The Dry Forests and Woodlands of Africa

Managing for Products and Services

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Environmental Services from the Dry Forests and Woodlands of Sub-Saharan Africa

Crispen Marunda and Henri-Noël Bouda

Introduction

The Millennium Ecosystem Assessment described three categories of environmental services as:

1. Provisional services which are renewable resources such as wood, fibre, fruits and other non-timber products that have been traditionally harvested and used directly by communities.
2. Cultural services that include the spiritual, religious, aesthetic, educational, scientific, inspirational and recreational (e.g. nature-based tourism).
3. Supporting services which underpin all other services and include biodiversity conservation, soil formation, nutrient and water cycling, and regulatory services which include air quality regulation, climate regulation, water regulation, erosion regulation, water purification, disease regulation and natural hazard regulation.

In Africa, the main environmental services from dry forests and woodlands are conservation of biological diversity, protection of watersheds and regulation of water flow, desertification control and soil amelioration, and climate stabilization through carbon sequestration (Nair and Tieguhong, 2004). Some of the environmental services in Africa are becoming commercialized and therefore provide benefits to the communities and create new incentives for sustainable forest management (Jindal, 2004). This re-configured approach to the way forests and woodlands are viewed underpins a fundamental change from treating the forests and woodlands as sources of free and inexhaustible products, to seeing them as a source of services that enhance the economic value of the forests and woodlands and their contribution to livelihoods and the environment. Payments for environmental services (PES) are emerging market-based instruments that can be used to create sources and markets for such services (Engel et al, 2008; Wunder, 2005; Ferraro and Kiss, 2002 cited in Wunder, 2005; Lindell-Mills and Porras, 2002). The fact that the majority of the people in Africa are the customary custodians of the dry forest and woodland resources, and PES is about people managing natural resources for which they are compensated, makes environmental services an important service that can be tapped, marketed and the benefits used to improve people's livelihoods.

This chapter describes the environmental services from the dry forests and woodlands of Africa focusing on two services: carbon sequestration and watershed services. The other major environmental services from forests and woodlands, such as biodiversity conservation are described in detail in Chapter 3. Environmental services that support agricultural production, such as soil conservation, windbreaks and nutrient recycling, are only briefly described. These environmental services are used locally and have no markets or if available the markets are extremely thin and highly uncertain.

The chapter also explores the development and promotion of payments for environmental services beyond the boundaries of traditional forestry as a new way of providing market-based incentives for sustainable forest management in Africa. An analysis of barriers and recommendations to adopting environmental payment schemes within the context of Africa is provided. More importantly, the chapter aims to improve our understanding of the importance of environmental services in enhancing the value the dry forests and woodlands beyond production of timber and non-timber forest products.

Environmental and Ecosystem Services

In a general sense, environmental services, or ecosystem services (ES) are the functions and services that biologically driven systems provide which contribute to the overall functioning of the environment, but that are not generally considered to be owned by individuals. In short, environmental services are the natural functions of an ecosystem that can be secondarily used for the benefit of humans (Barbier and Swanson, 1992; Daily, 1997). The four most recognisable environmental services (Wunder, 2005; Grieg-Gran et al, 2005; Katila and Puustjärvi, 2003; Pagiola et al, 2002) are:

1. carbon sequestration;
2. regulation of fresh water and river flows;

3. forest landscape beauty;
4. biodiversity.

These four main environmental services have received a lot of attention because of the international nature of the services, previous valuation studies and the potential for markets for these services. In the dry forests and woodlands of Africa, some of the minor environmental services (e.g. soil improvement, water and nutrient circulation, wind-break and shelter) are very localized and do not lend themselves to market mechanism (i.e. there are no buyers). These are particularly important in the dry forest of Africa since a large percentage of the population depends on natural resources for livelihoods. Unlike the physical products from dry forests and woodlands that are easily recognized and valued at a local scale and often within individual land units managed specifically for production of the goods, environmental services are somewhat less obvious and may appear over large spatial scales and extending over multiple sectors and landscapes.

In order to demonstrate the growing importance of the environmental services concept, we need to consider how it emerged and how it is being used as an incentive for sustainable forest management. The concept of environmental or ecosystem services emerged from the conservation and development imperative and from the need to provide new incentives and mechanisms for sustainable forest management, community participation in nature conservation, collaborative forest management and successful implementation of integrated conservation and development projects. Most of these practices are anchored on the premise that the communities (or other stakeholders) can protect and manage forests and woodlands and benefit directly from products such as timber, fruits, fodder and non-wood forest products. The dry forests and woodlands of Africa are well recognized for many products (e.g. Campbell, 1996; Malaise, 1997) but the commercial benefits to the state are meagre, making contemporary forms of forest management practices unattractive (Matta and Kerr, 2006). Environmental services from forests and woodlands are now providing an alternative mechanism for optimizing investment and creating new forms of incentives in environmental protection and conservation through valuation of services and linkages to markets (Costanza et al, 1997).

The matching of sources of ES (different land-use systems) and markets (usually carbon-emitting sectors in the industrialized countries) has given rise to what are now termed payment for environmental services (Lindell-Mills and Porras, 2002; Pagiola et al, 2002; Wunder, 2005). Sven Wunder (2005) defined PES as 'a voluntary transaction in which a well-defined environmental service (ES), or a land use likely to secure that service, is being bought by at least one ES buyer from at least one ES provider if, and only if, the ES provider secures ES provision'. In Africa, examples of PES are few and these have concentrated on carbon sequestration projects in eastern Africa (Jindal, 2004). In 2008, the Katoomba Group commissioned a study that inventoried PES projects across eastern and southern Africa (Kenya, Tanzania, Uganda, Malawi and South Africa) and 68 PES and PES-like initiatives split between bio-diversity, carbon, water and other were identified (Bond, 2008). Watershed services have also received some attention within the broader context of integrated catchment management. Cases for watershed services in Africa are rare largely because this is often a site-specific service (Dillaha et al, 2008). Current work on the Rovuma in Tanzania shows some promise. Other environmental services, such as soil erosion regulation, nutrient and water cycling have not been analysed within the context of PES but more as approaches that enhance agricultural productivity at the household level. By drawing attention of the policy-makers and international community to the ES from the dry forests and woodlands, their value can be influenced and swing the balance towards conservation. As Wunder (2005) noted 'might work in marginal areas… such as dry forests where modest attention (payments) might favour conservation'. African dry forests and woodlands could now be viewed as more valuable for the environmental services they provide, although in the absence of a system for valuation and their inclusion in national economic accounting, there is often much less recognition of their overall contribution (Nair and Tieguhong, 2004).

Carbon Sequestration in the Dry Forests and Woodlands of Africa

Global context of carbon sequestration

The Intergovernmental Panel on Climate Change (IPCC, 2001) described carbon sequestration as the process of removing carbon dioxide (CO_2) and other greenhouse gases from the atmosphere and storing it in other potential reservoirs, such as land, forests and oceans. Increasing concentration of greenhouse gases in the atmosphere is expected to warm the Earth and change the climate. Carbon sequestration lends itself to transfer value techniques in which the value estimates obtained for sequestration in one location can be transferred to other regions (UNFCCC, 2003). Carbon dioxide (one of the six greenhouse gases) mixes relatively rapidly and completely in the global atmosphere and thus the contribution of carbon sequestration to the general circulation system is independent of where it takes place (Sohngen and Brown, 2006). This transferability of carbon sequestration makes it a suitable candidate for climate change mitigation under the UN Framework Convention on Climate Change (UNFCCC) Kyoto Protocol through the Clean Development Mechanism (CDM). Afforestation and reforestation create effective sinks for absorbing carbon from the atmosphere and these two activities are currently eligible for funding under the CDM (UNFCCC, 2003).

At the 13th Bali Conference of Parties (CoP13) of the UNFCCC held in Indonesia in December 2007, a new strategy on Reduced Emissions from Deforestation and forest Degradation (REDD) took centre stage as a new strategy to reduce harmful gases from the atmosphere. The REDD policy entails that developing countries which are experiencing deforestation may on a voluntary basis receive compensation if they reduce national deforestation rates (Skutsch and Trines, 2008). Tackling deforestation has been a priority developmental and environmental issue for most countries in the dry zones of Africa. The REDD deal gives more opportunities and scope for such countries to reduce deforestation rates through new incentives. For dry forest and woodland countries with lower carbon stocks but higher deforestation rates compared to wet forest countries, the challenge remains as to what approaches to adopt to reduce deforestation and, more importantly, to identify the markets for carbon credits created by such strategies.

Forests and woodlands play an important role in carbon sequestration and by investing in forest development and conservation, countries in the dry forest and woodland regions of Africa can benefit from carbon trading. A number of corporate institutions in Europe are already benefiting from carbon trading by investing in tree planting in some parts of Africa. The market for environmental services from forests and woodlands is growing rapidly around the world, often facilitated by national and regional policies as well as international conventions and agreements. Certain segments of society that are able and willing to pay for these services are creating opportunities for the forest owners. Markets for carbon sequestration based on dry forest and woodland management and protection have been adopted in Mozambique, Senegal, Uganda, Tanzania, Malawi and Madagascar (Jindal, 2004; Bond, 2008). Authorities responsible for managing dry forests and woodlands in Africa need to articulate the contribution of the forests and woodlands in sequestrating carbon and demonstrate that they have management strategies in place that enhance net carbon assimilation and attract buyers. Unfortunately, Africa contributed less than 3 per cent of the total global trade in carbon offsets in 2003–2004 (Jindal, 2006, citing Lecocq and Cupoor, 2005). The carbon projects in Africa are expected to sequester about 26.85 million tonnes CO_2 (Jindal et al, 2008: the 2006 international prices for carbon credits ranged from US$3.50 per tonne CO_2 at Chicago Climate Exchange to US$15.80 per tonne CO_2 in various European markets).

Carbon stocks and balance in dry forests and woodlands of Africa

The potential of dryland ecosystems to sequester carbon has been estimated to be up to 0.4–0.6 billion tonnes of carbon per year (UNFCCC, 2006). Lal (2004) gave estimates of carbon sequestration in dryland ecosystems and concluded that such areas have a huge potential as carbon sinks. The large surface area of African dry forests and woodlands, albeit fragmented in places, gives CO_2 sequestration in these systems some global significance. To demonstrate the potential of dry forests and woodlands to sequester carbon, there is need first to assess the carbon stock currently held and deforestation rates. The amount of carbon stored in the soil and in the woody biomass depends on the soil and vegetation type. Recognizing that little is known of the belowground carbon stocks in dry forests and woodlands, Tables 10.1 and 10.2 show the

Table 10.1 *Trends in carbon stocks in forest biomass 1990–2005*

Region/sub-regions	*Carbon in living biomass (Giga tonnes)*		
	1990	*2000*	*2005*
Eastern and southern Africa	15.9	14.8	14.4
Northern Africa	3.8	3.5	3.4
Western and central Africa	46.0	43.9	43.1
Total Africa	65.8	62.2	60.8

Note: Giga tonne = 1 billion tonnes.
Source: Based on FAO (2005)

trends in carbon stocks in above ground living biomass from the major regions and selected African countries with dry forests and woodlands. It is quite clear that the eastern, southern and northern subregions of Africa that are covered by the dry forests and woodlands, have less above ground living woody biomass compared to western and central African tropical forests. This is due to the inherently slow growth rates of dry forest and woodland species and the high levels of utilization (leading to high levels of deforestation). Because of the low above ground carbon stocks in the dry forests and woodlands, not much interest has been given to these areas compared to rainforests (Zahabu et al, 2007). However, new opportunities for compensating reduced emission through reversing deforestation now exist under REDD and dry forest and woodland countries need to take advantage of the global focus on reduced emissions from deforestation.

Table 10.2 *Carbon stock in forests and woodlands (living woody biomass) and annual forest area change (%) for selected African countries with dry forests and woodlands*

Region/Country	*Carbon stock (Megatonnes)*	*Annual forest areas change (%)*
Southern Africa		
Botswana	141.5	–0.9
Malawi	161.0	–0.8
Mozambique	606.3	–0.2
Namibia	230.9	–0.8
South Africa	823.9	0
Eastern Africa		
Ethiopia	252.0	–0.9
Kenya	334.7	–0.3
Sudan	1530.7	–0.8
Tanzania	2254.0	–1.0
West Africa		
Burkina Faso	298.0	–0.3
Chad	236.0	–0.6
Mali	241.9	–0.7
Niger	12.5	–2.3
Senegal	371.0	–0.4

Source: FAO (2005, 2006, 2007)

Table 10.3 *Carbon stock values for selected vegetation types*

Woodland types	*Carbon stock (tonnes carbon per ha)*	*Reference*
Congo-Guinea and Congo-Zambezian	160–209	Chapter 2, this volume
Zambezian warm dry forests	88–97	Chapter 2, this volume
Sudanian Savanna	56–78	Chapter 2, this volume
Kalahari Highveld	22–34	Chapter 2, this volume
Sahel with isolated shrubs	12–31.2	Woomer et al (2004)
Somali-Masai	13–78	Chapter 2, this volume
Degraded savanna and remnant forests	9–113	Woomer et al (2004)

Table 10.2 also shows the annual change in forest cover in the selected countries. It is quite clear that there is a net loss of forest cover, implying a net loss of woody carbon. Most of the countries (except South Africa) have a net loss in forest cover. It also has been reported that dryland ecosystems also store huge amounts of soil organic carbon (SOC) with the world's dryland soils containing 241Pg (pentagram) of SOC (Eswaran et al, 2001). Estimates for SOC stored in Africa's dry forests and woodlands are very few. As an example, the miombo woodlands in Southern Africa have a capacity of storing more than 100 tonnes of carbon per hectare of soil (Williams et al, 2008). Tschakert and Tappan (2004) gave an estimate of 11.3 tonnes per hectare for Senegal whilst Woomer et al (2004) gave similar figures of 11.6–25.3 for carbon per hectare for that country's Sahel Transition Zone. Soil organic carbon is also subject to loss due to soil erosion. For example, Lal et al (1999) estimated that erosion in the drylands leads to emissions of 0.21 to 0.26Pg of carbon per year. Table 10.3 shows the carbon stocks in different woodland types. It is quite clear that there is a wide variation in the estimates of the amount of carbon within woodland type and between different types.

Deforestation, land clearing for agriculture and uncontrolled burning has resulted in aggregate loss of terrestrial carbon from all vegetation types in the drylands of Africa. The net change of forest area in Africa is the highest among the world's regions, with an annual net loss, based on country reports, estimated at –5.3 million hectares annually, corresponding to –0.78 per cent annually (FAO, 2000). Table 10.2 also shows that for most countries with dry forests and woodlands, there is a net loss of forest area. The dry forests and woodlands of Africa have a history of disturbance due to human activities through land clearance for agriculture, fire, charcoal production and firewood collection. Such activities impact on the carbon stock for woodlands such as miombo (Chidumayo, 2002) and result in net loss of carbon into the atmosphere. Williams et al (2008) showed that clearing for agricultural land in miombo woodlands in Mozambique resulted in the loss of 19 tonnes of carbon per hectare. Woomer et al (2004) estimated that Senegal lost 292 megatonnes of carbon over 35 years from 1965 to 2000. Apart from deforestation, the dry regions of Africa are also prone to desertification which exacerbates the loss of soil carbon through exposure of carbonaceous material to climatic elements caused by soil erosion (Lal et al, 1999). Managing this imbalance in dry forest and woodland landscapes is a key strategy for removing atmospheric CO_2.

Managing natural woodlands for carbon sequestration in Africa

A key element for payment for environmental services is the ability to clearly define 'a land use system likely to secure that service' (Wunder, 2005). Payment for environmental services systems presuppose the existence and integration of technical capacity to enhance carbon storage in production systems and that resource users (or communities) have the capacity to adopt and maintain land resource practices that sequester carbon. This is the main challenge facing dry forest countries and they will need to articulate the CO_2 sequestration roles of woodlands to attract carbon finances. Whilst the dry forests and woodlands of Africa have low carbon stocks per unit area but not in total amounts, they present a huge potential to act as sinks provided appropriate woodland management strategies are developed and implemented. The new developments under UNFCCC (e.g. REDD) provide countries with high rates of deforestation an opportunity to reduce deforestation and offset carbon at a global level. A country like Tanzania, for example, with 34 million hectares of forest land, can potentially earn US$630 million per year or around US$119 per rural household from the REDD policy if woodland management strategies to reduce deforestation and degradation are developed and implemented (Zahabu et al, 2007).

Forestry climate change mitigation activities may be grouped into three categories. The first includes activities that avoid the release of emissions from carbon stocks, such as forest conservation and protection. The second includes activities that store carbon, for example, afforestation, reforestation and agroforestry. The third involves substituting the use of carbon-intensive products and fuels with sustainably harvested wood products and wood fuel, for example, wood substituting for concrete or steel and bio-electricity substituting for fossil fuel electricity. Within the context of dry forests and woodlands of Africa, the first two options are plausible as they provide other goods and services for immediate consumption by both local and international communities. In sub-Saharan Africa there are a number of carbon offsetting projects based on managing forests and woodlands and Jindal (2006) identified 19 such projects.

Avoided deforestation through forest conservation and protection

The capacity of dry woodlands of southern Africa to regenerate is well documented (Piearce, 1993). The species commonly found in these woodlands are vigorous resprouters and if left undisturbed, can accumulate huge amounts of carbon. For example, regrowth miombo woodlands in Mozambique are estimated to accumulate 0.7 tonnes of carbon per hectare per year (Williams et al, 2008). Most of the miombo species are able to regenerate through stump resprouts and root suckers after destruction of the above ground parts (Backéus et al, 2006; Chidumayo, 1997, 2004; Frost, 1996). For other dry forest vegetation types, such the Sudanian savanna, Ky-Dembele et al (2007) found that disturbed savanna woodlands in Burkina Faso regenerated mainly from coppice, root suckers and water sprouts. *Acacia*-dominated woodlands regenerate well from seeds scarified as they pass through the alimentary canal of browsing animals and this has been documented as the major source of seedlings compared to fires. In southern Africa, the resilience of *Acacia*, *Dichrostachys* and C*ommiphora* species in certain cases can even cause extensive bush encroachment (Wiegand et al, 2005). Consequently, if savannas were to be protected from fire and grazing, most of them would accumulate substantial carbon and the carbon sink would be large (San Jose et al, 1998).

A number of interventions have been tried and tested in the dry woodlands of Africa to improve the condition of woodlands and their productivity and service function. In Tanzania, the *Ngitili* concept has gained international recognition as a management system for miombo woodlands practised by a community for production of goods and services (Barrow and Mlenge, 2003; Monela et al, 2005). Box 10.1 briefly describes the *Ngitili* practice while Box 10.2 is another example of a community based woodland management project for carbon sequestration in the Nhambita area of Mozambique. This project involves communities managing natural woodlands and planting trees for products and services (Zohlo, 2005; Jindal, 2004). In some cases the private sector has taken the lead in establishing forests and woodlands for carbon sequestration although concerns are emerging about the negative impacts on local people of some such initiatives (Box 10.3). In arid lands of western Africa, the Sequestration of Carbon in Soil Organic Matter (SOCSOM) project (Box 10.4) traced the fate of soil carbon over long periods of time and simulated management strategies to increase carbon stock (Touré, 2006). Over periods of time these practices could stabilize and the carbon in the woodlands and soil will act as a critical adjunct to reducing emissions. In such management systems, the carbon stocks are at a very low risk of loss and thus represent a pool of sequestered carbon that is effectively permanent in the dry forest and woodland areas.

Silvicultural practices to increase carbon stocks in dry forests and woodlands

At the field level, woodland management practices to enhance biomass production have been documented by a number of researchers and these are summarized in Table 10.4. The management systems are designed to increase the woody biomass of different woodland systems. These management approaches can present a suite of practices that resource managers can adopt to enhance the value of environmental services and fulfil one of the conditions of PES, to engage in management practices that ensure the production of the services by the service provider. The response of the woodlands in terms of biomass accumulation varies from place to place as it is a function of a number

Box 10.1 Ngitili: An indigenous natural resource management system of Tanzania

The *Ngitili* natural resource management system is an indigenous practice used by the Sukuma people of the Shinyanga and Mwanza districts of Tanzania. The objective of the practice was to provide fodder for livestock during the dry season and droughts, restore soil fertility and produce wood products. The success of the practice in restoring vegetation and woody biomass has increased its value as a carbon sequestrating strategy. The main trees in *Ngitili* are *Acacia*, *Brachystegia*, *Albizia*, *Commiphora* and *Dalbergia*.

The practice involves conservation of fallow areas and rangelands to restore vegetation, especially browse species and grasses. *Ngitili* is a Sukuma term meaning enclosure. A household can have its own *Ngitili* (about 5ha) and over the years as livestock herds increased, communal *Ngitilis* became common; these can be as large as 50ha. The practice is based on excluding livestock from grazing in the protected areas and prohibiting cutting trees for a period of time. During the wet season, the *Ngitilis* are closed off to animals in order to allow vegetation to regenerate. During the dry season the animals are allowed to graze in the *Ngitilis* at a very low intensity level to start off but increase as the other sources of dry season fodder get depleted. The success of the project depended very much on the local ownership rights of the local communities through local community law (village law) enforced by local scouts called *sungusungu* or *wasalama*. Penalties for breaking local by-laws such as causing forest fires would attract a penalty of US$10 which has increased over time to US$40.

The main management strategies include formulating local by-laws and institutions, developing forest management plans that cover site selection, species selection, responsibility, conservation management, protection, preparation of fire guards around degraded woodlands, promoting early burning and promoting more benign uses, such as beekeeping and honey production.

So far over 300,000ha have been put under a *Ngitili* form of management and the communities are benefiting from goods and services. Records show increased species diversity in some areas, increase of biomass (carbon stock) and increased ecosystem integrity. The value of the *Ngitilis* is estimated to be US$14 per person per year, US$1190 per household per year and US$89.6 million per district per year (Monela et al, 2005). The *Ngitili* natural resource management practice was recognized by the UN in 2002 and was awarded a prize under the Equator Initiative. The challenge now is to expand the *Ngitili* practice to other areas, prevent selling of 'restored areas' to outsiders and create new markets for other environmental services from the areas e.g. carbon sequestration.

Source: Based on Kamwenda (2002)

of factors which include rainfall, soil type, temperature and management practices. Because of the low returns from the dry forests and woodlands in terms of physical products, some of the management practices are deemed uneconomic. The management practices are designed to achieve specific tangible products, and examples of management of forest for carbon sequestration

Box 10.2 Miombo community land-use and carbon management in Mozambique – Nhambita Pilot Project

Nhambita is a small community located near Gorongosa National Park in the Sofala province of Mozambique. The community was resettled after initially being displaced from the National Park. There are three main land-use systems: protected area, buffer zone and communal area in which the local communities are engaged in subsistence farming, hunting, fishing, livestock rearing and charcoal production (Zohlo, 2005). The dominant tree species are *Brachystegia boehmii*, *B. spiciformis* and *Julbernardia globiflora*.

The Miombo Community Land-Use and Carbon Management project aims to develop forestry and land-use practices that promote sustainable rural livelihoods in partnership with rural communities in a way that raises living standards, and to assess the potential of these activities to generate verifiable carbon emission reductions.

The project was developed as a result of the increasing concern about global climate change, and the recent evolution of carbon markets. The Nhambita project was launched in 2003 as a collaboration between the environmental company Enviro-trade Ltd and the University of Edinburgh. The project is supported by the European Commission. The project is a collaborative effort between several different organizations, which include the University of Edinburgh, the Edinburgh Centre for Carbon Management, Enviro-trade (UK), International Centre for Research in Agroforestry (Kenya) and the Park Administration of the Gorongosa National Park (Mozambique).

Local farmers and forest communities manage the planting and growth of trees in return for proceeds from the sale of carbon offsets to customers in the developed world using the Plan Vivo methodology developed by the Edinburgh Centre for Carbon Management. The Plan Vivo is a carbon management system that was developed for small farmers under the Scolel Te Project in Mexico in 1996. The Plan Vivo is a Trust Fund which provides technical and financial assistance to local farmers to take up forestry/agroforestry activities and then, on their behalf, sells carbon offsets that are generated.

By May 2007 the project had planted 230,000 trees as a combination of agroforestry and woodland restoration and has over 500 farmers involved who have benefited from the payments and have been encouraged to become involved in other micro-finance initiatives, such as beekeeping and carpentry using miombo tree species planted by the project. The project will pay US$242.60 per hectare to farmers who agree to undertake carbon sequestration activities on their farms, such as planting of trees, promoting agroforestry, etc. The project will also pay US$40.50 per hectare to a community fund on the basis of the number of hectares that are brought under carbon sequestration.

The Mozambique Carbon Livelihoods Trust was launched in 2007 to ensure that the community's and individual farmers' proceeds of carbon offset sales from Carbon Livelihoods projects were safeguarded. Approximately one-third of the proceeds of any carbon sale goes directly to this fund and is paid out to individual farmers over seven years; other payments are reserved for forest management and conservation activities.

Source: Chapter authors

Box 10.3 Concern with carbon trading forests in Tanzania

In its Bulletin no 35, the World Rainforest Movement highlighted the growing concern with proposed carbon trading forests in Tanzania. The Escarpment Forestry Company, which is a subsidiary of Norwegian company, Tree Farms, has planted 1900ha of *Pinus patula* and *Eucalyptus saligna* in Sao Hill, Mufindi and Kilombero districts, being the beginning of proposed carbon trading forests. The company is also supporting the Tanzania Greenhouse Gas Action Trust. However, serious concerns have been expressed, locally and internationally, about the socio-political, ecological and economic benefits of the carbon forests. For one thing, the company has paid a paltry land rent of US$1.9 per hectare. The negotiated 99-year land lease has important sovereignty implications. However, the most serious concern is that the operations will exploit cheap labour and will contribute to further marginalization of the rural poor.

Source: Owino (no date)

are very few. Perhaps some of these practices might have a greater impact if applied at a larger landscape scale for the production of environmental services.

There are a number of barriers to adopting some of these management practices at the local level. Campbell et al (2007) and Kokwe et al (2005) analysed some common barriers applicable to open access dry forests and woodlands with special reference to the miombo woodlands of Zambia. Key barriers include tenure rights which in many parts of Africa are not defined adequately and hence it is difficult to allocate responsibility and benefits. This

Table 10.4 *Summary of common silvicultural practices in the dry woodlands, savanna and parklands of Africa*

Woodland type	*Management practice*	*Reference*
Miombo woodlands	1. Clear felling, coppice with standard, selective cutting and thinning 2. Silvicultural thinning and pruning 3. Controlled burning to reduce fuel load 4. Grazing to reduce fuel load 5. Coppicing and pollarding 6. Fertilizing miombo fruit trees	1. Shackleton and Clarke (2007) 2. Mbwambo and Nshubemuki (2007) 3. Frost (1996); Campbell (1996); Chidumayo (1988) 4. Gambiza et al (2008) 5. Chidumayo et al (1997) 6. Akinnifesi et al (2006)
Sahelian *Acacia-Vitellaria* parklands	7. Selective thinning to improve productivity	7. Baumer (1994); Lovett and Haq (2000)
Gum arabic *Acacia* savanna	8. Exclusion and grazing to reduce fuel load	8. Egadu et al (2007)
Sudanian and Zambezian woodlands	9. Agroforestry	9. Unruh et al (1993)

Box 10.4 The SOCSOM project in Senegal

Sequestration of Carbon in Soil Organic Matter (SOCSOM) is a project funded by USAID to investigate carbon sequestration potential in Senegal. The project used remotely sensed imagery and biogeochemical computer modelling to develop carbon sequestration strategies that could eventually be applied across the country and the rest of western Africa.

The semi-arid and sub-humid regions of Africa have the highest potential for carbon sequestration in the world due to their severely degraded soils. But by increasing irrigation, reduced tillage, restoring grasslands and savannas, and extending fallow periods, coupled with applications of compost and organic waste and the adoption of erosion control strategies, countries could replenish their soil carbon stocks. In the process, this would benefit farmers through increased agricultural productivity.

Researchers estimated the patterns of carbon stocks and changes using a computer simulation model. Models on the impact of human activities and climate change were developed and included information on changes in land cover and land use. Additionally, data on crop composition, crop rotation patterns, grazing, fire, fertilizer use and irrigation from the literature and censuses were incorporated into the simulations. The model results showed the actual and potential soil carbon gains, and the economic and ecological costs and benefits. Between 1900 and 2000 the total carbon stock in soils and vegetation decreased from 141 to 89 tonnes per hectare – a reduction of 37 per cent. In the world of carbon sequestration this means that Senegal has much more 'space' left to fill with carbon. The potential revenue from managing the dry landscape for CO_2 sequestration was about €70 million (US$95 million) a year, or just under €2.5 billion (US$3.4 billion) over the 35 years that it will take to reach a new carbon steady-state.

The project has expanded to include other western African countries, such as Burkina Faso, Ghana, Mali and Niger.

Source: Touré (2006)

has been addressed through community based natural resource management but there are still a number of lingering problems (elite capture, definition of community, governance and transparency issues, inequitable benefit sharing). Participation of community members in woodland management is usually very low unless they have immediate and direct benefits. The other barrier is lack of incentive to encourage resource users (and owners) to provide their inputs (labour, time and technical capacity) in management of dry forest (Nhira, 1996). The low value of dry forests and woodlands in terms of revenues from products and services also serves as a disincentive to managing dry forests and woodlands. According to Inamadar et al (1999) local communities or user groups do not participate in forest management programmes whose transaction costs are perceived to be higher than benefits. This is true for dry forests and woodlands because there is a perception that the natural capital and value of the resource is low. As the global community recognizes the value of dryland ecosystems as sinks for carbon, new opportunities might emerge from REDD programmes and the described management practices will be useful in increasing carbon stocks provided the barriers discussed above are addressed.

Afforestation and forestation activities to create carbon sinks

Under the Clean Development Mechanism, forestation and afforestation projects are eligible for funding under the Kyoto Protocol of the UNFCCC. In principle, tree planting has been the major driver of forests as sinks for atmospheric carbon (Murdiyarso and Skutsch, 2006). Whilst tree planting in the dry forests and woodlands has been mainly for timber products (plantation), woodfuel (woodlots) and products (e.g. gums from acacia), there has been a growing need to recognize the multiple functions of the plantation to include carbon sequestration. Because dry forests and woodlands have relatively low carbon stocks, tree planting for timber has historically been the main source of additional carbon stock. There is now growing evidence that plantations are a huge source of carbon even after they have been harvested and most of the carbon locked away in buildings, furniture and paper products (Forestry Tasmania, unpublished reports). Most of the commercial plantations in Africa are located in the relatively wetter parts of the dry forest regions (e.g. the pine and eucalypt plantations in Kenya, South Africa, Mozambique and Zimbabwe).

Agroforestry

Carbon sequestration through changes in land use and management is one of the important strategies to mitigate the global greenhouse effect (Unruh et al, 1993; Tan and Lal, 2005). Agroforestry has been described as an important land-use system suitable for carbon sequestration because of the carbon storage potential in its multiple plant species and soil. Whilst reforestation and afforestation projects are plausible as a means of stabilizing CO_2, there are a lot of other competing land-use systems. This is particularly so in the dry forest areas of Africa where there is competition for land for crop production and livestock grazing. Agroforestry provides an alternative land-use system that combines tree planting and agriculture (Sanchez, 1999). In many parts of Africa, agroforestry has been introduced to improve small-holder agricultural productivity through nutrient input by trees, fodder for livestock, wind-breaks and erosion control. Essentially agroforestry increases woody biomass per unit agricultural area. In the dry forest area, the potential of agroforestry to sequester carbon has been reported by Unruh et al (1993) who estimate that nearly 1549 million hectares are under agroforestry and possibly contain about 11,540 million tonnes of above ground woody biomass. Agroforestry can also indirectly help CO_2 sequestration by decreasing pressure on natural forests (avoided deforestation) and plantations that are the largest sink of CO_2 (Montagnini and Nair, 2004).

The amount of carbon accumulated in agroforestry systems depends on the existing land use and environmental conditions. In Senegal, for example, the capacity to sequester carbon increases with rainfall and generally decreases with temperature provided soil conditions are not limiting (Batjes, 2001). From the studies by Unruh et al (1993), agroforestry systems that included a firewood production component had the greatest potential to accumulate carbon. However, this presents a problem in that all the firewood is converted to energy increasing the 'leakage of carbon' from the systems. Even with fodder trees that are fed to animals, the carbon is eventually lost to the atmosphere. The residence time for the carbon is short but the advantage of the system is that pressure is temporarily removed from natural forests.

Success of agroforestry in the carbon budget will depend on the availability of suitable tree species, secure tenure system, critical number of farmers and suitable climatic conditions. Countries with dry forest and woodland areas need to invest in research to identify suitable agroforestry species and quantify their carbon stocks. Such capacity and information will be crucial if countries in the dry regions of Africa are to promote the carbon sequestration service function of agroforestry systems.

Urban tree planting

Urban tree planting schemes also have a potential to sequester carbon, apart from adding aesthetic value to cities and towns. Such schemes may qualify for carbon credits under 'agriculture, forestry and other land uses', which is increasingly gaining momentum as part of the post-Kyoto climate change regime. In South Africa, the carbon storage of *Jacaranda mimosifolia* street trees in the City of Tshwane (Pretoria) was estimated to be 41,978 tonnes of carbon, valued at US$839,560 (Stoffberg and van Rooyen, 2006). Tree planting in or near urban centres has been practised in many urban centres in Africa with the objective of supplying firewood to urban dwellers. Whilst most schemes did not succeed due to a number of factors (ill-defined ownership, inappropriate species), they may become an important stock of carbon in the future. The high level of urbanization in most African countries is driving up the demand of traditional energy (from firewood and charcoal) in the cities. The ultimate effect is increased rates of tree cutting (and deforestation) to meet the energy demands in the growing cities. Thus tree planting near towns using the right species and with clearly defined ownership rights can help to reduce pressure on natural forests and woodlands.

WATERSHED ENVIRONMENTAL SERVICES IN THE DRY FORESTS AND WOODLANDS OF AFRICA

A sufficient and reliable water system is essential for supporting livelihoods through food production, preserving ecosystems, sustaining economic development and providing vital goods and services, such as hydroelectricity. The major river basins in Africa provide habitat to the majority of the population and are the main areas of economic activities. The yield and quality of water in the river

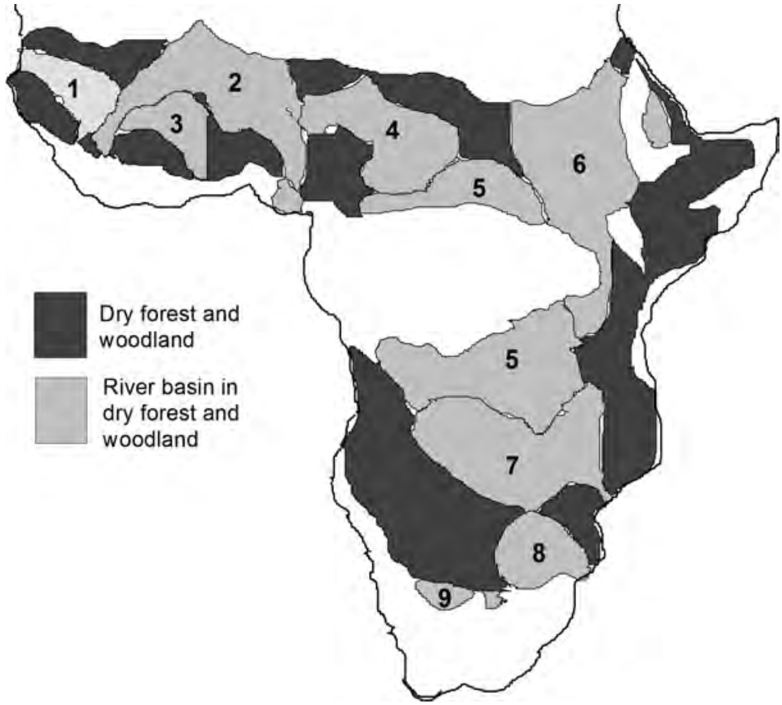

Figure 10.1 *Extent of major river basins in dry forests and woodlands of Sub-Saharan Africa*

Note: Senegal (1), Niger (2), Volta (3), Chad (4), Congo (5), Nile (6), Zambezi (7), Limpopo (8) and Orange (9)

systems is largely a function of rainfall input and land-use patterns within the catchment areas. There is now a growing recognition of the importance of upstream land management on downstream activities that are dependent on water (e.g. water supply to municipal areas, irrigation and hydroelectricity). This basic relation has given rise to the recognition of watershed services. Good upstream forest management provides a host of watershed services, including water purification, groundwater and surface flow regulation, erosion control and stream-bank stabilization. The importance of these watershed services is increasing as water yield and quality become critical issues around the world. The financial value of watershed services becomes particularly apparent when the costs of protecting an ecosystem for improved water quality are compared with downstream benefits, access to water and water security issues. Innovative market-based mechanisms for watershed services include self-organized private payments, public payments or incentives, and trading schemes

BOX 10.5 RELATIONSHIP BETWEEN FORESTS AND PRODUCTION OF WATER SERVICE

- Forests slow rate of runoff.
- Forests reduce soil erosion and sedimentation in waterways.
- Forests filter contaminants and influence water chemistry.
- Forests reduce the total annual water flow in a watershed.
- Forests can increase or decrease groundwater recharge.
- Forest loss shifts aquatic productivity.
- Forests may influence precipitation at a larger regional scale, but the effect of forest cover in most areas is limited.

Source: Adapted from Johnson et al (2001)

Major river basins in Africa containing dry forests and woodlands

All the major river basins in sub-Saharan Africa are either located or have most of their headwaters in dry forests and woodlands (Figure10.1). Of these river basins, five (the Congo, Nile, Niger, Chad and Zambezi) occupy about 42 per cent of the geographical area and sustain more than 44 per cent of the African population (UNEP, 2006; Singh et al, 1999). The Volta river basin covers large parts of western Africa and flows through the dry forest areas in that part of Africa. The river basins of Africa support many economic activities that include agricultural production, fishing, forestry, transport and tourism, and contain the largest areas of dry forests and woodlands. Apart from rainfall input, the land-use systems and human activities within the basins affect the quality and quantity of water in the basin. The forested or wooded areas are generally superimposed over watershed areas, and thus the status and management of these forest areas may have a significant effect on the hydrology of the rivers.

The growing population in the fertile river basins is exerting pressure on the forests and woodlands, soil and water resources. Most land use practices have unintentionally altered the hydrological function of most of the watershed areas. This major threat has been exacerbated by extreme and temporal variability in climate and rainfall. It is generally well known, however, that the relationship between forest cover and the production of water services is variable, complicated and poorly understood. Box 10.5 shows some of the general biophysical relationships between forests and water.

Watershed services

The watershed services in the dry forests and woodlands of Africa can be viewed from three levels. The first is rather modest and local, often involving watersheds that supply rural settlements and individual rural households and their livestock. The second is the national water supply to dams for urban water supply, industries and hydroelectricity generation. The third is an extension of the second at a regional level where watercourses may be shared and thus invariably the services offered, e.g. the Zambezi. Whilst it is difficult to establish the actual management practices that produce watershed services, the fact that woodland and forest form the dominant land-use system in the headwaters of most rivers implies their importance and function in the hydrology of the rivers. Currently, the main drivers behind the generation of the watershed services are the protection practices and degradation on upstream areas of the catchment areas, and these become more complicated by level.

The basic notion is that where upstream action generates downstream benefits in terms of water and other aesthetic benefits, and the consumption (or enjoyment) of the service by beneficiaries, this creates the watershed service function of forested/wooded catchments. With regards to the buyers of watershed services, the market is rather small and is usually within the specific countries or between neighbouring countries. Studies by IIED found little evidence of the existence of, or demand for, market-based mechanisms, either by governments or potential 'buyers' of watershed services (Geoghegan, 2005). Public budgets are the main source of funding for watershed services (Gouyon, 2002). Dillaha et al (2008) listed some of the potential buyers of water services and these include hydroelectricity companies, municipal water suppliers, irrigation schemes, industrial companies and tax revenue collection institutions. Within the African context, the lack of investment in such sectors and low value of capital makes payments for water services difficult or uneconomic. The general approach is to compensate those people in the upper reaches of drainage basins who refrain from land uses that exacerbate flooding, periodic water shortages, water quality problems and other problems at lower elevations (Landell-Mills and Porras, 2002; Pagiola et al, 2002). In fact Dillaha et al (2008) suggested that PES in Africa are 'essentially public works programmes'. The Working for Water Program in South Africa is one such programme. The programme aims to control invasive alien species in catchments for the protection of water resources and ensuring water supplies (van Wilgen et al, 2001) resulting in socioeconomic benefits, such as creating labour-intensive tree clearing programmes in the catchments (Le Maitre et al, 2001).

It would appear perhaps that for African dry forest and woodland countries, economic sectors benefiting from watershed services should create funding to invest in forest management in water catchments or pay land users and owners who actively participate in land management. In the case of most countries where the state government still controls and manages forest resources, the payments for water services could be via tax revenues that are specifically collected and allocated to the natural resource management ministries or agencies. In most dry forest countries, state-led systems of protection and regulation of water are giving way to more decentralized ones that emphasize community-based and co-management approaches. The trend is the creation of new institutions for water catchment management variously called water catchment authorities, councils or boards. These institutions may be self-organized, organized with the involvement of state agencies, or representing new decentralized levels of formal authority, and are taking management action at the local level (Geoghegan, 2005). These institutions could be the channel through which watershed services are produced and environmental payments collected on behalf of local communities who manage the resources.

At regional levels, increasing populations present the most serious threat to water adequacy. A larger population leads to higher water demand for production of food and for domestic, municipal and industrial use. This situation results in the construction of dams or altering river courses hence redistributing water allotments among sharing countries (Gleick, 2000). The drive to secure shared water supplies has been noted as one of the urgent political issues on the UN's global agenda and the Nile River is an example of such a case in Africa (El-Fadel et al, 2003). The scarcity and security concerns over water will most likely result in the development of new markets for water and watershed services. Thus countries with a high proportion of river basin areas may want to argue for compensation for investment in management from downstream countries. An example of where this could be applicable is in the Nile River where Ethiopia has a large proportion of the Nile basin and any catchment management in the country will impact water availability in Egypt. Shared river basins, like those found in many parts of Africa, have the potential to generate payments for watershed services amongst nations, and portions of the payments could be directed towards the land managers, who are often local communities.

With increasing incidents of drought and levels of degradation of watershed areas, water scarcity is brought into sharper focus and interest to different stakeholders, countries and end-users. More dams will be constructed causing conflict of interest with downstream users (e.g. Nile river in Uganda, Ethiopia, Egypt; Zambezi river in Zambia, Zimbabwe and Mozambique). This water scarcity has heightened the value of watershed services as a provider of improved water supply and quality. This can explain the increasing development of integrated catchment management strategies between countries (e.g. Zambezi River Action Plan and Nile Basin Initiative) to improve water supply and minimize conflicts. The interest in water sharing (and conflict) and valuation of water provision has brought to the fore the need to value and market watershed services. It is therefore most likely that the market expansion will continue in the future.

Within a national developmental context, the critical issue to consider is how natural resource management can take into consideration the water services from forests and woodlands and how to compensate upstream resource managers or communities. Due to the lack of investments in sectors that might 'buy' watershed services in Africa, countries should consider allocating more fiscal resources to public programmes. The public programmes can then drive local activities aimed at curtailing deforestation and degradation, promoting conservation practices that build personal and community responsibility by giving economic value to watershed protection; and creating new livelihood options for those providing watershed protection services in the catchment. An example of this kind of incentive is the working for water programme in South Africa where communities are getting jobs from clearing alien invasive plants (van Wilgen et al, 2001).

Most of the river basins are trans-boundary and different countries pursue different management agendas, often in conflict with conservation priorities or water requirements of other countries. To address these potential issues of conflict, a number of countries have come together to form river basin management strategies. The initiatives are funded mostly by international organizations. Whilst the initiatives are mainly concerned with managing the water resources, they can also be good channels through which to promote the watershed services of forests and woodlands. Watershed services in the dry forest and woodlands areas are still developing and the challenge is for the countries to demonstrate the linkages between woodlands and the provision of water services.

Other Local Level Environmental Services from the Dry Forests and Woodlands of Africa

The dry forests and woodlands of Africa form a major frontier for agricultural expansion and play a crucial role in providing services to this sector. The majority of the rural people of Africa live in the dry forest and woodland areas and the major economic activities are crop farming and livestock husbandry. The dry forests and woodlands of Africa also vary considerably across a range of socio-economic settings, land use patterns and tenure systems and thus differentiating the types and levels of environmental services. The key support services include providing browse and fodder to livestock (see Chapter 8), soil amelioration, sand dune stabilization, shade and shelter, weed control, soil moisture and nutrient recycling. These support services are produced and consumed locally by communities and individual households. Because the demand is usually internal, no prices and markets have been developed, but their contribution to increasing and sustainable agricultural productivity has been widely researched and reported. Furthermore, environmental services such as water and nutrient cycling have the potential of attracting monetary markets and are very important in terms of livelihoods and rural economy.

Livestock production systems

The Sahelian, Sudanian and Somali-Masai vegetation types support livestock production systems that are the mainstay for the nomadic herdsmen in west, eastern and northern Africa. Pods and foliage from *Acacia* species are well acknowledged for the fodder value throughout the dry lands of Africa (Barnes, 2001). Chapter 8 in this book has described the livestock production systems in African dry forests and woodlands.

Soil moisture and nutrient recycling

Acacia species in the Sahel, the Horn of Africa, East, southern and north Africa are utilized for many products (fuel, timber, forage, gum, tannins, fibre, medicine, food, handicrafts, domestic utensils) and environmental services, such as sand dune stabilization, soil fertility improvement, shade and shelter, game refuge and amenity (Wickens et al, 1995). The agroforestry forest parks (forét-parcs), which are areas with moderate to densely wooded natural tree and shrub growth (Baumer, 1994), also play an important role in supporting agricultural production through nutrient and moisture recycling. Miombo woodlands of southern Africa support agricultural production through soil moisture and nutrient recycling through litter inputs (Stromgaard, 1988; Nyathi and Campbell, 1993).

Other services

The shrubs and scattered trees in the Sahel are well known for reducing wind speeds and sediment transport (Leenders, 2006; Leenders et al, 2007) while others control weeds. *Acacia albida* trees are known to completely control *Striga hermonthica* weeds in millet fields (Gworgwor, 2007). The pollination services of bees associated with honey production in the miombo woodlands of Zambia are well known (Mickels-Kokwe, 2006). These services from African dry forests and woodlands play an important role in supporting local economic activities. Individual households invest time, labour and technology in practices that produce these services. The main incentive is that the benefits accrue directly to the households. The markets for such services are non-existent, or if they are present, they could be operating at very small scales, for example, local level sand dune stabilization to protect an individual farm could benefit a wider area if such a practice were adopted by more members of the community. The challenge for countries in the dry forests and woodlands of Africa is how to up-scale these local level practices to yield landscape level environmental services that benefit the wider community and can be bundled together and sold to bigger markets.

Key Issues and Challenges

Whilst the dry forests and woodlands of Africa are well known for providing livelihood options to many millions of people in Africa, their role in providing environmental services has not been fully explored. A number of constraints appear to hinder the development of environmental services provided by African dry forests and woodlands. These include a lack of understanding of the value of services, insecure tenure, poorly defined markets, lack of institutional and technical capacity, and lack of a transparent benefit sharing mechanism. An elaboration of these issues follows.

Lack of understanding on the values of the resources

At national levels, statistics on the contribution of forests and woodlands to national economies are still very poorly understood (FAO, 2004). Such inadequacies in the valuation of ecosystem service are also apparent at the global level (Constanza et al, 1997). Apart from the very few carbon projects cited in this chapter, and the few examples of watershed services, it is still difficult to give estimates of the value of environmental services. This lack of monetary estimates creates the notion amongst policy-makers that dry forests are not very important. This is generally reflected by the declining budgetary allocations to the forestry sector in many countries. It is therefore recommended that countries in the dry forest areas should undertake studies that estimate the contribution of forest to livelihoods and national economies (Bond, 2008). There is a particular need to assess the contribution of environmental services to the total value of forests and woodlands.

Insecure tenure

Most of the dry forests and woodlands in Africa are open access areas and generally there is insecure access to forest resources and services. This tenure system, typical across most of Africa, is an important barrier to the production of environmental services and payment schemes (Muramira, 2005; Mwangi and Mutunga, 2005; Ochieng et al, 2007 cited in Dillaha et al, 2008). Consequently the major environmental services, such as CO_2 sequestration and watershed services, are perceived as public goods that come from common resources. As such, the investment in management practices by individuals does not guarantee maximum benefits to the individuals. Also at the very local level, it is not clear who should produce these services and who should benefit. A key question to the generation of ES is what is the role of the resource owners and users, communities and national governments? Most ES are viewed as free goods and these attract free riders, so some stakeholders could be benefiting from the services without investing capital, labour, finance, assets and human capital.

Achieving tenure security is an important first step in promoting production of environmental services. Because informal and formal laws on tenure systems overlap in many parts of Africa, enhancing tenure security should be regarded as a long-term process involving negotiations and conflict resolution. Some approaches that countries can adopt include supporting community based natural resource management programmes where a community is clearly defined, access rights are legally recognized and supported, forest management plans are put in place and equitable benefit sharing arrangements are agreed upon.

Lack of clearly defined markets

On the market side, the non-exclusive nature of environmental services has contributed to the lack of clearly defined markets for such services. A community or government might invest in good management practices that generate environmental services but because of the public nature of the good, there might be no clearly defined market. This is a major bottleneck in the development of markets for CO_2 sequestration since carbon cycling operates at a global scale due to its atmospheric form and is 'very poorly captured' in any set of prices or markets (Kinzig et al, unpublished data). Even with watershed services, the markets are not clearly defined and in most cases public funds (public payments schemes) are used to compensate upstream activities (e.g. Gouyon, 2002) or support communities to participate in catchment management projects (e.g. work for water programmes in South Africa).

The REDD is a new source of markets for countries in the dry forest regions experiencing high rates of deforestation and although the details of the programme remain to be finalized, it presents opportunities for countries with dry forests and woodlands to get involved in payment for carbon sequestration. Countries with dry forests and woodlands should therefore invest in creating an understanding of how these policies work at the global level so as to position themselves in negotiations.

Transaction costs

The transaction costs associated with negotiating, implementing, and monitoring environmental services can be high. Environmental services are being promoted as a mechanism for reducing poverty of rural communities. Because of the tenure systems in the dry forests and woodlands of Africa, there are multiple small-scale land-owners and users and potential beneficiaries. Transaction costs increase when multiple parties are involved (Kerr et al, 2006). As a result most investors usually avoid small-scale projects and dealing with many small landowners. This could be a significant barrier to the provision of environmental services, and countries need to develop strategies to reduce such costs, such as setting up intermediary organizations that can work directly with communities on environmental services (Jindal, 2006).

Governance and institutional barriers

A central tenet of environmental services is the need for good governance and transparency to ensure that the poor communities benefit. Historically forest and woodland resources have been associated with corruption and elite capture of benefits by a few powerful people. This negative perception that 'someone else will benefit' and the tragedy of the commons syndrome could be some of the barriers hindering the development of environmental services. Whilst it is important for governments to play an arbitration role in payment for environmental schemes, increasing government regulation could curb PES efficiency and implementation scale, and could eventually harm the poor (Wunder, 2007). A stable and well-defined regulatory environment is necessary to promote investment in environmental services and to ensure that the resource managers are fairly compensated for the management of resources. Enabling policies and laws that promote and protect community interests in natural resource management are therefore urgently needed to address these constraints.

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