

Complex agroforestry systems in Sumatra

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Introduction

Based on ten years of experience on agroforestry systems research¹ in Sumatra, and also quite a lot of never evolving debates on what is agroforestry and what is not agroforestry, our most important results concerning what we have called "complex agroforestry systems" are summarized here.

Complex agroforestry systems are still ignored or depreciated by most research and extension services and are therefore facing numerous problems of recognition in Indonesia. However, more and more international institutions dealing with agricultural research and development quote these systems as models of what should be encouraged in the humid tropics.

The main reason of this international recognition is that these systems, which according to our studies, have proved to be economically profitable, compatible with relatively high population densities, and ecologically viable in the long term, are the only sustainable land use system in tropical forest lands which allows to combine at the same time intensive agricultural production, soil and water resources protection, and conservation of a high degree of forest biodiversity.

Complex agroforestry systems are first described through the example of damar agroforests in the south western part of Lampung, and the example of fruit trees/timber trees agroforests in West Sumatra. Other examples are then briefly referred to in order to point out the differences between simple and complex agroforestry systems. Finally, some important points for the future of these systems are underlined.

¹ In Indonesia with LIPI from 1980 to 1985, in Africa with UNESCO from 1986 to 1988 and back in Indonesia with BIOTROP from 1989

From shifting cultivation to man made Dipterocarp forest (Krui)

In the very western part of Lampung, near Krui, between villages and natural forest, all the land opened by shifting cultivation is now occupied by an original system dating back to the end of last century.

This system is based on the cultivation of a resin-producing Dipterocarp: *Shorea javanica* K. & L. (damar mata kucing) which is presently associated to several fruit, timber and material tree species, palms, bamboos, as well as to numerous self-established species issued from surrounding primary and secondary vegetations (Torquebiau 1984; Michon 1985; Mary and Michon 1987; Michon and Jafarsidik 1989; Michon 1991). Patterns of species diversity and structural complexity in the damar gardens are similar to those of a natural forest ecosystem with a high tree canopy, several "layers" of smaller trees and treelets, and an herbaceous ensemble dominated by species characteristic of a forest undergrowth (fig.1).

Common problems linked to the establishment and maintenance of Dipterocarp plantations (irregular seed supply, lack of seed dormancy, difficult mycorrhization, garden establishment on bare lands) have been solved by villagers with simple technologies. When fruiting season occurs, seeds collected in the gardens are planted in small, rather sunny nurseries. Seeds are closely spaced (5cmx5cm or 10cmx10cm), and seedlings, which usually do not develop over 20-30cm high, can survive in such conditions for 4 to 5 years with a seemingly low rate of mortality. Nurseries can thus supply young subjects whenever needed (replacement of old trees, plantation on new lands) from a fruiting season to the next.

The conventional establishment of damar gardens is a classic taungya-like process of tree-plantation (fig. 2): seedlings are planted within young coffee stands established on ladang, which protects them from direct sunlight for 4 to 6 years and the success of transplantation is quite good. After several years, direct light is necessary to stimulate rapid growth. First tapping occurs 15 to 20 year after transplantation. A tree may then yield resin for 30 to 50 years.

The silvicultural process is not conceived as a mass treatment applied to an homogeneous, even-aged population of damar trees, but aims at designing a forest-like ecosystem which produces and reproduces without disruption either in structural or in functional patterns. Global continuity is ensured through a balanced combination between appropriate management of individual trees and natural dynamic processes prevailing in tree population. As natural decay of planted trees is predictable -over 65,70 years-, villagers can easily foresee and plan their replacement. The main task of the farmer is to introduce regularly young trees in the garden plot in order to constitute and maintain an uneven-aged pool of replacement trees, or to control and favour natural regeneration. In a well managed garden, size of the replacement pool more or less equals that of the productive stand. When a large gap accidentally occurs in the canopy, villagers have to develop and control the whole regeneration process; young trees introduced in the gap are associated to cultivated sun-tolerant species (bananas, vegetable tree species or clove trees) which there replace natural pioneer species and provide some shade to young trees.

Labour allocated to common garden management and maintenance is mingled with labour devoted to resin harvest, and the tempo of harvests is determined by labour requirements for rice cultivation, so that tree gardening never competes for labour with subsistence agriculture.

Timber production in an agroforest (Maninjau)

No one can be insensitive to the delicate balance achieved by the lake, the agricultural fields, and the forest which altogether make up the landscape of Maninjau in West Sumatra. However, natural forest in this scenic caldera is only restricted to its higher margins, as the major part of the forested area is in fact another original example of agroforest (Michon, Mary et al. 1986).

Under a canopy of high durian trees associated to various forest species are grown commercial crops (cinnamon, coffee, and nutmeg) as well as various fruit trees, managed forest species, palms, bamboos, and medicinal plants (fig. 3).

Here, timber production from the agroforestry gardens is quite important and original. It relies on both actual cultivation of timber species and management of naturally occurring forest species as well as utilization of fruit trees.

Two species are largely cultivated for their wood. They are native to the local forest ecosystem: "surian" (Toona sinensis (A.Juss.) Roem, a Meliaceae) and "bayur" (Pterospermum javanicum Jungh, a Sterculiaceae). They make-up 30 to 70% of the canopy tree cover. Both can be harvested after 25-30 years when their diameter reaches 35 cm. Processing in boards is done by village carpenters who also deal with sale outside Maninjau area. A third species, Alangium kurzii, is also being much cultivated for roofing works. Managed forest species include mainly Meliaceae, Lauraceae, Fagaceae, Myrtaceae and scattered Dipterocarpaceae. They are not actually planted but reproduce from seeds produced by mother trees conserved in the agroforestry gardens or carried by winds and animals from the nearby forests. Seedlings or saplings are selected by the villagers, they can be transplanted whenever needed, and they benefit from the cares given to commercial tree crops (mainly weeding). Utilization of the timber of over-aged or bad-producing fruit trees is also important. The preferred species include durian, cempedak, and various Baccaurea species.

Altogether, timber production from complex agroforestry systems in Maninjau relies on around forty species, each particular species being given a preferred use. Some of those species are known to be sometimes used by foresters but are not common commercial species (mainly Lauraceae, and some late pioneer species as Acrocarpus or Terminalia). Here again, labour devoted to "silviculture" is totally mingled with that needed for commercial tree crops.

Simple agroforestry systems: trees and agriculture

The broad definition² of agroforestry which is now commonly adopted by ICRAF (International Council for Research in Agroforestry) and most research institutes has allowed to draw together for a new dialogue experts from such compartmentalized sciences as ecology, agriculture, forestry, or geography, ethnobotany and socio-economy.

² "Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components." (Lundgren and Raintree 1982; in Nair 1989)

But this also induces some confusion: in spite of all the existing classifications of agroforestry systems (see for example (Nair 1989), in most meetings where the very fashionable word "agroforestry" is pronounced, too much time is still devoted to debating whether that particular association between plants X and Y, or this particular form of shifting agriculture, or these "jungle rubber" gardens, are true agroforestry systems, and if all are considered, what do they have in common?

Based on our experience with traditional agroforestry systems in Sumatra and regarding the fact that global qualities (among which soil and water protection, biodiversity conservation or reduction of economic risks) are commonly attributed to "agroforestry" without any distinction, it appeared necessary to draw a simple but important boundary in the undifferentiated mass of "agroforestry systems" (de Foresta and Michon 1991).

We have divided the numerous facets of agroforestry associations into two major physiognomic categories, namely "simple agroforestry systems" and "complex agroforestry systems", which are linked to two different conceptions and demand different research and development approaches.

In Indonesia, where both development and diversity of agroforestry systems are remarkable, this distinction is important to emphasize, as a few well-known associations of one tree species and one annual crop almost always overshadow, in programme or debates on Indonesian agroforestry, the bulk of complex practices directly inherited from traditional agriculture.

Simple agroforestry systems are associations of a small number of components, usually one tree species which can be of major economic importance (coconut, rubber, clove, teak...), or have a more qualitative role (*Erythrina*, *Leucaena*), and an annual species (paddy, maize, vegetables, forage herbs) or a treelet (bananas, cocoa, coffee), both being always important economically.

These simple agroforestry associations represent what may be called the "classical" agroforestry model as it is the most favoured in research and development programme of most institutions dealing with agroforestry (see for instance Stepler and Nair 1987; Nair 1989).

The most-documented form of "simple" agroforestry system in Indonesia is the "tumpang Sari" system initiated and developed by the Forestry Services during the colonial period. Tumpang Sari has been for long associated with all types of forest plantations in Java, and is now being extended as well for new schemes of industrial forest plantations outside Java.

Simple agroforestry systems are also important in plantation agriculture (Siregar, Sudradjat et al. 1990): almost everywhere in Sumatra, coffee is still commonly associated with *Erythrina* trees which give both shade to coffee bushes and firewood to smallholders while being beneficial to the soil, associations between coconut and cocoa are spreading and diversification of industrial rubber plantations (the association rubber/rattan for example) are being tested.

Simple agroforestry associations are common in traditional agricultures, in which most dry fields include trees either as true components (coconut with maize) or as borders (teaks, *Glicidia*, *Leucaena*, in Lampung for instance). Trees are also commonly associated with irrigated ricefields, which sometimes reflects natural constraints, such as the association between coconuts and ricefields in the swamp areas of Sumatra's East Coast.

Complex agroforestry systems: forest and agriculture

To the above examples of Krui and Maninjau, can be added another one, especially important in Sumatra: in the hills and lowlands of the eastern part of the island, where the last tracks of mixed dipterocarp forest are being exploited and rapidly converted, smallholder "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 culture.

Complex agroforestry systems are systems in which a high number of components (trees as well as treelets, lianas, herbs) are associated, and physiognomy and functioning of which are close to those observed for natural ecosystems, either primary or secondary forests.

They are encountered most exclusively in peasant agricultures of the humid tropical world. In Brazil, these systems are "managed forests" evolved from progressive and integrated transformations of the original ecosystem, but in Indonesia, they are true gardens or plantations ("kebun"), established after total removal of the original vegetation, through replanting of desired species and natural enrichment (cf. fig. 2).

The "agroforestry label" is sometimes discussed for complex agroforestry systems as the herbaceous component is not obvious. Nevertheless, because of their establishment process they could be attached to "temporary associations between trees and annual crops" in the usual classification of agroforestry systems. On another hand, they are also directly related to the taungya system ("tumpangsari") because of their establishment process. But, much more than this establishment phase of complex agroforestry systems, it is the "mature" phase, which is made up of an intimate mixture of crops and actually deserves the name of "agroforest", which fully concerns both agriculture and forestry.

Most of the existing complex agroforestry systems (except the "talun" system encountered in West Java), which are not homegardens but far more extended gardens, have been conceived outside Java and especially in Sumatra, sometimes for hundred years, within shifting cultivation systems (Torquebiau 1984; Michon 1985; Michon et al. 1986; Mary 1987; Mary and Michon 1987; Seibert 1990). In Sumatra, where they have been developed with either domesticated 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 anecdotic: their diversity, their dynamism and importance, in terms of surface and production make them a major element of smallholder agriculture in the Island.

Agroforests provide a large variety of complementary food (fruits, vegetable, spices) as well as all common material used in villages (construction wood, firewood, thatching and basketry material), and are therefore especially important in sustaining household consumption.

However, in Sumatra, commercial production is the major economic function of these systems: agroforests usually provide between 50 and 80% of total agricultural income of villagers (Mary 1986). But the diversity of both income sources and secondary productions ensured by these systems are other essential assets for the economic security and welfare of villagers. Income from the agroforest allows to cover both every-day expenses, with regularly harvestable products as rubber latex, damar 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.

These systems, often considered as devoted only to self consumption, have clearly a major economic importance for local communities: the main determinant of their establishment and management is not food nor material, but commercial (Mary 1986; de Foresta and Michon 1991). Complex agroforestry systems are established above all to provide monetary income and often represent the only source of cash money for households. They also contribute, through the global importance of their components (rubber, coffee, clove, fruits, spices), to export agriculture of Indonesia: as an example, more than 70% of the rubber latex exported by Indonesia is provided by the "jungle rubber" agroforests.

Besides this economic importance, one should mention the simplicity of their establishment and management, as well as their economic flexibility (Michon 1985; Mary and Michon 1987; de Foresta and Michon 1991).

The diversity of their products is an important insurance against economic risks linked to commercial agriculture.

Their maintenance and reproduction implies no sophisticated technology nor important monetary or labour investment.

As far as structure and composition are concerned, an Eucalyptus plantation is as different from a natural forest as is a cassava field. It restores a forest material, but not a diversified ecosystem, and although allowing a rather good protection of soils and water, it plays a minor role in the conservation of the world forest heritage. The planned spreading of such plantation (Hutan Tanaman Industri) can be considered, as far as only wood is concerned, as an acceptable economic substitute to natural forests, but it will drastically reduce biodiversity at the country level.

Complex agroforestry systems actually exhibit forest-like structures, which create in the agricultural lands niches in which forest species, either trees, shrubs, herbs, epiphyte or lianas, can establish and reproduce, and in which various animal species can feed: in Padang area, West Sumatra, for example, one of the richest and most densely populated provinces of Outer Indonesia, natural lowland forest have long been replaced by extensive tree gardens in which more than 150 tree species (for fruits, timber, export commodities) are commonly managed. Moreover, it has been estimated that several hundreds of self-established forest species are conserved, such as valuable "meranti" and other wood species, as well as orchids, undergrowth plants, palms and lianas.

Conclusion

The great number of components and the management practices which allow naturally established plants to develop as far as they do not hamper the main economic components, usually gives to agroforests a "neglected" aspect.

In fact, with their physiognomy so close to that of natural forests, these complex agroforests are very generally confused with secondary or primary forests and therefore completely overlooked as land use systems.

The following examples chosen in our study areas illustrate the present confusion: in the map of Krui area published by Agraria according to field surveys undertaken in May 1970, there is no mention of any kebun damar, and Krui is surrounded by a large patch of natural forest; in a quite recent report about west sumatran lakes, the agroforests around Maninjau lake are still confused with natural forest; in the latest map issued by the Ministry of Forestry, jungle-rubber around Muarabungo is still confused with secondary forest...

As they do not match the criteria usually taught in highschools or universities regarding the rationality of agriculture, forestry or agroforestry practices, it is difficult for research and extension officers to recognize complex agroforestry systems as such in the field. An example of such a difficulty is detailed by one of us in this workshop (H. de Foresta).

A special effort in the field of knowledge dissemination should therefore be made as soon as possible, because the above difficulty, and moreover the inability to overcome it, paves the way to important mistakes as those quoted above, mistakes which can be fraught with consequences, especially for rural people.

As far as environmental impact is concerned, large-scale development of complex agroforests as those developed by peasants in Sumatra appears highly desirable. However, their productivity, in terms of cash income per unit of land, is still low and irregular and complex agroforestry systems will no longer stand the comparison with other agricultural systems, more risky, but more profitable in the short term.

Thus, further spreading of complex agroforestry systems mainly depends on an increase of their profitability. Until now, this increase has been achieved by the reduction of the less productive components of the system to the benefit of selected high yielding crops. This process leads soon or later to the replacement of the complex model by simple agroforestry systems or monocrop fields.

How to improve the profitability of complex agroforestry systems without destroying their very nature? Obviously, there is here a great and urgent need of scientific research in order to answer this major question. BIOTROP and ORSTOM are collaborating in that particular field, and are at present exploring two research directions: increasing the commercial use of products already existing in the agroforests, and introducing improved plant material. Obviously timber is a good candidate regarding the first direction (de Foresta and Michon 1990), as all agroforests may be characterized by the abundance of potential timber trees, the large availability in seeds and seedlings, and the fact that the species involved are well known and managed by villagers for long. An example of the timber potential of agroforests is detailed here by one of us (N. Wijayanto).

It is important to understand that complex agroforestry systems represent one of the most meaningful and still successful contribution of villagers to conservation of the world's natural heritage. Those villagers who are commonly identified as the first threat for tropical rainforests 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.

Complex agroforestry systems 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 already gone or doomed to destruction, complex agroforestry systems can contribute to maintain in the landscape a useful and diversified forest ecosystem from which peasant is not excluded.

Indonesians are generally proud of their rich and diverse cultural heritage. We hope that the present paper has shown that they have no reason to feel ashamed about their complex agroforestry systems, which are probably the most important part of this cultural heritage in the field of agriculture, and, moreover, which are definitely one of the major contributions of Indonesia to humid tropical agriculture.

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Legend of figures:

fig.1: A "damar" agroforest in Krui, Lampung, Sumatra

fig.2: Establishment of complex agroforestry systems: the case of damar agroforests

fig.3: timber trees in the agroforest of Maninjau, West Sumatra