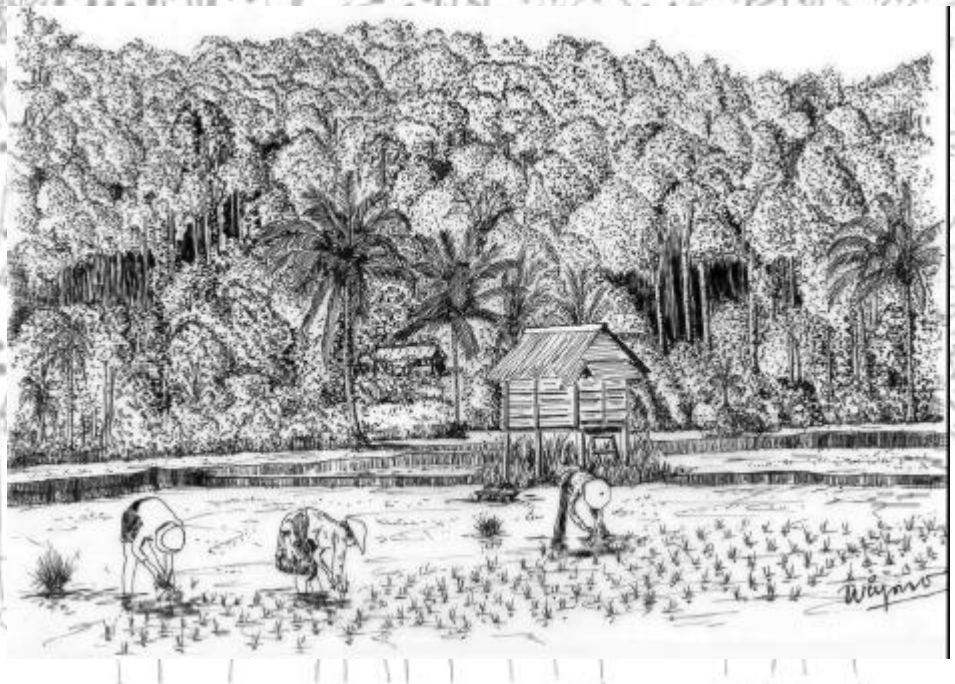
Lecture Note 1

Complex Agroforests

Hubert de Foresta, Geneviève Michon and Achmad Kusworo



INTERNATIONAL CENTRE FOR RESEARCH IN AGROFORESTRY

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Hubert de Foresta, Geneviève Michon and Achmad Kusworo

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Lecture note 1

COMPLEX AGROFORESTS

By Hubert de Foresta, Geneviève Michon and Achmad Kusworo

I. Objectives

- To provide an understanding of complex agroforests as a major agroforestry system in Southeast- Asia.
- To discuss strengths and weaknesses of agroforests for agricultural development, forestry and farmers.

II. Lecture

1. A reminder: agroforestry is a new discipline, but agroforestry practices have been developed by farmers for centuries

Farmers have integrated trees in their farming systems for centuries. They did not wait for scientists to develop the concept of agroforestry; just like man did not wait for agronomists to invent and develop agriculture.

Agroforestry is widely promoted in Southeast Asia as a solution for developing more sustainable land uses. But most policy makers, scientists and extension agents dealing with agroforestry programs rarely consider that most agroforestry systems have evolved from local farmers' practices. What farmers are actually doing indeed differs from one country to the other in the region. However, agroforestry is still mainly understood in terms of "development projects", and therefore usually promoted from an "outside" point of view, with "outside" tree crops or mixed-cropping techniques. With only a few exceptions, projects do not explore either the local agroforestry knowledge base nor the local farmer-developed agroforestry practices.

2. Farmer-developed agroforestry systems in Indonesia: an overview

Until now in Indonesia, only two agroforestry systems are officially recognised. One has been developed by the forestry service, the other by local people:

Tumpangsari, an Indonesian version of the taungya system, first developed by the beginning of this century by the forestry service in Java to improve the management of state-owned teak plantations, and

Pekarangan, the Javanese tree-homegarden, which is often described as one of the most sophisticated homegarden systems in the world.

Apart from these, other systems are occasionally mentioned:

1. The "**talun/kebun**" system in West Java, a combination of a succession of native species (bamboo, fast-growing timber trees and fruit trees, which form the "talun" phase) with a mixture of annual crops and seedlings of perennials (the "kebun" phase, which can be a rejuvenating phase of the "talun" or the first stage with clearing of forest followed by the cultivation of annual crops and planting of selected tree species).

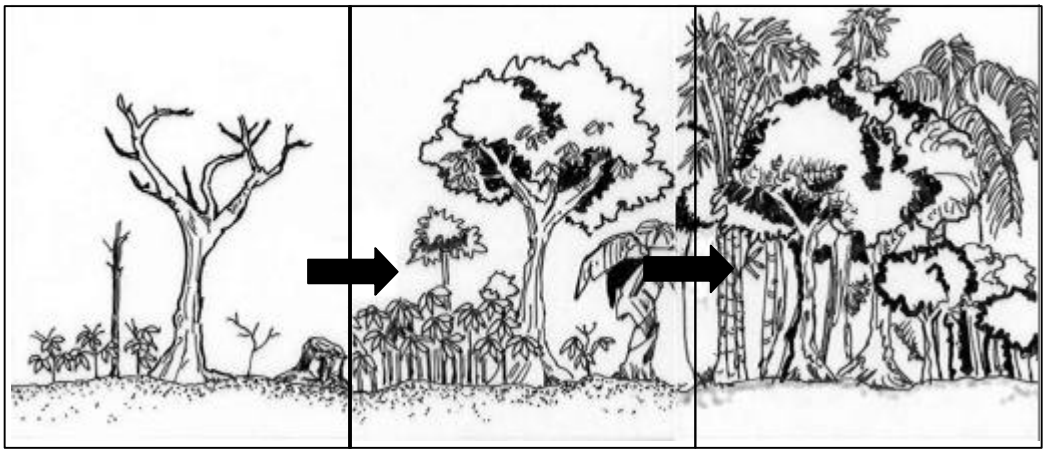

Figure 1. The talun/kebun system (Adapted from FAO and IIRR, 1995)

2. Dry land farming involving tree management practices implemented by farmers in Java is also sometimes mentioned.

Until recently, little information was available on agroforestry practices in the "outer" islands, which were perceived as strongly dominated by what were called shifting cultivation systems. This lack of documentation and simplistic view does not reflect the reality of the numerous and diverse systems developed locally. While agroforestry systems and practices developed and implemented by farmers outside projects can be observed almost everywhere in the archipelago, they were invisible to most scientists, extensionists and policy-makers. The idealisation of agroforestry as intrinsically "modern" is certainly one of the reasons of this invisibility.

How do 'traditional' systems differ from 'modern' systems?

- Systems usually perceived as **'traditional** (or indigenous) are those systems that **have been developed by farmers** in response to perceived needs and existing opportunities, without the involvement of formal research and extension services.
- Systems usually perceived as **modern** are those systems that have been developed by scientists and that are promoted by **projects** using techno-scientific arguments.

Both 'traditional' and 'modern' systems may co-exist at the same time. The main difference is that 'traditional' systems are the result of long evolution and adaptation to local conditions, while long-term suitability of 'modern' systems to local conditions is unproven.

A division can be made between two broad groups of agroforestry systems: **simple agroforestry systems** and **complex agroforestry systems**. Simple agroforestry systems are tree-crop associations and are easily recognisable once one has accepted that farmers are indeed agroforestry practitioners. Complex agroforestry systems are much more difficult to recognise: they are successional systems and, while early stages usually exhibit typical agroforestry features, their mature "forest" phase—**agroforest**— has often been confused with natural

forests, even by agroforestry experts. Simple agroforestry systems are briefly presented below, followed by a focus on the lesser-known complex agroforestry systems.

3. Simple agroforestry systems

Simple agroforestry systems can be characterised as follows:

1. A piece of land planted with a mix of **perennial** and **annual crops** with:
   - One tree species and one to a few annual crops, or short-cycle species; or
   - Trees as main field components (e.g. coconut with maize or peanut); or
   - Trees as borders such as teak (*Tectona grandis)*, mahogany *(Swietenia macrophylla)* and rosewood *(Dalbergia latifolia)* in East and Central Java, and *Maesopsis* and *Paraserianthes* in West Java.

Trees are also commonly associated with irrigated rice fields either on dikes or along roads, and are used in the agricultural system either for their products, for environmental services or for both.

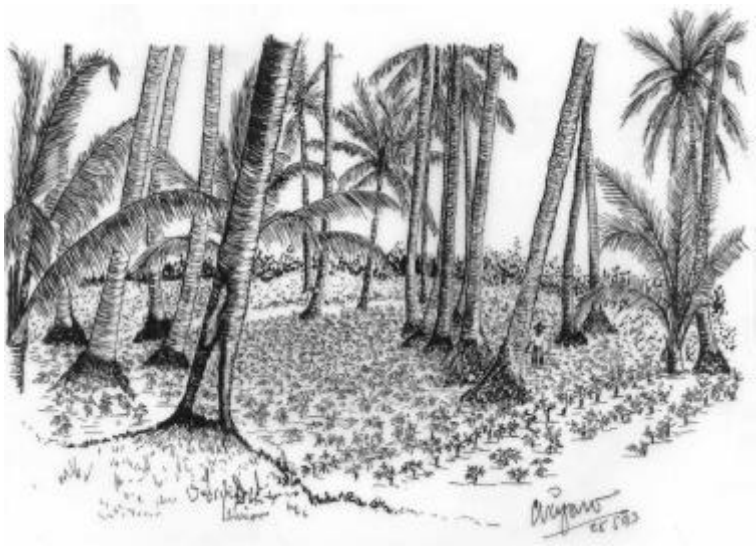

Figure 2. A simple agroforest: the indigenous coconut with peanutsystem

2. A planned combination of **perennial trees** and **shrubs**:

A piece of land is planted with different species of trees. An example is coffee associated with *Erythrina* or *Gliricidia* trees. Reasons for planting *Erythrina/Gliricidia* are:

- to provide a manageable (through pruning) level of shade for coffee trees,
- to provide firewood or fodder
- as a live pole for climbers (e.g. vanilla or pepper)
- to improve soil fertility through litter fall, fixing nitrogen from the air, old tree-root channel etc.

4. Complex agroforestry systems

Common observers often confuse multispecies complex agroforestry systems bordering obvious agricultural areas, especially on the forest margins, with a mix of “virgin” and “degraded” forest.

That kind of agroforestry combination that **looks like forest**, we have called **complex agroforestry system**. In its mature phase this system is characterised by:

- A complex vegetation structure,
- A high number of components (trees as well as seedlings, shrubs, lianas, herbs), and
- An ecological functioning similar to that observed in natural forests (nutrient cycling, dissemination and regeneration processes, etc).

Two broad categories of complex agroforestry systems should be distinguished: **tree-dominated homegardens** and what we have called **agroforest** or **complex agroforests**.

Tree-dominated homegardens are always located **near the house** and are usually **small (0.1 to 0.3 ha).** These two characteristics allow homegardens to benefit from quite intensive care (manure, tree pruning, weeding, etc). Being easily recognisable because of their integration within household compounds, tree-homegardens are relatively well known and documented, and their importance is well acknowledged.

Figure 3. A traditional homegarden around the house in West-Java, dominated by trees. *Arenga pinnata* 5; *Artocarpus heterophyllus* 25; *Baccaurea racemosa* 6, 10; *Coffea robusta* 25; *Colocasia indica* (c); *Durio zibethinus* 11, 23; *Eugenia polycephala* 1, 7, 9, 16, 17, 19; *Gnetum gnemon* 13; *Mangifera foetida* 12; *Mangifera indica* 14, 15; *Mangifera odorata* 21; *Lansium domesticum* 4, 9, 12, 22, 26, 27; *Musa paradisiaca* (b).

Agroforests are composed of **a mosaic of small (1–2 hectares)** individually-owned; individually managed units which make up forest massifs of various sizes. **They are not located in household compounds**, even though they often border villages, and they are rarely intensively managed.

Agroforests are sometimes **managed forests**, evolved from progressive and integrated transformations of the original ecosystem through tree planting and natural vegetation management, such as the Benzoin agroforests in North Sumatra province. But most often agroforests in Indonesia evolved from shifting cultivation systems, and are true plantations

established after total removal of the original vegetation through planting of desired tree species, and through natural enrichment. Agroforests are definitely part of the world of smallholders' tree-crop plantation agriculture. Like coffee or cocoa smallholder' plantations, agroforests are established and managed by rural households, mainly because of the medium to long-term sources of income they provide.

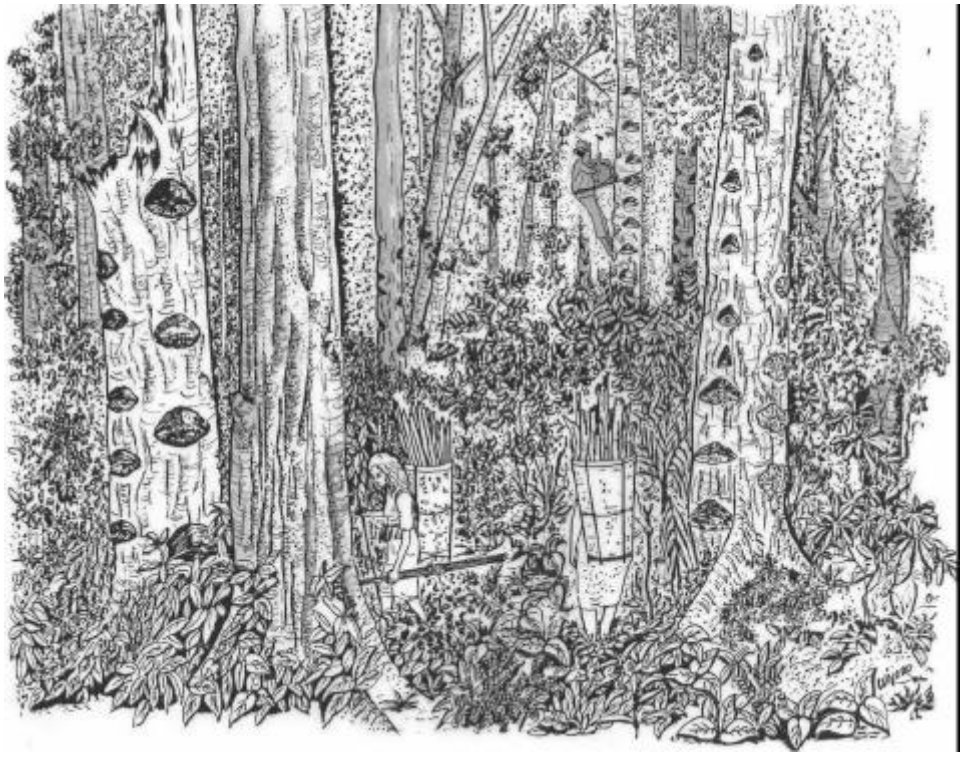

Figure 4: A complex agroforest

Examples:

- In the hills and lowlands of Kalimantan and eastern Sumatra where the last tracks of mixed *Dipterocarp* forest are being logged and rapidly converted, smallholder **jungle rubber** agroforests cover an estimated area of 2.5 million hectares. In these systems rubber trees are associated with numerous wild and cultivated tree species, complementing either irrigated or dry rice cultivation.
- In the southwestern coast of Sumatra, an impressive model of agroforest based on *Shorea javanica* (damar) is exploited for its resin. It was developed by villagers more than a century ago and now covers some 50,000 hectares.
- The illipe nut gardens of West and Central Kalimantan provinces are also examples of an agroforest system integrating *Dipterocarps* and other useful tree-species.
- Across Sumatra in the mid-1980's, a mosaic of other agroforest types was estimated to cover more than 1 million hectares in patches of a few hectares. It associates various fruit species as well as economic spice producing trees (cinnamon, clove and nutmeg) and timber species under a canopy of durian (*Durio zibethinus*) or kemiri *(Aleurites moluccana)* trees.
- In East Kalimantan impressive fruit forests have been developed **(lembo**) which seem to be among the richest systems in number of tree species.
- In northern Sulawesi and on Lombok islands, a sugar-producing palm tree *(Arenga pinnata)* dominates agroforests.

- In the Moluccas, agroforests associate fruit and nut trees to the traditional spice trees: clove and nutmeg.

Agroforests are definitely not anecdotal in terms of production, at regional nor national levels. They provide:

- 80% of the rubber latex consumed and exported by Indonesia (the world's second largest producer after Thailand);
- 95% of the various fruits marketed in the country;
- 75 to 80% of the *Dipterocarp* damar resins traded in and outside the country; and
- A significant portion of rattans, bamboo and firewood used in the country, and the bulk of medicinal plants and handicraft material.

Moreover, agroforests ensure the self-sufficiency of most rural households in complementary foods, fuelwood as well as light and heavy material.

Box 1

Case study: Establishment of damar agroforest in Krui (illustration see Figure 5)

In the very western part of Lampung province in Sumatra, between villages and borders of the Barisan Selatan National Park, all the land that was under shifting cultivation is now under a resin-producing dipterocarp *Shorea javanic*, locally known as "*damar mata-kucing*". Damar agroforests are associated with various fruit and timber tree species, palms, bamboo, and numerous self-established species originating from the neighboring primary and secondary forests. Patterns of species diversity and structural complexity are similar to those of natural forest ecosystems with a high tree canopy, several layers of smaller trees and treelets, and an herbaceous ensemble dominated by species characteristic of a forest undergrowth.

Common problems related to establishment and maintenance of dipterocarp plantations (irregular seed supply, lack of seed dormancy, difficult mycorrhizal symbiosis, conditions of establishment) have been solved by villagers with simple technologies. Instead of a seed bank farmers keep a 'seedling bank'. Replanting 'wild seedlings' or 'wildlings' closely together in agroforest conditions ensures mycorrhization and makes seedlings readily available when they are needed for gap replanting. Under the shade of mature trees seedlings remain viable for over five years, and thus the problem of irregular seed supply is overcome.

How does an agroforest begin and develop?
The initial vegetation, which can be primary or secondary forest, or even *Imperata* grassland, is felled and burned. Upland rice is planted together with other food crops: semi-perennial commercial crops such as coffee and pepper, and trees providing environmental services such as *Erythrina* and *Gliricidia*. Seedlings of the tree species that will later form the skeleton of the agroforest (damar trees and fruit trees) are usually produced in small individual farmer nurseries. They are usually transplanted into the already rich mixture of crops, either progressively or at once during the first 1 to 3 years after the plantation opening.

After the last harvest of food crops, coffee and pepper (8 to 15 years in this case), the plot is temporarily abandoned. Planted trees mixed with natural regrowth further develop until they become productive. This period can be a phase of intense competition between planted trees and the pioneer vegetation. The intentional introduction of semi-perennial crops, whose primary goal is to increase profitability and to lengthen the productive commercial period of the plot, considerably reinforces the competitive advantage of planted trees, by delaying the establishment of natural regrowth.

Another practice to mitigate the effects of competition has been used on a large scale for the establishment of rubber agroforests: farmers plant many trees (700 to 1000 rubber seedlings per ha) that are let to grow with pioneer vegetation after rainfed rice is harvested. The assumption is that, even though mortality takes its toll, trees will reach the productive stage in sufficient numbers (about 400 trees/ha).

When damar trees begin to produce (after 20 to 25 years), the plot is completely weeded; except useful spontaneous species that are carefully preserved. At this time the plantation has gone through different stages: staple food producing, followed by commercial crop production, and then through an unproductive building phase, to a fully productive agroforest.

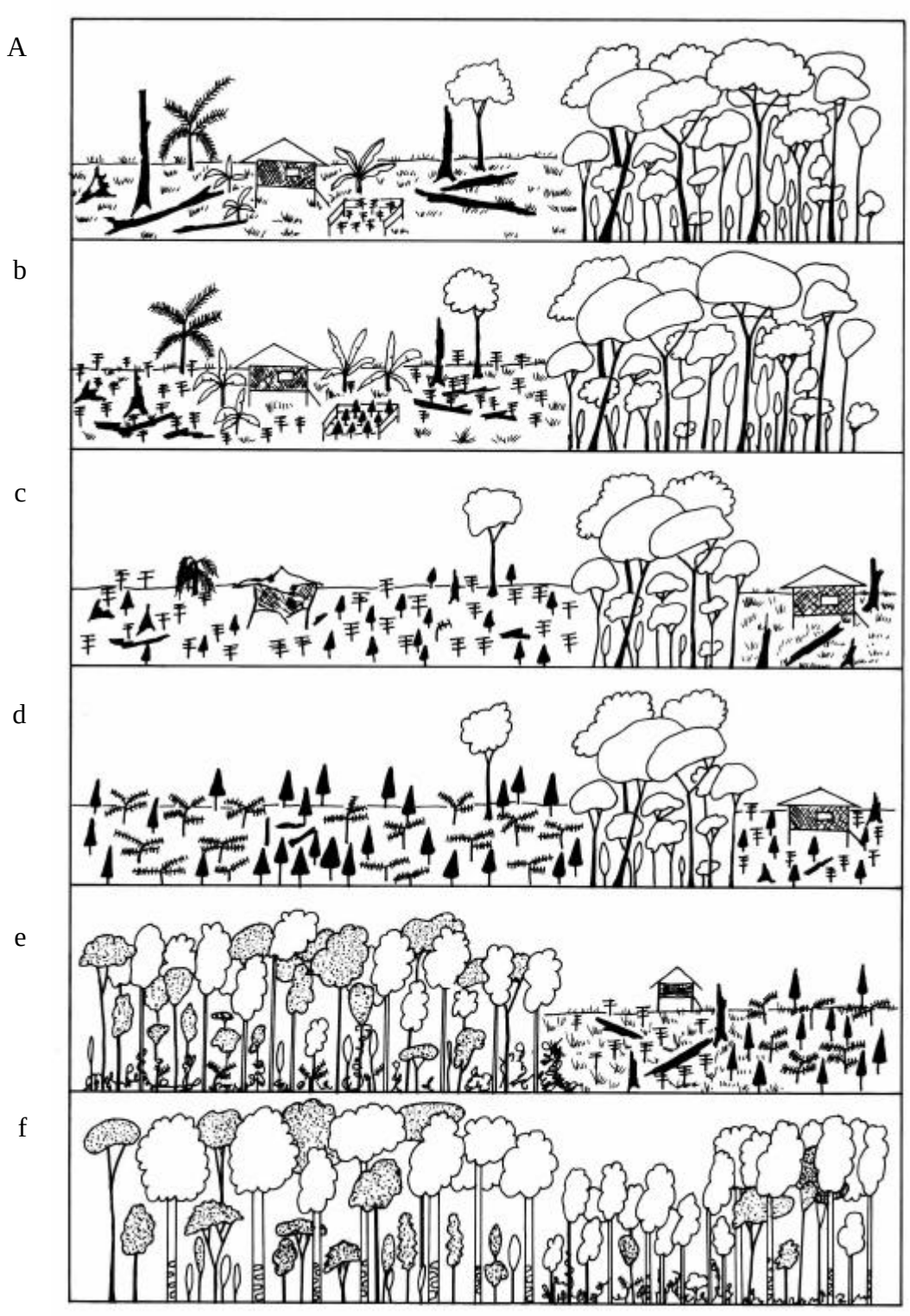

Figure 5. Development of a damar agroforest. The "ladang" is opened and planted with rice and pepper (a: year 1). (Ladang stands for dry-land agriculture. It is mainly seen as the cropping phase in a shifting cultivation system in the uplands). The damar, after a period in the nursery while the pepper begins to produce (b: years 2–3) are planted in year 4 (c) and benefits from cultivation care given to the pepper plants until the latter are abandoned (d: years 8-10). The "damar" develops together with the spontaneous vegetation until it enters production at 25 years (e). The mosaic of temporary fields and fallow 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.

5. Why should we grant special consideration to agroforests?

In spite of their relative success in the conditions in which they were conceived, indigenous agroforests are usually not transferable as such to other regions or other countries. Nor should they be considered as the pinnacle of agroforestry practice in the regions where they do exist.

Rather, they represent a very valuable source of inspiration and should be considered as models of utmost interest for the development of sustainable forms of agriculture and/or of forestry. They combine durable economic profitability and long-term conservation of both soil fertility and global biodiversity. Farmer-developed agroforests exhibit qualities that interest the present and future development of both agriculture and forestry, especially in areas where annual food crop cultivation depends on heavy applications of fertilisers or where only perennial crops are capable of sustained production.

5.a For agricultural development

Agroforests provide a proof-tested original model of **sustainable** and **profitable** commercial agriculture suited to conditions prevailing in smallholder farms.

The development of commercial agriculture, especially perennial crops, is often planned and implemented as a total conversion of actual production systems to monocultures with **high inputs of energy, capital and labour**. Experimentation and domestication research on commercial tree crops are almost always conducted under standard conditions which are far from those commonly encountered on smallholder farms.

Local production systems in rural areas, including agroforests, are generally considered as devoted to subsistence production. Promotion of commercial agriculture on smallholder farms includes a technological “package” that entails a total reorganisation of farming systems. There is generally no attempt to develop an integrated process by taking advantage of the existing structures and practices. Agroforests, when they have been recognised, are generally considered by outsiders as mere "**kitchen gardens**", i.e. no more than an anecdotal complement to open field cultivation for self consumption, and providing villagers with complementary foods and light materials like firewood.

This dominant perception is not supported by facts and recent studies on agroforests show the tremendous economic importance they have for local communities. Agroforests do provide complementary food and various material products; but, as in other tree-crop plantation systems, their main immediate/direct role for smallholders is to supply a regular flow of income. Agroforests are often the sole source of cash for households: in Sumatra, agroforests provide between 50 and 80% of villages’ total income through both products and activities linked to their collection, processing and marketing. Like most tree-crop plantations, agroforests are also part of a capitalization strategy: these long-lived plantations are created assets and they become part of a patrimony that will stay in the family and be transferred to children.

5.a.1 From Farmers’ Perspective

As a model for commercial agriculture, agroforests provide additional benefits to farmers:

As a **“bank”** that enables the diversification of income sources and rhythms. Income from agroforests usually covers both everyday expenses — with regularly harvested products such as rubber latex, resin, cinnamon bark—and, at least partly, annual expenses — with seasonal products such as fresh fruits, coffee, clove, nutmeg. Other commodities, such as timber, provide occasional, but important, sums of cash that often serve as savings for exceptional expenses.

Agroforests provide both **security** and **flexibility** through the diversification of commercial crops under a permanent structure. Diversity, though not allowing rapid accumulation of capital

in the form of immediately realisable assets, constitutes an important insurance for farmers against risks of single crop failure or risks inherent to the unpredictable evolution of market prices.

Flexibility is an important quality for smallholders: in cases of falling prices of one commodity, the concerned species can simply be neglected in the garden for a while until its exploitation becomes profitable again. This process does not involve any disruption to the system itself. In ecological terms, the agroforestry plot will be maintained intact and will still be productive, the concerned species will survive in the structure and will be ready for further exploitation, and new species can be introduced as well. In economic terms, there will still be something to harvest, or even new productions to try without reorganising the farming system. Another mark of flexibility is the shift in economic status that some species may encounter: species, present sometimes for decades in the agroforest, may suddenly acquire a new commercial value following market evolution. This has been the case in the 1980's in many places of Sumatra for fruits such as durian and langsat *(Lansium domesticum),* and more recently for timber.

Agroforests ensure the subsistence needs of farmers through its diversity of secondary products: agroforest acts as a common "kitchen garden" providing complementary foods (fruits, vegetable, spices), medicines and other products.

5.a.2 From shifting cultivator perspective

Agroforest systems provide a tested model for a successful transition from ***shifting cultivation*** to ***sustainable*** and ***profitable permanent agriculture***.

A high economic value and diversification of income.

We have discussed some of the direct benefits agroforests provide to smallholders' economies: diversification of income sources and rhythms, risk reduction and flexibility, diversity of secondary production, and creation of an inheritance. One other point has to be mentioned: establishment of agroforests and subsequent management operations require little investment, in terms of both labour and cash. Therefore, even though yields of the dominant species are not as high as in intensive monoculture plantations, agroforests provide a very good return to labour. This point is especially important as labour and cash resource, not land availability, represent the main constraint farmers' face in most shifting cultivation areas in the humid tropics.

No sophisticated techniques are needed. On the contrary, they are based directly upon shifting cultivators' traditional knowledge of their forest environment.

The case study of Krui, Lampung, Indonesia demonstrates how farmers developed and established the damar agroforest (Text-box 1).

Agroforest establishment processes are directly linked to shifting cultivation. The planting in the swidden of trees, which is well known to local people and fully acknowledged to target economic value, will divert the whole destiny of the field, from a swidden/fallow cycle to an agroforest. This results in a permanent mosaic of the landscape, with areas permanently devoted to food crops and forest-like areas which are now efficiently protected, as they represent the major economic component of surrounding village communities.

5.b For forestry development

In the sphere of forestry, agroforests provide a silvicultural model that integrates farmers, a diversified production of forest products, and the conservation of biodiversity.

Benefits of agroforest systems to the field of forestry can be listed as follows:

5. b.1 Simple techniques for managing complexity: the example of **Dipterocarp Agroforest**

Most agroforests are true plantations established, after total removal of the original vegetation, through planting selected species and through natural or directed enrichment. Agroforest establishment does not involve sophisticated techniques (Text box 1). Neither does agroforest maintenance, which involves techniques closer to gardening than to dominant forestry models for tree-crop plantation (Text box 2).

Box 2

Maintenance of damar agroforest

Agroforest maintenance operations in permanent agroforests such as damar or Maninjau agroforests

Silvicultural management of the productive agroforest phase is not conceived as a mass treatment applied to a homogeneous, even-aged tree population. It rather aims at maintaining 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 individual trees adapted management and natural dynamic regeneration processes. As natural decay of individual trees is predictable, villagers can easily foresee and plan their replacement. The main task is then to build up and maintain an uneven-aged pool of replacement trees; this is done by regularly introducing seedlings in the agroforest plot or/and by controlling and favour natural regeneration of the desired tree species. 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 sun-tolerant species such as bananas, vegetables and coffee, which here fill the role of natural pioneer species, while providing shade to young economic trees.

5.b.2 Alternative model for diversified **timber production**

Commercial timber production is considered as the exclusive domain of big private or State companies. Existing production from complex agroforestry systems is rarely mentioned and statistics are either not accurate or lacking. Nevertheless both the existing and potential resources offered by agroforest systems, and the timber management practices developed by agroforest farmers are worth investigating.

Agroforests as those encountered in Maninjau district, West Sumatra province, illustrate the potential of these systems as alternative models for sustainable timber production by smallholders. Under a canopy dominated by high durian trees, mixed with various forest species, commercial crops (cinnamon, coffee, and nutmeg) are grown, as well as various fruit trees, palms, bamboo, and medicinal plants. Timber production relies on the cultivation of selected timber species, on the management of naturally occurring forest species, and on the value of various fruit tree species.

Three species are commonly grown for their wood, *Pterospermum javanicum*, *Toona sinensis* and *Alangium kurzii*. They are native to local forest ecosystems and account for 30 to 70% of the crown cover. They can be harvested after 25-30 years when diameters reach 35 to 40 cm. Processing is done by village carpenters who also sell outside the area. Other local forest tree species, belonging to various families such as Meliaceae, Lauraceae, Fagaceae, Myrtaceae and Dipterocarpaceae, are managed though to a much lesser extent. All timber species reproduce either from seed produced by mother trees conserved in agroforest plantations or from seed disseminated from the nearby forests by wind and animals. The three major species have abundant natural regeneration in agroforest conditions. Villagers select seedlings or saplings of the desired species, and either maintain them if their location is judged satisfactory, or transplant them when needed. Young timber trees benefit from the intensive care given to the commercial tree crops (mainly durian and cinnamon). Utilisation of the wood of over-aged or non-producing

fruit trees is also important. The preferred species include durian, 'cempedak' (*Artocarpus integer*), and various *Baccaurea* species.

Altogether, timber production here relies on about forty species, each of these being specifically managed and having specific uses. Labour devoted to "silviculture" is totally integrated with that needed for commercial non-timber tree crops.

Agroforests have up to now not been established with timber production in mind, and in most agroforest systems that we know in Indonesia, timber production is either marginal or lacking. However, along with the ever increasing economic value of timber, more and more agroforest farmers are now following the tracks of their Maninjau colleagues and develop their own timber management techniques.

Even though more research is needed, we can already underline the remarkable adaptation of agroforests to the integration of sustainable timber practices in their already diversified overall management. Agroforests are all characterised by an abundance of potential timber trees, a large supply of timber species seeds and seedlings, and the fact that the species involved are well known and managed by villagers for long.

5. b.3 Alternative model for the conservation of forest biodiversity outside protected areas

It is commonly acknowledged that the replacement of natural ecosystems with agricultural systems by man involves a drastic reduction in biodiversity. This is also the case with forest plantations, even though it is less commonly recognised. As far as species composition is concerned, an *Eucalyptus* plantation for instance, though it is often called a “forest” and succeeds in restoring a forest material, is definitely closer to a cassava field than to a natural forest.

Complex agroforestry systems, as those encountered in Indonesia, have not only proven to be economically profitable, compatible with high population densities (up to 100-150 inhabitants/km2), and ecologically viable in the long term. They also are the only production system in tropical lands, which allows combining agricultural production with the conservation of a high degree of biological diversity.

Agroforests replace previous natural vegetation with a complex community of perennial species, which not only allows the direct conservation of numerous useful forest species, but also acts as shelter for hundreds of forest species not directly useful *in our present state of knowledge*.

In the present global context of degradation and destruction of tropical forest resources, and given the current trends of “dispossession” of traditional rural societies by both economic development and migratory forces, agroforests assert an original but very efficient social take-over of forest richness by local farmers groups. Where natural forests are doomed to destruction, agroforest development re-establishes and maintains diverse and rich forest ecosystems in which farmers are integrated.

In terms of global biodiversity conservation strategy, the strength of agroforests should be clarified. Biodiversity levels achieved in agroforests are still far from those reached by natural rainforests, but they are very impressive compared to other production systems. Agroforests cannot therefore be conceived as substitutes to protected areas of natural forest, but they have a substantial role to play as a supplement, in multiplying for a significant fraction of forest species the opportunities to live and reproduce outside protected areas.

6. Are agroforests doomed to disappear?

Weaknesses/Threats:

a. With increasing population density the expected economic returns from land increases

Agroforests present undeniable benefits in terms of environment and economy; they also have demonstrated their sustainability and they are well adapted to smallholders' conditions. But as any production system, they have a certain domain of application: for instance, it would be foolish to try to develop agroforests in areas of Java where population density reaches **1000 inhabitants per km2**;

b. Insecurity of land and tree tenure / government development programs

In spite of their positive aspects, existing agroforests are currently facing important threats:

b.1. Agroforests in Indonesia cover several millions hectares, but they are not mentioned in any of the land-use categories currently adopted by government services: being too far from current conceptions of both agriculture and forestry, agroforests are denied their existence.

b.2. Direct and pressing threats, as they can be observed in Indonesia, are caused by the prioritisation of large-scale industrial plantation projects in development programmes for rural areas.

b.3. Establishment is also doomed to fail in regions where land and tree tenure is not secure.

c. Lack of accurate and solid data on most agroforest systems

The almost total lack of research regarding agroforests also contributes to these threats: accurate and solid data are currently available only for a few well known cases, first experimental attempts to improve agroforest productivity have been set up in 1995 and only for rubber agroforests.

d. Wide applicability in other regions?

More research is needed to find out what systems can be developed in what areas regarding population density, climate, soil, markets,…

e. Agroforests are not easily recognisable

The multiple forms they can take, their resemblance with natural vegetation, and consequently their unclear differentiation both on remote-sensing documents and in the field make it difficult to establish common and obvious criteria for recognition. Most agroforests are presently mapped on official documents at best as "secondary forests" and at worse as "degraded unproductive land". They are therefore taken together with the bulk of actually degraded lands that new policies wish to rehabilitate. For example, a "reforestation" project in the west coast of Lampung planned to convert to *Acacia* plantations thousands of hectares of damar agroforest that were mapped as degraded vegetation!!! *An obvious solution could be to* ***integrate members of local communities in land-use mapping and land-use planning processes.*** The historical component deserves more attention.

f. Agroforests look like jungle

The high number of components and their spatial arrangement give agroforests a disordered, neglected look. Agroforest physiognomy leads observers, including most agronomists and

agroforesters (used to the order of monocultures or simple associations) to interpret this apparent disorder as a sign of carelessness, or even abandon. Foresters should theoretically be more able to appreciate complex agroforests as they are close to a natural forest and as they technically represent a remarkable silvicultural success. Unfortunately most of them do not show any interest as a dominant obsession in foresters'community is that farmers and forests are not compatible. To most foresters, there is still no middle ground between natural forests and industrial timber plantations and farmers'success in establishing and managing agroforests is perceived at best as anecdotal. It is difficult for agronomists, agroforesters and foresters used to the simple order of monocultures or to the virginity of forests to admit agroforests as true production and protection systems. *Education as well as the development of participatory appraisal methods will help develop perceptions closer to reality, but it will take time*.

g. Productivity is difficult to measure

Agricultural economists are used to a certain range of crops and crop patterns, and they are often quite reluctant to appreciate a tangle of tree crops and unuseful plants. They also usually lack the necessary background to identify trees or herb species of economic interest.

h. Agroforests are not "modern"

Agroforests are perceived, especially by local scientists, extensionists and policy makers, as a relict form of primitive agriculture which they are not proud of, as a sign of underdevelopment. Such perception is indeed far from reality: agroforests encountered, since the very beginning of their conception, continuing processes of innovation and adaptation, in relation to constant changes in ecological, economic and social conditions, in relation also to the evolution of markets. Present agroforest systems are in fact the modern result of a long history of adaptations and innovations, trials and failures, incorporation of new species and new agroforestry strategies.

7. Do agroforests have a future?

From a forestry perspective, foresters have now to assume a new role in rural development. With the urgent needs for improved social forestry programs and the promotion of the "buffer-zone" concept for national parks, they have to integrate forest production with forest conservation, and they can no longer afford to ignore rural communities.

From an agricultural perspective, given the failure of many agricultural programs that promoted continuous annual cropping systems in previously forested areas, agronomists have also begun to think of trees as potential vectors for sustainable development.

On the agroforestry side, simple agroforestry associations have been largely tested and promoted, their limits have also been felt, in the fields of biological performance, economic benefits, farmers acceptance, diversification potentials, etc. With the integration of sustainability as a central concept in development, policy makers cannot anymore ignore the environmental consequences of development orientations and programmes they promote.

Trainers and extensionists can now explore their respective countries in search of local farmer's developed agroforest systems and help develop with their colleagues and students a national agroforest knowledge base. Agroforestry trainers have an important role to play in raising public awareness concerning that agroforestry at large and agroforest systems in particular can offer now and in the future.

8. Remaining Research Questions

Conventional methods for measuring benefits from a given agricultural system cannot capture the diversity components of an agroforestry system:

1. How to accurately assess profitability in these conditions, and at what time scale?
2. How to include environmental, biodiversity and social functions and benefits in these assessments?

These fundamental questions are not yet solved, though they are essential for a global economic assessment of agroforests.

Questions:

- Could you give a brief description of agroforest practices in your country? Where are they currently practiced? What are the benefits to farmers? What are the bottlenecks?
- Is there a potential wider domain for adoption?
- What are the key questions that research can usefully address?

III. Reading Materials

Text books

FAO, IIRR. 1995. Resource management for upland areas in SE-Asia. An Information Kit. Farm field document 2. Food and Agriculture Organisation of the United Nations, Bangkok, Thailand and International Institute of Rural Reconstruction, Silang, Cavite, Philippines.
ISBN 0-942717-65-1:p 207

Book chapters

de Foresta H, Michon G. 1993. Creation and management of rural agroforests in Indonesia: potential applications in Africa. In: Hladik, C M *et al*, eds. *Tropical forests, people and food. Biocultural Interactions and Applications to Development*. Unesco MAB Series, No 13, Unesco and Parthenon Publishing Group: p 709-724.

Michon G, de Foresta H. 1995. The Indonesian agro-forest model: forest resource management and biodiversity conservation. In: Halladay P, Gilmour DA, eds. *Conserving Biodiversity Outside Protected Areas. The Role of Traditional Agro-ecosystems*. IUCN: p 90-106.

Michon G, de Foresta H. 1999. Agroforests: incorporating a forest vision in agroforestry. In Buck LE, Lassoie JP, Fernandes ECM, eds. *Agroforestry in Sustainable Agricultural Systems*. CRC Press, Lewis Publishers: p 381-406.

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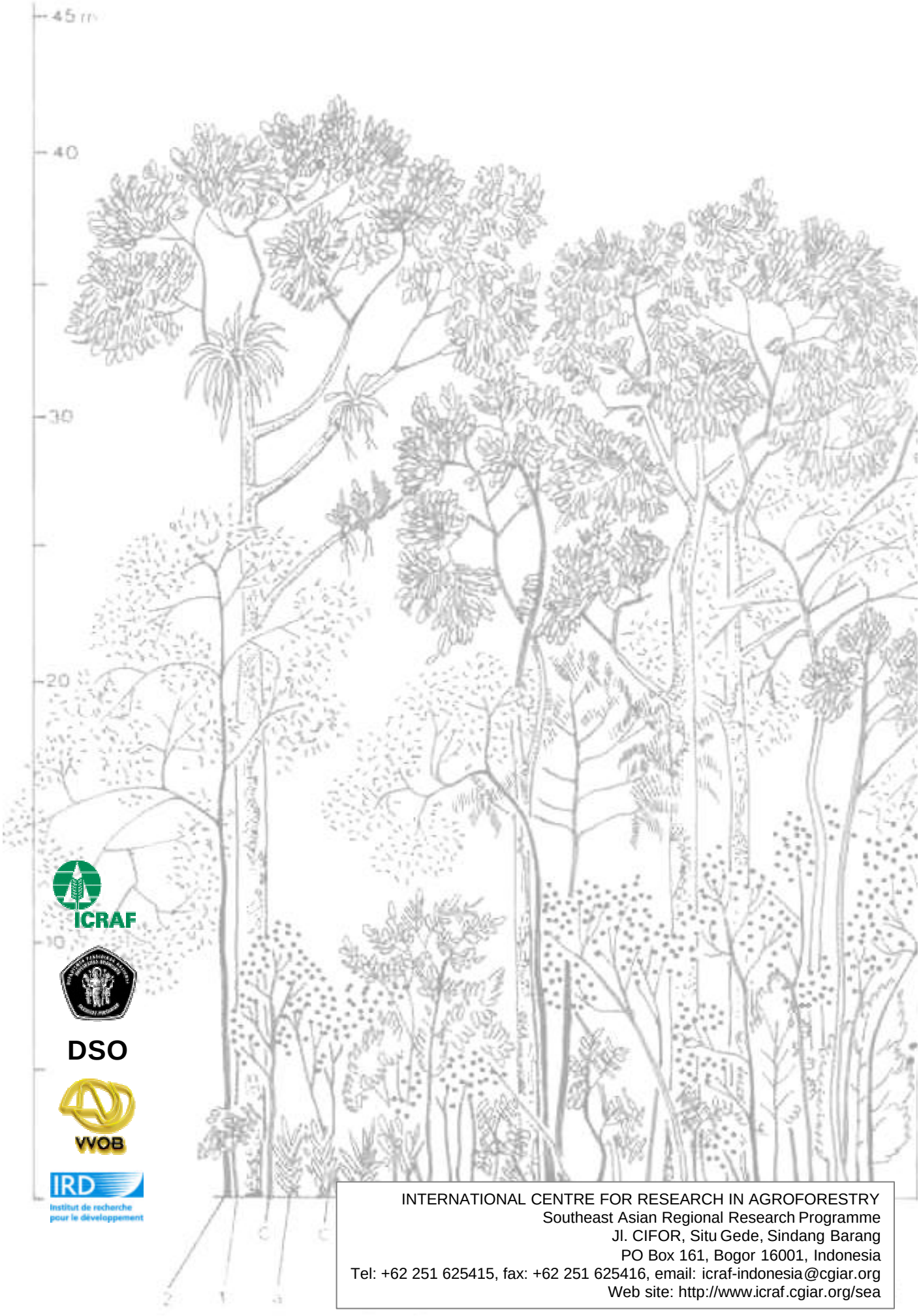
de Foresta H, Michon G. 1997. The agroforest alternative to *Imperata* grasslands: when smallholder agriculture and forestry reach sustainability. Agroforestry Systems 36:105-120. Dordrecht: Kluwer Academic Publishers

Booklet

Agroforests. Examples from Indonesia. Published by ICRAF, ORSTOM, CIRAD-CP and the FORD foundation.

Web site

http://www.icraf.cgiar.org/sea



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IRD
Institut de recherche pour le développement

INTERNATIONAL CENTRE FOR RESEARCH IN AGROFORESTRY
Southeast Asian Regional Research Programme
Jl. CIFOR, Situ Gede, Sindang Barang
PO Box 161, Bogor 16001, Indonesia
Tel: +62 251 625415, fax: +62 251 625416, email: icraf-indonesia@cgiar.org
Web site: http://www.icraf.cgiar.org/sea