AGROFORESTRY AS A FORM OF LAND USE WITH EMPHASIS TO COMPLEX AGROFOREST IN INDONESIA

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Abstract
Agroforestry as land use management systems have been practised by local communities in Indonesia for centuries. Agroforestry systems in Indonesia can be found as densely vegetated pieces of land. This multispecies and multilayer vegetation structures is an ingenious answer of local communities combining management of small pieces of land for multiple products in an efficient manner. Agroforestry systems harbour a rich collection of plant and animals, despite the commercial orientation of the management. Agroforestry is an important source of income for the farmers. These characteristics make agroforestry systems an attractive option for social forestry programmes in Indonesia.

Keywords: agroforest, damar, homegarden

1. INTRODUCTION
It is estimated that in 1970 about 140 million hectares of Indonesian land area was covered by forests. The figure decreases to 120 million hectares in 1999\(^1\), of which only 86 million hectares is intact forests. In the last 3 years the decline increases to a dramatic figure of 1.6 million hectares annually. The main causes of this massive deforestation is due to logging concessions that violate the contracts and grossly damaged the forest and to some extent also forest clearing for creating new agriculture lands. Mismanagement of forest resources has created 36 million hectares of degraded land or 18.8% of the total land area.

Realising that the increasing population pressure on limited land resources is one of the main factors contributing to land degradation, Department of Forestry has created various schemes based on social forestry approach. The schemes have two major objectives: improving farmers' or local people's income, and in the same time reducing deforestation and land degradation by reforestation programmes. In the beginning the programmes had been directed more toward professional forest management interests as timber production, but in the last decade more attention has been given to the involvement of local communities and their immediate livelihoods in forest management.

Many communities throughout the Indonesian Archipelago have been practicing land management systems based on multispecies tree plantation
since centuries ago. The vegetation structure in a mature “garden” is highly diversified and physiognometrically resembles natural forests. These agroforests provide food and forage supplies, and more importantly provide a long-term employment and secure income for the farmers. Being a complex vegetation system, it would be inferred that agroforestry systems naturally retain higher productivity, sustainability, and stability than annual-crops based agroforests. The agroforestry systems are flexible and can easily be adapted to the local condition and farmers’ needs and objectives. This paper tries to view some of the structure aspects of agroforestry systems in Sumatra and Java.

2. CLASSIFICATION OF AGROFORESTRY SYSTEMS

Agroforestry has been practising by local people in the tropics for centuries. But the modern agroforestry has developed just since the beginning 1970s when concerns on land degradation and deforestation emerged and agroforestry was reassessed as a land use system applicable to both farmland and forest.

Agroforestry as a form of land use has two common characteristics:

- Trees are deliberately planted on the same land as agricultural crops and/or animals, either in the same time or in sequence;
- Significant interaction between trees and non-woody plants, either in ecological and/or economical terms.

Considering the complexity of agroforestry systems, it is very difficult to make a simple definition of any agroforestry system that is able describing major factors that influence the production system and management, and in the same time should be flexible and practical. Nair proposed that categorisation of agroforestry should be based on some criteria according to:

- Structural basis, which refers to the composition of agroforest components in space and time;
- Functional basis, which refers to the role of the system’s components;
- Socio-economic basis, which refers to the level of inputs or intensity of management and commercial goals;
- Ecological basis, which refers to the environmental condition and ecological suitability.

In reducing the complexity of the and arrangement, and also by management and socio-economic features. Following criteria for classification as mentioned before, Nair indicated four major agroforestry systems, each of which can be sub-divided into sub-systems or practices. In this context, an agroforestry practice refers to specific land management and usually consists of arrangements of agroforestry components. An agroforestry practise becomes an agroforestry system when it is developed to such extent to form a land use system in the same area. For illustrations, Table 1 summarises major agroforestry systems and practises world-wide.

Homegardens in Java and other parts of Indonesia can be categorised as agrosilvopastoral practices. A mixed-tree garden in Sumatra can be classified as either taungya system or an improved fallow practice during the first 4 years of its development. A mature mixed-tree garden, however, should be a form of multilayer tree gardens or plantation crop combinations.

Agroforestry systems in Indonesia are practically a form of forest management rather than farming for food
crops. In line with this consideration, agroforestry in Indonesia can be classified into two groups: simple agroforestry systems and complex agroforestry systems\(^6\). The former is characterised by association of a small number of vegetation components, typically food crops and trees. In contrast, a high number of components (trees, shrubs, and lianas) can be found in complex agroforests.

Table 1. Major agroforestry systems and practices

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From: Nair\(^5\)
Figure 1. Evolution of ladang into permanent agroforests a. Shifting cultivation cycle; b. permanent agroforests cycle From: Mary and Michon

Figure 2. Profile diagram of a damar agroforest in Pesisir Sub-district, Lampung

Aglia domestica No 25 Parkia speciosa Nos 2,30,40,45,47
In appearance, complex agroforests resemble natural forests rather than farmland. In its mature state, complex agroforest is characterised by: (1) complex vegetation structure; (2) high diversity of trees, shrubs, lianas; (3) ecologically functioning similar to natural forests. In this paper agroforest term will be used interchangeably to a complex agroforest.

3. AGROFORESTRY SYSTEMS AS PRACTISED IN SUMATRA AND JAVA

3.1. Cultivation cycle

Agroforestry systems in Sumatra evolve from shifting cultivation practices (Fig. 1).

Typical shifting cultivation cycle is initiated by clearing cut secondary or primary forests followed by burning the biomass. Rice is then planted in ladang (ladang is an Indonesia term for dry field) in year 1 and 2. After 2 years of rice crops, because the following harvest becoming poor, the field is abandoned and the farmers open new field. The fallow period is usually 15-20 years. When forest for new land is becoming limited, farmers start to introduce specific trees among the rice crops. This creates a new step which culminating with permanent agroforests.

An example is given from damar agroforests in Lampung below:

1. In year 1, farmer cut the primary forest and open new ladang. Upland rice is planted together with fast growing plants (papaya and banana). Meanwhile, seeds of coffee, damar tree and fruit trees, such as durian (Durio zibethinus) and duku (Aglaia dookoo) are sown in a seedbed.

2. In year 2, coffee saplings are planted in between the upland rice (2500 coffee saplings per ha). Due to the occupation of space by coffee plants, the rice yield is reduced from 1.2 t/ha in year 1 to 0.7 t/ha in year 2.

3. In year 3, damar and fruit trees are planted among the young coffee stands at a density of 100 damar trees per ha and 25 fruit trees per ha.

4. Years 4-6: coffee is harvested. The first harvest from 4 years old coffee stand yields 600 kg/ha. The yield decreasing in year 5 and subsequent year due to competition with damar and fruit tress and lack of maintenance.

5. The damar trees develop together with spontaneous vegetation until the are ready to be tapped at year 25.

6. The field now covered by permanent damar agroforests.

Farmers open new ladang in year 3 and initiate the same cycle. This farming method creates a mosaic of plot with different stages of agroforest development throughout the entire landscape.

Climatic condition, farmer’s own needs, access to the market, and price of the products influence the farmer’s choice on the main tree species. In anticipating market fluctuation, farmers often plant

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From: Torquebiau
different tree species. One tree species may dominate the agroforest, but agroforests with no dominating trees but as mixture of numerous tree species are also common in certain region.

3.2. Vegetation structure and management: damar based agroforest in Lampung

Damar is an Indonesia term to refer to resin produced by damar tree (*Shorea javanica*, Dipterocarpaceae). In trading, damar is classified into damar mata kucing (cat’s eye damar), (damar merah (red damar) and damar hitam (black damar). Damar is one of important non-timber forest products from Sumatra and usually is collected from natural forests1).

In west coastal part of Lampung Barat District, Lampung Province, local peoples tap damar from trees grown in a forest-like agroforestry system. This damar agroforest can be found in North Pesisir, Central Pesisir, and South Pesisir Sub-districts. The area covered by the agroforest was estimated to be some 100 000 ha along the strip between the coast in the west and a steep mountain range in the east up, which borders the Bukit Barisan Selatan Nature Reserve7,9).

Damar agroforests can be characterised into four types:

- **Type a**: repong damar (damar combined with fruit trees), which is the typical damar agroforest
- **Type b**: mixed forests of damar trees, fruit trees, timber trees, shrubs and herbaceous plants (vegetables and medicines)
- **Type c**: damar and / or clove trees and occasionally fruit trees or timber trees
- **Type d**: new damar trees planted in the former monoculture clove plantation. In 1970’s, stimulated by high price of clove, farmers established monoculture crop of clove. Due to the spread of “Sumatra disease” which killed the plantation, farmers move back to the well-known damar trees.

Fig. 2 shows a typical profile plot of a repong damar (type a). The plot size is 50 x 20 m and only trees with height more than 5 m are drawn. The profile shows that damar dominates by 41 trees out of a total of 57 trees. The damar trees are not homogenous in age; 19 trees are resin-productive (trees of the present), 15 trees are not yet resin-productive (trees of the future), and 7 trees are no more resin-productive (trees of the past). The projected area of the crown of the trees of the present covers 126% of the plot surface (1000 m$^2$), and the trees of the future cover 50% of the plot surface. The upper canopy is occupied by trees of the present (102% of the plot area). The high crown coverage indicates the productivity of the plot. The total crown area is 187% from the plot surface, which indicates a high degree of crown overlapping. This is closely similar to the conditions found in natural forests.

As far as canopy cover and the number of species growing in the plot is concerned, damar agroforest does really resemble forest. Damar trees dominate the agroforests, while planted fruit, vegetable and timber trees as well as wild plants enrich the ecosystem. This mixture of different plant species creates a multi-storied vegetation structure. Damar trees, durian trees and some wild timber trees occupy the upper canopy. Fruit trees such as duku form the second layer.

As consequence of this multi-layered stand, light intensity on the forest floor is low and as a result the undergrowth is less dense. In some open spaces where the upper canopy is not completely closed, herbaceous plants such as Zingiberaceae, Musaceae,
Marantaceae and Melastomaceae grow abundantly. This additional vegetation provides vegetables and medicine for the farmer. The composition of damar agroforests is not homogenous. Fruit trees are usually more abundant in a plot near village (repong damar type a). Agroforests in area far from village are less tended and used as sources for timber or industrial crops (mixed-garden type b).

Dipterocarp trees are difficult to raise in nursery. Farmers in Pesisir have developed farming system to maintain constant supply of young damar trees whenever they are needed. Damar trees are flowering irregularly, probably every 3-5 years. When damar trees flowering and fruiting, farmers collect seeds from ground surrounding the trees. Seeds are soon sown in bamboo pots and seedlings are kept alive – but not growing – for several years in the pots. The seedlings or saplings are then planted in the agroforest when necessary, i.e. as soon as a tree of the past died and gap so created. This newly planted becomes a tree of the future. Gaps around a dying tree often left in order to allow pioneer trees (such as Macaranga and Trema) to grow; such trees provide fuel wood for the farmer.

3.2. Homegarden in Java

Homegarden are well-known agroforestry systems widely adopted in Java island as well as in outer island. In Java homegarden is an integral part of economy of farmers. In case the agriculture field failed to produce a good harvest, farmers rely on their homegardens as the last resort for food supply and cash. In densely populated island of Java, three different types of tree-based farming systems could be found:

- In lowland area, homegarden is established in same piece of land where house is built.
- Farmers in mountainous area and less densely populated area develop talun-kebun system, which combining kebun (tree and food crops) and talun (forest) in sequential phases. This system is similar to swidden cultivation method in region where forestland is available.
- In drier area trees are planted as rows along the border of the plot and the middle part is reserved for food crops.

The first written record on Javanese homegarden appeared in a charter of the 9th century and it is suggested that Central Java is the centre of origin of Javanese homegardens. Homegardens develop well in communities adopting the matrilineal system such as Aceh, West Sumatra and Java, as well as in West Timor. Homegardens vary in size, from 100 square metre to several thousand square metres. The total homegardens area in Java was 375 000 ha in 1903, increased to 1 417 000 ha in 1937 and in 1986 reached 1 612 568 ha, which represents 14, 18 and 17% of the total agricultural land, respectively. However, the contribution of homegardens to the national agricultural productivity is not known as usually the yield is consumed locally.

The most striking features of homegardens is their diversity. Traditional homegardens are dominated by different species of trees, associated with shrubs in the garden’s floor and climber that make use of the trunks as living stakes. Cultural influences, climate, and economical reasons determine the choice of tree species and varieties. Wherever water is abundant, fish ponds become the central part of homegarden management. Homegardens in villages surrounding bigger cities usually are dominated by
fruit trees, such as duku, durian, rambutan and nangka, which generates cash money to the farmers.

The vertical structures of homegardens in Parung Banteng Village, Bogor, West Java\(^{13}\) and Cibitung Village, Bogor, West Java\(^{14}\) represents a multi-layer structure found in agroforests in Sumatra as discussed above. Three age groups of trees can be identified: young, not yet productive trees (trees of the future); fully/expanded and productive trees (trees of the present); and dying trees (trees of the past). The multilayer structure of the productive trees is occupied by four different “ensemble”:

- Ground ensemble, from ground to 3 m high, is dominated by spontaneous herbs and shrubs as well as seedlings of trees
- Ensemble I, from 3 to 12 m high, is dominated by palms (Arenga pinnata, Areca catechu, Salacca edulis) and small trees
- Canopy ensemble, from 15 to 25 m high, is occupied by fruit trees such as duku, rambutan (Nephelium lappaceum), menteng (Baccaura racemosa), Garcinia sp., and vegetables. This layer is the dominating canopy and covering 100% of the surface area.
- Tall ensemble, up to 35 m high consists primarily of emergent trees such as durian and Parkia.

The horizontal structure of the producing trees shows on intermixed and indistinct stratification of vegetation as the case in agroforests and natural forests. This “discontinuation” structure is a result of natural competition for light (similar to the early phase of natural forest succession) and this discontinuity is increased by human factor (management). Management by farmers is aimed to maintaining continuity of yield around the year and to maintain the overall stability of the vegetation structure. Sustainable yield can be ensured by pooling of young, trees of the future in the vicinity of the old ones. Farmers obtain young trees by vegetative propagation (cutting and air layering) or buying from the market or brought from the neighbours. Natural seedlings are selected carefully and transplanted in nursery beds. Open spaces created by a fallen tree is cleared and then planted with banana or leguminasae trees such as Parkia and Albizia. By doing this, farmers prepare for the next succession phase as he can then plant shade tolerant tree species and thus avoiding the disturbances in his homegarden.

4. CONCLUDING REMARKS

Agroforest systems are characterised by multispecies and multilayer vegetation structure. The complex structure of agroforests stabilises the systems: it keeps erosion rate and nutrient loss at minimal level and therefore help to lower the input level required. Agroforest systems play important role in agricultural economy in Indonesia and are important sources of income for millions of smallholder farmers. From viewpoint of socio-economic aspects, agroforest systems can be considered as social forestry. So they could be complemented with overall forest policy and development.

Wide application and development of agroforest systems as sustainable farming methods in Indonesia needs better knowledge on the interaction between trees and other vegetation components; biology of wild fruit and timber producing trees, end products processing and marketing.

BIBLIOGRAPHY


