

keen self-interest to succeed and improve their families' livelihood through the production of tree products for home-use or market sale.

7.2 Implementation

A farmer or a group of farmers can establish small scale plantations of multipurpose tree species that can provide valuable crops such as timber, poles, fuelwood, food, fodder, and other non-timber forest products for home use or for sale. The plantation helps to protect the farm environment by enhancing soil fertility and reducing soil erosion, provide shade for people and farm animals as well as environmental improvement.

Please refer to Appendices and Annex below:

Appendix 1 – Species selection

Appendix 2 – Seed procurement

Appendix 3 – Nursery operation

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Appendix 5 – Tending the plantation

Appendix 8 – Procedure in species selection for poverty reduction

Appendix 9 – Consolidated farmer-specified ideotypes

Appendix 10 – Some tree species producing non-timber forest product

Annex 1 – Seed requirement calculations

8. Agro-Forestry Systems^{*}

8.1 Justification

Agroforestry is a system consisting of a tree component with a crop component and sometimes with an animal component on the same plot.

Agro-forestry practices can increase farmer's annual incomes. Some increases in revenue come from harvesting different tree crops in different seasons. The result is that income and employment are distributed more evenly throughout the year. There are also many other reasons for growing trees on farms, such as the provision of shade for cooler soil temperatures, reduction of soil moisture loss, and protection of the soil from wind and water erosion. Agro-forestry systems can reduce the risk of total crop failure. For example, if the viability of one crop is reduced by pest damage or market failure, the farmer can make up for it by harvesting another crop.

In many cases, the easiest way to create agro-forests is to focus on the domestication of non-timber forest products (NTFPs). For agro-foresters, NTFPs are simply under-storey crops and their domestication offers a means for bringing agro-forestry into community forestry and farmers into forests. The main management technique for achieving this is enrichment planting with NTFPs.

8.2 Implementation

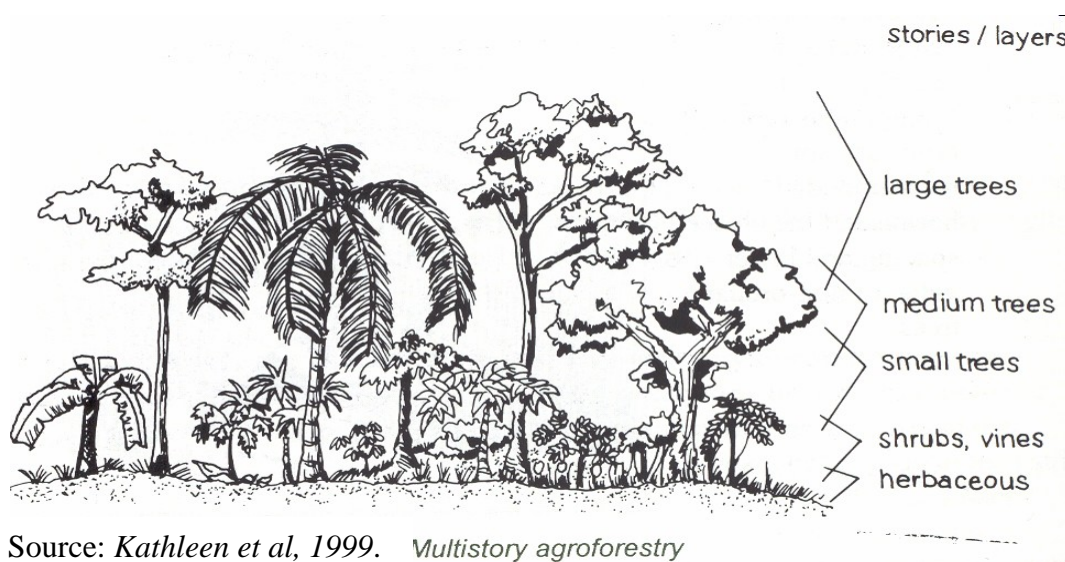
There are various agroforestry options that permit the simultaneous or sequential planting of various agricultural crops, animal rearing and cultivation of timber and non-timber species.

This section was extracted and modified from Kathleen et al, 1999.

8.2.1 Multi-Storey Agro-Forestry

This system has at least three layers of intercropped plants of different heights. It is commonly developed by small farmers as they:

- Plant nurse trees for shade-tolerant crops like coffee and cacao.
- Make productive use of space between and under cash crops like rubber and coconut.
- Enrich fallows with species like rattan and yams.
- Establish a variety of low input, low maintenance tree crops.



Source: Kathleen et al, 1999. *Multistory agroforestry*

Ecological planning: For any crop combination that you consider, predict how the multi-storey agro-forestry system will grow and change over time. Each year, some plants will become less productive, and others will grow and cast additional shade. Plan the development of the multi-storey agro-forestry system so that:

- The first plants established are adapted to full sunlight.
- The first cropping system includes *Imperata* control measures.
- Plants that can give shade are planted before plants that can tolerate shade or require shade.
- Plants that enrich the soil are planted before plants that can tolerate shade or require shades this needs updating – it is to do with enrichment not shade.
- Plants that require sun are not planted where other plants will shade them before they mature.
- Medium-sized and large trees will have room to grow and will not become too crowded later. Think ahead to the width of the tree's canopy when it is mature. Consider whether the trees around it will also grow tall and wide, if they will crowd it, they should be harvested or not be planted at all.
- All growing space is used: crops fit together vertically (tall, medium, and short), horizontally (all planting spots occupied), and underground (deep-rooted and shallow-rooted plants).

Economical planning: Any farming system requires planning to diversify products and spread labour and income through the year. The first crops planted should provide food or income within 3-4 months (for example, sweet potato). Choose crops that give both subsistence produce and cash income. Plant trees that bear different fruits at different times of the year. A multi-storey agro-forest will change every year for the first several years, with changes in labour requirements and products.

Below is an example of how multi-story agroforestry can be established:

1. Plant nurse trees: Fast-growing nitrogen fixing trees can be planted first to improve site conditions. This approach is often used for crops like coffee on poor sites, where nurse trees are valued for shade and soil enrichment throughout the life of the coffee crop (see Table 1). Common species suitable for this method are *Albizia lebbek* (chres), *Gliricidia sepium* (snaov), *Dalbergia cochinchinensis* (kra ngoung), *Pterocarpus indicus* (thnong) and *Acacia mangium*. All these species have special characteristics such as: they cast a light shade or can be pruned to adjust shade; are nitrogen-fixing; produce timber, fodder, or other useful products; are sun-loving; adapted to local climates and soils; and fast-growing.

2. Intercrop annual crops: Choose an intercrop each planting season that is adapted to current sun or shade conditions. Shade-tolerant under-storey crops include: *Ananas cosmosus* (pineapple), *Capsicum* spp. (peppers), *Colocasia esculenta* (sweet taro), *Curcuma domestica* (turmeric), *Anthurium* spp. (flowers), *Ipomea batatas* (sweet potato), *Xanthosoma sagittifolium* (dryland taro), *Zingiber officinarum* (ginger), and mushroom cultures.

3. Plant shade-tolerant trees. After one year or when the nurse trees provide enough shade, plant shade-tolerant trees. Plant them 3-4 m apart, or at the recommended spacing for the tree crop. Plant them 1-2 m away from the nurse trees.

4. Fertilize, prune and weed as for other tree crops.

Table 1: Example of Crop Combinations

Size of tree	Sun-loving (first to be planted)	Shade-tolerant when young (can be planted later)
Tall (large tree)	<i>Albizia saman</i> (raintree) <i>Artocarpus altilis</i> (breadfruit) <i>Casuarina</i> spp. <i>Cocos nucifera</i> (coconut) <i>Gmelina arborea</i> <i>Mangifera indica</i> (mango) <i>Pterocarpus indicus</i> <i>Swietenia macrophylla</i> (mahogany) <i>Tectona grandis</i> (teak)	<i>Durio zibethinus</i> (durian) <i>Garcinia mangostana</i> (mangosteen) <i>Nephelium lappaceum</i> (rambutan) Many timber trees
Medium-tall (small tree)	<i>Anacardium occidentale</i> (cashew) <i>Azadirachta indica</i> (neem) <i>Elaeis guineensis</i> (oil palm) <i>Psidium guajava</i> (guava) Many fruit trees Many fuel wood trees	<i>Areca catechu</i> (betel nut) <i>Annona muricata</i> (soursop) <i>Bambusa</i> spp. (bamboo) <i>Cinnamomum</i> spp. (cinnamon)
Medium-short (shrubs, vines, epiphytes)	<i>Carica papaya</i> (papaya) <i>Manihot esculenta</i> (cassava, tapioca) <i>Musa</i> spp. (banana)	<i>Coffea</i> spp. (coffee) <i>Flagellaria indica</i> (rattan) <i>Piper nigrum</i> (black pepper) <i>Theobroma cacao</i> (cacao) orchids
Short (herbaceous)	Upland rice Many vegetables	Shade-tolerant vegetables Other shade-tolerant crops

Source: Kathleen et al 1999.

5. Prune nurse trees. When nurse trees provide too much shade, cut branches and use the leaves as mulch.
6. Thin trees. Watch for adjacent trees with canopies starting to grow into each other. Also watch out for sun-loving trees that are being shaded by less valuable trees. One by one, remove weak or lower-value trees to make space for healthy or higher-value trees. Be careful not to damage other trees when cutting. The remaining trees will grow faster.
7. Enrich with other crops. Plant shade-tolerant crops for food and cash income.

8.2.2 Soil Erosion Control with Contour Planting

How contours work

Contours are level lines across a slope at a constant elevation, they curve from side to side to stay level, but never upslope or downslope.

Vegetative barriers are located on the contour to control soil erosion. Water flowing down the slope picks up soil. When it reaches a contour barrier it slows down, the soil particles settle out, and more water enters into the soil.

Lay out contour lines fairly accurately. If lines are laid out by eye, they may go up and down on irregular slopes and may cause more erosion than if the barrier were not there.

Contour barriers can include piled crop wastes, grassy strips, and hedges. Crops are planted between the contour barriers.

Species suitable for contour hedgerows

Combine species that complement each other: for example, plant a row of *Flemingia* for leaves that decompose slowly and provide mulch, and a row of *Leucaena* for leaves that decompose rapidly and provide nitrogen. Try local native species and naturalized species first, and avoid new species that bear many seeds.

Commonly recommended species

- *Casuarina equisetifolia*
- *Moringia oleifera*
- *Gliricidia sepium*
- *Leucaena leucocephala*
- *Dalbergia cochinchinensis*
- *Pterocarpus spp*
- *Toona sureni*
- *Albizia lebbek*
- *Tamarindus indica*
- Combinations of these species

Characteristics of a good species

- Fixes nitrogen or has leaves rich in nitrogen and phosphorus
- Can be direct-seeded
- Survives frequent trimming
- Grows straight up (erect form)
- Produces large amounts of leaves
- Is adapted to local climate and soil
- Has deep roots, few spreading roots
- Planting material available
- Produces fodder, fuelwood, etc.

Spacing with contour lines

The spacing of trees and shrubs within contour lines depends on how much planting material is available, and how much labour is available for trimming. If trees are not closely spaced, be sure to pile crop wastes in the hedgerow to control erosion.

Establishment:

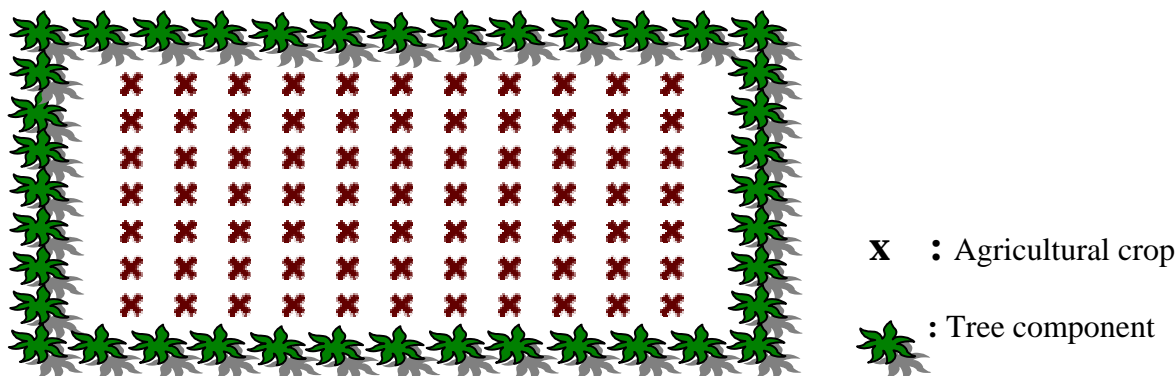
1. Plant trees or shrubs on the contour.
2. Cultivate every other terrace and plant annual crops. Permanent crops may also be

- planted every second or third terrace.
3. Let the hedgerows grow until they are well established (one year old or 1.5-2m tall). Trim the hedgerows to 40cm or knee-height.
 4. Mulch the terraces with trimmings from the hedges.
 5. After the leaves and twigs have dropped from trimmed branches, pile the branches at the base of the hedgerow.
 6. Cultivate the remaining terraces and plant them with annual crops.

8.2.3 Other Examples of Agro-Forestry Systems

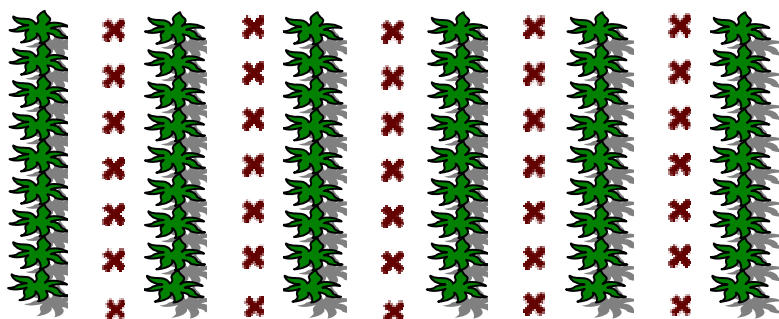
Trees along borders or farm boundaries

This option involves cultivation of timber and non-timber tree species along borders of agricultural crop plantations and animal pastures.



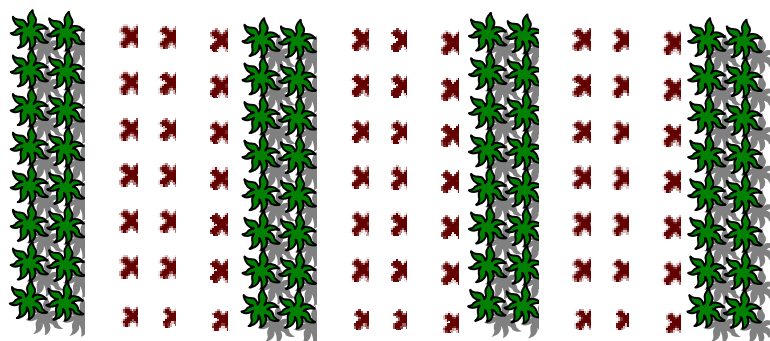
Alternate rows

In this system the short-term crops are cultivated in rows between the tree crops.



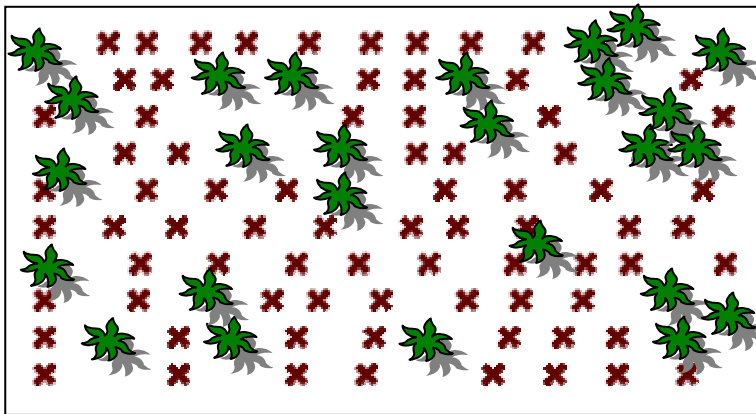
Alternate strips

The wide inter-hedge area can be planted with tree crops such as fruit trees and timber species.



Random mixture

Timber trees are planted randomly on all vacant areas (see Section 8.2.1).



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Appendix 2 – Seed procurement

Appendix 3 – Nursery operation

Appendix 4 – Plantation operation

Appendix 5 – Tending the plantation

Appendix 6 – Guideline for decision making in reforestation

Appendix 8 – Procedure in species selection for poverty reduction

Appendix 10 – Some tree species producing non-timber forest product

Annex 1 – Seed requirement calculations

9. Plantation on Public Land

This type of tree planting can be conducted by communities (through community forestry), government and development agencies. Some NGOs (Mlob Baitang, Lutheran World Federation, Santa Sena), Associations (Lion Club), and private sectors (British American Tobacco Company) are good partners for communities and the government in implementing this form of reforestation.

Trees can be planted in row(s) along road sides, canal sides, dam sides, or as small woodlots in school yards, pagodas, around ponds and lakes; for fuelwood, fruit, fodder etc. Here the system of multi-storey plantation, or the Miyawaki method can be applied.

Species use: Most public lands are bare-lands. Species producing NTFPs are recommended for planting. However, from the beginning, select light-demanding species so that they can stand in full sunlight, in addition the species must be tolerant to frequent pruning (for fuelwood) or browsing by animals (sheep, goats, cattle).

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