Agroforestry in Sustainable Agricultural Systems

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CRC Press
Boca Raton London New York Washington, D.C.

LEWIS PUBLISHERS
Boca Raton London New York Washington, D.C.

Acquiring Editor: John Sulzycki
Project Editor: Albert W. Starkweather
Cover design: Dawn Boyd

Library of Congress Cataloging-in-Publication Data

Agroforestry in sustainable agricultural systems / edited by Louise E. Buck, James P. Lassoie, and Erick C. M. Fernandes
p. cm. -- (Advances in agroecology)
Includes bibliographical references and index.
ISBN 1-56670-294-1 (alk. paper)
1. Agroforestry. I. Buck, Louise. II. Lassoie, J. P. III. Fernandes, E. C. M.(Erick C. M.) IV. Series
S494.5.A5 A375123 1998
634.9'9—ddc21 98-31470
CIP

International Standard Book Number 1-56670-294-1
Library of Congress Card Number 98-31470
Printed in the United States of America 1 2 3 4 5 6 7 8 9 0
Printed on acid-free paper

17 Agro-Forests: Incorporating a Forest Vision in Agroforestry

Genevieve Michon and Hubert de Foresta

1. INTRODUCTION

Though extensively practiced throughout the tropics by indigenous farmers, agroforestry as a science-based technology was first introduced through forestry, not agriculture. It developed in the mid-19th century, when professional foresters strove to improve the economic efficiency of forest

1-56670-294-1/99/$0.00+$.50

plantation establishment through the technology that later became known as the "taungya system" (King 1987). This first development of modern agroforestry was not concerned with farmers, nor was it considered a system that could improve global land utilization patterns in forest areas. In the early 1970s, when global concerns for the degradation of forested lands increased, agroforestry was reassessed as a system of land management applicable to, and with great potential for, both farmlands and forests. This new brand of agroforestry was primarily targeted at improving the conditions of the rural poor. It did not fundamentally change perceptions about farmers and farming in forestry sciences, but it did contribute to a broader vision of agricultural sciences in general. Suddenly, trees in agricultural landscapes, that had remained quite invisible to agronomists, became valued as important elements of the agricultural system itself. But how far did this reassessment of trees in agriculture translate into a better integration of forestry and agriculture?

Probably to balance a history that for more than one hundred years had ignored the importance of farms and farmers to promote the forest itself, modern agroforestry science as developed through the International Centers emphasized its agricultural side at the expenses of its forest dimension. But even after more than a decade of development, in many parts of the world agroforestry remained more "agro-" than "-forestry" oriented. With the exception of the taungya system, agroforestry research perceived studies related to forest resource management as outside of its mandate. See for example, Steppler and Nair 1987; Nair 1989; Kartasubrata et al. 1989; Vergara and Briones 1987. While focusing on integration of trees into farmers fields, agroforestry research neglected the forest itself.

Ignoring forests seems inappropriate, for in the real rural world of the tropics many forms of forest management directly interact with the management of farmlands. Hunting, gathering and extractivism are essential complements to field culture in forest margins. Farmers often manage more or less artificial forests, either evolved from natural vegetation or purposefully established within their farmlands, as central elements of their farming systems. Is that not real agroforestry too? This hidden face of agroforestry has recently been unveiled in the American tropics where present research programs include major components on forest-related systems, but it remains ignored in agroforestry programs developed in Africa and in Asia.

The importance of forest resource utilization by indigenous communities is a well recognized fact, but how forest management relates to field culture should be more systematically considered. What does the forest actually contribute to agricultural development at local and national levels? What is the extent and the role of indigenous forest gardening and how does it affect land development in general? What mechanisms and strategies have farmers developed to integrate forest resources into their farming systems? How do farmers compensate for the depletion of natural forests in their direct environment? All these questions, and many others, should logically fall into the scope of agroforestry research. But they commonly do not, as this is considered more the field of forestry research. By neglecting its forest-related side, modern agroforestry science is probably losing considerable understanding of the present dynamics of farming systems in "forest areas." It is also drastically reducing its potential impact on the future development of the so-called forest lands.

By undermining the forest dimension of their vision, the main institutions for agroforestry research are also failing to address important issues that stand at the crossing between agriculture and forestry and represent new challenges in rural development. How to orient smallholder farmers to forest resource management, and especially how to integrate forest production on farmlands through domestication and cultivation of timber as well as non-timber forest resources are the questions? Also, how to involve farmers in conservation, especially for biodiversity conservation outside protected areas? Can agroforestry help reduce the present trend toward segregation between forest and agriculture? Can it help balance the planned expansion of obviously unsustainable forms of agriculture at the expenses of natural forests, and the related shrinkage of the forest resource base of smallholder farmers? Can it positively address the roots and dynamics of forest clearing by smallholders and help restore forest functions through adequately designed systems? Finally, can it achieve a real integration between agriculture and forestry?

This chapter focuses first on those indigenous examples of forest management that achieve a true integration of forest resources and structures into farmlands — cyclic and permanent cultivation of artificial forest in swidden agricultural systems in an Indonesian context. Agroforesters often deny the "agroforestry label" to these indigenous systems, as their "forest" component is so immediately visible that it obscures what pertains to the "agro" part of it. However, a close look at these systems reveals how, more than the plot itself, it is the whole conception of resource management and land development that concerns the interface between agriculture and forestry. The paper then highlights the qualities of these reconstructed forests from an agroforestry perspective and proposes initial approaches for their analysis. Based on these defined qualities, it examines how these indigenous systems can inspire new models for the "forest end" of the agroforestry continuum, and how their extrapolation to other areas can be accomplished. Finally, we discuss the potential benefits of incorporating a larger "forest vision" in the agroforestry approach.

2. INDIGENOUS FOREST FARMING AS TRUE AGROFORESTRY OPTIONS

Studies on indigenous forest management have multiplied during the last 15 years. Few of them, however, have emphasized the importance of basic differences between the various systems encountered throughout the tropics. Among these differences, the most significant might be the distinction between extraction — passive resource management in natural ecosystems — and production — active management of resources, usually occurring through the establishment of artificial forests into farmlands. It is essential to overcome the classic confusion between these two strategies for forest resource management for, despite obvious similarities in the biological and ecological nature of harvested forests and artificial forest-gardens, their historical justification, socio-cultural and institutional foundations, and political implications diverge. And whereas managed forests may not have their place in agroforestry research, cultivated forests that clearly associate forest resources with agricultural management touch directly upon basic agroforestry issues.

Southeast Asia, and Indonesia in particular, is rich in examples of indigenous forest resource management. However, if Indonesian farmers are often cited as skilled managers of natural forests, it is less often acknowledged that an essential part of this indigenous forest resource management is carried out outside natural forests in complex tree gardens established within agricultural lands for active production of forest commodities. These gardens are often viewed as scattered home gardens. They are not! They usually form large blocks that extend beyond villages and their permanent open fields, like the damar gardens in the south of Sumatra that form an obvious 25,000 hectares forested unit in agricultural lands. They are sometimes referred to as "managed forests." This is confusing as a "managed forest" most commonly refers to natural vegetation, which forest gardens are not. They are always born from forest clearing and tree plantation. They are regarded as devoted to personal consumption through the provision of complementary foods and materials. They are much more than that. Most of them assume a determining role in the farm economy, as the main income-generating unit of the production system. Indonesian forest gardens are in fact closely related to plantation agriculture, as the main incentive for their development is the production of commodities for trade. The fact that these commodities are forest resources like fruits and spices, rattan, resins or latex might be misleading, but one should not forget that those forest resources have long been and still are essential commodities in forest trade. Forest gardens are also commonly regarded as anecdotal components of backwards traditional agriculture. But, again, they are not. In Indonesia, they are so diverse, so dynamic and so important that they are a major element of 20th century smallholder agriculture. They can be found, in one form or another, in almost every farming system evolved from former forest lands.* They cover altogether several million hectares

* Rubber-based forest gardens cover between 2.5 and 3 million hectares in the lowlands of Sumatra and Borneo (Dove 1993; Gouyon et al 1993), and the total of fruit-dominated forest gardens in Sumatra alone approximates 3 million hectares (Laumonier 1983; Laumonier et al 1986; 1987).

FIGURE 1. Some forest commodities such as damar resin in Indonesia, though considered harvested from natural forests are actually produced in complex agroforestry systems. Illustrator: G. Michon.

(Michon 1993). They provide 80% of the rubber latex consumed and exported by Indonesia, roughly 95% of the various fruits marketed in the country, and 80% of the Dipterocarp resins traded in and outside the country, a significant part of bamboos and small cane rattans, an immense part of the firewood used in the country, and the majority of such items as medicinal plants and handicraft material (Figure 1).

Active production of forest commodities in Indonesia is a modern fact, but it is by no means a recent strategy in indigenous resource management. According to some authors, it probably launched the bases of plant domestication that began, in this part of the world, not from annual food plants but through the transfer of forest trees that produced materials essential to subsistence, such as tannins for fishing nets or bark fibers for clothes, to artificial environments nearby dwellings (Sauer 1952; Barrau 1967). Forest cultivation really expanded under two complementary dynamics (Michon et de Foresta, 1996). One was linked to subsistence resources in the forest and led to the domestication and cultivation of more than a hundred fruit and nut species. In shifting cultivation areas, this subsistence-oriented tree gardening established cultivated forests around settlements, which further remained as semi-managed "fruit islands" disseminated along the successive migration routes. These fruit forests remain along roads and river banks all over the archipelago. The other forest production dynamics evolved with the expansion of long-distance trade in forest products and created large areas of forest-gardens along the forest margins of the great islands: Sumatra, Kalimantan, Sulawesi, the Mollucas. This commercial forest gardening probably emerged between the 1st and the 5th century through the domestication of spices and stimulants — tea, clove, nutmeg and local species of pepper — traded from the lowland forests to China and the Middle East. It really expanded, however, during colonial times, with resources as varied as cinnamon, illipe nut, rattan, damar or rubbers. These indigenous dynamics of forest cultivation remained distinct from the plantation movement imported by the Dutch colonizers. The variety of forest garden systems developed by local people had nothing in common with the uniform colonial estate model. Except for rubber, they used different forest species. Colonial planters exclusively brought species from other parts of the world; oil palm and coffee from Africa, and rubber, cinchona and cocoa from Southern America, whereas indigenous people dealt mainly with local species. These examples of commercial forest cultivation emerged continuously in the course of recent centuries.

One of the oldest traded forest products in the region is benzoin, a fragrant resin that is produced by *Styrax* sp., Styracaceae, entering incense mixtures and perfumery or pharmaceutical preparations. Benzoin was produced in permanent agroforestry systems in North Sumatra, probably before the 18th century (Marsden 1783). Cinnamon production, the aromatic bark of several species of *Cinnamomum*, Lauraceae (Indonesian cinnamon is traded as *Cassia vera* and is mainly provided by the cultivated *Cinnamomum burmanii*), became established two centuries ago in the central highlands of Sumatra (Heyne 1927; Burkill 1935). In western Borneo, the illipe nut forests developed at the beginning of the 19th century. *Tengkawang*, or illipe nut, is a fatty nut produced by roughly 15 *Shorea* species, Dipterocarpaceae, that provides a substitute for cocoa butter in the manufacture of chocolates, margarines and cosmetics. In South Sumatra and Central and East Kalimantan, rattan cultivation emerged 100 years ago (Heyne 1927). Rattan includes 600 different species of climbing palms, 12 to 15 of which are used regularly in Indonesia. Only two are cultivated: *rotan sega*: *Calamus caesius*, and *rotan irit*: *Calamus trachycoleus*. At the beginning of this century, in the south of Sumatra, swidden farmers started cultivating damar trees (Michon and Bompard 1987). Damar trees are resin-producing Dipterocarps, from the genus *Shorea*. The cultivated species is *Shorea javanica*, which produces *damar mata kucing*. Their colleagues in the eastern lowlands began appropriating the Amazon rubber tree (Pelzer 1945). Nowadays, new types of commercial forest gardens are still being developed with fruit and timber species (de Jong 1994; Salafsky 1994).

Integration of forest resources into farmlands occurred not only during various periods in history, but also through different strategies related to complex sets of circumstances. Differences in the intensity of agricultural practices, in the level of forest-related knowledge, in the strength of socio-cultural habits or in the power of local institutions resulted in the creation of different types of structures. Present indigenous forest gardens can be grouped into two main categories. The first set consists of gardening practices of various intensities that remain integrated into forest structures and dynamics. It includes forest-gardens evolving from localized enrichment planting or gradual substitution of species in natural forests, as well as gardens established as productive fallows, integrated in the cycle of shifting cultivation. The second set of forest-gardens implies a more or less permanent replacement of the natural ecosystem by cultivated forests, established after total removal of the original vegetation and intensive replanting of useful trees.

2.1 Forest Production Integrated into Forest Structures and Dynamics

Some indigenous forest gardens rely on an *in situ* replacement of the few and scattered individuals of a given commercial species in the wild by many planted individuals of that same species, coupled with practices that locally modify the forest to the benefit of these planted species. These include selective slashing of competing vegetation and a slight opening of the canopy. This enrichment planting is integrated into existing forest structures, but never destroys or replaces them.* The forest is artificial in spots, to more or less important degrees, but without any meaningful impact on its biology, structure, ecology or function. This practice is presently limited to some forms of rattan production in Central and East Kalimantan, where rattan is planted in late successional forests after slashing of the undergrowth bushes and vines (Godoy et Feaw 1989). Rattan canes use the standing canopy trees as support. The resulting "rattan garden" does not differ from an old successional vegetation structurally nor floristically but the astonishingly high density of rattan clumps clearly indicates the artificial nature of this seemingly "secondary" forest. The rattan

* This practice has been mainly documented in the Amazon, with the management of cultivated stands of *Euterpe* palms for palm heart and juice production — in swamp forests (Anderson 1987), or of Brazil nuts (Lescure 1995).

FIGURE 2. Some semi-permanent forest gardens, like rattan gardens in Central and East Kalimantan, are included in the cycle of shifting cultivation. Illustrator: Wiyono, ORSTOM.

stand is managed until cane quality and growth performances of the rattan clumps decrease, which may take several decades. A new cycle can then be initiated through selective slashing of remnant vegetation and replanting of rattan seedlings (Figure 2).

Most cases of rattan production in Kalimantan, however, are associated with younger stages of forest succession and are fully integrated within shifting cultivation cycles (Sevin 1983; Weinstock 1983; Fried 1995). Rattan seeds are co-planted with rice in the swidden, and the canes develop with the fallow vegetation that they use as a support. These early "rattan fallows" are not visited during the whole period of rattan growth, and the rattan canes can be harvested 8 years after the plantation. The commonly cultivated rattan species grow in clumps so that harvest of individual canes does not entail the death of the productive plant. The rattan garden can yield canes for the following 20 to 35 years, which usually goes with a notable enrichment of garden plots with fruit trees. The garden can also be completely harvested after two or three "crops" — 3 to 6 years after the first harvest — for a new rice-and-rattan cycle.

In this rotational system, the forest production phase is well integrated within existing agricultural cycles, under the form of a planted fallow. This refers to what has been defined as "rotational agrisilvocultural systems" in classical agroforestry classifications (Nair 1990). The forest phase of this agro/forestry cycle is ecologically equivalent to early successional vegetation, with dense stands of intertwined pioneer trees and climbers. Its main function is the production of commodities for the market. Depending on the degree of planting and control in the garden, however, it can also fulfill several secondary economic functions from occasional subsistence production, gathering of wild vegetables, firewood and fruits, to intended commercial ones, mainly fruits.

Another outstanding example of rotational forest production is represented by rubber gardens in the lowlands of Sumatra and Kalimantan. Though the cultivated rubber tree is not a native species, swidden cultivators in Sumatra and Borneo have adopted it in their swidden production system not long after its introduction in the colonial estates (Pelzer 1945; Dove 1993; Gouyon et al. 1993). Rubber trees, sown in a rice swidden and growing among a classical fallow vegetation, can be tapped after 8 to 10 years. The "normal" cycle for this smallholder rubber production is 35 to 40 years, but some rubber gardens are more permanent, with gradual replacement of decaying trees by self-established rubber seedlings. After 70 to 80 years, however, yields are definitively declining and the vegetation has to be slashed for a new cycle. These native rubber gardens have overcome rubber estates in terms of surface area and volumes of production. In the lowlands of Sumatra and Kalimantan they represent the major land-use systems in smallholder farming.

Rubber gardens tend to be more permanent than the rattan gardens discussed above, and the tree density is higher. However, as for rattan gardens, their structure is similar to that of classic successional vegetation and, although rubber trees are exotics, rubber gardens are often confused with and classified as "natural secondary forests." Due to their relative perennial nature, combined with tending practices that leave a major role to natural processes, they harbor a considerable number of plant species. This half-managed richness allows the provision of secondary products — plant foods and material, timber, game meat — which compensates for the relative low productivity in rubber. Beside their economic importance to farmers, rubber gardens play a determining role in the conservation of plant and animal biodiversity in the lowlands. This role is dramatically increasing with the depletion of the last unlogged dipterocarps forest of this ecotone (de Foresta 1992).

2.2 Cultivated Forests in Farm Lands

Other forest gardening practices in Indonesia have resulted in the establishment of permanent structures closer to those of late successional or old growth forests, which constitute examples of true "forest culture" (Michon et Bompard 1987). These permanent tree gardens are also established through classic subsistence slash and burn as tree seedlings are directly planted in the swiddens. The management of the establishment phase constitutes a complex process of forest reconstruction that can be illustrated by the example of damar gardens in Sumatra (Michon et Bompard 1987; de Foresta et Michon 1993; Michon et al. 1995).

The plantation begins as a classic "taungya system." Damar seedlings, usually raised in nurseries, are introduced in an already planted rice swidden or, preferably, a young coffee or pepper plantation established after rice production. This coffee-damar association is maintained for up to eight years. It allows seedlings to grow in the best possible conditions in terms of micro-environment and concurrence. However, the parallel with more conventional tree plantations does not go further, and the consecutive phases are conceived more in a logic of connivance with the forest ecosystem than of environmental confrontation. Once the crop phase is abandoned, damar trees freely develop with the natural pioneer vegetation that establishes spontaneously. During this period of relative abandonment, through natural processes of dispersion and niche colonization, the young plantation gradually acquires the structure and composition typical of any secondary forest. This successional forest-garden becomes more complex over the years due to a combination of free functioning — development of natural silvigenetic processes — and integrated management — selective cutting and enrichment planting. This management pattern does not fundamentally change when the damar garden begins producing. In the mature plantation, a balance between natural dynamics and appropriate management of individual trees helps maintain a system which produces and reproduces without disruption in structural or functional patterns. It also allows further diversification through the establishment of more climactic forest species among the cultivated stand. Once established, damar gardens usually reproduce without any major disruption, as decaying trees are replaced whenever needed. Unlike plantations that evolve through

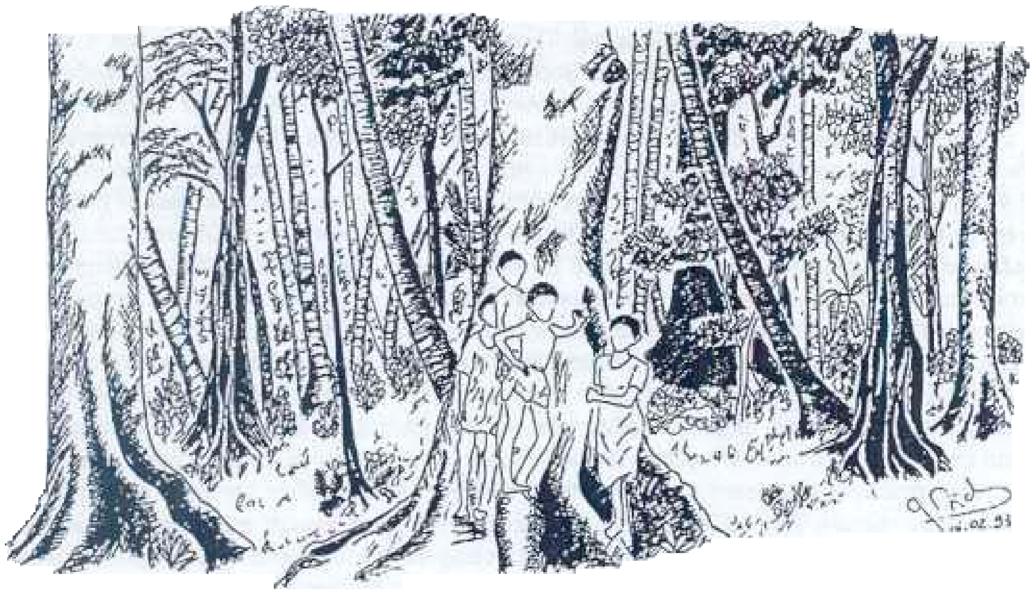

FIGURE 3. For damar resin production farmers have developed a system of highly complex forests cultivated in the middle of farmlands. Illustrator: G. Michon.

cycles of total harvest, damar gardens remain permanent without reverting to a phase of massive regeneration (Figure 3).

After 40–50 years, the damar plantation reaches its full production period. From a socio-economic point of view, it is not fundamentally different from any specialized commercial plantation. It provides the majority of household income and constitutes an essential complement to ricefields in the farming system (Mary 1987; Levang 1992). From a biological point of view, however, the mature phase finally resembles more the forest it replaced than a conventional tree plantation. As a natural forest, it is characterized by a high canopy, dense undergrowth, high levels of biodiversity and perennial structures. Apart from damar trees that form the frame of the garden, the damar plantation shelters several tens of commonly managed tree species, and also several hundreds of additional species of trees, treelets, liana and epiphytes that are spontaneously established and often used. As natural lowland and hill dipterocarp forests in the area are severely depleted, the damar gardens constitute the major habitat for many true forest plants and animals, among which are represented some highly endangered mammal species including Sumatran rhinoceros, Sumatran goat, tigers, tapir, gibbons and siamangs (Sibuea et Herdimansyah 1993; Michon et de Foresta 1995; Thiollay 1995).

The "agroforestry nature" of damar gardens is more visible in the establishment phase, which constitutes taungya system associating tree seedlings and annual crops, than in the mature phase that can be characterized as a forest. However, it is the mature phase where forest and agriculture really intersect. Damar gardens have the ecological integrity of a forest, but rely on agricultural practices and are managed mainly as an agricultural enterprise in the middle of farmlands. They epitomize what integrating forest into farming systems can look like.

Benzoin gardens of the Tapanuli regency in North Sumatra represent another original practice of indigenous forest plantation (Watanabe 1990; Simanullang 1988; Katz et al. 1997). In this case, the silvicultural pattern does not result in the establishment of a forest garden that remains permanent, but rather integrates a semi-cyclic phase of actual forest production in a global continuum of old-growth forest. Benzoin trees are first planted in the undergrowth of montane forest. Canopy trees and undergrowth species are then selectively cut as the benzoin develop, in order to maintain a balance

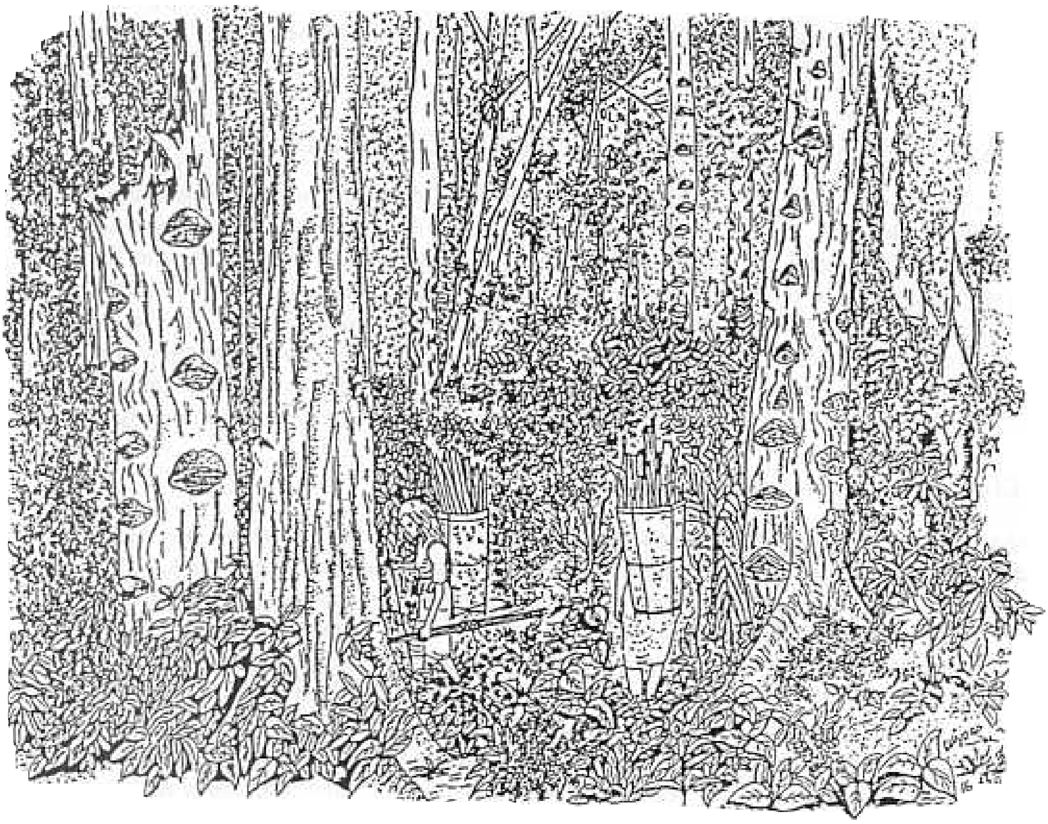

FIGURE 4. Spice and nut trees in forest gardens of the island of Saparua, Moluccas. Illustrator: Wiyono, ORSTOM.

between high light and low temperature in the micro-environment of the benzoin trees. The resulting diversity of large tree species associated with benzoin is not as high as for damar gardens — only good hardwood species and pines in the canopy are effectively favored. But the undergrowth retains many bushes and epiphytes typical of the surrounding montane forest. As long as benzoin trees are tapped for resin — from year 10/12 to 25/45, the garden is more or less carefully maintained and its structure remains somewhat open. The gardens are then gradually abandoned, after a maximum of 65 years, with less and less control over the self-established tree species. This increasing lack of maintenance allows the abandoned garden to quickly revert back to a typical high growth forest. After several decades, the resulting montane forest can be reutilized for benzoin production if needed.

Many other examples of permanent or semi-cyclic forest gardens have been reported. In West and central Sumatra some cinnamon gardens integrate the production of cinnamon plus coffee or nutmeg below a high canopy of large cultivated trees targeted at timber and fruit production. The cinnamon stand is usually completely harvested after 8 to 10 years and then replanted. However, some gradual harvesting can occur if needed. Self established vegetation is usually conserved, but due to the high density of the cinnamon stand, biodiversity concentrates mainly on epiphytes on the canopy trees, small lianas, and undergrowth herbs (Michon 1983; Aumeeruddy 1993). Many types of fruit-based forest gardens can be found throughout Sumatra and Kalimantan. In North Sulawesi or in Lombok, forest garden systems are centered around a palm producing sugar, whereas in the Moluccas, they associate coconut trees and tall Canarium in the canopy with tahitian chestnut, nutmeg or clove, or a mixture of both, plus banana groves in the lower levels. The most remarkable systems in terms of plant richness and similarity to old growth forest are to be found on the island of Borneo, with illipe-nut gardens in West Kalimantan (Momberg 1993; Padoch et Peters 1993; Sundawati 1993) and "lembo" fruit forests in East Kalimantan (Bompard 1988; Seibert 1989; Sardjono 1992) (Figure 4).

3. AGROFORESTS: THE QUALITIES OF EXISTING EXAMPLES

In the large range of agroforestry systems and practices, the Indonesian forest gardens exhibit very specific qualities linked to their structure and management. To understand these particularities it is useful to introduce an artificial, but clear distinction that allows us to differentiate the existing agroforestry models based on physiognomic criteria (de Foresta et Michon 1991). This distinction leads to the definition of "simple" and "complex" agroforestry systems. "Simple" and "complex" refer here to the structure and biodiversity of the system without any pejorative connotation. The terms do not refer to the establishment and management processes which can be indeed quite simple for "complex agroforestry systems" and sometimes very complex for "simple agroforestry systems."

3.1 Complex and Simple Agroforestry Systems

"Simple agroforestry systems" refer to associations involving a small number of components arranged with obvious, usually well-ordered patterns: one or a couple of tree species, either as a continuous canopy, in equally distant lines or in edges, and some annual species for ground cover. The tree component can be of major economic importance such as coconut, rubber, clove, teak, or have a more service-oriented role such as *Erythrina*, *Leucaena*, or *Calliandra*, planted for fodder as well as for soil fertility. The annual species is almost always important economically, as with paddy, maize, vegetables, and forage herbs. The ground species can also be a semi-perennial like banana, cocoa, or coffee. These simple agroforestry associations represent the classical agroforestry model, which is favored in research and development programs of most institutions dealing with agroforestry (Steppler and Nair 1987; Nair 1989). Most agroforestry experimentation and extension projects until now have also concentrated on simple tree/crop associations; which are important as improved technologies, such as alley-cropping, hedgerows and improved fallows. These are also practiced in plantation agriculture as with coffee under *Erythrina*, coconut and cocoa or rubber and rattan. In traditional agriculture in Indonesia, most dry fields include trees either as true components, such as coconut with maize, or as borders of teak, mahogany or rosewood. Trees are also commonly associated with irrigated ricefields, which sometimes reflect natural constraints, such as the association between coconuts and ricefields in the swamp areas of Sumatra East Coast. Or they characterize areas of high population density, such as kapok trees cultivated for centuries on the dikes of Javanese ricefields or the recent trials of introduced clove and lime trees on mounds in the middle of Sundanese ricefields.

Complex agroforestry systems are tree-based with a forest-like configuration. They associate a high number of components, among them trees as well as treelets, lianas, and herbs. Their physiognomy and functioning are close to those observed for natural ecosystems. Complex systems are encountered most commonly in peasant agricultures of the humid tropical world. Except for home garden systems, a particular form of complex agroforestry association that has been well documented all over the world, complex systems, although common components of indigenous farming systems, have been ignored and poorly investigated.

This striking physiognomic, physiological and functional reference to a natural forest ecosystem — the "forest preference" in agroforestry — is one of the main features separating "complex" from "simple" agroforestry systems. It is also the main determinant of their diverging ecological as well as economic functions. To emphasize this forest affinity, we have introduced the term "agroforest" (Michon 1985; Michon et Bompard 1987). This term tends now to be widely appropriated. It is often conveniently applied to any type of agroforestry association, be it a complex multistoried garden of forest trees, a simple association between trees and herbs or even a taro garden overshadowed by papaya "trees." This recent but increasingly widespread confusion will soon obscure the uniqueness and the potential impact of the original concept. As the term "forest" refers to a complex association of plants dominated by large trees, "agroforest" applies only to those multistrata systems that exhibit typical features of a true forest ecosystem, i.e., a closed canopy structure, a multilayered configuration, a great diversity, a dominant forest origin of plant components and the predominance of natural processes in vegetation development and regeneration. The agroforest concept also implies a relative continuity in time and space. Even if it consists of a mosaic of different management units, often exhibiting different silvigenetic units, an agroforest constitutes a large and easily recognizable forest block in agricultural landscapes. A mosaic of open fields and small tree gardens can be compared to a fragmented forest ecosystem. Even though complex in structure and composition, it usually does not allow the full development of forest functional processes, especially those that relate to species regeneration and, more globally, biodiversity (Simberloff 1992). Though related to "complex agroforestry systems," this kind of agroforestry mosaic should not be considered an "agroforest," unless a highly fragmented agroforest.

The implications of the concepts, simple and complex agroforestry systems, go far beyond this physiognomic description. Simple and complex agroforestry systems relate to two different, though potentially complementary, conceptions of land development. One refers to field management: simple agroforestry systems address the integration of trees in agricultural lands. The other refers to resource management: complex agroforestry systems address the integration between forests and agriculture. This difference not only embraces important ecological aspects but, has essential socio-political implications especially concerning the global role and interest of smallholder farmers in the management of forest lands and resources.

3.2 Rationale and Outputs of Agroforest Development in Indonesia

Existing agroforests hold a high degree of local particularity. They also exhibit qualities that are of central interest in the framework of sustainable development, and that are quite different from those commonly acknowledged for simple agroforestry combinations. These include, among others, the simplicity of establishment and maintenance techniques, the conservation of plant and animal biodiversity, the protection of soils, high economic profitability, diversity and flexibility.

The rationale and the qualities of the Indonesian examples consistently feature the ambiguity of their nature and their development: neither really a forest, nor totally a plantation. As exhibited in the examples, agroforests begin as specialized plantations, as an attempt to switch from the management of wild resources in traditional extractive systems to their adoption as new crops in farming systems. These plantations diversify into a mixed stand of planted tree crops and useful resources which have similarities to a climax formation: the evergreen rainforest. This diversification process is not totally planned by the farmers, but it is commonly accepted and purposefully retained. Agroforest management maximizes the benefits of this forest similarity. This "forest preference" in agroforest development is essential, as it allows a combining of the ecological qualities of a forest and the economic benefits of a diversified, multipurpose plantation.

3.2.1 Agroforests as an Original Process of Land Development: Ecological Qualities

As a process of land development, indigenous agroforests constitute an outstanding example of forest conversion through plantation establishment that changes the original forest cover, but in the final analysis does not drastically threaten the forest quality or its biodiversity. Even if it does not revert to the pre-disturbance state, this "forest preference" allows an original process of guided reforestation to develop that restores a good range of economic forest resources as well as essential forest functions. As in a forest, agroforests provide soil protection against erosion, leaching and landslides, and ensure the control of water flows on slopes at a watershed level. The observance of integrated management practices that respect natural processes in vegetation development allows a fairly good level of conservation of plant and animal biodiversity. Even in cyclic agroforests, where mass regeneration is used to rejuvenate the system, the significant natural regeneration of tree-to-tree replacement enables the farmers to wait longer before felling and replanting. Agroforests, either cyclic or permanent, are the only plantation system that allows the restoration of a fair proportion of original forest plants and the capture of wild animals. Besides conserving wild species, the agroforest plays an important role in genetic conservation of useful plants by ensuring the maintenance of a wide range of genotypes of economic trees, especially fruit, spices and nut species.

Agroforests as An Integrated Management Unit: Technical Qualities

The forest similarity also maximizes the benefits of "minimized intervention" that gives the major role to natural processes in the evolution and shaping of the cultivated ecosystem (Michon et Bompard 1987). It avoids resorting to intensive labor, sophisticated techniques or costly technology, while maintaining labor and chemical inputs at low levels. As the production of basic commodities relies mainly on primary production of the vegetation, the necessary inputs are generated by the agroforest itself. The strict economy of minerals between the agroforest components allows the maintenance of natural fertility potential. The active reproduction of productive structures through anticipated interventions is enhanced by natural regeneration processes. Through the "forest preference," the agroforest strategy not only achieves a simple transfer of forest resources and structures, it also guarantees the renewability of these resources and structures, thus assimilating the long-term aspect linked to the management of forest species.

Agroforests as an Original Model of Commercial Tree Gardening: Economic and Socio-Cultural Qualities

From an economic point of view, agroforests are a determining element in the generation of cash income (Mary 1987; Levang 1992). At household level, they ensure the economic independence and welfare of farmers, being the main source of income for the family, a standing reserve similar to monetary savings for urban people, and an important family patrimony that is transferred from one generation to the next. The village community also benefits from agroforests either through their direct production or from their derived activities: harvesting, transport, sorting, processing and marketing of the agroforest produce raise additional value and create job opportunities that are especially important for the landless members of the community. At the national level, agroforests provide important quantities of essential commodities for both national markets and export. The originality of this example of commercial tree gardening is that it is not conceived as an exclusive enterprise: while focusing on income generation, as estates do, the agroforest allows the maintenance of numerous other economic functions that help, as the forest does, to diversify the farmer's income and reinforce his economic stability. Through the diversification of income sources and rhythms, the agroforest serves as a "bank" that allows farmers to cover both every-day expenses with regularly harvestable products such as rubber latex, resin, coffee, cinnamon bark and annual expenses, at least partly, with seasonal products as fresh fruits, clove, and nutmeg. Other commodities such as timber provide occasional, but important sums of cash for exceptional expenses. This diversity of income sources is essential in areas where habits of storing cash are not developed and where credit is very expensive or unavailable — which represents the bulk of rural areas in the tropics. The "multifunctional" strategy also follows the age-old model of multipurpose forest use: the forest preference in the agroforest contributes to maintaining a large variety of wild foods and materials for immediate consumption or sale, or "just in case." By allowing a certain economic as well as ecological flexibility in the management of the main crop, this forest preference also constitutes an insurance against risk.

It is important to stress that agroforests never occur in isolation in native production systems: their main quality is that they are highly compatible with other activities. They are usually associated with permanent food production systems, shifting cultivation practices, specialized plantation practices, and sometimes with extra-agricultural activities.

Socio-cultural benefits associated with the agroforest system are also important. Besides maintaining an obvious coherence between practices and the cognitive base of the society, most of the agroforest management rules ensure a good distribution of benefits through several mechanisms, among them seasonal employment, processing and marketing of agroforest produce and free gathering of wild products such as small fruits, leaves, firewood, medicinal plants.

3.2.4 Agroforests as a Strategy in Forest Resource Management: Socio-Political Qualities

The socio-political consequences of the agroforest development process might be the most important, from the farmers' point of view. Agroforests secure a better grip on forest resources for farmers. Transferring wild resources from the forest to the field has occurred under different types of dynamics, including the need to increase natural levels of production or to escape from natural competitors and pests, to avoid the depletion of commercial resources in the wild, or any kind of stimulus from outsiders.* However, by switching from the management of wild resources in traditional extractive systems to their adoption as new crops in farming systems, Indonesian farmers also often aimed at maintaining or reestablishing their traditional authority over important forest resources and at capturing more efficiently the benefits of their management. There is historical evidence that the transfer of wild resources into cultivation has immediate as well as indirect effects on the bases of authority over these resources. Colonial plantations have clearly demonstrated how domestication can deprive indigenous collectors not only of the benefits of forest collection, but also of their basic rights to forest resources.**

Many examples of agroforest development were carried out as an answer to a politically induced dispossession of native collectors, as in the case of rubber or damar at the turn of this century (Dove 1994; Michon et de Foresta 1996). In many areas in Indonesia, most relations between local populations and the forest resources do not occur anymore through the forest itself, but through one or another type of agroforest. Through agroforests, farmers could secure reappropriation of the coveted resource, but this process had an unexpected consequence: the restoration of numerous other resources that were not initially encompassed in the domestication effort. This allowed farmers not only to reshape bits and pieces of the former forest economy, but also to reroot this economy in an agricultural context that allowed the establishment of new rules and regulations for the use and the control of forest resources. Establishing agroforests is a tentative strategy for legal land and resource appropriation, based on agricultural claims over forest lands through tree plantation. It could constitute a powerful weapon in political contexts where legal rights of farmers over forest resources are abused.

Indigenous agroforests, in spite of their relative success in the areas where they were conceived, are still to be improved. However, they should be considered now as models of utmost interest for the development of sustainable forms of land-use which could combine both agricultural and forest qualities in an economic as well as ecological perspective. These models clearly do not concern Indonesia only, but globally any area where forest and agriculture need true integration. The Indonesian agroforest model not only can, but should be extensively extrapolated. It is essential to

* Chinese traders played a determining role in stimulating the cultivation of rubber by smallholders, by providing rubber seedlings to local farmers. Local rulers — the Sultan of Kutai in East Kalimantan- —or missionaries — in Bengkulu, Sumatra- reportedly recommended or actively supported rattan cultivation in their respective regencies.

** Homma (1992) argues that the high productivity in forest plantations unavoidably leads to the fall in prices of natural products and to the economic collapse of any collection business. In the case of rubber, intensive rubber cultivation in colonial estates in Southeast Asia has clearly and quickly entailed the spoilage of indigenous forest collectors mainly in the Amazon but also in Southeast Asia and Africa.

understand that extrapolation does not mean transposition, and it would be useless to try replicating damar or benzoin gardens of, let us say, Congo or Brazil.

It needs to be stressed that even if the Indonesian examples do retain some "Indonesian" specificities, these are not determining factors in the establishment or reproduction of the agroforest systems. In particular, the common assumption that such systems owe their success to the high fertility of volcanic soils in Indonesia is wrong. Such highly fertile soils occur mainly in Java where complex agroforestry systems occur exclusively in the form of small home gardens. True agroforests like the damar gardens in Sumatra or fruit forest-gardens in Kalimantan have developed on low quality ferralitic soils. Benzoin gardens are reproduced on highly infertile podzols while rubber agroforests occupy the less fertile soils developed through agriculture in the lowlands in Sumatra and Kalimantan.

In the same way, the early development of trade links between Indonesia and the outer world might have been an important historical criterion for development of agroforests, but as markets are presently developing all over the world, it is no more a local specifity. Indonesian agroforest models globally hold more "generalizable" qualities — like technical simplicity, good adoptability in shifting cultivation systems, or integration of local tree species and commodities — than local specifities. If the model is now more or less defined and understood, more precise criteria for extrapolation have to be worked out. These concern mainly extra-sectorial factors like market accessibility, global land tenure security, product taxation, local institutions, etc. The most promising arena for extrapolation is that where integration of forest resources into agricultural systems is preferable to segregation between forestry and agriculture, such as the integrated development of forest margins, integration rather than exclusion of farmers in the management of permanent forest areas, or forest production through forest domestication for and by farmers. In this arena, Indonesian examples represent an invaluable source of inspiration for the future.

4. AGROFORESTS AS A NEW PARADIGM IN AGROFORESTRY

In attempting to systematize the conditions for extrapolating the agroforest examples, there is a common danger of focusing exclusively on the concept of a technological package. This could too easily obscure the real importance of agroforest as a new paradigm in agroforestry.

The paradigm of agroforestry itself is founded on tree management in general (Bene et al. 1977), which includes farms as well as forests and single trees as well as complex tree formations. However, it focuses on trees as components of a wider agricultural, forest or agroforestry system. Agroforests do not represent agroforestry in general. In the wide agroforestry landscape, it is clear that they do not address the management of scattered trees on farmlands, nor the introduction of trees in open fields as a support for agricultural production.

Agroforests are only that part of agroforestry that focus on the management of "forests" in farmlands. The implications of the agroforest paradigm, however, might concern agroforestry as a whole. Though narrowing the agroforestry focus towards its forest end, the paradigm enables a reevaluation of agroforestry systems and practices as integral biological and social processes in the context of global resource management by farmers. More than just proposing models of complex plant associations, the agroforest paradigm address fundamental logics in resource development that touch the very interface between forests and agriculture.

In forestry, plantation intensification follows the agricultural model through extreme specialization and homogenization typical of the development of grain crops. In agriculture, they simplify the structure and the function of the cultivated "forest" to the limit. From the perspective of sustainable development, these production-oriented tendencies have demonstrated their limits. Further development of forests and agriculture urgently need a fair dose of fresh imagination.

Existing agroforests synthesize centuries of positive interdependence between farmers and forests in a model that has not been sufficiently explored, but constitutes an invaluable source of inspiration for devising systems for better agro/forestry harmonization. The derived agroforest paradigm enables a view of the original alliances between agriculture and forestry through the incorporation of forest resources, structures and logics in farmlands. Agroforests represent an ecological, cultural and socio-economic replicate of forest structures and features in agriculture that allow an optimum balance between production and conservation functions and maintain continuity with local representation and knowledge systems that have evolved from former forest traditions. What are the merits of this forest preference in agriculture?

Ecological Benefits of the "Forest Preference" in Agroforestry Systems

4.1.1 A Farmer-Oriented Technology

The main quality of the agroforest model for smallholder farmers' development, as epitomized in the Indonesian examples, lies in the simplicity and the low costs of the techniques involved. This is in sharp contrast to intensive plantation agriculture based on trees, or with plantation forestry, which both depend heavily on specialized techniques, genetically altered plant material and capital and energy intensive processes of crop establishment and maintenance. Modern tree-based plantations either lie far beyond smallholders' financial and technical capacities, and therefore involve the participation of large firms, or require a heavy dependence on credit. Agroforest development, on the other hand, is affordable by local populations as it relies on simple techniques that all shifting cultivators in humid tropical countries have at their disposal. It is based on local knowledge shared by all farmers and does not imply high energy or capital inputs (de Foresta et Michon 1993).

The establishment phase requires technical skills in maintaining personal nurseries, in planting and transplanting tree seedlings on swidden fields, in managing intercropping phases and in carrying-out selective clearing to sustain the growth of the commercial plants. The management of mature agroforests mainly involves relevant selection skills when managing the undergrowth, and above all enough anticipation to allow efficient and timely regeneration of the productive structures (Michon et de Foresta 1995). The ecological knowledge required for the maintenance of agroforests is more important than simple technical skills, and mainly addresses the ecological qualities of the plants and animals components, rather than the fundamentals of ecological processes. Farmers do not need to know how natural recovery in forest gaps operates, but they do need to know which plants will — and which won't — grow in the sunlight of this gap. This kind of basic knowledge of species is usually quite well shared among shifting cultivators.

4.1.2 The Ecological Benefits of a Forest?

The ecological qualities of agroforests are basically those of a natural rainforest. They range from soil protection against erosion and leaching and water conservation through improved drainage of rains, to relatively high levels of carbon sequestration in trees, and conservation of a good portion of the original forest biodiversity. The extent to which these qualities are maintained is not fully comparable to what is happening in an undisturbed rainforest. But these are not targeted outputs, simply benefits derived from an original conception of crop structure and management. The main function of an agroforest is not to restore a forest, but to produce selected commodities. The originality of the model is that these forest qualities apply to agricultural lands that were cleared for economic development. There is no other system in agriculture that allows forest qualities and functions to be preserved to such an extent. The present models used in plantation forestry, although producing forest material and rehabilitating some of the forest ecological functions, do not replace a true forest ecosystem. Though forest cover is shrinking at an unprecedented rate throughout the tropics, the purpose of agroforest development is certainly not to compete with active forest conservation measures. Besides providing an original model for multipurpose forest development, however, it can help in reducing the ecological costs of natural forest conversion for intensive production.

4.1.3 Restoring a Forest? Ecological Integrity in Agroforests

The most original and fundamental feature of the agroforest strategy is how the reestablishment of forest features becomes a tool in agroforest establishment and management. The construction of a forest not only reinstates structure and diversity, but also restores integral biological and ecological processes that are vital for both commodity production and reproduction of structures. In existing examples, farmers do not try to simulate natural processes, they just let them happen and intervene only slightly at key points. The benefits of these processes to the farmer are not expressed in the form of resource production only, but also in the form of ecosystem development. Dynamic processes of vegetation recovery after disturbance are first channelled to speed up and secure the integration of slow-growing trees in the cultivated system. This has proved quite efficient for rapid restoration of not only the resource, but also ecosystem integrity (Figure 5).

Farmers in Sumatra and Kalimantan have succeeded in what remains a dream for most foresters: establishing, maintaining and reproducing, at low costs and for large areas, a healthy dipterocarp plantation. These plantations rely on selected and planted forest trees and exhibit high density stands and a good productivity. But they also exhibit ecological sustainability, low cost establishment and easy regeneration over the years, which is uncommon in conventional plantation forestry. The mimicry of natural structures then enables the use of internal dynamics to sustain the production process and maintain a continuous balance between "obsolescence" and regeneration of the cultivated stand. Plants and animals that colonize the agroforest are not weeds, but support essential ecological processes that are crucial in the maintenance of this "natural" integrity of the agroforest as ecosystem. These natural processes schematically replace the complex technical nature and high energy costs that sustain forest plantations. In this sense agroforests constitute an attempt at "ecosystem domestication" through the full integration of economic and non-economic components, and the utilization of natural ecosystem dynamics to the benefit of a selected, artificially established population of trees.

4.2 Promoting Forest Diversity to Increase Economic Benefits

Among the economic qualities related to this forest preference in agricultural development, the most important ones are related to economic diversity, flexibility and reversibility.

Agroforest as a Sustainable Economic Strategy

Risk management through diversification is a common strategy for smallholder farmers. The development of commercial strategies in agriculture, especially through intensive perennial crop cultivation, usually assumes the complete conversion of existing production systems to monocultures with high inputs of external energy, capital and labor. This increases risks of ecological failure as well as vulnerability to market fluctuations. The agroforest model rests on diversification of structures and components, and this harmonizes intensification and risk management at the plot level through a fusion of commercial production with a wide range of other economic and ecological functions.

Short and long term economic flexibility is also directly linked to the forest qualities of the agroforest. An important principle in agroforest management is that the harvest of the main commercial commodity can be delayed in case of necessity: 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 of the system itself. The agroforestry plot is maintained intact and still productive while the species concerned can survive in the structure and will be ready for further

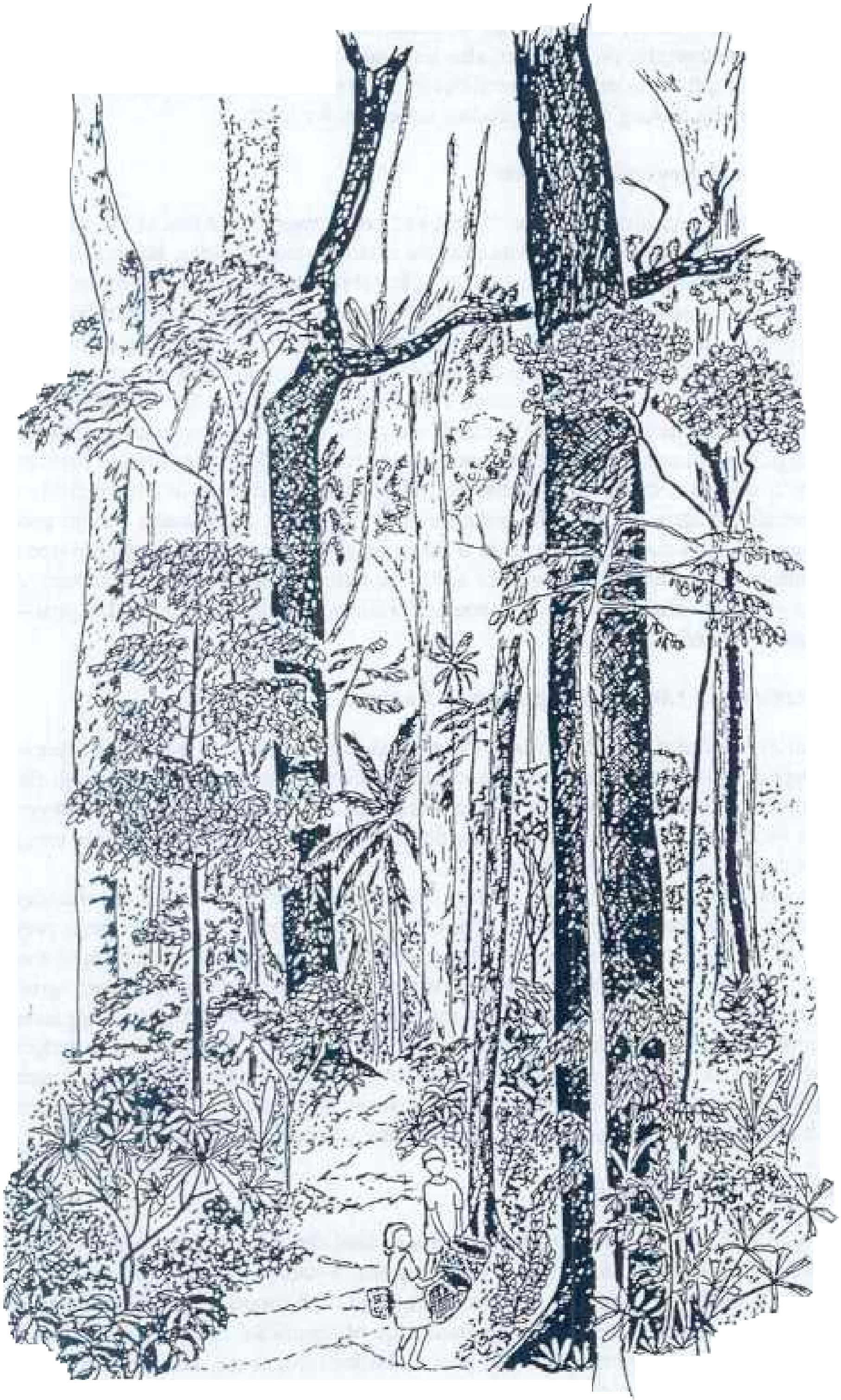

FIGURE 5. The restoration of a dipterocarp forest though planting, maintenance, and reproduction by farmers. Illustrator: G. Michon.

exploitation. The complementary principle is that the agroforest harbors other resources that can be harvested if needed to balance the temporary weakness of the main crop. This aspect of temporary relay in harvesting commercial products can also be turned into a more general process, with the possibility of switching from existing commodities to more profitable ones as the market changes, as often happened in the history of forest product collection for trade.

4.2.2 Agroforests: A Reversible Process

The main economic significance of the "forest end" of the agroforest lies in the maintenance of high levels of reversibility that are apparent in the establishment process, but are also present in the mature agroforest. If analyzed in the context of forest management, the agroforest represents an example of forest development for commercial purposes that entails a total transformation of the original ecosystem, but succeeds in restoring most of its resources and retaining its biodiversity. The process of forest conversion through agroforest enables reversion to forest in a more significant way than through conventional forest plantations. This should offer a lesson for foresters who rarely attempt to manage forests as a global ecosystem. If encompassed in the framework of agricultural plantation strategies, agroforest development represents a process of forest conversion for intensive production which does not conform to economic reductionism and does not irreversibly close economic potentials formerly linked to the presence of natural forest. Agroforests shelter potential economic resources which could be developed if the main economic crop fails, as new tree crops can easily be integrated without disrupting the overall structure of the production system. Agroforests can also generate valuable inputs — material, fertilizer, genetic resource, and capital — for further evolution if needed.

4.2.3 Agroforests and Land Development: In Context

These qualities acquire a new dimension if examined in the context in which agroforests are currently developed: that of forest conversion processes for commercial agriculture through shifting cultivation. This conversion process represents a real, and dual transformation of production systems as it leads from swidden agriculture in temporary fields to more or less permanent field cropping, and from forest extractivism to forest plantation.

Agroforests embody an intensification process of shifting cultivation through the introduction of long-lived crops in the traditional swidden. The commercial importance of these crops prevents any further use of the fields in the short term. The ecological advantages of such a rupture of the traditional cycle in favor of permanent or semi-permanent forest structures are obvious: agroforest establishment practically removes these fields from the realm of slash and burn cycles, thus preventing probable reduction of site fertility through shortening of fallow periods. It also helps to reduce the global extent of slash and burn for food-cropping as it provides income that will be used to purchase food. The long-term economic advantages are also important as agroforest-based farming systems can accommodate much higher population densities than subsistence shifting cultivation.

4.2.4 Agroforests and Capitalization

Agroforest establishment also represents a process of land development that relies on capitalization. This is a major revolution in livelihood strategies. Wealth in strict shifting cultivation systems cannot be generated through agriculture as the cultivation process, in spite of fairly good levels of labor productivity, does not enable the production of significant surpluses. Investments in field preparation are mostly converted into food production for subsistence, being consumed more than capitalized. The organization of the slash-burn-and-harvest cycle allows farmers to carry out income-generating activities during certain periods, mainly through forest collection. Wealth is then created through tapping the forest rent. Planting forest trees on the swidden first constitutes the best way to increase returns to initial labor investment with minimal additional inputs. At the same time, agroforests consistently minimize labor inputs, they allow extra-agricultural activities for income generation if needed. Wealth is then generated through tree production. Besides generating goods for consumption and sale, agroforests can provide surpluses for saving or converting into "luxury" consumption. Above all, they create assets that will increase the production capacity of the farm, and that can be transferred to children. Agroforests constitute the basis of a family or lineage patrimony that comprises the capital that feeds further production as well as the rent itself. More than an income-generating strategy, agroforest development constitutes an integral appropriation process involving switching from the exploitation of natural stocks to the establishment of production structures and property rights that will be transmitted to future generations. This pertains to more global strategies that touch sensitive socio-political issues.

4.3 Agroforest and the Reappropriation of Forest Resources by Smallholder Farmers

A main feature of the forest preference in agroforest establishment is the restitution of an integral forest in a context that is totally different from that currently in use in forestry. The transfer of wild resources to cultivated lands, from the sphere of Nature to that of Agriculture, is an essential process not only for domestication purposes, but for empowering smallholders in the "forest business." This empowering process relies on practical, conceptual and legal aspects of forest lands and resources development.

The strong preference of governments in many tropical countries for a production-oriented open-field model in plantation forestry might have obvious advantages and well established economic foundations, but it has socio-political attributes that may lead to the marginalization of smallholder forest farmers, or even to their total exclusion from the future management of forest resources. In the classic plantation model, increasingly specific technical knowledge and domesticated plant material are developed through research institutes and become available to farmers only through markets or credit. Besides the increased risks due to ecological as well as economic fragility, processes of crop establishment and maintenance are so capital intensive that they lie far beyond smallholders' financial and technical capacities. For these financial and structural reasons, plantation forestry is developing under the control of private or state corporations that physically and legally replace local farmers on forest lands.

Agroforests originate from the transfer of selected forest species to agricultural lands, but they rely on processes that restitute a whole range of resources. As they maintain the pre-existing resource and knowledge bases of indigenous management systems, rely on techniques based on local knowledge shared by every farmer, and do not imply high energy inputs, they allow local communities to maintain control and authority over these resources. Moreover, the agroforestry strategy enables restitution of the former forest resource base in a "cultivated" form which might be more beneficial to the farmers' rights and interests. In most ideologies and political regimes of tropical countries, the "agricultural" context secures better legal structures for land or resource appropriation by smallholders than does a forestry context. Indigenous forest management, however sustainable or profitable, has never been seriously considered by the governing elites, as reflected in the widespread lack of legal recognition of native rights and traditional property regimes concerning forest lands and resources in tropical countries. Moreover, most forest lands in the tropics, and the resources they bear, are under State control. The status of "public goods" facilitates tacit "appropriation" of resources traditionally controlled by indigenous people by those who are close to the seat of national power. On agricultural lands, private property, for either collective or individual owners, is more easily recognized and implemented. In such a context, cutting the forest and planting trees might help native resource management systems to gain official support and be enough to secure property rights themselves, or at least the right to claim for such legal rights. The agroforest strategy therefore constitutes both a symbolic and a political act of appropriation.

5. THE LESSONS FOR AGROFORESTRY RESEARCH

The recognition of agroforests as a new paradigm in agroforestry introduces several alternative dimensions into classic agroforestry approaches. First, it involves the integration of forest perspectives into logics that have remained basically agricultural. Second, it concerns the application of these agricultural logics to the management of forest resources. Insight from this forest perspective for agroforestry research applies to various complementary levels, beginning with the choice of the research object or the definition of the research approach, to the refinement of the model itself and its implications for development.

5.1 The Objects and Approaches of Agroforestry Research

Field experimentation and testing of new agroforestry technologies has long been considered the "noble way" of agroforestry research. This technocratic approach has softened over the years, but still influences the scientific perception of other approaches. In particular, the study of existing systems remains viewed as journalistic works of "description" rather than valid research, especially if it concentrates on non-quantifiable aspects and does not provide files of hard data for statistical analysis. Understanding the value of local agroforestry examples as potential models for innovative agroforestry development, as illustrated by the agroforest story, is developing. What is currently underestimated is the value of including local examples of forest management in the scope of agroforestry-related research. This is incongruous with the current aims of agroforestry to mitigate deforestation and land depletion. Understanding local forest management systems not only will reveal practices that are of utmost importance for land development, but will help in clarifying the interrelations between what is commonly perceived as "agriculture" and as "forestry." It is also likely to generate new insights into the underlying causes of deforestation as well as possible remedies to land depletion. To reach this objective, such examples need to be analyzed in an evolutionary and comparative perspective that puts them "in context." More than focusing on the present patterns and qualities of existing systems, it is important to understand when and why they emerged, how they have succeeded in solving local problems and how and why they are surviving or disappearing. Characterization of determining factors and driving forces that have led to various present situations is essential in assessing not only their impact, but also their future. In this analytical process, bio-ecological or economic factors should be placed in parallel with political or socio-institutional ones, as the current importance of indigenous systems reflect not only the technical or economic validity of the models to which they refer, but, ultimately, the enforcement of socio-political choices from the governing spheres.

Including local forest management examples in agroforestry research will also directly benefit agroforestry experimentation. Until now, the economic and political necessity of providing tangible results in a reasonable time span has forced the experimental approach to concentrate on fast-growing tree species rather than dealing with long-lived forest trees. Does this mean that practical agroforestry research is condemned to work with short-gestation tree crops, keeping true forest resources out of its scope? Indigenous examples based on long-lived trees could be understood as experiments in their own right especially in the arenas of domestication, tree crop association, and system design, conclusions of which could immediately benefit global agroforestry research. Existing structures could also be used to foster further scientific experimentation dealing either with plant material — like selecting genetically superior strains or testing existing, high yielding varieties of forest plants — or with management techniques. This type of experimental research is presently being carried-out by CIRAD and ICRAF-SEA in Sumatra and Kalimantan with the testing of highly productive rubber clones under the technical and environmental conditions of the "jungle rubber" agroforests (Penot and Wibawa 1996).

Dealing with forest resources and forest structures in agroforestry will also require new types of experimentation that can integrate the principle of "forest preference" into development. The most promising field for such experimentation concerns domestication. It implies, of course, widening the range of domestication candidates to the bounty of forest resources, especially commercially important ones. But, once species have been prioritized it implies that the development of improved plant material should be designed for a complex, forest-like environment, rather than for conventional plantation conditions. Present selection and breeding techniques should be adaptable to both forest-like ecological conditions and farmers, technical as well as energetic preferences. Instead of trying to adapt wild species to homogenous open field conditions, plant selection effects could try to draw from "forest" characteristics of the species for both ecological and economic benefits. Low branching varieties of canopy fruit trees have no particular appeal in an agroforest environment, and transforming undergrowth forest species into light-demanding cultivars, as happened for coffee or cocoa, is not the best way to allow the integration of the species into a domesticated forest ecosystem. (See Chapter 16.) Nor is relying on sophisticated hybridization techniques the best way to empower local farmers in the domestication process.

The main feature of the agroforest paradigm for agroforestry approaches is the new focus it puts on restoration or maintenance of ecological processes, rather than on land-use systems.* Introducing forest models in agroforestry not only widens the range of agroforestry technologies and mixture designs, but also provides an ecosystem perspective.

5.2 New Fields for Agroforestry Implementation and Development

The agroforest paradigm addresses the classical fields of agroforestry implementation, rehabilitation of lands degraded through unsustainable agricultural practices, or prevention of foreseen degradation, but with a different perspective. In particular, it can reorient agroforestry action, from promoting the introduction of several universally recognized "agroforestry" species of either fast-growing or multipurpose trees in agricultural lands where original trees have long disappeared, to maintaining local forest resources traditionally known, used and managed by peasants in more productive domesticated forests. It also offers new fields for implementation, namely the management of lands traditionally classified as "forests" rather than "agricultural lands." For multipurpose forest production it offers challenges to the poorly defined model of "extractive reserves." In forest areas where the development perspective rests on intensive forest plantations, the agroforest paradigm provides an ecologically as well as socially interesting alternative to the common introduction of firm-managed fields of *Acacia* or *Eucalyptus*. For conservation areas, it can help devise useful models for buffer zone management. On forest margins, it can provide a smooth transition from shifting cultivation to permanent agriculture. Lastly, for rehabilitation of forest lands through reforestation, it might help in shaping acceptable models for social forestry. In this field, the participation of agroforestry research is essential as smallholder farmers all over the tropics are increasingly involved in the rehabilitation of deforested lands. Due to their "smallholder" dimension, agroforests can enable the promotion of new forms of reforestation by local people. Another promising field for further agroforest development is the production of good quality timber on agricultural lands. As it is vanishing from natural forests, timber might well be the principal next crop for smallholders, and agroforests offer interesting technical as well as social models for its management.

The main task of the agroforest paradigm for applied agroforestry activity is to undermine the still pervasive dichotomy between forest resources and agricultural commodities, between agricultural systems and forests and between forest and agricultural lands. Agroforestry until now has been defined for agricultural lands and agricultural systems. The challenge now is to find new crops for new agroecosystems. This means investigating how forest resources and forest structures can be transferred to agriculture, through new concepts, logics and strategies.

* This input has been recently integrated by R. Leakey in a new definition of agroforestry. Leakey, who has visited Indonesian agroforests, claims that agroforestry should be more than "prescriptions for land use," but instead a land-use development process which, similar to natural ecological processes, increases in complexity over time (Leakey 1996).

5.3 A Revision of Development Models for Agriculture

The most meaningful questions raised by the agroforest paradigm relate to the very conception of agriculture and agroforestry. Does modern agriculture, which is usually perceived as the ultimate, least reversible step of an artificialization process, necessarily imply a total partition from the original environment? Should patterns of tree cover in agricultural lands be quite different from those found in natural forests? Should agroecosystems escape natural, ecological laws through intensive human control (Michon and Bouamrane 1997)?

These basic questions can be stated in terms of continuity or partition with the initial "natural" state, of confrontation or connivance with Nature (Henry 1987). This confrontation/connivance perspective relates to two main models defined by ethnobotanists for the development of agriculture, based on differences in patterns of plant manipulation and ecosystem design for cultivation (Haudricourt and Hedin 1943; Geertz 1966; Barrau 1970). One concerns the development of grain crops. It epitomizes "agriculture" in its narrow sense, the cultivation of *ager*, the open field (Barrau 1967; Michon and de Foresta 1996). It rests on a clear distinction between the cultivated field and the natural ecosystem through oversimplification of structural patterns and adaptation of the wild plant to these artificially simplified open fields through domestication. This clearly reflects a "confrontation" approach. It relies on heavy and uniform human interventions and control. In the modern version of this "grain model," homogenization and control extend to the genes, with a generalized use of hybrids and clones which depend on man for production and reproduction. Artificialization culminates in intensive use of chemical and mechanical inputs, associated with high energy consumption, aiming at maximum yields while overcoming natural constraints. The grain model reflects on the productivist mentality which sustained the development of modern agriculture. As it has achieved incredible results in raising food production throughout the world, it tends to be considered the only valuable model for efficient (agri)cultural development. Though it was initially devised for annual crops, the grain model has deeply influenced modern horticulture and silviculture in the tropics: forest plantations and plantation agriculture based on tropical forest trees, such as *Acacia*, *Eucalyptus*, rubber, oil palm, or cocoa, replicate the biological model and the technical options of a corn field.

The second model concerns the development of trees and tuber crops. It is commonly referred to as "horticulture," the cultivation of *hortus*, the garden. This retains the complexity of the natural ecosystem, trying to replicate its structure to accommodate the exigencies of the cultivated. The garden model reflects "connivance" approaches. Diversity is the key word ranging from plant types, herbs, tuberous perennials, trees and lianas, to species and genotypes and including architectural diversity that mimics natural ecosystems, as well as functional diversity, from production aspects — foods or various plant materials — to social functions. Though their evolution "gardens" have integrated many exotic species, but even their modern version maintains these basic patterns of diversity and complexity. The garden, devised for multipurpose production as well as for optimal management of ecological and economic risks, does not comply with the strict exigence of short term productivity in agriculture. Whereas "gardens" are still a major component of indigenous agricultures in the tropics, swiddens, home gardens, anthropogenic forests and forest-gardens are all variations of the "hortus" model — they are relatively absent of modern, scientific agriculture.

This opposition between two diverging models is essential to understand. On the one hand is a technically complex but biologically homogenous and structurally oversimplified model whose deviation from a "natural" model depends on complex sets of knowledge and inputs and on heavy interventions and control. On the other hand is a biologically and structurally complex, but technically simple model requiring management that relies not on segregated knowledge or inputs, but on the free development of functional processes existing in natural forest vegetation. If "mastering" is the key word in the grain model, "taming" is more appropriate for the agroforest strategy. The question should be not which strategy expresses the greatest achievements in transforming and channelling ecological processes to the benefit of humankind, but which appears as the most adapted to present constraints of the tropics, ecological as well as socio-economic? The open field model has proven its success for immediate development, but its long term negative consequences are obvious. Reverting to less productive, but more sustainable models is currently acknowledged. But what does it mean for the tropics? In humid tropical environments, the open field model implies a total partition with the climax formation: the evergreen rainforest. The agroforest, on the contrary, rehabilitates it, not in its undisturbed stage, but in its basic dynamics and functions.

The agroforest paradigm also addresses the integration of agriculture and forestry. It achieves this amalgam between a long term perspective of forest ecology and development, and short-term imperatives of production in agricultural systems. Elaborating on this original association between forests and agriculture may allow the design of alternative strategies for forest domestication and culture.

6. CONCLUSIONS

The most recent important development in agroforestry was the formulation of new research priorities that address more widely the integration of forestry and agricultural problems: mitigating deforestation, alleviating poverty, devising sound alternatives to slash and burn agriculture, helping biodiversity conservation through improved agroforestry practices or carbon sequestration through tree growing. In this new strategic context, agroforestry would benefit substantially by including a broader vision of its "forestry" mandate. This means an integration not only of trees, but of forests in farmlands. The aim is to capture not only forest components, but also forest functions, dynamics and benefits for agriculture, and to translate the socio-cultural dimensions of forest resource management into the agricultural domain. There are many obvious and immediate justifications for such an enlargement of the "forest side" of agroforestry. Ecologically, tree crops are more sustainable than intensive food cropping on marginal soils, and forest-like systems are more likely to succeed than specialized tree plantations. Economically, pure forest crops, such as timber, have bright economic prospects in agriculture. From a socio-political point of view, forestry and agricultural issues are more and more interwoven in the race for sustainable development, and a large part of the lands available for further agricultural development in the tropics are under the jurisdiction of forestry services. But there is another essential reason for agroforestry research to be more involved in forestry issues, a reason that draws upon the socio-political dimension of devising new alliances between forests and agriculture.

The agroforest paradigm can help in revising the relations between central State power and farmers' communities in forest areas. Smallholders or landless farmers all over the tropics have often been largely deprived of their traditional forest resources by forest development projects and expelled from forest lands by coercive forestry regulations. Present forestry laws are often too rigid to accommodate significant changes related to the devolution of forest management to local communities. Or if they allow it, it is often because forest resources are so depleted that foresters urgently need the help of farmers to replenish them. This call for participative approaches in forestry might well be a poisoned gift; farmers are urged to succeed where foresters have so obviously failed. They certainly will be blamed if they fail. They also may be dispossessed if they succeed. However, this new political orientation of many tropical countries also opens unexpected opportunities for smallholders. In addition to fostering participative approaches to conservation and conventional social forestry, the agroforest concept may help to enable the development of a legal framework for forest resource management by local farmers through the transfer of management responsibility into an agricultural context.

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