.82 - 1.43%),  $\alpha$ -pinen (0.96 - 1.24%),  $\alpha$ -myrcene (0.66 - 1.00%), 4-terpineol (0.46 - 0.52%) and camphene (0.16 - 0.27%) as the main leaf oil components. The oils could be used for medicinal purpose except in the case of Maychew it needs purification and enrichment so as to make its 1,8-cineole content greater than 70%.

**Keywords:** *Eucalyptus globules*, Hydro-distillation, *Eucalyptus* oil, GC/MS, 1, 8-Cineole, Tigray.

**Teshome T., 2010. Analysis of Individual Tree Volume Equations for *Cupressus Lusitanica* in Munessa Forest, Ethiopia. *The Southern African Forestry Journal*, 203(1):27-32.**

Three different volume equations were fitted to individual tree volume (V) data collected on 260 *Cupressus lusitanica* trees from 49 plantations in Munessa Shashemene Forest, Ethiopia. The data were first split randomly into equation development and equation testing

data sets of equal size. Diameter at breast height (D) and height above the stump to the tree tip (H) were used as independent variables to predict volume over bark from a stump height of 30cm to the tip of the tree. The parameters, standard errors and mean square errors for each of the three equations were estimated with weighted least squares regression analysis using the modelling data set. The equations were then compared on the basis of fit statistics using the equation testing data set. The equation form  $V = \alpha_0 + \alpha_1(H/D)\alpha_2D^2H + \alpha_1$  was the best and, therefore, it was fitted to the combined data set.

**Teshome T. & Petty J.A., 2000. Site index Equation for *Cupressus lusitanica* Stands in Munessa Forest, Ethiopia. *Forest Ecology and Management*, 126: 339-347.**

The timber production potential of a given site (site quality) is measured by site index, dominant height of the stand at an index age. Stem analysis data from *Cupressus lusitanica* stands in Munessa Shashemene Forest, Ethiopia, were used to compute site index equations. The proportional curve method was adopted to construct an average guide curve. Four linear and two widely used non-linear equations were fitted to adjusted mean dominant height–age data. The Schumacher equation was chosen as giving the best fit. Site index curves are reproduced, giving dominant heights in the 12–27 m range at a reference of 15 years.

**Tewari D.D., 2001. Is Commercial Forestry Sustainable in South Africa? the Changing Institutional and Policy Needs. *Forest Policy and Economics*, 3(3-4): 333 -353.**

Commercial forestry is an important industry in South Africa, generating considerable employment and foreign exchange. The industry has grown rapidly since World War II with active government support. However, since the beginning of the transition to democracy in 1991, there have been increasingly vociferous attacks on the industry regarding its urban and big-business bias and its role in damaging the environment. The transition to democracy has brought a change in the structure or make-up of its stakeholders actor constellations and the dynamics of policy change. As a result, a new network of actors, or coalition, who have different and diverse expectations from the industry, has emerged. This network's primary goal is to monitor and control the environmental functions of commercial forestry, as opposed to the old network whose actors have believed, and continue to do so, that commercial forestry's primary goal is profit maximization. The tension between the two has generated conflicts and the need for a change in the policy and institutions to ensure the sustainability of the industry. In this article, this process of policy change is explained with the help of an advocacy coalition framework; and a set of policy guidelines that might defuse the tension between the two coalitions and set the industry on a sustainable path is briefly discussed.

**Woldeyohanes Fantu, Ahmad Ainuddin Nuruddin, Faizah Abood Haris, & Abdul Rashid Ab Malikd, 2005. Aboveground Biomass Equations for Selected Eucalyptus Species. *Ethiopian Journal of Natural Resources*, 9(1): 87-122.**

In Ethiopia, plantations of fast-growing species are being established to increase the supply of wood, especially for biomass fuel. For proper planning of such plantation development accurate methods of aboveground biomass (AGB) production, need to be developed.



The objectives of this study were to i) to develop regression equations for different tree components of three selected eucalypt species, and ii) determine the biomass distribution in the above-ground components of the selected three species. The selected eucalypt species were *Eucalyptus globulus*, *Eucalyptus grandis*, and *Eucalyptus saligna*. For each species, 24 sample trees (20 for regression and 4 for validation test) were randomly selected from respective forest stands located in the central part of Ethiopia. Biometrical data were obtained by felling the sample trees. The sample trees were further stratified into three diameter groups based on measured diameter at breast height (DBH). ANOVA and prediction equations were computed by using base-10 log-transformed dry weights (kg) of above-ground biomass (AGB) components and their corresponding log-transformed DBH, squared DBH (DBH<sup>2</sup>) and DBH<sup>2</sup>\*height (H). The data were analysed with statistical software SPSS 11.5. The allometric equation with DBH<sup>2</sup> as predictor variable showed better results (higher R<sup>2</sup> and lower SE) than other growth parameters. Since DBH can be easily measured with higher accuracy and provide better estimates, it was recommended as an adequate growth parameter for AGB estimation. The study showed that there were considerable variations in biomass distribution in the aboveground in the respective forest stands. This resulted due to variability of individual trees in size structure. For all size groups, stem wood accounted for high proportion (82.4 to 85.9%) of total tree in three *Eucalyptus* species.

**Keywords:** Biomass, Biometrical data, Breast height diameter, Predictor variable, Growth parameter

**Zenebe Mekonnen Gebretsadik, 2013. Productivity of *Eucalyptus camaldulensis* (Dehnh.) in Goro Woreda of Bale zone. *Ethiopia Research Journal of Agriculture and Environmental Management*, 2: 252-260.**

*Eucalyptus camaldulensis* is one of the exotic eucalypts introduced to Ethiopia in 1890s from Australia. It is one of the most adopted eucalypts in Ethiopia by smallholder farmers as well as in government and private medium scale plantations and grows well in more or less lowland areas as compared to other eucalypts such as *Eucalyptus globules* which grows in highland areas. It is used for poles, firewood, particle boards and construction in Ethiopia. The objective of this study were: i) to know the productivity of seedling and coppice stands of *E. camaldulensis* at selected age and site; ii) to know whether there is variation in productivity between stand types; and iii) to compare profitability of *E. camaldulensis* with other cereal crops. Fifteen sample plots of size 25 m radius has been laid in a plantation of *E. camaldulensis* for stand inventory. The inventory result has showed that the mean volume per tree for the seedling stand of *E. camaldulensis* over the fourteen years is 0.06 m<sup>3</sup> and that of the first generation coppice stand over the seven years is 0.02 m<sup>3</sup> indicating MAI of 12.88 m<sup>3</sup>ha<sup>-1</sup>per year and 13.63 m<sup>3</sup>ha<sup>-1</sup> per year respectively. One-way ANOVA has showed that there is significant difference in productivity of seedling stand and first generation coppice stand of *E. camaldulensis* in the study area ( $p < 0.001$ ) and the profitability of growing *E. camaldulensis* when discounted to 10% interest rate is found to be higher than four major cereal crops grown in the study area.

**Keywords:** Coppice stand, Density, Ethiopia, Mean annual increment, Plantation, Profitability, Seedling stand.

## 5.4. Soil Nutrient, Water and Crop Yield Under Plantation

**Arnold M., 1998. Trees as Out-grower Crops for Forest Industries: Experience from the Philippines and South Africa. *Network Paper 22a Winter 1997/98*. Rural Development Forestry Network. Odi, London.**

Arrangements under which small farmers grow wood and fibre crops under contract to a forest industry company can be beneficial to both sides, but need to be carefully designed and implemented if they are to avoid having adverse impacts. This paper reviews the experience of two long-running and generally successful schemes of this nature. The need to understand the type of smallholder situation for which tree out-growing could be appropriate is emphasized. The importance of there being an equitable balance between company and growers, and of developing institutional arrangements to bring this about, is also noted.

**Agdebe O.O., Adeola A.O. & Oyeboade O.A., 1987. Taungya in Nigeria: Tree Planting Time and Fertilizer Effects on Growth and Crop Yield. *Forest Ecology and Management*, 20 :291-298.**

The growth of *Gmelina arborea*, a forest crop tree, and the yields of food crops as affected by tree planting time and fertilizer levels, were investigated in taungya experimental research farms spread over four vegetational zones of southern Nigeria. Yields of food crops were depressed significantly ( $P < 0.05$ ) when both the tree and food crops were planted at the same time or within a period of less than 1 month. Yield reductions of food crops due to planting time of tree crops were 13 %, 25 %, and 31% for maize, yam, and cassava, respectively. Early-planted *Gmelina* seedlings performed markedly well in terms of height and girth increments, probably due to exposure to a longer period of rainfall and soil nutrient availability. Trees planted in May, June and July reached a mean height of 1.97, 1.44 and 0.74 m, respectively, by the following December the equivalent girths were 17.7, 11.6, and 7.6 cm. Whereas application of 15:15:15 N: P:K fertilizer significantly increased agricultural yields, it tended to depress the girth increment of young *Gmelina* forest tree crops, possibly due to competition for space and light with the food crop.

**Anatoli Poultouchidou, 2012. Effects of Forest Plantations on Soil Carbon Sequestration and Farmers' Livelihoods: A Case Study in Ethiopia: M.Sc. Thesis, Swedish University of Agricultural Sciences, Uppsala.**

The establishment of monoculture forest plantations with exotic, fast-growing species is common in tropical countries. This study was conducted to determine both (1) the long-term effects of plantations on soil organic carbon (SOC) and (2) the social impact of the plantation on farmers' livelihoods in Ethiopia. Tree plantations of *Cupressus lusitanica* and *Eucalyptus saligna* were established on abandoned mechanized farmland nearly 30 years ago. SOC amounts under forest plantations were compared with SOC of mechanized farmland, traditional farmland and natural forest which was the reference site. The study had a retrospective design and differences in SOC contents were compared between the five land uses sampled at two different occasions with a 10-year interval. Moreover, 20 farmers in total, both male and female, living at different distances from the plantations,

were interviewed in order to assess the difference in the social impact of the plantations on farmers' livelihoods. The results showed that the amount of SOC sequestered under the five land uses in the 0-20 cm soil layer differed significantly and was highest under *C. lusitanica* followed by *E. saligna*, natural forest, and traditional and mechanized farmland. However, the forest plantations do not yet seem to be in a steady-state with respect to SOC. Due to the establishment of plantations, farmers' livelihoods have changed in different aspects. The impact of the plantations was stronger in households situated closer to the plantations than for those people who lived further away from the plantation area. Those farmers who lived near the plantations had easier access to collect firewood and graze their livestock. They had also more job opportunities and access to shelter and were inspired to start on-farm *Eucalyptus* plantings. On the other hand, they also had to face problems associated with the plantations such as loss of agricultural land due to the establishment of plantations, crop destruction by wildlife, and conflicts with the forest guards.

**Keywords:** Plantations, Soil organic carbon, Farmers, Livelihood

**Birru Yitafuru, Anteneh Abewa & Tadele Amare, 2013. Expansion of Eucalyptus Woodlots in the Fertile Soils of the Highlands of Ethiopia: Could It Be a Treat on Future Cropland Use?. *Journal of Agricultural Science*, 8: 97-106.**

A study was conducted to assess the effect of land use change from eucalyptus to cropland on soil physico-chemical properties and perceptions of farmers in Koga irrigation area, Amhara Region. Soil samples were taken from 4 sites of three land uses (eucalyptus woodlots, cropland, and eucalyptus land use changed to cropping) and at 0-20, 20-40 and 40-60 cm depths. The three depths were used for analysis of soil chemical properties, whereas the first two depths for physical properties. Furthermore, randomly selected 15 farmers were interviewed for their perception on the state of soil fertility and crop yield conditions on lands that were recently changed from eucalyptus to cropland. The result showed that except for available P, sampled plots that were changed from eucalyptus to cropland were found better in soil chemical properties (pH, N, CEC) and SOM contents as compared to croplands. As compared to the other two land uses, total N was found larger at eucalyptus woodlots. Regarding soil physical properties (bulk density and texture), little or no difference was recorded among the different land use types. On top of that, farmers perceived that plots that were under eucalyptus have better fertility, require less nitrogen fertilizer and crops perform well compared to plots that are continuously under cropping. Thus, results of this study confirmed that changing land use from eucalyptus to cropland is possible without detrimental effect on soil properties and without affecting productivity of lands to raise crops.

**Keywords:** Eucalyptus, Land Use, Land Use Change, Koga, Mecha District, Soil physicochemical property

**David L., Bidegaray P., Hansen D.O., Mc Sweeney K., 2008. Placing the Plantation in Smallholder Agriculture: Evidence from Costa Rica. *Ecological Engineering*, 3(4): 358–372.**

Where large-scale plantation agriculture spatially coexists with smallholding agriculturalists, they interact in multiple ways. A number of researchers have addressed the broader social,

environmental, and economic consequences of smallholder/plantation relationships. Few studies, however, have examined the household-level conditions that drive smallholders to engage in plantation wage work. Research from off-farm and non-farm labor markets offer a number of clues to what types of households participate in plantation wage work. These studies, however, use aggregate economic categories and fail to consider the specific case of plantation wage work. Utilizing household survey data, this paper seeks to understand the relationship between smallholders and plantations by examining the household-level conditions that lead to engagement with plantation wage work within Costa Rica's Dos Novillos watershed. Our principle findings are: (1) agricultural assets are negatively predictive of engagement in plantation wage work; (2) a household's male labor availability is strongly predictive of a household's level of engagement in the plantation economy; (3) participation in plantation wage work appears to be an income strategy for asset-poor households more generally. Overall, this study finds little engagement in plantation wage work by smallholding agricultural households. Instead, this type of work appears to be the domain of asset-poor households that are marginally engaged in agriculture. This paper concludes by suggesting policy prescriptions and an agenda for future research in this watershed.

**Deweese P.A., 1995. Trees on Farms in Malawi: Private Investment, Public Policy, and Farmer Choice. *World Development*, 23 (7): 1085-1102.**

Agricultural intensification in Malawi has proceeded at the expense of the country's extensive woodlands. Rather than clear their farmlands of all trees however, farmers plant or leave preferred species in fields and around households. A number of indigenous and exotic agroforestry species are being promoted through extension. An analysis of potential capital and management costs *vis-a-vis* increased potential production of local and hybrid maize shows that investments in tree planting are most favorable when they involve low costs and low risks. In order to reduce the farmer's costs of tree planting, government introduced a Tree Planting Bonus scheme which has provided cash payments as an incentive for farmers to plant trees. The program has been costly to administer and has had a limited impact. Survey data suggest that existing markets for poles and other wood products probably provide better tree planting incentives. Planners need to carefully consider household resource allocation processes with regard to trees and tree based products before they can expect to achieve a significant impact in encouraging rural afforestation

**Desalegn T., Adane A & Demel T, 2014. Effect of *Eucalyptus camaldulensis* Stand Conversion into Crop Production on Growth and Yield of Maize: the case of Koga Watershed Areas in Northwestern Ethiopia. *Ethiopian Journal of Science*, 6(1):58-69.**

Farmers in the highlands of Ethiopia commonly plant eucalypts on their farmlands. However, growing eucalypt is becoming a great concern due to its alleged long-term site effect. In view of this, a study was conducted in Koga watershed, northwestern Ethiopia, to investigate whether croplands afforested with *Eucalyptus camaldulensis* can be reused for annual crop production after its removal. In this study, we compared growth and yield of maize between adjacent clear-felled *E. camaldulensis* stands and continuously cultivated farms at three paired sites. Plant height, leaf area, dry matter production and grain weight were evaluated as parameters for maize growth and yield. Maize plants grown on clear-

felled eucalypt stands were taller and developed larger leaf areas than those grown on continuously cultivated farms. Dry matter production and grain yield were also significantly higher in maize plants established on clear-felled eucalypt stands. Farmers also responded that the growth and yield of maize grown on the clear-felled eucalypt stands were better than those grown on continuously cultivated farms. The results suggest that contrary to the popular belief, agricultural lands afforested with eucalypts can be re-used for annual crop production.

**Keywords:** Clear-felled stands, Croplands, Crop performance, Farmers' perception, Ethiopia

**Fortmann L., 1988. Great Planting Disasters: Pitfalls in Technical Assistance in Forestry. *Agriculture and Human Values*, 5 (1-2):49-60.**

Social forestry, in contrast to traditional forestry, is intended to meet biological or environmental, procedural and equity goals. Social forestry projects may not fulfill this multiplicity of goals either because priority is given to a single goal or because various factors including the structure and norms of implementing institutions and the distribution of local power overwhelm procedural and distributive intentions. Thus, despite participatory and equitable project designs, social forestry projects may result in the distribution of benefits to the rich and costs to the poor and products that either have little local value or lose their value over time. Factors leading to these outcomes are explored and countervailing measures considered.

**Florian Fritzsche, Asferachew Abate, Masresha Fetene, Erwin Beck, Stephan Weise & Georg Guggenberger, 2006. Soil–Plant Hydrology of Indigenous and Exotic Trees in an Ethiopian Montane Forest. *Tree Physiology*, 26: 1043–1054.**

Fast-growing exotic trees are widely planted in the tropics to counteract deforestation; however, their patterns of water use could be detrimental to overall ecosystem productivity through their impact on ecosystem water budget. In a comparative field study on seasonal soil–plant water dynamics of two exotic species (*Cupressus lusitanica* Mill. and *Eucalyptus globulus* Labill.) and the indigenous *Podocarpus falcatus* (Thunb.) Mirb. in south Ethiopia, we combined a 2.5-year record for climate and soil water availability, natural-abundance oxygen isotope ratios ( $\delta^{18}\text{O}$ ) of soil and xylem water, destructive root sampling and transpiration measurements. Soil was generally driest under *C. lusitanica* with its dense canopy and shallow root system, particularly following a relatively low rainfall wet season, with the wettest soil under *E. globulus*. Wet season transpiration of *C. lusitanica* was twice that of the other species. In the dry season, *P. falcatus* and *C. lusitanica* reduced transpiration by a factor of six and two, respectively, whereas *E. globulus* showed a fivefold increase. In all species, there was a shift in water uptake to deeper soil layers as the dry season progressed, accompanied by relocation of live fine root biomass (LFR) of *C. lusitanica* and *P. falcatus* to deeper layers. Under *P. falcatus*, variability in soil matric potential, narrow  $\delta^{18}\text{O}$  depth gradients and high LFR indicated fast water redistribution. Subsoil water uptake was important only for *E. globulus*, which had low topsoil LFR and tap roots exploiting deep water. Although *P. falcatus* appeared better adapted to varying soil water availability than the exotic species, both conifers decreased growth substantially during dry weather. Growth

of *E. globulus* was largely independent of top soil water content, giving it the potential to cause substantial dry-season groundwater depletion. *Keywords:* *Cupressus lusitanica*,  $\delta^{18}O$ , *Eucalyptus globulus*, *Podocarpus falcatus*, root distribution, sap flow, seasonality, tensiometry.

**Keywords:** *Cupressus lusitanica*,  $\delta^{18}O$ , *Eucalyptus globulus*, *Podocarpus falcatus*, Root distribution, sap flow, Seasonality, Tensiometry.

**Guo L B, Sims R E H. 2003. Soil Response to Eucalypt Tree Planting and Meatworks Effluent Irrigation in a Short Rotation Forest Regime in New Zealand. *Bioresource Technology*, 87 (3): 341-347.**

The effects of planting three eucalypt species and irrigating with meatworks effluent on soil were assessed during the first 3-year rotation of a short rotation forest regime at Oringi, Dannevirke, New Zealand. The results showed tree planting alone reduced the soil infiltration rates, but had little influence on soil nutrient concentration other than reduction of nitrate levels. Species variation had limited influence on soil change. Effluent irrigation relieved the reduction of infiltration rates by tree planting, and increased nutrient concentrations, but reduced the soil pH. These changes should be considered when managing eucalypt short rotation forests sustainably in the longer term, either linked with effluent irrigation or not.

**Jagger P. & Luckertba M.K., 2008. Investments and Returns from Cooperative and Household Managed Woodlots in Zimbabwe: Implications for Rural Afforestation Policy. *Land Use Policy*, 25: 139–152.**

For several decades, the Zimbabwean government, donors, and NGOs have actively promoted the establishment of cooperative woodlots in Zimbabwe's communal areas. However, despite the provision of considerable extension support and subsidies to these cooperatives, household woodlots are far more common. This paper investigates the motivations of households and groups in Zimbabwe's communal areas to plant trees. Estimates of private economic returns suggest that cooperative woodlots are generally more profitable than household managed woodlots. However, household managed tree planting yields higher economic returns in the absence of subsidized land and other inputs. Statistical analysis indicates that, relative to cooperatively managed woodlots, household managed woodlots tend to be associated with access to non-timber benefits such as windbreaks, and access to market benefits through harvesting. However, relative to cooperatively managed woodlots, household managed woodlots receive less extension advice, and are associated with lower projected private returns because of subsidies provided to cooperative woodlot groups. Although the literature on cooperative management is replete with examples of successful cases, for the case of woodlots in Zimbabwe, it appears as though policy makers may be promoting the wrong management option. Household management of woodlots, rather than cooperative management, may provide greater economic returns, and accordingly better incentives, for the adoption of tree planting.

**Lill V., Kruger W.S. & Van Wyk D.B., 1980. The Effect of Afforestation with *Eucalyptus grandis* and *Pinus patula* on Stream Flow from Experimental Catchments at Mokobulaan, Transvaal. *Journal of Hydrology*, 48: 107-118.**

This paper reports results of a catchment experiment on the Eastern Transvaal escarpment, South Africa. Gauging of flow from the catchments under natural grass cover began in 1956. One of the catchments was planted to *Eucalyptus grandis* in 1969 after 12 years of calibration, a second was planted to *Pinus patula* in 1971, and the third was maintained in the natural condition. Simple regression analysis procedures were used and showed that afforestation with *Eucalyptus grandis* exerted an observable influence from the third year after planting, with a maximum apparent reduction in flow, expressed as rainfall equivalent, of between 300 and 380 mm yr.<sup>-1</sup>, and with maximum reductions in seasonal flow of about 200--260 mm yr.<sup>-1</sup> in summer and 100--130 mm yr.<sup>-1</sup> in winter. Conclusions from the *Pinus patula* treatment are very tentative, but the effect of afforestation is apparently delayed by one year relative to that of *Eucalyptus grandis*, and apparent streamflow reductions are smaller.

**Kindu M., Glatzel G., Tadesse Y. & Yosef A., 2006. Tree Species Screened on Nitosols of Central Ethiopia: Biomass Production, Nutrient Contents and Effect on Soil Nitrogen. *Journal of Tropical Forest Science*, 18: 173-180.**

Shortage of tree biomass is a severe problem in the highlands of Ethiopia. A screening trial was conducted from 1997 till 2002 to select fast growing and high biomass producing tree species, evaluate foliage and wood macronutrient contents of different tree species, and assess effect of tree species on soil nitrogen beneath their canopies. Seven tree species: (i) *Acacia decurrens*, (ii) *Chamaecytisus palmensis*, (iii) *C. proliferus*, (iv) *Eucalyptus globulus*, (v) *E. camaldulensis*, (vi) *Grevillea robusta* and (vii) *Hagenia abyssinica* were evaluated in a randomized complete block design with three replications. All species were exotic except *H. abyssinica*, *Grevillea robusta* exhibited slow height growth and wood production as compared with the five exotic species. *Acacia decurrens* provided the highest mean dry biomass at 64 months. Foliar N levels in *A. decurrens*, *C. palmensis* and *C. proliferus* were significantly higher than those in the other four tree species. *Acacia decurrens*, *C. palmensis* and *C. proliferus* are N-fixing tree species. *Hagenia abyssinica* had higher K levels in the foliage and wood. *Eucalyptus* species tended to deplete soil fertility whereas *C. palmensis* and *C. proliferus* improved soil fertility. *Chamaecytisus* species and *A. decurrens* can be short-term options for soil fertility improvement and a source of fuelwood respectively.

**Keywords:** Aboveground biomass, Exotic, Indigenous, Nitrogen, Phosphorus

**Masresha Fetene & Erwin H. Beck, 2004. Water Relations of Indigenous Versus Exotic Tree Species, Growing at The Same Site in a Tropical Montane Forest in Southern Ethiopia. *Tree Structure Function*, 18: 428-435.**

The objective of the study was to compare the water relations of two indigenous (*Podocarpus falcatus* (Thunb.) Endl., *Croton macrostachys* Hochst. ex. Del.] and two exotic tree species (*Eucalyptus globulus* Labille., *Cupressus lusitanica* Miller) growing in the same location in the montane Munessa State Forest, southern Ethiopia. Stem flow was measured with Granier type thermal dissipation probes. Sap flux, normalized per unit

sapwood area, and the total sapwood areas of the particular trees were used to estimate daily transpiration. Maximum daily transpiration values (60 kg water) were recorded for Croton when at full foliage. After shedding most of its leaves in the dry season transpiration was reduced to 8 kg per day. Eucalyptus had the next highest transpiration (55 kg), in this case at the peak of the dry season. It transpired 4–5 times more than Podocarpus and Cupressus trees of similar size. Maximum stem flux density was tree-size dependent only in Croton. Diurnal patterns of stem flux indicated that Croton, Eucalyptus and Podocarpus, in contrast to Cupressus, responded more directly to light than to atmospheric water pressure deficit. At high VPD (>1.0 kPa) stem flux reached a plateau in Croton and Podocarpus indicating stomatal limitation. Per unit leaf area Croton had the highest and Podocarpus and Cupressus the lowest daily transpiration rates. In summary, the pioneer tree Croton had the lowest and Podocarpus the highest water use efficiency. The contribution of the study to the understanding of the role of each tree species in the hydrology of the natural forest and the plantations is discussed.

**Michelsen Anders, Lisanevork Nigatu, Friis I.B., 1993. Impacts of Tree Plantations in the Ethiopian Highland on Soil Fertility, Shoot and Root Growth, Nutrient Utilisation and Mycorrhizal Colonisation. *Forest Ecology & Management*, 61: 299-324.**

In order to elucidate ecological effects of plantation establishment in Ethiopia, soil physical and chemical characteristics, above-ground herbaceous biomass and nutrient content, fine root biomass and productivity and mycorrhizal colonization were studied in a natural montane forest and in adjacent 28-40 year old plantations of the exotic species *Cupressus lusitanica* and *Eucalyptus globulus* and the indigenous *Juniperus procera*. The field studies were combined with bioassays of growth and nutrient uptake of *Acacia abyssinica*, *Chloris virgata* and *Eragrostis tef* in soils derived from each site. The Cupressus and Eucalyptus soils had lower nutrient content than Juniperus soil and that of the natural forest. The number of forbs and graminoids was high in all sites, but their coverage was poor in the Cupressus site. The production of fine roots in topsoil was twice as large in the Eucalyptus and Juniperus sites than in the other sites, whereas the standing crop of fine roots was higher in the Cupressus site. Vesicular-arbuscular mycorrhizal (VAM) fungi were abundant in roots and soil of all sites. Their colonization of roots of some of the most common forbs and graminoids was generally lower in the dry season than in the rainy season. In the bioassay, growth of *Chloris virgata* and *Eragrostis tef* was reduced in soil of all the plantations, most strongly in Eucalyptus soil, compared with their growth in soil of the natural forest. Nutrient concentration and pool sizes in herbaceous plants varied strongly between sites because of differences in species composition and herbaceous standing crop. Owing to the difference between herbaceous biomass harvested in the forest and biomass accumulation in the bioassay, it is suggested that vegetation and soil analyses are combined with bioassays in surveys of the fertility of soils after plantation establishment. The negative effect of Eucalyptus on the growth of *Eragrostis tef* in the bioassay should be considered when plans for future land use in Ethiopia are elaborated as respectively these are the most widely planted tree and crop species planted here.



**Muluneh Mengist, 2011.. Eucalyptus Plantations in the Highlands of Ethiopia Revisited: A Comparison of Soil Nutrient Status After the First Coppicing. M.Sc. Thesis, Department of Forest- and Soil, University of Natural Resources and Applied Life Sciences, Vienna, Austria.**

In Ethiopia, the growing demand for fuel wood, construction wood, and other multiple forest uses, led to intensive expansion of fast growing and short rotation *E. camaldulensis* plantations. The ongoing expansion of these fast growing plantations triggers two debates, one on environmental impacts and another on economic roles. One debate connects with soil acidification, nutrient depletion and excessive water consumption, the second connects with the economic role of this fast growing species, its high biomass production, drought tolerance and browsing resistance. However, depletion of soil nutrients, lowering of ground water table and soil acidification are not yet evaluated from the sustainable utilization point of view. To address this knowledge gap, the present study tried to investigate the impact of an *E. camaldulensis* plantation after 10 years on soil nutrients and soil acidity at a plantation sites in the north western part of Ethiopia, in Jufi. To determine BA and volume.ha<sup>-1</sup>, a systematic plantation inventory was done using circular plots with a radius of 5.64 m. For the nutrient content analysis, soil and leaf samples were collected from three consecutive blocks under *E. camaldulensis* coppice. Around each soil pit (50 cm deep), 3 coppices were selected for leaf samples from DBH classes of < 5, 5.0-9.0, 9.1-14.0 and 14.1-19.0 cm. The leaves were collected from the selected trees by bending and climbing. From each block, soil sampling was done in 10 soil sampling pits: 5 pits were 50 cm and the rest 20 cm deep. Sample collection was done in 10 cm subsections using a soil corer. Soil samples were treated according to the standard procedures and were analyzed for C and N contents, P, S and exchangeable base cations (Ca, K, Mg, Mn, and Na). Leaf samples were analyzed for N, Ca, K, Mg, Mn, Na, S and P. Data were analyzed by using descriptive statistics, ANOVA and Pairwise comparisons of mean (Scheffe-Test). After 10 years, soils under *E. camaldulensis* plantation showed low level of SOC, increasing acidification, low level of base exchangeable cations and CEC and increased content of soil N. Under these plantation sites substantial changes in SOC, Ca, K, Mg and CEC occurred in the upper soil sections whereas N and pH (H<sub>2</sub>O) changes occurred across all soil depths. Reduced contents of C: N was observed in lower soil sections. The average above ground wood stem of basal area (BA) and volume per hectare were estimated to be 13.11 m<sup>2</sup>. ha<sup>-1</sup> and 68.71 m<sup>3</sup>.ha<sup>-1</sup> respectively. Except for K, all nutrients in *E. camaldulensis* leaves indicated significant increases especially in blocks 1 and 2 after 10 years. But on the contrary except for Ca, all leaf nutrient contents decreased in block 3. Therefore, *E. camaldulensis*, like other fast growing trees, can reduce soil nutrients contents and increase soil acidity. On the other hand, due to its fast growing, high biomass production, multipurpose uses, drought and browsing resistance, *E. camaldulensis* has been expanded by local communities on differently used land and has been promoted by government. For the sustainable productivity of sites under *E. camaldulensis* forest and to reduce the environmental impacts of the species, there is a need for proper management activities.

**Keywords:** *E. camaldulensis*, Coppice, Nutrient, Leaf litter, Biomass.

**Sirawdink Fikreyesus, Zerihun Kebebew, Amsalu Nebiyu, Nardos Zeleke & Seife Bogale, 2011. Allelopathic Effects of *Eucalyptus camaldulensis* Dehnh. on Germination and Growth of Tomato. *American-Eurasian Journal of Agriculture & Environmental Science*, 11: 600-608.**

The study was conducted to determine the allelopathic effect of *Eucalyptus camaldulensis* on tomato crop. Leaf, root, bark and fruit extracts and soil sample of *Eucalyptus camaldulensis* were used to run the experiment under laboratory and field condition respectively. The aqueous extracts showed significant ( $P < 0.01$ ) inhibitory effect on germination, root and shoot elongation of tomato plants. The inhibitory effect was proportional to the concentrations of the extracts and the higher concentration (5-10%) had the strongest inhibitory effect. Results also revealed that inhibitory effect was more pronounced in radicle length and germination efficiency rather than plumule length. Soil sample also showed significant ( $P < 0.01$ ) inhibitory effect on shoot length, root length, leaf area index and dry weight. However, there was no significant difference in the survival of the seedlings planted on the different soil samples. From the obtained results, it can be concluded that, eucalyptus seem to be a potential threat to the vegetable industry under small-scale farming condition. The other conclusion is that, tomatoes are incompatible with *Eucalyptus* in agro-forestry systems. Therefore, it could be recommend that different remedial practices (like removal of excess leaf litters, planting after the rains) should be done before planting vegetables, in land previously planted with *Eucalyptus* in order to reduce the potential risks. Finally, it is important to carry out long-term field based studies to investigate the significance of these results.

**Keywords:** Allelopathy *Eucalyptus camaldulensis*, *Lycopersicon esculentum*, Germination

**Shiferaw Alem & Jindrich Pavlis, 2014. Conversion of Grazing Land into *Grevillea Robusta* Plantation and Exclosure: Impacts on Soil Nutrients and Soil Organic Carbon. *Environmental Monitoring and Assessment*, 186(7):4331-4341.**

Different studies have shown that the effect of land use conversion on soil nutrients and soil organic carbon (SOC) is variable, which indicates that more investigations that focus on different specific geographical locations and land use types are required. The objectives of this study were (1) to evaluate the effect of grazing land (GL) conversion into *Grevillea robusta* plantation and exclosure (EX) on soil nutrients and soil organic carbon (SOC) and (2) to examine the impact of soil organic matter (SOM) on soil nutrients. To achieve these objectives, soil samples were taken from a soil depth of 20 cm ( $n=4$ ) in each of the studied land areas. Each soil sample was analysed in a soil laboratory following a standard procedure. Analysis of variance (ANOVA) and Pearson's correlation coefficient were used for the data analysis. The result indicated that conversion of GL into EX improved the soil electrical conductivity (EC), exchangeable K, cation exchange capacity (CEC), total N and available P ( $p < 0.05$ ), while the exchangeable Mg, SOC, available K and SOM were decreased ( $p < 0.05$ ). Conversion of GL into *G. robusta* improved the soil EC, exchangeable (K, Ca, Mg), CEC, SOC, total N, available K and SOM ( $p < 0.05$ ). There was a significant relationship between SOM and available P, total N, SOC and EC. There were no significant relationships between SOM and pH, available K and CEC. Finally, the results indicate that both land uses, established in acidic Nitosols, have variable impacts on soil chemical properties and that *G. robusta* plantation improved most of the soil nutrients and SOC much better than the EX land use.

**Keywords:** Exclosure, Grazing land, *Grevillea robusta*. Land conversion, Soil nutrients, Soil organic carbon

**Shiferaw Alem, Tadesse Woldemariam & Jindrich Pavlis, 2010. Evaluation of Soil Nutrients Under *Eucalyptus grandis* Plantation and Adjacent Sub-Montane Rain Forest. *Journal of Forestry Research*, 21: 457-460.**

A study was conducted to evaluate the status of soil nutrients under *E. grandis* plantation in comparison with that in its adjacent submontane rain forest. Twenty square plots, with an area of 20 m×20 m for each, were established in both of *E. grandis* plantation and its adjacent sub-montane rain forest, independently. Soil samples were collected from each square plot, at five points (at the four corners and at the center) of each plot. The collected soil samples were mixed to make a composite and representative sample for each plot, independently. The analyses were done in a soil laboratory following appropriate methods. The analysis result indicated that there were no significance differences between *E. grandis* plantation and its adjacent sub-montane rain forest in the level of major soil nutrients (total N, available P, exchangeable K, Ca and Mg), pH and total carbon of soils ( $p < 0.05$ ). There were significance differences between two sites of forest soils in percentage of clay particles, and exchangeable Na content. *E. grandis* plantation was found improving soil nutrients and total carbon as compared with that of its adjacent sub-montane rain forest.

**Keywords:** *Eucalyptus grandis*; Plantation; Rain forest; Soil nutrients; Sub-montane

**Temesgen Tadesse, Rashid M. Hassan, Claudia Ringler, Tekie Alemu & Mahmud Yesuf, 2009. Determinants of Farmers' Choice of Adaptation Methods to Climate Change in the Nile Basin of Ethiopia. *Global Environmental Change*, 19: 248–255.**

This study identifies the major methods used by farmers to adapt to climate change in the Nile Basin of Ethiopia, the factors that affect their choice of method, and the barriers to adaptation. The methods identified include use of different crop varieties, tree planting, soil conservation, early and late planting, and irrigation. Results from the discrete choice model employed indicate that the level of education, gender, age, and wealth of the head of household; access to extension and credit; information on climate, social capital, agroecological settings, and temperature all influence farmers' choices. The main barriers include lack of information on adaptation methods and financial constraints.

**Tilashwork Chanie, Amy S. Collick, Enyew Adgo, C. Johannes Lehmann, Tammo S. Steenhuis, 2013. Eco-hydrological Impacts of Eucalyptus in the Semi humid Ethiopian Highlands: The Lake Tana Plain. *Journal of Hydrology and Hydromechanics*, 61: 21–29.**

Eucalyptus is the tree of choice for wood production by farmers in Ethiopia. Although there are many claims about its harmful effect on ecology and water availability, little actual research exists. The main objective of this study was, therefore, to study the extent of harm of Eucalyptus on the ecosystem. This study was conducted at the Koga Water-shed near Lake Tana in Ethiopia. Twenty-five farmers were interviewed and a field experiment with three replications was carried out to quantify the effect of Eucalyptus on various soil physical

and chemical properties and maize crop measurements and to compare bulk density, soil moisture contents, maize crop counts and shading effects in fields bordered by Eucalyptus and *Croton macrostachyus*. Our results show that Eucalyptus decreased both soil nutrients and maize yields within 20 m of the trees. Although moisture content was not affected during the monsoon, it decreased faster within 30 m of the Eucalyptus trees than elsewhere. Soils become water repellent, too. Local farmer s' perception agreed with our experimental findings and indicated that Eucalyptus trees are exhausting the once productive land. They also reported that Eucalyptus dries up springs. Despite this, the growers insist on planting Eucalyptus because of its cash income.

**Keywords:** Eucalyptus, Soil water repellency, *Croton machrostachyus*, Koga watershed

**Ulrich Lüttge, Annika Berg, Masresha Fetene, Pascale Nauke, Dirk Peter & Erwin Beck, 2003. Comparative Characterization of Photosynthetic Performance and Water Relations of Native Trees and Exotic Plantation Trees in an Ethiopian Forest. *Trees-structure and Function*, 17: 40-50.**

Comparative ecophysiological studies by measurements of photosystem II chlorophyll a fluorescence, porometry and stable isotope analyses were performed on regrowth of trees in a plantation of Eucalyptus saligna in Ethiopia. In the Shashemene-Munessa State Forest of the eastern escarpment of the Great Rift Valley, young plants of *E. saligna* and the native tree Podocarpus falcatus were compared under the canopy of an established *E. saligna* plantation, and the native tree Bersama abyssinica was also included. For further comparison fully sun-exposed plants of *Eucalyptus globulus* in a young newly established plantation, and trees of *P. falcatus* and the native pioneer tree Croton macrostachys in a remnant natural forest were examined. Photosynthetic yield measurements and light response curves suggested a gradation of sun-adapted to shade-adapted behaviour of *E. globulus* (exposed) > *C. macrostachys* > *E. saligna* (understorey), *P. falcatus*, *B. abyssinica*. As indicated by carbon isotope discrimination, long-term water-use efficiency (WUE) tended to be higher in *P. falcatus* than in *E. saligna* in the understorey of the plantation. Transpiration measurements showed that Eucalyptus spp had the highest and *P. falcatus* the lowest instant leaf conductance for water vapour. Thus, *P. falcatus* competes well photosynthetically and by a more favourable WUE. These measurements support the expectation that the *E. saligna* plantation has a nurse effect for regrowth of native trees. With the management practice of regularly coppicing *E. saligna* in a 7-year rhythm a native *P. falcatus* forest may regenerate.

**Yeshanew Ashagrie, 2004. Effects of Land-Use Changes on the Properties of a Nitisol and Hydrological and Biogeochemical Processes in Different Forest Ecosystems at Munesa, South-Eastern Ethiopia. Ph. D. Thesis, Universität Bayreuth, Germany.**

The effects of conversion of natural forest into different exotic tree species plantations and crop cultivation were investigated at Munesa, south-eastern Ethiopia with the objectives of (i) determining changes on soil physical and chemical properties, (ii) quantifying water and nutrient fluxes under the different forest ecosystems, and (iii) assessing nutrient dynamics in water flowing through the soil under the different forest ecosystems. Soil samples were taken from the organic layer and at 0–20, 20–40, 40–70, 70–100 cm depths from the mineral soil. Rainfall and through fall were collected using plastic funnels mounted 1 m above the

ground. Soil solutions were collected with zero-tension (organic layer) and tension (mineral soil at the depth of 20, 50 and 100 cm) lysimeters. After 26 years of cultivation, surface (20 cm depth) soil structure was deteriorated and total soil organic carbon (SOC) and N contents both in bulk soil and water stable aggregates were significantly reduced. Below 21 years old *Eucalyptus* plantation no significant changes on the above mentioned parameters could be identified, but significant reductions in SOC, N and S concentrations associated with the sand and silt separates were evident. There were also significant reductions both in quality and quantity of particulate organic matter (POM) due to cultivation and only in quality of POM due to 21 years *Eucalyptus* plantation. The organic layer mass under 21 years old *Pinus patula*, 21 years old *Eucalyptus globulus* and third rotation *Eucalyptus globulus* (established 42 yr ago) decreased by 43%, 57% and 15%, respectively, relative to the natural forest. There were also significant reductions in the organic layer C and N stocks (9 to 60% and 25 to 68%, respectively), being highest under *Pinus* and lowest under third rotation *Eucalyptus*. In the mineral soil, to 1 m depth, there was a significant ( $P < 0.05$ ) reduction (16 to 20%) in SOC stock after conversion of natural forest into forest plantations. The N stocks under the 21 years old *Pinus* and third rotation *Eucalyptus* plantations were significantly reduced amounting 27 and 20% respectively, whereas 21 years old *Eucalyptus* had nearly an equivalent amount of N as that of the natural forest, probably due to a dense forest floor vegetation, fixing N. The changes in the organic layer and mineral soil S stocks after plantation establishment were not significant. Of the total annual rainfall (1190 mm) recorded during the monitoring period (October 2001 to September 2002), about 47% and 18% were intercepted by the canopies of *Cupressus* and the natural forest, and *Eucalyptus*, respectively. Total annual nutrients (Ca, Cl, K, Mg, Na, NH-N, NO-N, PO-P, SO-S) deposition by rainfall was 12 kg ha<sup>-1</sup> yr<sup>-1</sup>. Through fall K, Mg, Ca and Cl fluxes were enriched relative to rainfall, whereas Na, NO-N, NH-N, PO-P and SO-S were depleted. Total annual through fall nutrient inputs (Ca, Cl, K, Mg, Na, NH-N, NO-N, PO-P, SO-S) were 14 kg ha<sup>-1</sup> yr<sup>-1</sup> under *Cupressus*, 21 kg ha<sup>-1</sup> yr<sup>-1</sup> under the natural forest and 24 kg ha<sup>-1</sup> yr<sup>-1</sup> under *Eucalyptus*. Water passing through the different forest floors differed only in K, Mg and NO-N concentrations, the latter two being higher under the natural forest and *Eucalyptus* plantation than *Cupressus*. Potassium was greater under *Eucalyptus* than the natural forest and *Cupressus*. Except for NH-N in the natural forest, forest floor leachate nutrient concentrations were enriched in all forest types in relation to through fall. Most nutrient fluxes to the mineral soil decreased in relation to through fall fluxes, whereas NO-N fluxes increased by over 50% in all forest types. At all soil depths, the concentrations of most nutrients in the mineral soil solution decreased relative to the concentrations in the forest floor leachate, but Mg, Na and NO-N at all depths in *Cupressus* plantation and SO-S and Na at some soil depths in the natural forest and *Eucalyptus* plantation had increased. The vertical trends in soil solution nutrient concentrations showed a decreasing trend with depth increments for most of the nutrients, but the concentrations of Cl and Na in all forest types and Ca, Mg and NO-N in *Cupressus* increased with increasing soil depth. At 1 m soil depth, the concentrations of Ca, Mg and NO-N in *Cupressus*, respectively, were 8, 7 and 23 times higher than in the natural forest and 3, 4 and 81 times higher than in *Eucalyptus* indicating losses by leaching. Generally, the results of this study emphasize the importance of forest type, species composition and management in affecting carbon and nutrient storage, water and nutrient fluxes and dynamics.

**Zenebe Mekonnen, 2010. Community Opinion, Marketing and Current Debates on Eucalyptus in Huruta District, Arsi Zone of Oromia Region, Ethiopia. Gil L, Tadesse W, Tolosana E & López R, Eds. Eucalyptus Species Management, History, Status and Trends in Ethiopia. Proceedings from the Congress held in Addis Ababa.**

The fast growth rate of *Eucalyptus* to provide possible products for the livelihood consumption and for the market has over won the continuing planting of the species irrespective of the policy resistant from the policy makers in Ethiopia. Until the end of the 1990s, the main tree seedling produced in government nurseries was *Eucalyptus*, but starting from the early 2000s, production of *Eucalyptus* in government nurseries has been given up. On the contrary, *Eucalyptus* gives some attention for concern in the context of diversified plantations by smallholder farmers, because owing to its importance to the household livelihood strategy by providing income and wood products for household consumption. With a large proportion of the world population in general, and of developing countries such as Ethiopia in particular, depending on wood for cooking and heating, the economic importance of *Eucalyptus* is immense. *Eucalyptus* outputs have significant impacts of change on rural livelihoods. The objective of the study is to review existing literature on *Eucalyptus* from science, policy, and farmers' perspectives and to assess the local market value and commercialization of *Eucalyptus* by farmers. In this study it was found that *Eucalyptus* wood products contributes 78 % of the local market economy for firewood, 100 % each for construction poles and posts, 20 % for charcoal and 93 % for the four wood product types at Huruta town which amounts a total of birr 99,867 (\$ 12,484) in two weeks in 2005 markets and which is \$15,189 when discounted at 4 % interest rate at the current market. Farmers have remarked that planting fast growing trees like *Eucalyptus* is the best alternative strategy to minimize the existing firewood scarcity in the locality rather than the use of cow dung and crop residues. The three extensive benefits farmers can obtain if they choose to grow *Eucalyptus* as a commercial tree on their land are (i) diversifying their farm income by growing it as a crop; (ii) increasing the productivity of their existing farm endeavour; and (iii) improving the sustainability of their current farming system.

**Keywords:** Eucalyptus, Market, Livelihood, Commercialization, Controversy, Wood source scarcity



