CHAPTER 60

CREATION AND MANAGEMENT OF RURAL AGROFORESTS IN INDONESIA: POTENTIAL APPLICATIONS IN AFRICA

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INTRODUCTION

Indonesia, like other countries in the humid tropical zone, is losing its forests, and along with them its forest food and other resources. The originality of the Indonesian situation is that, alongside the general tendency to deforestation, is a significant trend in the opposite direction. Useful forests are being reconstructed by rural farmers, using imaginative agroforestry techniques.

The objective of this chapter is to show, with the aid of examples from Indonesia, how certain agroforestry systems could help in the better management of humid tropical land and forest resources, whilst guaranteeing a high level of food security and relative economic prosperity for local populations.

After describing the structures, functions and methods of establishing and managing these agroforestry systems, we will try to draw the principal practical lessons for efforts to test and adapt agroforestry systems in other humid tropical forest regions. A brief account of the possibilities for implanting these systems in African forests is presented, based on our experience in Mayombe, Congo.

AGROFORESTRY AND AGROFORESTS

In Indonesia, agroforestry is not simply a new subject of study, but an ancient and widespread practice which marks rural landscapes everywhere. The innumerable combinations of agroforestry associations encountered, whether in Java, Sumatra or Kalimantan, can be grouped, albeit schematically, into two main groups: simple and complex agroforestry systems.

Simple systems are so called because of their low number of component species, usually a herbaceous or shrubby species associated with a tree species. They are usually associated with very high population densities – exceeding 800 people km^{-2} on Java – are very intensive and are as different from natural forest in their structure and management as is a rice-paddy.

Complex agroforestry systems contain a wide diversity of component species and closely resemble natural forest. They integrate agricultural production into a true forest ecosystem, and, in their mature phase, these systems fully deserve the name "agroforest". Although they often form small islands, concentrated round habitations in the most densely populated places (Michon, 1983, 1985; Michon and Mary, 1990), these agroforests, which today cover several million hectares, are most abundant in regions with a moderate population density – roughly 20 to 150–200 people km^{-2} – where the natural forest is still close, either in space or time.

Complex agroforestry systems are integral elements of production systems, and often represent the only source of monetary income for their farmers. Their diverse spontaneous and planted species also provide a significant part of the family's diet. This diversity also represents an insurance against risk which monoculture systems cannot provide, in case of a bad harvest, or a fall in market price of one of the products, for example.

Like the natural forest ecosystem, the Indonesian peasant agroforestry systems ensure the protection of soils and water resources. In contrast with other agricultural systems developed in these latitudes, however, they also conserve a significant proportion of biodiversity, both plant and animal.

It is these complex agroforestry systems, peasant agroforests, or forest-gardens, which will be discussed here for their twofold interest – economic and ecological. Despite important problems in certain regions, principally linked to the pressures of intensification due to high population densities, the economic success of the complex Indonesian agroforestry systems, and their ecological value, cut clean through the ocean of disastrous observations which characterize the rural zones of humid tropical forest regions, and make these systems a model of viable and sustainable development which is extremely important for these regions. This model is all the more important in that its development is due entirely to the shifting cultivators who are so often picked out as being principally responsible for shrinking the forest cover. In this example, these cultivators are shown to be expert artisans in forest reconstruction.

VARIETY OF STRUCTURE AND FUNCTION

Indonesian agroforest can resemble primary forest, admittedly with a slightly simplified structure, as is illustrated by the architectural profile of a *Shorea javanica* agroforest ("kebun damar") around Krui in southern Sumatra (Figure 60.1).

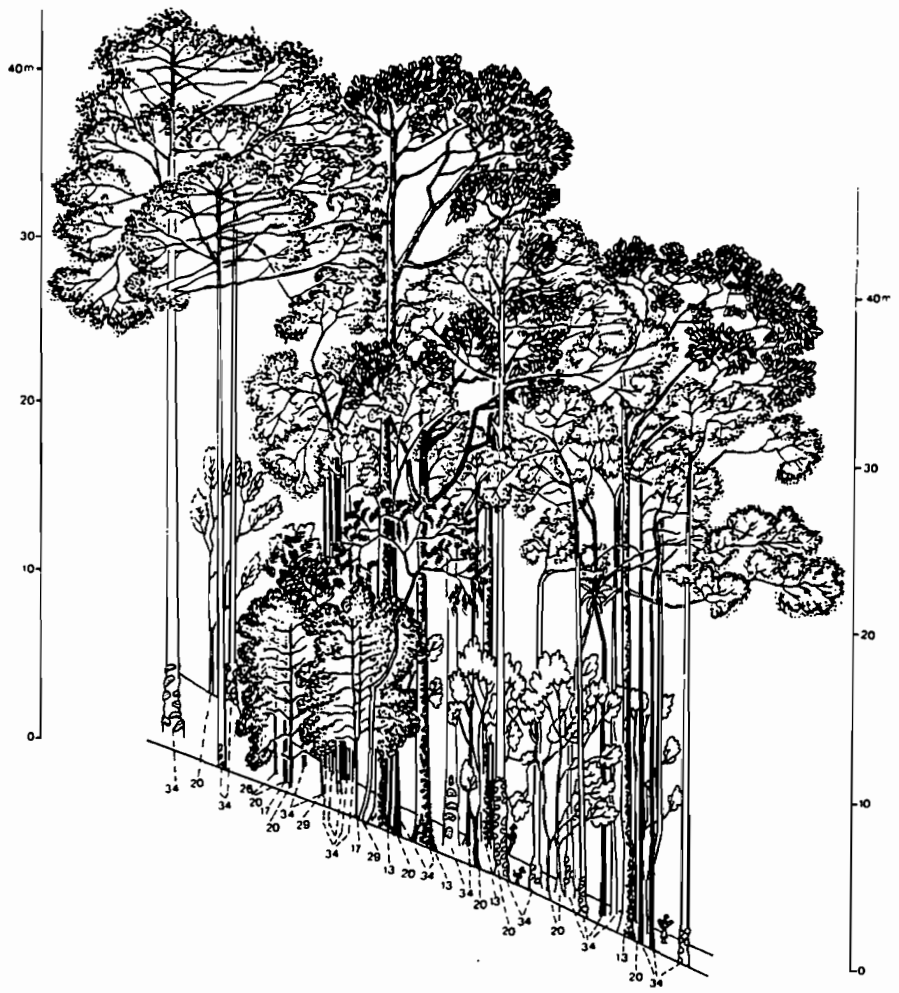

Figure 60.1 Architectural profile of a "damar" agroforest (20 x 30 m). Krui region, Lampung province, Sumatra. "Damar" trees (*Shorea javanica*, 34) are associated with fruit trees (durian, *Durio zibethinus*, 13; "langsat", *Lansium domesticum*, 20; "rambutan", *Nephelium lappaceum*, 26; "manggis", *Garcinia mangostana*, 17; and "petai", *Parkia speciosa*, 29) in an intensive plot. The canopy height and stratification of the vegetation resemble primary forest.

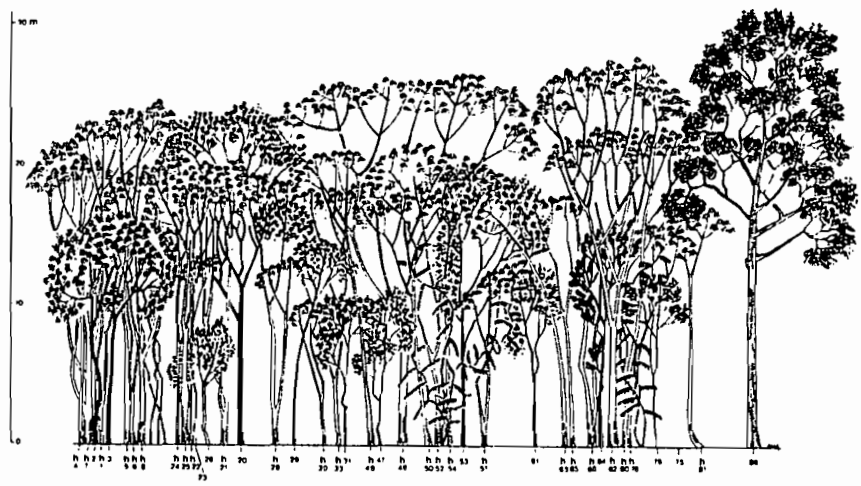

Figure 60.2 Architectural profile of a rubber agroforest (10 x 50 m). The rubber trees (h = *Hevea brasiliensis*) are clearly dominant in the canopy, where they are associated with wild trees preserved for their fruits ("rambutan", *Nephelium lappaceum*, 31, 53, 61; "cempedak", *Artocarpus integer*, 64) or for wood (*Milletia atropurpurea*, 2,3; *Lithocarpus* cf. *elegans*, 20; *Schima wallichii*, 29, 86). The dense understorey (omitted for clarity), the high density (over 750 trees ha^{-1} with d.b.h. >10 cm), the low canopy and its homogeneity make these agroforests resemble pioneer forests.

They can equally resemble secondary forest, like the rattan agroforests ("kebun rotan") in central Kalimantan (Sevin, 1983; Weinstock, 1983), or like rubber agroforests ("kebun karet") which dominate the landscapes of the eastern plains of Sumatra (Figure 60.2).

The forest structure and atmosphere of these "gardens" means that they play the same ecological roles as natural forests: protection of soils and maintenance of their fertility, protection of water resources, and conservation of a large proportion of the biological diversity of the forest, both animal and plant (Michon and Bompard, 1987; Michon and Foresta, 1990). The preliminary results of a study currently being carried out in Sumatra give an idea of the opportunities presented by agroforests for preserving biodiversity: on a transect line of 100 m in a rubber agroforest, we counted 268 species of higher plants, all belonging to the floristic set of the region's primary and secondary forests! This capacity to maintain other forest species, a unique characteristic amongst the numerous production systems in existence, should be heavily emphasized in a period when the survival of the millions of species associated with the tropical forests is threatened.

Just as the Indonesian farmers do, we have named the different types of agroforests by their principal products ("damar", "rattan", "karet"), all products destined for sale. These names underline the primary function of

these forests, to enable the people who manage them to earn an income. It is around these commercial products, which come from local or introduced species, that these forest-gardens are built and spread.

"Damar" for example, a resin produced by several species of large trees of the Dipterocarpaceae, has been the subject of commerce since ancient times. One of these species, *Shorea javanica*, was domesticated by farmers in southern Sumatra more than a century ago (Torquebiau, 1984; Michon, 1985, 1991; Mary, 1986; Mary and Michon, 1987; Michon and Jafarsidik, 1989). They were able to develop an agroforestry park, covering several thousands of hectares, where the collection of damar resin ensures a regular income to the inhabitants.

Rubber, introduced by Dutch planters at the beginning of the century, was rapidly adopted by peasant farmers in the somewhat infertile zones of eastern Sumatra (Geertz, 1966; Scholz, 1983; Booth, 1988), and the collection of latex still provides them with a regular income. The cultivation of rubber is undoubtedly at the origin of the most important agroforestry complex in economic terms: Indonesia is one of the largest world producers of rubber and more than 70% of the country's rubber exports come from hundreds of thousands of small plantations of the agroforestry type, which occupy in total more than two million hectares and provide a livelihood for some seven million people (Barlow and Muharminto, 1982; Gouyon *et al.*, 1990).

The openly economic orientation of Indonesian agroforests does not prevent them from playing a role of primary importance in providing food and other material products to rural communities. Despite an often marked specialization, the dominant crops are associated with a whole string of species whose products, used locally, ensure a higher level of self-sufficiency to the farmers. These species may be cultivated, but products come more often from the spontaneous plants in the agroforests.

This spontaneous component is an extremely important source of materials (bamboo, construction wood, various rattans and lianas, etc.) It provides a regular and inexhaustible source of firewood, and if Indonesia does not suffer a real shortage of firewood, it may be largely thanks to the abundance and the size of agroforestry systems in the country (Anonymous, 1990).

Within the spontaneous component of the agroforest, the forest food plants merit special attention. They are all qualitatively important in the villagers' diet, but their most remarkable feature is their variety.

More than 300 wild fruit species were listed as used by people in the Indonesian forest (Heyne, 1950). More than 50 have been domesticated and are cultivated, either in commercial orchard-gardens, associating durian (*Durio zibethinus*) and langsat (*Lansium domesticum*) for the international market, with more local cultivars produced for the village market as in the Palembang region of Sumatra, or, more frequently, associated with other

Figure 60.3 Architectural profile (20 x 50 m) of an agroforest producing fruit, wood and spice in the region of Lake Maninjau, West Sumatra province. The fruit trees are mainly "durian" (*Durio zibethinus*, 3,7, 11, 12, 15, 26, 32, 34, 40) which form the canopy. The median stratum is densely occupied by "bayur" (*Pterospermum javanicum*, 2, 8, 14, 22, 23, 25, 27, 31, 36, 38) cultivated for their wood for which there is a considerable regional market, while the understorey is reserved for the typically commercial species, coffee (*Coffea canephora* var. *robusta*, K), cinnamon (*Cinnamomum burmanii*, C) and nutmeg (*Myristica fragrans*, 13, 16, 20, 21).

kinds of commercial culture (Figure 60.3). But a larger number of species are found as subspontaneous species in the agroforests, which contain a variety of wild fruit trees (*Baccaurea* spp., *Mangifera* spp., *Nephelium* spp., etc.).

Similarly, of the 390 species of vegetables, herbs and spices listed by Ochse and Brink (1977), 106 are forest species, more or less maintained or cultivated, which are commonly found in the agroforests. Some are connected with the fruit trees: pods of the big Leguminosae like *Parkia speciosa,* fruits of some *Garcinia* spp., *Pangium edule* or *Aleurites moluccana* seeds, young leaves of *Mangifera,* durian flowers, bamboo shoots and palm hearts. However, most of the vegetables regularly eaten in the village come from wild species from the agroforest understorey: fern crosiers, young leaves of some Euphorbiaceae, Moraceae, and Urticaceae.

Besides their direct dietary importance, the fruit and vegetable resources of the forest-gardens are today acquiring a new dimension. In the increas-

ingly numerous regions where deforestation is advanced, the last wild representatives of several species are disappearing; in many cases, these species no longer exist except in agroforests; the "lembo" of East Kalimantan preserve several dozen fruit species and varieties that otherwise would disappear with the lowland forests (*Durio* spp., *Artocarpus* spp., *Nephelium* spp., and no less than twenty *Mangifera* spp.) with edible fruits (Bompard, 1986, 1988).

The agroforests primarily provide the farmers with an income, but the spontaneous vegetation associated with the commercial species planted also fulfills the traditional functions of the natural forest ecosystem: ecological functions, of course, but also, and of paramount importance, a subsistence economy function, as a source of gathered products on which many rural communities still heavily depend.

ESTABLISHMENT AND MANAGEMENT: FROM CULTIVATED FIELDS TO AGROFORESTS

Agroforests, or forest-gardens, which represent the mature forest phase of these complex agroforest systems, are not formed by progressive transformation of the natural forest, they are entirely reconstructed by the farmers.

Agroforests are established directly from shifting cultivation (Figures 60.4 and 60.5). The plot, which may be covered with primary forest, but which is more often occupied by secondary vegetation or old agroforests (often the case for rubber), 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, as is the case for damar (Michon, 1985) or, like rubber, be collected from old plantations (Scholz, 1983).

When the last harvest has been taken, the plot is abandoned and the trees which were planted develop amongst the natural vegetation until they become productive. The plot, which has passed through the stage of food producing field, then through a stage of pioneer vegetation, now fully enters the agroforest phase.

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, the trees are planted at high density, as for rubber (700 to 900 trees ha^{-1}).

The intercalation of semi-perennial commercial cultures, as is the case for damar agroforests, whose primary goal is to increase the profitability and the productive commercial period of the plot, also considerably reinforces the competitive advantage of the planted trees over natural regrowth, by delaying the establishment of pioneer vegetation.

Complex agroforestry systems are temporary tree/herbaceous plant associations (Nair, 1989). The phase dominated by herbaceous plants, here essentially upland rice, lasts no longer than one or two harvests. The method of establishing forest-gardens is thus far closer to "taungya" systems, but the

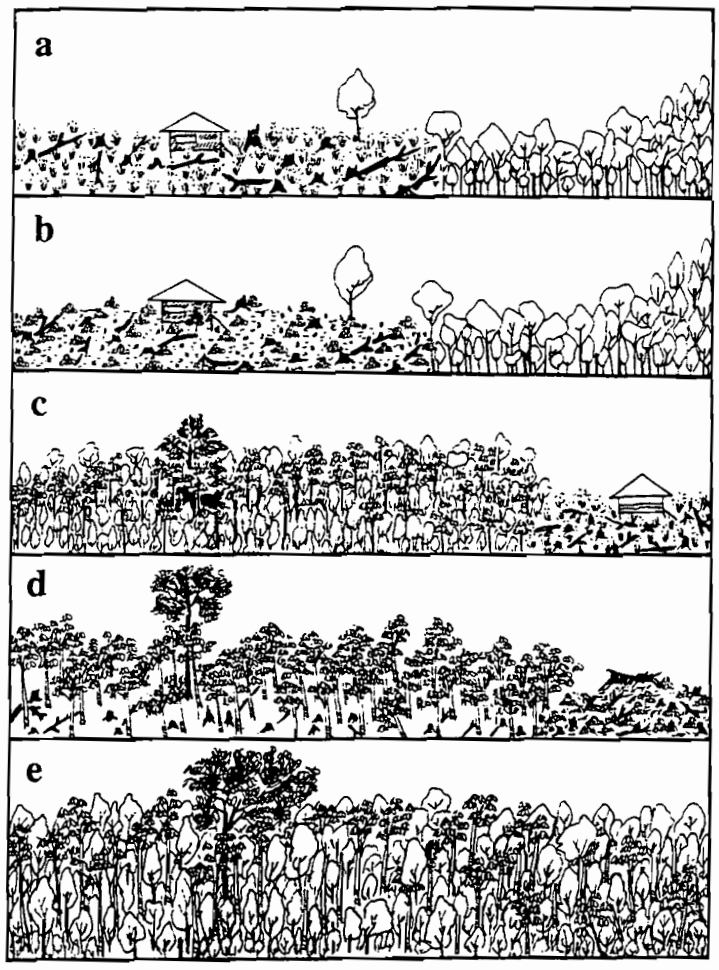

Figure 60.4 Construction of rubber agroforests. The "ladang" is usually opened in forested former fallow fields and planted with rice and rubber (a: year 1). The plot is abandoned after the last rice harvest (b: year 1–2) and the rubber develops within the pioneer vegetation (c: years 2–3 to 8–10). When the rubber trees become productive, the plot is cleared, except for useful trees (d: years 8–10); the low maintenance thereafter allows the spontaneous plants to become established, which gives these agroforests their characteristic structure (e; years 8–10 to 40–50).

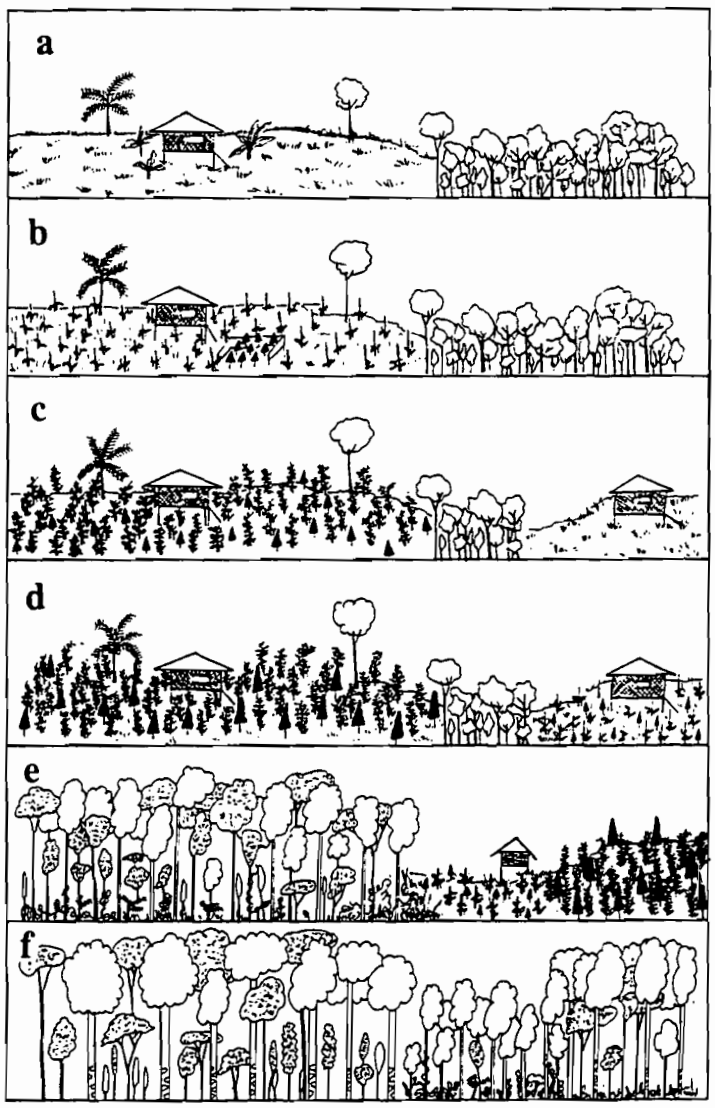

Figure 60.5 Construction of a "damar" agroforest. The "ladang" is opened on forested former fields and planted with rice and pepper (a: year 1). The "damar", after a period in the nursery while the pepper begins to produce (b: years 2–3) are planted in year 4 (c) and benefit from the care given to the pepper plants until the latter are abandoned (d: years 8–10). The "damar" develop together with the spontaneous vegetation until they enter production at 25 years (e). The mosaic of temporary fields and fallows characteristic of itinerant agriculture is now replaced by permanent forest cover, the damar agroforest (f). This illustrates the way damar agroforests were established around the villages in the Krui region towards the end of the 1940s. Since then, coffee has replaced pepper as intermediate crop and now that the old fallow fields have mostly been converted, the agroforests are expanding at the expense of primary forest.

similarity stops here, for in taungya systems, the tree phase is managed by forest services, does not include an agricultural component and is generally reserved solely for timber trees. By contrast, the tree phase of these complex agroforestry systems, which deserve unambiguously the name "agroforest", is managed by the farmers and is an intimate mixture of crops and wild plants, permanently situated on the agriculture/forestry interface.

When the trees begin to be productive, the plot is weeded, and the useful spontaneous species are often preserved. The care of the agroforest varies once it is established; it is often reduced to the minimum, the essential consideration for the peasant being to keep the paths through it clear and ensure access to the agroforest products. It is largely this minimal maintenance which favours the development of a significant spontaneous component, and which gives the agroforest its "disorganized" structure, making it resemble natural forest more than classic plantations. This spontaneous component, whose role in feeding the local populations was mentioned above, is never systematically destroyed, rather it is managed according to its usefulness or harmlessness.

Forest-gardens are reproduced by two main methods of regeneration: regeneration plant by plant, and mass regeneration. In the process of regeneration plant by plant, the development of useful species is favoured by biased selection and care for their natural regeneration, sometimes together with plantings to enrich some populations. In this case, regeneration is principally induced by natural phenomena; because they have a good knowledge of forest ecology, people put extraordinarily little work into this type of regeneration, and human intervention is usually limited to anticipating damage to the forest cover and controlling scar vegetation (Michon, 1985). Mass regeneration is frequently used for rubber agroforests: the old agroforest (40 to 50 years) constitutes the initial vegetation which will be cleared, burned, planted with rice and rubber, to form a new agroforest.

These two modes of regeneration are not exclusive; for example, the peasant farmers can afford to wait forty to fifty years before felling and replanting their rubber agroforests thanks to the existence of significant natural regeneration which means they can regularly begin tapping new trees to make up for the falling productivity of the old trees.

Other systems of regeneration are found, but their use is not widespread; this is the case, for example in the agroforests of Sumatra, where felling for regeneration is not followed by either burning, or plantation. Only a few seed trees are left standing, with the aim of allowing a homogeneous and vigorous population to become reestablished.

These methods of establishing and managing agroforests have evident economic advantages for the farmer. Relying as they do on simply directing natural forest processes and not on expensive agronomic management, they give an excellent return on work invested.

EXPORTING AGROFORESTS: INDONESIAN LESSONS

What lessons can be drawn from the complex Indonesian agroforest systems for the possible reproduction of similar systems in other humid tropical zones? Before presenting the principal conditions needed for successfully implanting agroforestry, some of positive results of transferring these systems should be underlined.

Systems of commercial production

The contribution made by local agroforests to local consumption is undoubtedly very important, fundamental even, but it is not usually the definitive aim, rather the happy consequence of a particularly profitable and minimalist management of commercial species.

Agroforests, which are so close to natural forests in their structure and function, are too often and too glibly thought of as only suitable for producing subsistence products. The examples cited above show that, on the contrary, the true incentive for the establishment and evolution of agroforests today is commercial production.

One of the remarkable characteristics of these agroforests is the management flexibility they offer in commercial production, due directly to the variety of their component species. Their management can respond very rapidly to changes in the market, principally by immediately exploiting products present in the agroforest which previously had no, or low, commercial value. The extension of the road network, for example, has brought many villages along the big rivers in Sumatra out of their isolation. The durian and langsat fruits, which have long been cultivated and produced by the local people in the village agroforests for their own consumption, have rapidly passed into commercial production.

Another example is the change in status of timber: in certain regions, with the rarefaction of exploitable natural forest, wood from agroforests, from either cultivated or spontaneous species, has acquired a new monetary value (Foresta and Michon, 1990, 1991). In the Krui region, where about twenty species are presently exploited for their wood in the "kebun damar", a genuine village forestry system has developed in the last two years: standing trees are bought by village traders, felled and cut on the spot into planks and chips which are then carried on people's backs to the village to be sold and taken to the towns by lorry. It should be emphasized that this "agroforest logging", managed from start to finish by the villagers themselves, only involves a low number of trees in each garden; the agroforest is treated as a forest whose functional equilibrium is respected through selective logging.

This example could become extremely important for the future of agroforestry and tropical timber alike. Besides the simple change of status, from subsistence production to commercialization of wood, this example shows that internal economic intensification of agroforests is possible: intensification which is not achieved with loss of biodiversity but, on the contrary, by a reinforced use of this diversity, using a product which existed before but previously had no monetary value.

An inevitable transition to fixed agriculture

For shifting cultivators, one of the fundamental consequences of the establishment of agroforests is the progressive but inevitable passage towards fixed agriculture: the temporary fields, which could formerly be cultivated after the fallow period, are now planted with perennial species. The economic value of planted trees, as well as their value as standing capital and patrinomy, prevent any reuse of the fields, thus removing them from the realm of itinerant agriculture.

Given the increasing demographic pressure which characterizes most of the humid tropical regions at present, the ecological advantages of this rupture of the traditional cultivation/fallow cycle in favour of agroforestry are evident: the degradation of soil which was suffering the impact of ever-shortening fallow periods is stopped, and permanent tree cover reestablished with its entourage of forest species. The economic advantages are no less important: the rural population takes more responsibility for the management of their land, communities are integrated into the wider economy and contribute to regional and national development, through the medium of commercial products.

In Sumatra, for example, if the land covered with agroforests, which in the mid 1980s was about 3.5 million hectares, or 60% of cultivated land, was still locked in the classic cycle of itinerant agriculture, would it not be today in a serious state of degradation? And what would be the social and economic consequences of such degradation? We may well ask, as we may wonder whether the state of today's degraded humid tropical lands would be better, along with the social and economic conditions of the people living on this land, if they were covered in agroforests.

Conditions for establishing successful agroforestry

The analysis of these Indonesian examples enables us to draw a list of the principal conditions which have to be fulfilled for these complex agroforestry systems to be reproduced in other places, conditions which any project implanting these systems will have to take into account.

The first condition is that the agriculturalists in the countries concerned should be able easily to assimilate the technical know-how needed to create agroforests. On this point, the example of the Indonesian agroforests is very encouraging: although they have a complex stucture, their establishment and management call on very simple techniques which all shifting cultivators in humid tropical countries have at their disposal. The extremely low level of investments needed, in terms of labour and capital, also weigh heavily in their favour.

The commercial orientation of complex agroforestry systems connects them directly to the regional and national economy, even the international economy for exported products. Since they are, first and foremost, directed by the market, the implantation of such systems, as for any commercial cultivation. requires favourable conditions for the distribution of the products. Some of these conditions, which call into play a large number of factors at different levels, are not open to control, like the rubber price for example; others, by contrast, fall directly within the scope of national economies, like the existence of a sufficiently developed communication and transport network.

Although it has not been mentioned so far, it is absolutely clear that the Indonesian agroforests could not have spread other than in a context of stable land control; it is imperative for farmers to know with quasi-certainty that the land they clear, on which they will plant trees and agroforests, will be recognized as their property, that it can be inherited by their children. The guarantee of a durable land tenure is absolutely fundamental, and constitutes a *sine qua non* condition for implanting complex agroforestry systems, as it is for any forms of plantation based on perennial species (see Humbert, 1993, this volume).

The last issue, which we have scarcely broached, but which should be emphasized, relates to the inability of forest-gardens to produce staple food, except in their brief period of establishment. Staple food production is generally not one of their attributes, excluding certain systems based on trees which produce large amounts of carbohydrates, like the breadfruit (*Artocarpus communis*) or the sago palm (*Metroxylon sagu*). In west Indonesia, where rice is the obligatory food, the agroforests are never the sole component of the agricutural landscape, and one or several cultivation systems always exist in parallel with agroforests, to ensure production of the staple food.

The conditions discussed above show clearly that it would be a serious mistake to consider only the peasant-farmers, and not the wider context. Certainly, the establishment of agroforests depends directly on the farmers, but as we have seen, it is not the practical conditions for establishing an agroforest, which demand neither sophisticated techniques nor costly investment, which pose the problem. The successful implantation of agro-

forests depends also, and perhaps above all, on factors as diverse as agronomic research, the international market for agricultural products, land law, the national economy and the state of the infrastructure.

AGROFORESTS IN AFRICA?

In a recent work, Gourou (1991) writes that the African equatorial sylva is too sparsely populated to be threatened with disappearance. The essential problem is to ensure a more prosperous life for its inhabitants. He suggests that the surest way of obtaining this improvement would be for them to become genuine exploiters of the forest, and for them to use their swiddens, after the harvest, for semi-cultivated commercial production, which would not require more work than planting the plants which will bring in commercial revenue.

Although the first of his statements is debatable, the others can only be applauded, as he is in reality proposing nothing other than the development of agroforests as a means of raising the standard of living of these farmers.

It is not our intention to analyse in exhaustive detail the possibilities for implanting complex agroforestry systems in the African forest, where no such systems have yet been established, at least to our knowledge.

However, we would like to mention that, from our experience in Mayombe, Congo, African agricultural practices provide indications which suggest that the implantation of agroforests would be welcomed in the countryside: gardens around houses are abundant and sometimes highly diversified in the villages, emphasizing the presence of traditions favouring the integration of arboreal components in the agricultural system, even if only on a small scale. Some cultivation systems are very close to Indonesian agroforest systems, if not in their composition and structure, at least in their method of establishment and managemement: this is the case for example for the extensive banana plantations in central Mayombe, whose minimal upkeep favours the growth of herbaceous forest species while preventing the proliferation of aggressive weeds like *Chromolaena odorata,* which smothers the bananas and means that the plantations have to be abandoned (Foresta and Schwartz, 1991). Finally, the recent installation of large mixed orchards based on "plums" (*Dacryodes edulis*) around certain villages seems to illustrate a genuine, although not widespread, desire on the part of the farmers to develop the cultivation of tree species for commerce. These could soon resemble true fores. gardens.

We have already mentioned the need to improve the cultivation systems producing the staple food. The invasion of the shrub *Chromolaena odorata,* (previously named *Eupatorium odoratum*) which originated in Central America, generally considered by scientists as disastrous, could eventually

turn out to be beneficial for many farmers: this famous "Eupatorium" which has spread throughout Africa like a pest, and undoubtedly poses control problems in plantations, seems to improve considerably the chemical and biological fertility of the soil (Foresta and Schwartz, 1991), as many farmers have begun to notice. The use of *Chromolaena odorata* in short fallow periods, although it will mean more work for the farmer, could be a simple, yet effective way of profiting from the agronomic qualities of this plant and intensifiying food cultivation, especially manioc, the staple food in many forested regions of Africa.

This is a resolutely optimistic vision. But even if the African farmer does not hold such a utopian view, why shouldn't tomorrow see prosperous farmers in stable landscapes in the African forest as in the Indonesian forests of today, so that the value and importance of products from the fields and agroforests means that there is no further need to fell the natural forest?

CONCLUSION

The simplicity of their establishment and management, the low level of investments needed, their ecological value, all these characteristics give complex agroforestry systems a value as a model for the rural management of forest land in humid tropical regions, notably for the management of land presently occupied by itinerant agriculture which is suffering under increasing demographic pressure.

For these areas, which are becoming more and more vast and more and more numerous, *and admitting that a certain number of conditions have to be fulfilled which are outside the control of the local populations*, the adoption of an extremely simple practice (i.e. planting trees in food producing fields) could enable the classic cycle of itinerant agriculture to be broken and create the transition to fixed agroforestry/agriculture, with all the ecological and economic advantages which this transformation implies.

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