

Agroforestry is a Form of Sustainable Forest Management: Lessons from South East Asia

By

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Abstract

Agroforestry as land use based on planted trees, provides productive and protective (biological diversity, healthy ecosystems, protection of soil and water resources, terrestrial carbon storage) forest functions that societies care about in the debate on sustainable forest management. Yet, the trees planted in agroforestry systems are excluded in formal definitions and statistics of 'forestry plantations' and overlooked in the legal and institutional framework for sustainable forest management. A paradigm shift is needed in the forestry sector and public debate to redress this oversight. We examine five issues that hinder a greening revolution based on farmer tree planting to contribute to sustainable forest management. *First*, issues of terminology for forests, plantations and reforestation are linked to land tenure and land use restrictions. *Second*, access to high quality planting material of proven suitability remains a challenge, especially at the start of a farmer-tree-planting phase of a landscape. *Third*, management skill and information often constrain production for high market values. *Fourth*, overregulation often restricts access to markets for farmer grown timber and tree products, partly due to rules intended to curb illegal logging from natural forests or government plantations. *Fifth*, there is a lack of reward mechanisms for environmental services provided by agroforestry. Current relationships between agroforestry and plantation forestry are perceived to be complementary, neutral or competitive, depending on the ability of (inter)national policy frameworks to provide a level playing field for the provision to society at large of productive and protective forest functions. In conditions where large-scale plantations operate with substantial government subsidies (direct or indirect, partly justified by environmental service functions), in contrast to non-existent or minimal subsidies for agroforestry, the potential to produce wood and simultaneously provide for many forest benefits and ecological services with agroforestry is placed at a disadvantage, to the detriment of society at large.

Introduction: including agroforestry can benefit sustainable forest management

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Over the past 50 years the earth's population doubled to reach its current level of 6 billion. Today the world's population is increasing by 80 million annually, with the total projected to reach 10 billion within 40 more years. If the Millennium Development Goals are to be realized, a considerable *per capita* increase in the provision of productive and environmental service functions is needed on the same total land base. Global population growth and increasing wealth (Millennium Development Goals) exert pressure to convert forests to agricultural, industrial, or residential uses. It also results in an increase in the demand for wood fiber, exerting pressure to increase tree production per unit 'forest' land. Forests are also expected to meet an expanding array of social objectives, like clean water, recreation, and biodiversity. Forestry as a sector is striving to meet these needs with a decreasing land base for forestry in its current form. Luckily, a major opportunity to meet the challenges exist, if only we are able to break the traditional sectoral divide between 'agriculture' and 'forestry', and recognize 'agroforestry' as farmer-led efforts to meet livelihood needs on a limited land base without categorical distinctions between 'perennial' and 'annual' components of their enterprise. In this paper we will draw on some of the successes of farmer-led tree planting in Southeast Asia and their relation to 'sustainable forest management'.

Ultimately the sustainability challenge is to find ways to sustain the provision of goods and services that society derives from forests in ways *...that "meet the needs of the present without compromising the ability of future generations to meet their own needs."* (Brundtland Commission, 1987).

Sustainability in this sense does not imply 'keeping everything as it has always been'. In fact sustainability requires a constant search for new ways to meet the overall goals, while addressing current challenges. There have been several large efforts throughout the world to identify criteria and indicators by which to gauge the progress of sustainable forest management. The Montreal Process on Criteria and Indicators for Sustainable Forest Management (SFM) identified seven criteria, of which the first six are essentially a statement of the goods and services that society derives from its forests:

- 1) Biological diversity
- 2) Wood and non-timber products
- 3) Healthy ecosystems
- 4) Soil and water resources
- 5) Maintaining carbon cycles
- 6) Multiple socioeconomic benefits
- 7) Legal and institutional framework

Agroforestry practices and agroforests are an important category of planted forests that have the potential to provide a wide array of forest-related benefits to society, generally meeting criteria 1 – 5 of this list. There may be quantitative differences in the degree these criteria are met in 'agroforestry' compared to 'plantations', depending on tree density, species diversity of planted trees and spatial arrangement in the landscape.

While agroforests are typically less diverse than native forest, they do contain a much greater number of plant and animal species than forest plantations (Michon and de Foresta, 1990, 1995; Murdiyarso et al., 2002). This diversity can, at time, provide ecological resilience and contribute to the maintenance of beneficial ecological functions. Similar to plantation forests, agroforests are "working forests" and they can help relieve some of the pressure to harvest native forests (although their presence as such is not a sufficient condition for protection of old growth forests (Angelsen and Kaimowitz, 2001; Michon and Bompard, 1987; Tomich et al. 2001a, b). Linked systems of upland and riparian tree-based buffer systems, designed in regards to other landscape practices and features, can optimize soil and water conservation in the watershed (Van Noordwijk et al., 1998b), along with other economic and social services. Much of the opportunity to store carbon through afforestation will occur on agricultural lands due to the vast land area devoted to agriculture throughout the world (Watson et al., 2000; Smith and Scherr, 2002).

Box 1. Key threat to sustainability of large-scale plantation forestry in Indonesia

The allocation of land for plantation development in Indonesia (both timber and oil palm plantations) has often been undertaken without recognizing the rights of local people who already occupy and cultivate the land. Fires initiated by the plantation companies have often been used to force local communities from their land. The feeling of perceived injustice by smallholders decreases their incentive to control the spread of fire to large-scale tree plantations. As a consequence of land tenure conflicts, local communities frequently burn plantation grown trees that have been established by large companies. Since the start of the political reformation period in Indonesia in mid-1998, the open manifestation of the land tenure conflicts (that date back to the 'New Order' period) between local communities and large companies has increased. There are increasing visual signs of violence and burning of property, as companies can no longer rely on armed security to quell the unrest. In many cases, tenure conflicts often become a trigger for forest and land fires. The nature of partnerships between communities and companies in the development of oil palm and timber plantations is also a very important factor in reducing the incidence of fire as communities with partnerships have a vested interest in protecting their assets. Many people believe that a good partnership between farmers and companies in developing oil palm or timber plantations will reduce land tenure conflict. The result of the study by Suyanto et al. (2001) as part of the CIFOR/ICRAF project on underlying causes of forest fire supported this view and quotes examples where actual progress is being made.

Most of these efforts have been a hard way to learn a simple lesson: unless farmers share substantially in the long-term benefits of forest plantation efforts, the interaction between the 'agro' and the 'forestry' component remains a competitive one (Van Noordwijk and Tomich, 1995). Because of land scarcity, large-scale plantations and smallholder development programmes tend to be mutually exclusive, at least in most developing countries of Asia and parts of Africa. What is needed is that foresters start to participate in farmers' tree planting efforts, rather than expecting farmers to participate in foresters' efforts (Garrity and Mercado, 1994).

In societies where the majority of people live in urban/suburban areas, concerns over the accelerating loss of open and green space tend to become prominent. This is a quality-of-life issue to many and raises the potential for agroforestry applications at the agricultural/community interface to restore ecological functions that provide for storm water management, wildlife habitat, recreational opportunities, and aesthetic enhancements.

Legal and institutional framework

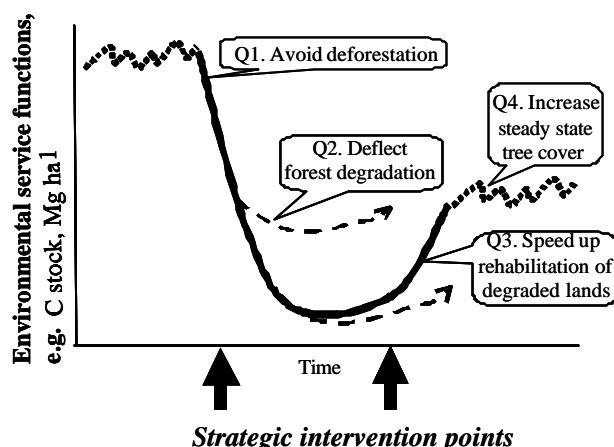
Criterion 7 of the Montreal process, the legal and institutional framework appears to be the main obstacle for including agroforestry in debates on sustainable forest management. By definition (literally) agroforestry has often been excluded. A paradigm shift may be needed.

The need for a paradigm shift in forestry

Logging old-growth forest remains, from a private perspective, the cheapest way to get high quality timber. Until the forest extraction frontier is effectively closed (either by effective protection of remaining forests, strict enforcement of rules on certified timber origin down the market chain, or through sheer exhaustion and depletion), planting trees needs specific subsidies and protection to compete successfully with other land uses. Once the supply from natural forests dries up, however, and the prices go up, the time lag between planting and harvesting of (even fast-growing) trees creates a gap in the supply (Fig. 1). Regulations aimed at curbing illegal logging (closing the forest extraction frontier) tend to obstruct the trade and transport of farm grown timber as well, and the transaction costs involved become a deterrent

for what should be the logical outcome of a timber shortage: positive incentives for smallholder production systems to respond to market demand by planting trees.

Figure 1. The overall pattern of loss of natural forest followed by the increase of farmer-grown or forester-managed tree plantations, variously described as a ‘U curve’, ‘inverse J’ or inverted Kuznets curve (‘it has to become bad before it can become better’).



Seen at the timescale of the evolution of a landscape (in the order of decades, usually), we can recognize four important questions: 1) can deforestation be avoided or halted, 2) can the process of forest degradation be deflected to a tree-based land use pattern that avoids the more serious stages of environmental degradation, 3) can degraded lands (from a forest function perspective) be rehabilitated, and 4) to what new level of tree cover and forest functions can land use recover in a new ‘steady state’, while meeting economic expectations of the land managers as well as society at large.

While we here focus on questions 3 and 4, a few remarks on question 2 may be relevant. Good markets for tree products such as fruits, resins and latex have allowed a transition of substantial areas of southeast Asian forest into ‘agroforest’, a land use that combines ‘planted trees’ with forest flora and fauna, either retained or naturally regenerated vegetation (de Jong et al., 2001). Tree planting in these agroforests can occur in an ‘open field’ stage, often in between food crops, or in small gaps or clearings in existing forest. The ‘miang tea’ agroforests of northern Thailand and some of the fruit tree, cacao and coffee agroforests originated from such ‘enrichment planting’, gradually modifying the species composition without a clear felling stage. The rubber, damar (resin) and other fruit tree and coffee based agroforestry has been through such a clear-felled (usually ‘slash and burn’) stage, but recovered their tree cover and most of the forest functions, allowing a greater population density to make a living (about 50 persons km⁻² for rubber agroforests, versus about 10 persons km⁻² in sustainable forms of shifting cultivation or plantation forestry). When the first generation of planted trees gets old, the choice may again be either ‘interplanting’ or a new clear-felling + planting rotation. In Indonesia farmers use different words for these two ways of planting trees (*sisipan* versus *tanam*) (Joshi et al., 2002). The term ‘plantations’ in Southeast Asia generally refers to a form of ‘land clearing’ (conventionally ‘slash and burn’, with various forms of ‘slash and mulch’ or ‘controlled burning as more recent alternatives) to form a break with the preceding vegetation. Both from an economic and an environmental perspective, however, the ‘enrichment planting’ approach to question 3 merits further interest.

While nearly all experiments with a large-scale ‘plantation’ style approach to *agriculture* have failed, the tradition in forestry is still to expect that there are economies of scale in the planting, managing and harvesting of *trees*. In fact, the ‘economies of scale’ may (in contrast to what is commonly perceived) not derive from the planting, care or management of trees as such, but from the harvesting, marketing and processing stage and from regulatory frameworks or subsidized credit directed to large operators (Barr, 2001, 2002), accentuated by a century of pro-plantation emphasis in research. Experience in countries such as New Zealand shows that the two sectors can exist side by side with generally healthy relations. Smallholders with diverse, risk-averse farms that include a significant tree component (‘agroforestry’) are seen, at least in a number of countries, to be the most efficient tree producers of the future. However, a number of constraints at policy level, in the way markets

work and in the way know-how and tree germplasm flow (see below) need to be addressed for the agroforestry potential to be realized.

National governments and international donors throughout Southeast Asia have made reforestation based on 'plantations' a priority, for a variety of reasons. However, public-led reforestation efforts have met with mixed success. In the Philippines the government strategy for reforestation has been to promote government and industrial plantations, primarily of *Gmelina arborea*, *Eucalyptus* sp. and *Acacia mangium*. Official records indicate that between 1976 and 1995, 1,300,000 ha of fast-growing trees were planted. About 50% of this total was established under the National Forestation Programme for watershed protection. The remaining half targeted wood production. The success of these plantations is not impressive. Analysis concludes that a success rate of 30% is generous, if success is defined as the proportion of area planted that actually evolves into secondary forests (Lasco et al., 2001). In Indonesia, the Five-Year Development Plan, *Repelita VI 1994-1999*, targeted public and industrial reforestation of 1,250,000 hectares per year. Government figures acknowledge that less than a third (400,000 hectares) of this goal was achieved (Moestrup 1999). The actual existence and long-term success of these plantations, primarily industrial or government reforestation schemes, are widely questioned. The reasons for the failure of public and industrial reforestation efforts in Southeast Asia are numerous. Key problems include: 1) conflicts over land often with overlapping claims by the state and local farmers, 2) the target mentality of the reforestation - or *tree planting* - activity; 3) inadequate attention given to technical details (species-site matching, plantation maintenance, etc); 4) lack of clear management and utilization objectives for the plantation; 5) disregard of the needs and objectives of the local communities; and 6) corruption (Carandang and Lasco 1998, Carandang and Cardenas 1991). In general these plantations are established by technicians and contract laborers who have no post-planting responsibility, concern or expectations of future benefits. Central planning of reforestation schemes often assumed that local people would protect the newly established forests. However, having been excluded from the planning process, local people feel no sense of ownership of the plantation and no incentive to protect the trees. Plantations are often heavily damaged or completely destroyed by fires (Suyanto et al., 2001; Box 1), grazing, or appropriation of the site for other uses.

In contrast, the loss of local forest resources often leads to increased incentives for spontaneous expansion of smallholder tree husbandry (Box 2). Farmers protect and plant more trees on their own farms - or on land under their control - to provide tree products for household needs and market demands. This is particularly true where wide-scale deforestation or proximity to urban centers creates high demand for timber, fruit and other forest products and the extractive forest frontier is far enough away (Box 5, below). In other situations (e.g. in central and east Java) the (temporary) migration of the young people to cities results in extensification of land use, with tree farming as a form of a 'living saving account'. Under these conditions, smallholder farmers see tree farming as a means to diversify their production, reduce risk, and build assets to enhance family incomes and security. Smallholder farmer tree planting systems are generally successful. Smallholders have limited time and financial resources. The trees they plant represent a conscious investment for which other options have been forfeited. Farmers generally restrict plantings to the number of trees that can be maintained. They integrate *tree growing* with their crop and animal

Box 2. Case study in the Philippines

In the Philippines *Gmelina arborea* was the basis of farmer-led, market-oriented agroforestation and land rehabilitation efforts (Garrity and Mercado 1994; Pasicolan and Tracey 1996). Philippine farmers grow *G. arborea* in monocultures or mixed with other timber, fruit and MPTS species. Block plantations are preferred, although border and contour plantings are also established. Most farmers establish 0.25-0.75 hectares of plantations at tree spacing of 3x3 to 4x4 meters (Magcale-Macandog et al. 1999; Pasicolan and Tracey 1996). In general these tree-farming systems are more profitable than annual crop production (Predo, 2002). The development of a viable and widespread smallholder timber production system in Claveria, Mindanao, Philippines has resulted in depressed prices for *G. arborea* timber, the main species produced by smallholders. Traders respond that the size and quality of smallholder timber is often sub-optimum, so they must reduce prices to compensate for the additional risk assumed. Reliability and quantity of supply are also important issues. In Leyte, Philippines a successful smallholder timber production project has led to disappointment due to a lack of markets. A nearby wood processor prefers to procure timber from commercial sources on another island because of the high transaction costs and unreliable timber supply encountered when dealing with many individual smallholders. (Mangaoang, personal communication) The selection or existence of the right marketing channel is an important issue for smallholders. After initial reliance on fast growing exotics, smallholder farmers in many areas of the Philippines are now interested in cultivating high-value indigenous species (including, timbers, fruit, etc) to meet market demand. Constraints that inhibit this process are a lack of germplasm, knowledge regarding propagation and management, slow growth rates and policy disincentives/ambiguities (Tolentino et al., 2002; and LSU 2002).

production activities. The management practices undertaken to assure good food crop yields – cultivation, weed control and fertilization – also benefit their trees. The available land, labor, and other resources are allocated according to the farmer's objectives. Because landholdings are small, farmers can select the farm niches most appropriate for tree production. The combination of limited resources, small individual plantings, and intimate familiarity with the planting site result in high tree survival and good growth rates. In summary, smallholder tree-growing activities benefit from intensive management over limited areas and vested self-interest – the desire of the farmer to profit from her/his investment of time and resources.

Our experience is that under conditions of secure land tenure and market access, smallholder farmers can and will cultivate a wide range of tree species as a component of their efficient, integrated and risk-averse livelihood and land-use systems and will effectively respond to the increased demand for wood products.

Thus, a paradigm shift is required in the forestry sector, to include the more flexible farmer-led approach in wood and fibre production as part of the solution to achieve sustainable forest

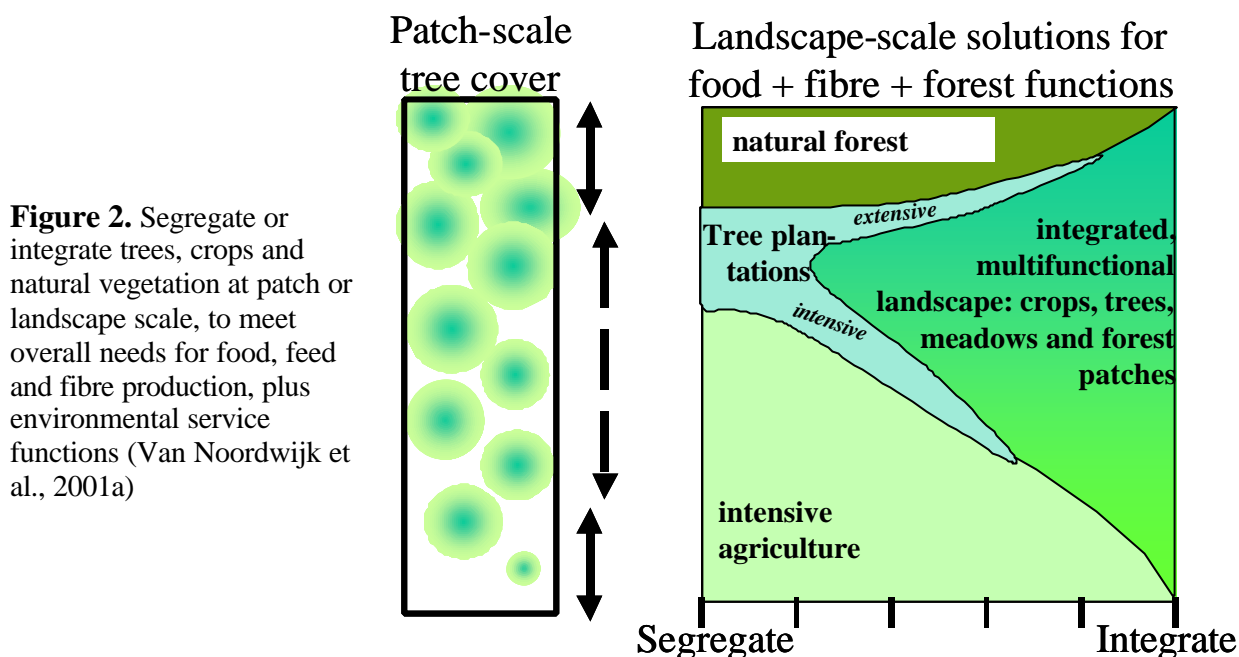
management objectives. There are, however, a number of bottlenecks that need to be widened before the full potential of this new green revolution can be realized. These bottlenecks relate to criteria 2, 3, 6 and especially 7 of the Montreal process. We will discuss these under five headings:

1. *terminology* issues linked to the legal status of land, restricting *access to land* or the right to plant and benefit from trees (SFM Criterion 7),
2. access to *planting material of good quality* and proven suitability for the site (SFM Criterion 2),
3. management skill and know-how to produce *tree products* of the qualities recognized and appreciated in *markets* for tree products (SFM Criterion 2 and 6),
4. *overregulation* of access to markets for farmer grown timber (SFM Criterion 7), *lack of reward mechanisms* for environmental services provided on farm (SFM Criterion 3, 6 and 7).

Bottleneck 1. Terminology, consequences for legal status and land tenure for small holders

The word ‘tree plantations’ to the general public combines the generally positive word ‘tree’ in association with the word ‘plantations’. The use of the word ‘plantation’ often has an emotional loading depending on the audience.

When we accept a (growing) need for agricultural and tree-based production systems (‘food and fibre’) as well as for the environmental service functions generally associated with ‘forest’, we can still acknowledge a wide spectrum of landscape level configurations that potentially meet these demands (Fig. 2). These configurations can be ranked on a ‘segregate’ versus ‘integrate’ axis, with multifunctionality of patch-level land cover increasing towards the ‘integrate’ side. The term *agroforestry* has generally been associated with concepts of multifunctionality (at tree, field, farm and/or landscape level), and as such it has transition zones towards food-crop base agriculture, intensive tree crop production systems, extensively managed tree plantations and natural forest.



Discussions on ‘forest functions’ tend to be qualitative (categorical) rather than based on measurable quantities. The concepts of ‘forest’ underlying the Kyoto protocols terminology of deforestation, afforestation and reforestation have been a major cause of confusion and debate. If the objective is increased storage of carbon in vegetation and soils, a terminology that is more directly linked to actual C stocks (and thus needed more than the two classes ‘forest’ and ‘non-forest’) would have directly qualified ‘agroforestry’ for carbon credits without much discussion. Parallel to the Kyoto protocol discussion on ‘what is a forest?’, the definition used by FAO in its global forest resource assessment (Box 3) is equally arbitrary in its exclusion of trees planted in the context of agroforestry.

Box 3. Current forest plantation definitions are an artificial mix of ‘observables’, presumed intentions of the managers, and legal status of land

In the definition of ‘forest’ from the Global Forest Resource Assessment 2000 (FAO 2001) (*our emphasis*), “forest includes natural forests and forest plantations. It is used to refer to land with a *tree canopy cover* of more than 10 percent and area of more than 0.5 ha. Forests are determined both by the *presence* of trees and the *absence* of other predominant land uses. The trees should be able to reach a minimum height of 5 m. Young stands that have not yet but are expected to reach a crown density of 10 percent and tree height of 5 m are *included* under forest, as are *temporarily unstocked* areas. The term includes forests used for *purposes* of production, protection, multiple-use or conservation (i.e. forest in national parks, nature reserves and other protected areas), as well as *forest stands on agricultural lands* (e.g. windbreaks and shelterbelts of trees with a width of more than 20 m), and rubberwood plantations and cork oak stands. The term specifically excludes stands of trees established primarily for agricultural production, for example fruit tree plantations. It also excludes trees planted in agroforestry systems.”

Comments:

The current set is a mix of:

Legal criteria -- everything that the State claims to be forest land, regardless of tree cover (‘temporarily unstocked’),

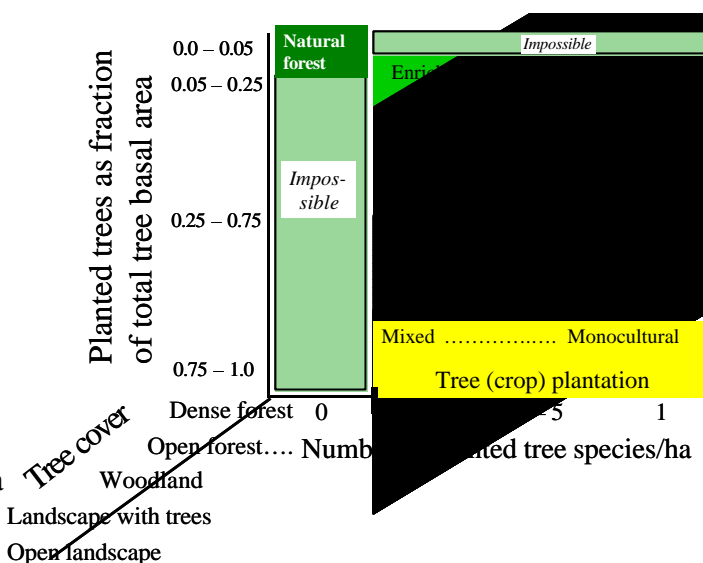
Intentions of the planter -- planting rubber trees for timber makes it into a ‘forest’, if the planter also or mainly expects to be able to tap latex, these same stands are not included,

Management plans -- temporarily unstocked areas can still be called forest as long as a forester has plans to replant...,

Definitions of a tree based on a plant height (which does not exclude bamboo, and with a little stretch, could include perennials such as cassava or sugarcane...)

The definition ‘also *excludes trees planted in agroforestry systems*’ for reasons unspecified.

Figure 3. In the continuum of landscapes with varying degree of human tree management, we can distinguish three main dimensions: the total tree cover (as observable in remote sensing), the ratio of natural regenerated and planted trees, and the number of tree species planted. In between three generally recognized entities ('natural forest', 'monocultural tree plantation' and 'agriculture'), a wide range of other combinations exists, for which the generic name 'agroforestry' is used; closed canopy forms of vegetation with a mix of planted and spontaneously established trees can be indicated as 'agroforest'



Agroforestry research has since long tried to predict where 'pure crop + pure tree' systems are to be preferred over mixed ones. Situations where the mixed systems outperform the monocultures can generally be identified on the basis of complementarity in the use of labour and other farm-level resources, in the use of space (light capture), belowground resources by differences in root distribution or phenology. Apart from these farm productivity considerations, however, existing *land use classifications* do not allow for forms intermediate between 'forest' and 'agriculture'. As there is no general consensus on operational definitions for 'forest', 'plantations' (or even 'tree'....), we propose to start by distinguishing 'natural forest' as having no (or only a few) planted trees, plantations as being dominated by planted trees and often consisting of only one or a few planted species, and agriculture as land without trees (Box 4). In between these classes there are many combinations of tree cover, fraction of trees that has been planted and species richness of the planted tree combination, that all can fall under our concept of 'agroforestry'.

Box 4. A consistent and operational terminology for landscapes can be based on total tree cover, number of planted tree species and fraction of tree basal area that is planted (as opposed to naturally established), as follows:

1) Fraction of tree cover (maximum during the year)		
>0.9	Closed forest	
0.75-0.9	Open forest	
0.5 – 0.75	Woodland	
0.25 – 0.50	Savannah	
0.05 – 0.25	Landscape with trees	
0 – 0.05	Open landscape	
2) Number of planted tree species		
0	Natural forest	
1	Monoculture	
2-5	Mixed	
>5	Polyculture	
		3) Planted trees as fraction of total tree basal area
		0-0.05
		0.05-0.25
		0.25 – 0.75
		0.75 – 1

Labels for tree cover: 0: Open landscape, 0.25: Landscape with trees, 0.5: Woodland, 0.75: Open forest, 1: Dense forest.

The term 'forest' has meanings far beyond the presence or absence of trees, and often refers to the legal status of land, an implicit or automatic claim of ownership or full control by the

state, or a domain where specific land use rights exist. This applies to the tropics as well as to the temperate zone, and is related to various schemes to regulate agricultural production.

Because agroforestry is intermediate between agriculture and forestry, it often faces challenges with this sector-based (and sector-biased) regulatory framework. This is not restricted to Asia. In Europe until recently experiments with new forms of agroforestry were prohibited because they created land use forms not covered by existing regulations (Lawson et al., 2003). In the USA discussion between 'forest service' and 'natural resource conservation service' over the boundaries of their domain focus on 10 versus 25% tree cover (<http://www.pwrc.usgs.gov/brd/DefComments.htm>).

In Indonesia the sectoral divide between forestry and agriculture is particularly pronounced. The Indonesian constitution places the control (not ownership) of natural resources in the hands of the State and states that these must be managed for the benefit of the Indonesian people. Authority for the establishment of a permanent forest estate is given to the Ministry of Forestry and seventy percent of the archipelago's land base (114 million hectare) is regulated by forestry and restricted for forest protection, rehabilitation or production. Delineation is to be carried out with the participation of local government and local people and the final stage of gazettement is a legal step taken by the Minister of Forestry. The result is a regulatory framework that inhibits community agroforestry in large areas. In fact, however, only 10% of the State Forest has completed the process of gazettement, and the legal basis of the designation as state forestland of the remaining area can be (and is) contested. Considerable parts of Indonesia's closed canopy forest are actually agroforests planted by local people. Such agroforests provide approximately 70% of the total amount of rubber produced in the country (on about 2.5 M ha of land), at least 80% of the damar resin, roughly 80 to 90 % of the various marketed fruits as well as important quantities of export tree crops such as cinnamon, clove, nutmeg, coffee and candle nut (Michon and de Foresta, 1995). In Sumatra alone, about 4 million hectares have been converted by local people into various kinds of agroforests (Michon and Bompard, 1987). According to the forestry regulatory framework, these land use systems are illegal within the State Forest since they are considered agricultural activities. Cases of forced evictions and the destruction of these agroforestry systems by forestry officials (with assistance from the military) are well documented (Fay et al., 2000). Forestry officials often justify their actions as being in defense of "forest functions" (Kusworo, 2000), without specifying what these functions are or proving that these functions are deficient in the actual land use. *Exclusion by definition* is thus the main threat to the contributions agroforestry can make to sustainable forest management, directly related to criterion 7 of the Montreal process. Improvements in this situation will require a 'negotiation support system' that is based on critical examination of claims on real environmental service function, along with recognition of the various stakeholder interests (Van Noordwijk et al., 2001b).

Bottleneck 2. Access to good planting material

Many smallholder tree production systems in Southeast Asia focus on fast-growing exotics – often timber species – for which there are reliable sources of germplasm and well-established propagation and management techniques. Currently, smallholders produce indigenous species only on a small-scale, often based on transplanting of natural regeneration. Farmer preferences for species largely depend on household needs and markets (Lawrence 1999; Yulianti and Rossetko 2002). The plantation sector has knowledge and germplasm of fast growing trees. However, farmers and the non-government organizations (NGOs) that support them have little access to quality tree germplasm or control over the tree species made available to them through government programs. Scientists or extension services generally make the decisions – screening new species in on-station trials or from available literature and evaluating them according to biophysical criteria, without considering markets (Franzel et al. 1998).

This technical constraint to agroforestry can be overcome. Farmer-designed trials (FDT) and participatory evaluation are a low-cost method to increase farmer participation in

species evaluation and agroforestry technology development process for their specific biophysical and socioeconomic conditions, as well as to enhance the effectiveness of research activities to meet farmers' needs and improve their welfare (Franzel et al. 1998).

Bottleneck 3. Producing quality products tailored to markets

Usually, smallholders start timber production systems by planting short-rotation species to meet household and local market needs. As more farmers begin producing timber, supply meets or exceeds demand and prices decline. At this point lead farmers either stop or diversify into long-rotation, premium-quality timbers. However, the dynamics of tree product supply, market demand, and marketing channels at the smallholder level are poorly understood by farmers and researchers alike.

Areas such as Gunung Kidul (Yogyakarta, Central Java, Indonesia) were heavily deforested in 1930's and at the bottom of the 'inverse J' (Fig. 1) till the 1960's. Then a market-oriented land rehabilitation process started where the state forestry company (Perum Perhutani) established Teak (*Tectona grandis*) and mahogany (*Swietenia macrophylla*), and smallholders focused on *Paraserianthes falcataria*. A recent study showed that 74% of the trees on smallholder farms are teak and mahogany; 22% are short-rotation timber species; the remainder are fruit, spice and MPTS species (Hariri et al., 2002). In 1998, in North Lampung 80% of homegarden trees were fruit, vegetable, medicinal and MPTS species; 14% were planted short-rotation timber; 4% natural regeneration and 2% planted premium quality timber species (Roshetko et al. 2002a). Currently farmer interest in timber farming is increasing in response to access to better quality germplasm (species, provenances, clones and seed source) and increasing market demand. These farmers can maximize profitability by processing fast-growing timber species (*Paraserianthes falcataria*) trees into boards or planks, but premium quality species (*Tectona grandis*) are better sold to producers as standing trees. Unfortunately, some farmers process high-value trees into low-quality planks in an unsuccessful attempt to gain higher profits. Other smallholders sell fast-growing timber as standing trees, similar to what small-scale timber producers in Sweden, Finland or Australia do. Most often smallholder farmers serve only as the producers of raw materials. Market agents perform the important roles of linking farmers to processors and manufacturers who transform the raw materials (commodities) into finished goods. (products or services). Local and regional dealers serve very important roles – collecting, sorting, grading and transporting raw materials. One of the largest risks reported by middlemen is unreliable quality and quantity of smallholder products. This uncertainty, plus the time and expense required to interact with numerous smallholder, are usually cited as the reason dealers pay low rates to individual farmers. The absence of price incentives

Box 5. East Kalimantan (Indonesia): not yet ready for farmer-grown trees

North Lampung (Sumatra) and areas in East Kalimantan, both in Indonesia, have similar topography, soils and climate, but are in a different phase of the inverse J of Figure 1. Former transmigration villages in both areas have similar land holdings per household, and in both most of the land surrounding the village is covered by *Imperata cylindrica* grasslands of low use, perpetuated by fire. In North Lampung farmers are keenly interested in planting trees on their farm, to make a transition to either labour-intensive rubber, oil palm or fruit tree stands, or to relatively extensive timber-based production systems (depending on the household level labour resources). In East Kalimantan, research by Murniati (2002) showed that technically a transition to tree-based production is feasible, but the 'opportunity costs of labour' are too high. Villagers can still easily earn income in legal and illegal logging, or make new clearings in logged 'production forest' lands. By reference to figure 1 we can conclude that this landscape has not degraded sufficiently to start the rehabilitation process.... Where the local market is still 'flooded' by timber derived from natural forest, the prospects for farmer-grown timber are poor.

at farmer level for higher quality products, however, maintains the status quo on quality.

This constraint on the contribution of agroforestry to sustainable forest management can be overcome, if public domain information access on market conditions improves. By understanding market linkages and interactions, it should be possible, at relatively low cost, to improve smallholder farmers' livelihoods by focusing their agroforestry production towards market opportunities (Roshetko and Yuliyanti, 2002).

Bottleneck 4. Overregulation of access to markets

Many national policies that are intended to conserve and protect natural resources discourage the cultivation – and thus conservation – of indigenous species by restricting their utilization or trade. Selective deregulation of trade in agroforestry timber species is an attractive policy option (Tomich and Lewis, 2001b; Box 6) that can stimulate equitable economic growth while protecting the environment.

Partly in response to market regulation, industrial timber plantation schemes, especially those linked to a pulp and paper processing plant, often develop 'outgrower' schemes, that lead to a vertical integration of production and processing, providing credit for the initial investment, linked to an obligation to sell to the factory. A recent overview (Mayers and Vermeulen, 2002) of the experience with company-community forestry partnerships, shows that farmers appear to be best off where the credit requirements for tree planting and tending are evaluated on financial viability criteria and de-coupled from the obligation to sell to a specific processor. Getting the dynamics of decision-making efficient, equitable and sustainable in 'community- forestry partnerships' is not easy but examples exist where it has been achieved.

Bottleneck 5. Lack of rewards for environmental services

Trees in a landscape, across the whole spectrum from natural forest to intensively managed plantations, can have positive environmental effects or 'provide environmental services'. In the absence of a 'reward structure', the presence or absence of these services is left to decision makers to whom off-farm benefits and costs are 'externalities'. Development of efficient and effective reward structures for environmental services, is thus an important way to achieve environment *plus*

Box 6. Deregulating agroforestry timber to fight poverty and protect the environment

Tomich and Lewis (2001b) stated in their ASB (Alternatives to Slash and Burn) Policy brief: “Policymakers in the humid tropics often justify export bans, taxes, marketing regulations and other controls on the timber trade in order to protect natural forests. ... In the absence of effective mechanisms for policing forest areas earmarked for conservation, restrictions on the tropical timber trade are seen as the next best way to curb illegal logging. While they may prevent some deforestation, these restrictions are nevertheless imperfect instruments. Loggers often can evade them, cutting trees and selling timber illegally. Where the value of the timber is high enough, civil service employees are underpaid and public control imperfect, the regulations may simply add to the ‘transaction costs’. Alternatively, wood is simply wasted, left unharvested when trees fall naturally or burned when forest is felled for conversion to plantations or ranches. Worse still, the policy measures aimed at protecting natural forest also are applied to agroforestry systems that are managed sustainably by small-scale farmers. The unintended result of treating all timber alike--regardless of its origin in forests or on farms--is that smallholders who plant and tend trees are unfairly penalised. They are effectively denied the opportunity to produce timber, a product that could provide them with a much-needed source of income.

“The ASB team in Indonesia identified three kinds of barrier to trade in agroforestry timber. First are **export taxes and quotas**: intended to promote domestic wood processing, these drive down the domestic price of timber and hence, in the case of agroforestry species, reduce the incomes of smallholders. Second are **royalties**, which in theory are applicable only to products from natural forests but in practice are applied to agroforestry products as well because of confusion about the products’ origin. Third are **complex bureaucratic procedures** that smallholders and local traders must follow before they can harvest or market timber and other agroforestry products. Similar barriers to trade are at work in many other countries in the humid tropics. As a result, farmers are discouraged from planting trees.”

development goals (Landell-Mills and Porras, 2002; Murdiyarso et al., 2002; Tomich et al., 1998, 2001a)).

In current discussions on terrestrial carbon storage in the context of the Kyoto protocol and similar efforts to slow down the increase in atmospheric CO₂ concentrations, the focus has been on reforestation with specific efforts for lands not ‘forested’ in 1990. For mechanisms such as these it is an important issue whether or not ‘agroforestry’ can qualify under the formal definitions – even though existing data show a considerable potential for increasing the ‘time averaged carbon stock’ of land managed by farmers, through an array of agroforestry practices (Palm et al. 1999, Roshetko et al., 2002b; Hairiah et al., 2002; Tomich et al., 2002; van Noordwijk et al., 1998a,c, 2003). Apart from the lack of recognition, however, current mechanisms will provide such an administrative burden that it is likely that ‘transaction costs’ will form most (if not all) of what buyers of certified carbon credits pay, with little (if anything) ending up in farmers’ pockets.

The relation between trees and water continues to be subject to confusion in the public debate, but the fact that young tree plantations, especially of evergreen species tend to use more water than established, deciduous forests or agricultural (non-irrigated) lands has gained attention in the form of the *Eucalyptus* debate. While there is no reason to single out *Eucalyptus* species in this regard, the high water use of fast growing, evergreen trees can be a concern in areas with a shortage of groundwater or subsurface flows of water. In other areas such interception of subsurface flows can be seen as the basis of an ‘environmental service

function', where it prevents salt movement in groundwater flows. 'Environmental service' perceptions will thus depend on the local agro-ecosystem, and should be left to local governance structures to decide.

In combination with bottleneck 1, the lack of institutional mechanisms for rewarding for 'sustainability' and 'forest functions' makes that sustainability criterion 7 of the Montreal process indicates the largest challenge for agroforestry. This constraint, however, might be overcome at relatively low cost through policy changes, once a broader awareness is raised of the opportunities that are currently missed.

Concluding remarks: widening all bottlenecks in the conduit to sustainability

As indicated in Figure 2, the need for forest and agricultural products as well as forest functions can be met by various combinations of natural forest, extensively and intensively managed forest plantations, intensively managed agriculture and multifunctional mosaics and patchworks generally associated with agroforestry. There is no *a priori* reason to exclude any of these options from the public debate. The smallholder agroforestry option may have been neglected so far, and remains absent from most statistics and global conventions, but in placing that on the 'mental map' we argue that balanced attention is needed, not special favours. In various parts of the world, current relationships between agroforestry and plantation forestry are perceived to be complementary, neutral or competitive. It may be difficult to judge at this stage how far we are removed from a 'level playing field', as the allocation of land to either large-scale plantations or smallholder agroforestry is essentially a political decision, with substantial economic implications. We suggest that an open-minded evaluation of the ability of (inter)national policy frameworks to provide productive and protective forest functions to society at large, through both plantation forestry and agroforestry, in the context of 'sustainable forest management'.

In the paper we discussed five constraints that currently may limit smallholder tree production. Three of these five are directly in the domain of national policies, and they indicate that substantial progress towards 'sustainable forest management' can be made by widening these policy-based bottlenecks, probably at low cost. Looking back at the seven criteria of the Montreal Process on Criteria and Indicators for Sustainable Forest Management (SFM), we may conclude that criterion 7 on the 'legal and institutional framework' may be the largest obstacle to recognition of agroforestry as a form of sustainable forest management. Priority should be given to the removal of artificial boundaries created in legislative and institutional contexts, that are at odds with the continuum of presence of 'planted trees' (and 'managed' trees) in the landscape. Tree farming will then emerge when and where it is appropriate, as long as society at large provides the right signals and rewards. The New Zealand example (see appendix) where a healthy farm forestry segment has evolved under current market conditions, may provide inspiration for other countries (e.g. in Europe) where a tradition for maintaining the agriculture – forestry divide persists. A provocative thought to conclude this contribution: in conditions where large-scale plantations operate with substantial government subsidies (direct or indirect, partly justified by environmental service functions), in contrast to non-existent or minimal subsidies for agroforestry, the potential to produce wood and simultaneously provide for many forest benefits and ecological services with agroforestry is placed at a disadvantage, to the detriment of society at large.

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Appendix 1. Farm forestry in New Zealand as inspiration for agroforestry elsewhere

Overall, the mood in the farm forestry community in New Zealand is very good. Farm foresters with their smaller scale plantings and significant emphasis on alternative species alongside radiata pine, seem to be viewed more favourably by most of the populace, compared with the larger companies. Radiata pine is the main species used, but a variety of other species have been successfully grown though most of the alternative species are carried by enthusiasm rather than detailed commercial analysis. However, Douglas fir and good quality cypress logs are currently selling at a substantial premium over radiata pine. The success stories of NZ farm forestry are due to a combination of factors. However, it is not all roses. There is opposition and criticism as well.

Success factors

- ❖ New Zealand farm forestry is based on radiata pine solid wood and especially clearwood from pruned logs and **not** pulpwood. Pruned log prices have remained very strong in the 1990s and typically provide 70% of net returns.
- ❖ Successful farm forestry depends on landowners giving reasonably high priority to their forest operations, and this is often not the case.
- ❖ The most successful operations are where the trees have been grown as plantations on lower productivity pastoral sites, (steeper slopes, gullies, sand dunes, etc.) which are quite common through much of the NZ hill country. However, sites do need to be accessible.
- ❖ Generally, on sites capable of carrying no more than 8-9 sheep per hectare, forestry is more profitable. At 5 sheep per hectare forestry is well ahead. There is a lot of this land, often scattered through farms.
- ❖ In a country that has had a history of severe surface soil erosion, soil conservation has been a notable gain from plantation forestry on many hill country sites. Several studies show reductions in soil erosion of around 90% on unstable slopes under closed canopy forest, compared to pasture.
- ❖ Farm foresters have done very well from harvesting plantation of no more than 1 hectare on accessible sites.
- ❖ Overall, the success of farm forestry in NZ relates closely to topography, climate, allocation of different sites to appropriate land uses, the ready availability of suitable planting stock, good infrastructure and stable land tenure systems.

Criticism and opposition

- The time delay. Landowners' attitudes vary markedly.
- The current strong market for sheep and beef cattle (Forestry has never been competitive with dairy farming).
- The major forestry corporates are struggling, for reasons largely unrelated to good farm forestry practices, but this has reduced confidence in forestry overall
- Many landowners are uncomfortable trying to take on new undertakings and human nature being what it is, poorly justified criticism is often the response.
- The strong dependence on radiata pine is perceived to be a problem and there is a need for diversification,
- Poor siting, access problems, storm damage etc. have resulted in a fair share of failures that seem to get more than their share of publicity when the mood is already dented.
- A boom in investor forestry in the 1990s with groups buying up whole farms, even groups of farms, and planting boundary to boundary radiata pine caused dislocation, community problems and blighted the reputation of forestry. The farm foresters' argument has always been that forestry should be integrated with other land uses.
- The buying and leasing of significant areas for short rotation, pulp regimes, with *Eucalyptus nitens*, especially in the far south, has caused dislocation and resentment in some local communities.
- There are serious labour shortages for silviculture and harvesting

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