Agroforests: an original agro-forestry model from smallholder farmers for environmental conservation and sustainable development

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Abstract

Agroforests are defined as complex agroforestry systems which look like and function as natural forest ecosystems, but are integrated into agricultural management systems. Their conception, their management and their economic and environmental qualities, clearly differentiate them from better known "simple" agroforestry associations as alley cropping, intercropping or hedgerow systems.

Different types of agroforests are conceived and managed by farmers over the Indonesian archipelago. Most of them evolved from shifting cultivation systems in forest areas. They appear in various forms and imply very different components from a region to another, but all exhibit the same fundamental ecological, technical and socio-economic qualities, such as soil protection, biodiversity conservation, use of simple techniques and technologies, high compatibility with local knowledge and representation systems, provision of good levels of monetary income, high returns to labour.

This paper will examine these qualities and draw conclusions on the potentials of agroforests for sustainable development of forest margins in the humid tropics. Among others, we will discuss the role of agroforests in the maintenance of site fertility and of forest biodiversity, their importance in preserving a large potential of possible economic choices for further development, and their contribution to capital accumulation processes for household development.

Agroforestry or Agroforestries?

During the last twenty years, agroforestry systems and technologies have played a more and more significant role in the definition and implementation of sustainable development of rural areas in the tropics. This role does not only imply research on modern technologies or promotion of new crops and trees associations, but also the acknowledgment of indigenous agroforestry practices as important bases for the development of these modern technologies and associations.

However, it is often inappropriate and misleading to speak of "agroforestry" in general. It is commonly acknowledged for example that agroforestry is essential for soil conservation or rehabilitation, especially in ecologically fragile areas. But does agroforestry always ensure soil conservation? not without a dense ground cover or good terracing system. Can agroforestry conserve biodiversity? in most cases, it does not conserve more than a dozen of species and crop varieties. Does agroforestry significantly reduce risks for the farmer? The answer can be yes for ecological risks, but most often no for economic risks.

It is therefore important to understand that agroforestry does not represent a uniform ensemble of systems and technologies and that the global qualities commonly attributed to agroforestry practices are not always observed. In particular, important physiognomic differences may induce totally different ecological as well as economic qualities from an agroforestry system to another, and require totally different scientific or experimental approaches for research and development.

Based on more than ten years of agroforestry research in Southeast Asia, particularly Indonesia, we tried to elaborate on an important dichotomy in the vast realm of agroforestry systems and practices. Namely, the distinction between "simple" and "complex" agroforestry systems.

Simple agroforestry systems, and agroforests

Simple agroforestry systems represent associations of a small number of components, usually no more than five tree species and an annual species (paddy, maize, vegetables, forage herbs) or a treelet (bananas, cocoa, coffee). These simple associations most often concern the "agro-" facet of agroforestry, and the best-documented form of "simple" agroforestry is alley-cropping. A famous simple agroforestry systems also concerns forestry, more precisely silviculture: the taungya system for the establishment of forest plantations. These simple agroforestry associations represent what can be called the "classical" agroforestry model as it is the most favoured in research and development program of most institutions dealing with agroforestry (see for example Nair, 1989).

In complex agroforestry systems, a high number of components (trees as well as treelets, liana, herbs) are intimately associated, and the physiognomy as well as functioning of such systems are close to those observed for natural forest ecosystems, either primary or secondary forests. Because of the dominance of tree components, of high plant diversity and of forest-like structure and functioning, these complex systems, that we define as "agro-forests", seem to concern more forestry scientists than agriculturists. However, they are not at all alien to tropical agriculture practitioners: agroforests characterize many peasant agriculture in the humid tropics.

In Indonesia, agroforests can be characterized as true gardens established after total removal of the original vegetation, through plantation of desired species. In Java, where less than 15% of primary forest is left and population densities in rural areas can reach more than 1000 persons/km2, 20% of agricultural land is occupied by impressive models of home gardens -the Javanese "pekarangan", associated to irrigated rice culture- in which plant diversity is fairly high. "Pekarangan" have been well-documented and are perfectly accepted as highly valuable models of agroforestry for small holders (Soemarwoto and Soemarwoto 1985; Soemarwoto 1987; Karyono 1990). But most complex agroforestry systems in Indonesia, which are not home gardens but far more extended gardens, have been conceived outside Java, sometimes for hundreds of years (Sevin, 1983; Torquebiau 1984; Weinstock, 1984; Bompard, 1986; Michon et al. 1986; Mary and Michon 1987; Colfer et al., 1988; Sardjono, 1988; Seibert, 1990; Gouyon et al, 1993; Dove, 1993; Momberg, 1993; Salafsky, 1993; Sundawati, 1993; de Jong, 1994). Most of them have been developed from shifting cultivation systems, with slash and burn practices associated to a taungya-like scheme for tree plantation establishment. Developed with either fruit species, local forest species providing timber and other commercial products (rattans, resins, spices) or exotic trees as rubber, these complex agroforestry systems are far from being anecdotal: their diversity, their dynamism and their importance, in terms of surface and production make them a major element of small holder agriculture in the great Outer Islands.

In the hills and lowlands of eastern Sumatra or Kalimantan where the last tracks of mixed dipterocarp forest are being exploited and rapidly converted, small holder "jungle rubber" agroforests in which rubber trees are associated with numerous tree species providing either fruits or timber, cover an estimated area of 2.5 million hectares, complementing either irrigated or dry rice cultivation. In the south of Sumatra, Damar agroforests based on a Dipterocarp tree exploited for its resin have been developed by villagers for more than 100 years. The illipe nut gardens of West and Central Kalimantan are also examples of complex agroforestry systems integrating Dipterocarps. In West and South Kalimantan, farmers have established rattan plantation in an agroforest pattern. In West and North Sumatra, various types of complex agroforestry systems associate, under a canopy of durian or kemiri trees, numerous fruit species as well as economic spices (cinnamon, nutmeg, clove) and timber species. In East Kalimantan, much diversified fruit forests have developed ("lembo") which seem to be among the richest systems as far as tree species are concerned.

This distinction between simple and complex agroforestry systems is not only academic, but also actually appears in present research and development program. National and international institutions dealing with agroforestry research and extension most often only recognize simple agroforestry systems as true agroforestry. Most agroforestry projects concentrate on simple associations with quick fuel producing, soil stabilizing or nitrogen fixing tree species either for diversification of plantation agriculture or for reforestation and rehabilitation projects. In Southeast Asia, except for the home garden system in Java, complex agroforestry systems are being much ignored and poorly investigated.

Existing agroforests constitute indigenous examples that, because of a high degree of local particularities, are usually not transferable nor commendable as such to other regions or other countries. However, they exhibit major technical, ecological and economic qualities which are of utmost interest in the framework of sustainable development, and that are quite different from those commonly acknowledged for simple agroforestry combinations. Among others, simplicity of establishment and maintenance techniques and strategies, fixation of shifting cultivation, conservation of plant and animal biodiversity, protection of soils, economic profitability, diversity and flexibility. Because of these qualities, agroforests represent a major model for an original agroforestry component for sustainable forms of rural development, integrating agriculture and/or forestry, and which could combine profitable economic results and long-term conservation of both soil fertility and global biodiversity, specially in areas where annual food cropping of staples is only possible with very heavy applications of fertilizers and where only perennial crops are capable of sustained production.

1) Is the agroforest model easily transferable? Simple techniques for managing apparent complexity

Agroforests do not require any sophisticated technology or sophisticated technical know-how: their establishment and management call on very simple techniques which all shifting cultivators in humid tropical countries have at their disposal (de Foresta and Michon, 1993).

Agroforests do not result from progressive transformation of the natural forest. They are entirely reconstructed by the farmers through shifting cultivation practices. The forest plot is cleared, then burned. Upland rice is planted together with less important food plants, and the trees which will later form the skeleton of the agroforest. The seedlings can be produced in nurseries or collected from old plantations. After the last rice harvest, the plot is abandoned and the trees continue developing together with natural vegetation. The period during which the plot is abandoned is a phase of intense competition between the planted trees and the pioneer vegetation. To mitigate the effects of this competition, trees are often planted at high density.

The intercalation of semi-perennial commercial cultures (coffee, pepper in Sumatra) may also help to considerably reinforce the competitive advantage of the planted trees over natural regrowth, by protecting the environment of planted trees and delaying the colonization of pioneer vegetation. When the planted trees begin to be productive, the plot is weeded, but useful spontaneous species are often preserved. Then, maintenance is often reduced to the minimum, the essential consideration for the peasant being to ensure easy access to the agroforest products. Agroforest trees are reproduced by two main methods: regeneration plant by plant, and mass regeneration. In the former process, regeneration is principally induced by natural phenomena, and human intervention is usually limited to anticipating damage to the tree cover and controlling vegetation in canopy gaps (Michon, 1985) with particular attention being given to the development of naturally established or planted seedlings and saplings. Mass regeneration is frequently used for some types of agroforests (rubber, rattan): in the case of "jungle rubber", the old agroforest (40 to 50 years) is clear cut, burned, and planted with rice and rubber to form a new cycle of productive agroforest (Gouyon et al., 1993). This latter mode of regeneration is often combined with plant to plant regeneration, so that the farmers can afford to wait longer before felling and replanting thanks to the existence of significant natural regeneration which rejuvenates the stand of useful trees.

2) Agroforests and ecological sustainability in development: a tree plantation which allows biodiversity conservation

This minimal maintenance favours the development of a significant spontaneous component which gives the agroforest its forest-like structure. And this constitutes the basis of one of the main originalities of agroforests in the wide range of agroforestry combinations: agroforests are the only known form of agroforestry which have the potential to restore and sustainably conserve a large part of the original forest biodiversity. In terms of biological structures and diversity, most of the other agroforestry combinations are closer to a cassava field than to a natural forest.

It is important to understand that agroforests are not specifically conceived by farmers to allow biodiversity conservation: biodiversity restoration in agroforests results mainly from unintentional processes. But, whatever the conception, the main economic role or the geographical location of existing agroforests, the same conclusion remains: agroforest structure and management strategy allows to "capture" and "fix" plant and animal biodiversity. In fact, biodiversity in agroforests results from two types of dynamics. The first one derives from the plantation of useful tree species -which recreates the skeleton of a forest system and acts as a catalyst for further biodiversity installation: in the agricultural lands, newly established agroforest structures create suitable environment and convenient niches for the establishment of forest plant species carried from the neighboring forests through natural dispersion, and offers shelter and feed to forest animals. As spontaneous vegetation and fauna starts establishing, the original structure diversifies, which enhances further establishment of diversified flora and fauna as in any silvigenetic process. In this natural enrichment process, man merely selects among the possible options given by ecological processes (selecting and/or introducing economic trees and protecting their development) thus favouring resources, but non-resources are also establishing and reproducing as far as they are not considered as "weeds" by farmers. And after several decades of such a balance between free functioning and integrated management, the global biodiversity levels are fairly high and reconstitute the true forest aspect of the agroforest. (Apart from major species, either cultivated or selected and protected, which form the frame of the agroforest, the spontaneous component of an agroforest may represents up to 50% of the tree stand alone, not taking into account liana, epiphyte and undergrowth species. Agroforests often shelter several tens of commonly managed tree species, but also several hundreds additional species, spontaneously established and often used. (Michon and Bompard 1987; Michon and de Foresta 1992; Michon and de Foresta 1995)). The closest the agroforest is to a natural forest -a source of seeds and a home for animals-, the faster the process will be. Therefore, agroforests established along forest margins are more likely to hold high biodiversity levels than those established in degraded areas. But even in the middle of true agricultural lands, agroforests may exhibit fairly high levels of biodiversity. Home gardens in the island of Java, where natural forest has restricted to the tops of volcanoes, shelter hundreds of plant species, either purposefully planted or spontaneously regenerating, as well as some interesting mammals and bird species.

Biodiversity restoration in agroforests is not only essential from the mere point of view of conservation. Of course, agroforest development restores plants and animals that otherwise would not have been conserved purposefully by the villagers because they do not appear as important economic resources. But they also allow to restore biological and ecological processes which are crucial in the functioning of the agroforest as an ecosystem. Those components which are not economic -or potentially economic- resources are not neutral, as they determine processes which themselves determine the overall survival of the agroforest. Agroforests allow to conserve biodiversity, but biodiversity is the warrant of agroforest production and reproducibility. Non-edible fruit trees in the agroforest help supporting populations of fruit-eating birds, squirrels and bats, which are essential natural pollinators - indispensable agents of economic production - and dispersers of economic fruit species - important auxiliaries of global reproduction.

It is important to acknowledge here that agroforests represent one of the most meaningful and still successful contribution of tropical farmers, specially shifting cultivators, to conservation of the world's natural heritage. Those farmers who are commonly identified as the first threat for tropical rain forests at the world's scale have actually succeeded in establishing and maintaining over decades sophisticated forest-like production units, which take-over the traditional roles (ecological as well as economic) of the natural forests they have cleared through shifting cultivation while providing advantages of commercial agriculture. Agroforests are far from answering all the problems linked to reinforcement of peasant pressure on forest ecosystems and resources. And in no way could they replace protected reserves of natural forest. But in areas where natural forests, submitted to all kinds of pressures, scope of which largely exceeds village scales, are doomed to destruction, or where forest degradation has already proceeded beyond acceptable limits, agroforests can contribute to maintain or restore in the landscape a useful and diversified forest ecosystem from which peasant is not excluded.

3) Agroforests and economic sustainability in development: facilitating the transition towards fixed agriculture while maintaining economic options opened.

In the "classical" model of agroforest development in Indonesia, the temporary fields of shifting agriculture, which could formerly be cultivated for food crops after a fallow period, are now planted with tree species. Agroforest development represents a true process of intensification of production systems. The commercial importance of planted trees prevent any re-use of the fields in the short term, thus removing them from the realm of shifting cultivation cycle.

Given the increasing demographic pressure that characterizes most of the humid tropical regions at present, the ecological advantages of such a rupture of the traditional cultivation/fallow cycle in favour of agroforests are obvious: the switch towards permanent tree culture prevents the vicious cycle of shortening of fallow periods/reduction of site fertility. The economic advantages are by no means less important: the benefits for the farmer himself are obvious. Commercial production is the major economic function of these systems: agroforests usually provide between 50 and 80% of total agricultural income of villagers (Mary et al., 1987; Gouyon et al., 1993; Levang, 1993). But the diversity of income sources, as well as secondary productions which meet subsistence needs, are an essential asset in the economic security and welfare of villagers.

Agroforest income allows to cover both every-day expenses, with regularly harvestable products as rubber latex, resin, coffee, cinnamon bark...), as well as annual expenses, with seasonal products as fresh fruits, clove, nutmeg. Other commodities, as timber, which provide occasional, but important sums of cash money, serve as money savings for exceptional expenses. Agroforests also provide complementary food (fruits, vegetable, spices) as well as all common material used in villages (construction wood, firewood, thatching and basketry material). At a regional level, as can be seen in Sumatra, agroforest based farming systems can accommodate far much higher population densities than shifting cultivation, the rural populations taking full responsibility for the sustainable management of their land; last but not least, without loosing control over their own development, communities are integrated into the wider economy and contribute to regional and national development, through the medium of commercial productions. In Sumatra, for instance, the land covered with agroforests, could be estimated in the mid 1980s to at least 3.5 million hectares (Vegetation Map of Sumatra, ICITV-BIOTROP), or about 50% of permanently cultivated land. Whereas in most mapped areas, populations densities reach 100 people per km2, if that land was still locked in the present short-cycled shifting cultivation, would it not be today in a serious state of degradation? And what would be the social and economic consequences of such a degradation? We may well ask, as we may wonder whether the state of today's degraded humid tropical land would be better, along with the social and economic conditions of the people living on this land, if large parts of it was covered with agroforests...

Lastly, unlike any other process of agricultural intensification, agroforests do not represent an irreversible specialization process. They allow to keep ecological site potentials as well as economic options opened for the future. Agroforests shelter potential economic resources which could be developed if the main economic crop fails, new economic tree crops can easily be integrated without disrupting the overall structure of the production system. Agroforests can also provide or even generate valuable inputs -material, fertilizers, genetic resources, capital- for further mutation if needed. This "reversibility" of the conversion process is essential where one of the main concerns of farmers is to reduce risks of any kinds.

Those people who developed agroforests in Sumatra and Kalimantan were shifting cultivators. But they are not anymore, and agroforests were the key of their success on their way to permanent agriculture. This is in fact a very crucial point, because it means that the agroforest pathway should be considered as one of the most suitable way to ensure a successful transition between shifting cultivation and a sustainable and profitable fixed agriculture.

4) Agroforests and economic sustainability in development: an evolution from shifting cultivation which allows capitalization

Classical shifting cultivation systems, in spite of fairly good levels of labour productivity, do not allow to produce significant surpluses. Investments involved in field preparation -mainly family labour inputs- are mostly converted in food production for yearly subsistence, but cannot usually be capitalized: as the field is abandoned, the labour investment is "lost" as the next opening will involve the same amount of labour as the former cycle. Wealth in strict shifting cultivation systems cannot be generated through agriculture, but, and this is a point to be stressed, the organization of the shifting cultivation cycle allows farmers to carry out other types of income-generating activities during the periods of food crop maturation or after the harvest, such as gathering of commercial forest products. Planting trees in the swidden constitutes the best way to increase returns on initial labour investment with minimal additional inputs. The only further investment involved is time, and, indirectly, land, as the tree plantation immobilizes the field for an unproductive period sometimes exceeding traditional fallow length. Tree production will sooner or later generate goods for consumption and sale, and very often surpluses. Trees also represent standing capital, as mentioned above, and constitute the basis of a family or lineage patrimony. This clearly represents a process of wealth accumulation which opens new options for further development, in or outside agriculture. In the same time, this process, as it constantly minimizes labour inputs, still allows extra-agricultural activities for income generation if needed. "Traditional shifting cultivators" in Indonesia are far from the miserable image of remote populations close to starvation in bad years. Many of them are much more well-off than most of the settled farmers in Java rice-producing areas. Most of them have permanent and spacious housing, sometimes good material equipment -motorcycles, television, more recently satellite dishes...- and sometimes also a bank account. And very often, this can be related to agroforest development. Agroforest farmers have clearly devised an original and efficient pathway for "intensification" which should be more seriously taken into consideration by development planners.

Conclusion

Agroforest does not constitute THE model for sustainable development, but just one of the components for such a development. Indigenous agroforests never occur in isolation in native production systems: they can be associated to permanent food production systems, shifting cultivation practices, specialized plantation practices, extra-agricultural activities...Their main quality is probably that they are highly compatible with other activities and other ecosystems.

Agroforests have an immediate role to play in the development of forest margins, either around pure conservation areas or as a complement to sustainable forest production systems. They could also be given a major role in the transition from pioneer agriculture to settled sustainable production systems in former forest areas.

But the real challenge might be the adaptation of the agroforest model, both to already degraded or heavily transformed areas and to more populated rural areas where they could open new options for further intensification. Agroforests have proven to be a good catalyst for biodiversity restoration. Could they also play a catalytic effect for welfare restoration in rural areas?

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