



Technical Note #25

Agroforestry Principles

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Cacao cropped under banana

In simplest language, agroforestry is the production of trees and of non-tree crops or animals on the same piece of land. The crops can be grown together at the same time, can be grown in rotation, or can even be grown in separate plots when materials from one are used to benefit another. However, this simple definition fails to take into account the integrated concepts associated with agroforestry that make this system of land management possibly the most self-sustaining and ecologically sound of any agricultural system. Thus, a second definition of agroforestry would be the integration of trees, plants, and animals in conservative, long-term, productive systems. Agroforestry can be considered more as an approach than as a single, finished technology. Although several finished systems have been devised and tested, such technology may require adjustment for particular situations. The flexibility of the agroforestry approach is one of its advantages.

Why Agroforestry?

Agroforestry systems make maximum use of the land. Every part of the land is considered suitable for useful plants. Emphasis is placed on perennial, multiple purpose crops that are planted once and yield benefits over a long period of time. Such benefits include construction materials, food for humans and animals, fuels, fibers, and shade. Trees in agroforestry systems also have important uses such as holding the soil against erosion and improving soil fertility (by fixing nitrogen or bringing minerals from deep in the soil and depositing them by leaf-fall).

Furthermore, well-designed systems of agroforestry maximize beneficial interactions of the crop plants while minimizing unfavorable interactions. The most common interaction is competition, which may be for light, water, or soil nutrients. Competition invariably reduces the growth and yield of any crop. Yet competition occurs in monoculture as well, and this need not be more deleterious in agroforestry than monoculture systems. Interactions between components of an agroforestry system are often complementary. In a system with trees and pasture, with foraging animals, the trees provide shade and/or forage while the animals provide manure.

Thus, agroforestry systems limit the risks and increase sustainability of both small- and large-scale agriculture. Agroforestry systems may be thought of as principle parts of the farm system itself, which contains many other sub-systems that together define a way of life.

Definitions

Alley Cropping: Growing annual crops between rows of trees or shrubs

Beautification: Planting trees for ornamental purposes

Boundary Plantings: Trees planted along boundaries or property lines to mark them well

Dispersed Trees: Trees planted alone or in small numbers on pastures or otherwise treeless areas

Earthworks: Constructions made of earth, usually to conserve or control water

Improved Fallows: Areas left to grow up in selected trees in trees-crop rotation systems

Individual Trees: Trees occurring alone, whether spontaneously emerging or planted

Living Fences: Fences in which the posts are living trees, or in which the entire fence consists of closely-spaced trees or shrubs

Nectar Crop: Trees valuable as a source of nectar for honey bees

Terraces: Level areas constructed along the contours of hills, often but not necessarily planted with trees

Vegetative Strips: Long, narrow areas of any type of vegetation, usually planted along contours for erosion control; may include trees

Woodlot: An area planted to trees for fuel, or timber

Summary Of Benefits Of Agroforestry

- Improved year-round production of food and of useful and salable products
- Improved year-round use of labor and resources
- Protection and improvement of soil (especially when legumes are included) and water sources
- Increased efficiency in use of land
- Short-term food production offsetting cost of establishment of trees
- Furnishing of shade for vegetable or other crops that require or tolerate it
- Medium and long-term production of fruits
- Long-term production of fuel and timber
- Increase of total production to eat or to sell

Components Of An Agroforestry System

Land

Agroforestry is not a system of pots on a balcony or in a greenhouse. It is a system by which land is managed for the benefit of the landowner, environment and long-term welfare of society. While appropriate for all landholdings, this is especially important in the case of hillside farming where agriculture may lead to rapid loss of soil. If the farmer owns the land, s/he has a vested interest in thinking conservatively, how the land can be maintained over long periods of time. Unfortunately, farmers who rent land may have less interest in the long-term benefits of agroforestry and may even fear that making improvements will raise the rent or result in the lease being terminated.

Trees

In agroforestry, particular attention is placed on multiple purpose trees or perennial shrubs. The most important of these trees are the legumes because of their ability to fix nitrogen and thus make it available to other plants. The roles of trees on the small farm may include the following:

- Sources of fruits, nuts, edible leaves, and other food
- Sources of construction material, posts, lumber, branches for use as wattle (a fabrication of poles interwoven with slender branches etc.) and thatching
- Sources of non-edible materials including sap, resins, tannins, insecticides, and medicinal compounds
- Sources of fuel
- Beautification

- Shade
- Soil conservation, especially on hillsides
- Improvement of soil fertility

In order to plan for the use of trees in agroforestry systems, considerable knowledge of their properties is necessary. Desirable information for each species includes its benefits, adaptability to local conditions (climate, soil, and stresses), the size and form of the canopy and root system, and suitability for various agroforestry practices. Some of the most common uses of trees in agroforestry systems are:

- Individual trees in home gardens, around houses, paths, and public places
- Dispersed trees in cropland and pastures
- Rows of trees with crops between (alley cropping)
- Strips of vegetation along contours or waterways
- Living fences and borderlines, boundaries
- Windbreaks
- Improved fallows
- Terraces on hills
- Small earthworks
- Erosion control on hillsides, gullies, channels
- Woodlots for the production of fuel and timber

Some very good food-bearing trees for agroforestry are given in Table 1. Table 2 lists some of the best of the non-food producing trees used in agroforestry. Some successful uses of trees in isolation are given in Table 3. Note that any tree can be used; however, in actual practice, very large trees are not key components of most agroforestry systems.

Non-trees

Any crop plant can be used in agroforestry systems. The choice of crop plants in designing such systems should be based on those crops already produced in a particular region either for marketing, feeding animals, or for home consumption, or that have great promise for production in the region. In keeping with the philosophy of agroforestry, however, other values to be considered in crop selection include proper nutrition, self-sufficiency and soil protection. Thus, selection of crops requires a judgment based on knowledge of the crops, adaptations, production uses, as well as family needs, opportunities for barter, and markets.

Any farm animal can be used in agroforestry systems. The choice of animal will be based on the value the farmer places on animal-derived benefits including income, food, labor, non-food products, use of crop residues, and manure. Some examples of the use of trees, crops, and animals together are given in Table 4.

Table 1. Trees or large shrubs with edible products for agroforestry systems

Species	Common Name	Edibility	Principle Uses
<i>Anacardium occidentale</i>	Cashew	flowers, seeds, fruit	garden, fence, pasture
<i>Annona muricata</i>	Soursop	flowers, fruit	garden, fence, pasture
<i>Borassus aethiopum</i>	Borassus palm	multiple food uses	garden, pasture
<i>Cajanus cajan</i>	Pigeon Pea	seed, leaves	hills, nitrogen fixation, fuel, hedgerows
<i>Carica papaya</i>	Papaya	flowers, fruit	garden, quick shade
<i>Cnidoscolus aconitifolius</i>	Chaya	leaves	rapid hedge
<i>Cocos nucifera</i>	Coconut	multiple food uses	pasture, roadside, construction
<i>Coffea arabica</i>	Coffee	seeds (bean)	hedgerows, hills, fuel
<i>Gliricidia sepium</i>	Mother of Cacao	flowers	living fence, feed, fuel
<i>Leucaena leucocephala</i>	Leucaena, Ipil Ipil	leaves, young pods	hills, alley cropping, nitrogen fixation, fuel
<i>Manihot esculenta</i>	Cassava	roots, leaves	rapid hedge
<i>Moringa oleifera</i>	Moringa, Drumstick	leaves, flowers, pods	fence, garden
<i>Psidium guajava</i>	Guava	flowers, fruit	pasture, fuel
<i>Sauropus androgynus</i>	Katuk	leaves	hedge, alley cropping

Table 1. Trees or large shrubs with edible products for agroforestry systems

Species	Common Name	Edibility	Principle Uses
<i>Theobroma cacao</i>	Cacao	pulp, seeds	understory tree, pasture
<i>Yucca guatemalensis</i>	Izote	flowers	hedge
<i>Ziziphus mauritiana</i>	Jujube	flowers, fruit	erosion control, fuel

Table 2. Principle trees for agroforestry systems (especially for hillsides)

Species	Common Name	Principal Uses
<i>Bursera simaruba</i>	Gumbo limbo	living fences, fuel, forage
<i>Calliandra calothyrsus</i>	Calliandra	vegetation strips, fallows, windbreaks, fuel
<i>Erythrina berteroana</i>	Pito	living fences, forage, rapid cover, nitrogen fixing
<i>Faidherbia albida</i>	Apple-ring acacia	terraces, dispersed trees, forage, nitrogen fixing
<i>Gliricidia sepium</i>	Mother of Cacao	living fences, forage, fuel, hardwood
<i>Leucaena leucocephala</i>	Leucaena, Ipil Ipil	alley cropping, soil conservation, food, nitrogen fixing, fuel, forage
<i>Moringa oleifera</i>	Moringa, Drumstick	living fences, rapid cover
<i>Senna siamea</i>	Siamese senna	terraces, fuel, nitrogen fixing
<i>Sesbania grandiflora</i>	Agati	rapid cover, forage, nitrogen fixing
<i>Sesbania sesban</i>	Sesban	planting stakes, quick cover, nitrogen fixing

Table 3. Examples of successful uses of trees on small farms (not necessarily with other crops)

Location	System	Tree Crop	Benefits	Other Plants
Central America	Living fence	Erythrina, Yucca, Gliricidia	food, feed	
Tropics	Windbreaks	Casuarina	fuel	
Central Africa	Dispersed trees	Faidherbia albida	fuel, feed, erosion control	
Niger	Improved fallows	Leucaena, Sesbania	soil fertility restoration	grasses
India	Earthworks	Dalbergia, Pongamia, Prosopis,	food, soil conservation	gasses (napier, mando)
Tropical Africa	Gully Protection	Tamarix	food, soil conservation	grasses

Table 4. Examples of successful agroforestry systems of trees and crops.

Location	System	Tree Crop	Benefits	Understory Crops
Costa Rica	dispersed trees	Cordia alliodora	lumber, shade, nutrients	coffee
Costa Rica	dispersed trees	Erythrina spp.	nitrogen, fuel, shade, nutrients	coffee
Puerto Rico	dispersed trees	Inga spp.	shade, nitrogen, fuel, wood	coffee, bananas, root crops
El Salvador	dispersed trees	Inga spp.	fuel, nitrogen, shade	coffee, cacao
Central America	dispersed trees	leguminous trees	lumber, fuel, shade, nitrogen	grains, pasture
Malaysia	dispersed trees	dwarf coconut	food, lumber	cacao
Tropics	dispersed trees	Coconut	food, feed	pasture
Mexico	dispersed trees	Brosimum spp.	food, lumber	many crops, pasture
Haiti	home garden	Mango	fruit	rice
Sri Lanka	mixed perennials	various fruit trees	fruit, other products	spices, vegetables
Philippines	home garden	various fruit trees	fruits, edible leaves	many vegetables

Table 4. Examples of successful agroforestry systems of trees and crops.

Location	System	Tree Crop	Benefits	Understory Crops
West Africa	home garden	fruit trees	fruits	vegetables
Ivory Coast	mixed perennials	cacao, bananas	food	yams
Puerto Rico	mixed perennials	oranges, avocados, bananas	food, nutrients	coffee, root crops
Tropics	alley crop	Leucaena leucocephala	erosion control, fuel, nitrogen, nutrients	annuals, grasses
Nigeria	alley crop	Gliricidia sepium	erosion control, fuel, nitrogen, nutrients	root crops, grains
Rwanda	vegetative strips	Grevillea, Albizia, and Leucaena spp.	timber, fuel, forage	

Getting Started With Agroforestry Systems

Steps in the decision-making process

1. Decide whether agroforestry systems are appropriate
 - Describe family and community needs
 - List the needs that could be met with an agroforestry system
 - List the potential benefits, and their relative importance, of an agroforestry system in the region in question
 - Find the limiting constraints in agriculture, including markets and marketing
 - Consider whether the people of the region are willing or capable of adopting a system
 - Then decide if it is worth the effort to develop one
2. Design a system
 - Select the area
 - Characterize its strengths and weaknesses with respect to existing soil, water, and crops
 - Select the trees, shrubs, or grasses to be used (see Tables 5-7; consider similar local plants)
 - Characterize the minimum space requirements, water and fertilizer needs, and shade tolerance of the desired crops

Further decisions as influenced by anticipated duration of the system

3. If the system is temporary
 - Plan the features of soil erosion control, earthworks, and gully maintenance first
 - Plan spacing of fruit trees according to final spacing requirements
 - Plan a succession of annual or short-lived perennials, selecting the most shade tolerant crops for the final years of intercropping
4. If the system is permanent
 - Plan the proportion of the permanent fruit and lumber trees on the basis of relative importance to the farmer
 - Plan the spacing of long-term trees on the basis of final space requirements times 0.5
 - Plan succession of annual and perennial understory crops, including crops for soil protection and enrichment
 - As large permanent trees grow, adjust planting plan to place shade tolerant crops in most shady areas
5. With both temporary and permanent systems
 - Always keep the ground covered, using various crops to protect soil from sun and erosion
 - Try the system on a small scale first
 - Measure the inputs and outputs of the system
 - Evaluate whether the benefits expected have been achieved
 - Expand or extend any new system cautiously

Seed And Information Sources For Agroforestry Species

ECHO provides sample (not bulk) packets of seeds of most of the agroforestry species listed in this publication. See our online (www.echonet.org) overseas seed listing. Seed requests can also be emailed (echo@echonet.org) or mailed (17391 Durrance Road, N. Ft. Myers, FL 33917). Other seed sources are listed in Table 5 below. Be aware that many trees that are able to survive under difficult conditions may also have considerable potential to become weeds. Management can be critical. For example, pruning minimizes the ability of *Leucaena* spp. to produce seeds.

Table 5. Suppliers of seed for agroforestry tree species (last updated February 2007)

Seed Supplier	Mailing Address/Telephone	Website URL
Australian Tree Seed Centre	CSIRO Division of Forestry and Forest Products, PO Box E4008 Kingston, Canberra ACT 2604, Australia Phone: +612 6281 8211 Fax: +612 6281 8266 Email: ffp-atsc@csiro.au	http://www.ffp.csiro.au/tigr/atscmain/index.htm
Directory of Tree Seed Suppliers in Indonesia	ICRAF, the World Agroforestry Centre Trees and Market Unit Jl. Cifor Situ Gede Sindang Barang, P.O. Box 161, Bogor 16001 Phone: 0251-625415, 625417 Fax: 0251-625416 Email: icraf-indonesia@cgiar.org	http://www.worldagroforestrycentre.org/sea/Products/AFDbases/seedsupplier/index.asp
Inland and Foreign Trading Company	Block 1090, #04-04/05, Lower Delta Road Tiong Bahru Industrial Estate Singapore 169201 Phone: 65 2722 711 Fax: 65 2716 118 Email: iftco@pacific.net.sg	http://www.iftco.com.sg/#cover
Kimseed	42 Sarich Court, Osborne Park Western Australia, 6017 Phone: 61 8 9446 4377 Fax: 61 8 9446 3444 Email: kimseed@kimseed.com.au	http://www.kimseed.com.au/frameset.html
New Forests Project	World Seed Program – New Forests Project, 731 Eighth Street SE, Washington, DC 20003, U.S.A. Phone: 202-547-3800 Fax: 202-546-4784 Email: wsp@newforests.com	http://www.newforestsproject.com/English/wsrequest.html
New Zealand Tree Seeds	P.O. Box 435, Rangiora, New Zealand 8254 Phone: 64-3-3121635 Fax: 64-3-3121638 Email: sales@nzseeds.co.nz	http://www.nzseeds.co.nz/
Raintree	Raintree Nutrition, Inc. 3579 Hwy 50 East, Suite 222 Carson City, NV 89701 Phone: 800-780-5902 Fax: 775-841-4022 Email: info@rain-tree.com	http://www.rain-tree.com/rtmprod.htm

Table 5. Suppliers of seed for agroforestry tree species (last updated February 2007)

Seed Supplier	Mailing Address/Telephone	Website URL
Sheffields Seed Company	269 Auburn Road, Route 34, Locke, New York 13092 U.S.A. Phone: 315-497-1058 Fax: 315-497-1059 Email: seed@sheffields.com	http://www.sheffields.com
The Banana Tree Inc. Easton, PA 18042 U.S.A	715 Northampton St. Easton, PA 18042 Fax: 610-253-4864	http://www.banana-tree.com/
Tree Seed Supplier Directory	Supplier information accessed from website by clicking on 'Botanic Nomenclature' and then on 'Botanic' or 'Common' name search	http://www.worldagroforestrycentre.org/Sites/TreeDBS/TSSD/treesd.htm

Table 6. Related resources and organizations found online

Type of information	Website URL and/or mailing address
Information on various species of tree crops	<ol style="list-style-type: none"> 1) Atcros (nutrient, chilling requirements of tree crops): http://www.wanatca.org.au/atcros/index.htm 2) California Rare Fruit Growers (fruit facts): http://www.crfg.org/ 3) Edible nuts (FAO information): http://www.fao.org/docrep/V8929E/V8929E00.htm 4) EDIS (by Univ. of Florida; fact sheets on tropical fruits): http://edis.ifas.ufl.edu 5) FAO (picture gallery with images of tree crops): http://www.fao.org/AG/Agp/agpc/doc/gallery/pic.htm 6) Moringa News (information, news, and links): http://www.moringanews.org/moringa_en.html 7) Neem Foundation (information on neem): http://www.neemfoundation.org/ 8) NewCROP (crop database by Purdue University): http://www.hort.purdue.edu/newcrop/default.html 9) New Forests Project (species descriptions): http://www.newforestsproject.com/English/trees.html 10) Oxford Plant Systematics (technical information; herbarium images): http://herbaria.plants.ox.ac.uk/ 11) Raintree (technical info; plant database): http://www.rain-tree.com/plants.htm 12) Traditional Tree Initiative (species information and selection): http://www.traditionaltree.org/ 13) Winrock (fact sheets): http://www.winrock.org/fnrm/factnet/factpub/factsh.htm 14) World Agroforestry Centre (databases): http://www.worldagroforestrycentre.org/Sites/TreeDBS/aft.asp
Organizations involved in agroforestry, many of which provide useful information about their projects.	<ol style="list-style-type: none"> 1) Agrofloresta.net (dedicated to agroforestry in Brazil; Portuguese): http://www.agrofloresta.net/ 2) Agroforestry.net (links to many organizations): http://agroforestry.net/links.html 3) CARE (type 'agroforestry' in search bar): http://www.care.org/index.asp 650 First Ave., 2nd Floor, New York, NY 10016, USA 4) Developing Countries Farm Radio Network (scripts of forestry-related broadcasts): http://www.farmradio.org/english/radio-scripts/forestry.asp 1404 Scott Street, Ottawa, Ontario, Canada, K1Y 4M8 5) ECOTOP (agroforestry systems in Bolivia): http://ecotop-consult.de/ C. Guillermo Viscarra N° 125 (Casi Uyuni), zona Tupuraya

Table 6. Related resources and organizations found online

Type of information	Website URL and/or mailing address
Publications- books, research results and/or information on forestry-related subjects	6) Floresta (programs in the Dominican Republic, Haiti, Mexico, and Tanzania): http://www.floresta.org Floresta USA, 4903 Morena Blvd, Suite 1215, San Diego, CA 92117
	7) Garden Organic (working name of Henry Doubleday Research Association- various projects): http://www.gardenorganic.org.uk/international_programme/ip_agroforestry.php Ryton Organic Gardens, Coventry Warwickshire, United Kingdom CV8 3LG
	8) International Society for Tropical Foresters (link to NGO lists) http://www.istf-bethesda.org/index-english.html [note link to NGO's in various countries] 5400 Grosvenor Lane, Bethesda, MD 20814
	9) International Union of Forest Research Organizations (forest science summaries, online library) http://www.iufro.org/ IUFRO Headquarters, Secretariat, Mariabrunn (BFW), Hauptstrasse 7, A-1140 Vienna, Austria
	10) KENGO (information about the Kenya Energy and Environment Organization): http://www.iisd.org/casl/CASLGuide/KENGO.htm KENGO, PO Box 48197, Nairobi, Kenya
	11) Petawawa Forestry Institute (research and information): http://www.glf.ca/forestry.ca/petawawa/index_e.html Canadian Forest Service, Natural Resources Canada, 580 Booth Street, 8th Floor, Ottawa, Ontario K1A 0E4
	12) Roy Danforth (using many tropical fruit species in promoting agroforestry in Africa) Imeloko Agroforestry Project, B.P. 1377, Bangui, Central African Republic)
	13) RWEDP (publications by the Regional Wood Energy Development Programme in Asia): http://www.rwedp.org/ FAO/RAPA, 39 Maliwan Mansion, Phra Athit Road, Bangkok 10200, Thailand
	14) USDA Forest Service (information about international projects): http://www.fs.fed.us/global/topic/welcome.htm US Forest Service International Programs, Outreach & Partnerships Unit 1099 14th Street, NW Suite 5500W, Washington D.C., 20005 U.S.A.
	15) Viikki Tropical Resources Institute (research publications and forestry-related courses) http://www.mm.helsinki.fi/mmeko/vitri/ Latokartanonkaari 9 (2. floor), P.O. BOX 27, FIN-00014 University of Helsinki, Finland
	1) Agroforestry Options for Small Upland Farms : http://www.floresta.org/Agroforestry_English_web.pdf
	2) DANIDA : http://www.sl.kvl.dk/Publikationer.aspx
	3) Living fences by Cornell University: http://ppathw3.cals.cornell.edu/mba_project/livefence.html
	4) Nitrogen Fixing Tree Startup Guide : http://agroforestry.net/pubs/nftguide.pdf
	5) Tropical Tree Seed Manual : http://www.mngr.net/Publications/ttsm
	6) USDA International Institute of Tropical Forestry : http://www.fs.fed.us/global/iitf/library1.html
	7) USDA National Agroforestry Center : http://www.unl.edu/nac
	8) World Agroforestry Center : http://worldagroforestry.catalog.cgiar.org/library/Pubsearch.asp

Table 7. Adaptation and Photos of Principle Tree Species.

Bursera simaruba

hot, dry tropics



Photo by Tim Motis

Callindra calothyrsus

wet tropics



Photo by Tim Motis

Erythrina berteroana

intermediate tropics



Photo by Tim Motis

Faidherbia albida

hot, dry tropics



Photo by Tim Motis

Gliricidia sepium

intermediate tropics



Photo by Tim Motis

Leucaena leucocephala

intermediate tropics



Photo by Tim Motis

Moringa oleifera

intermediate tropics



Photo by Tim Motis

Senna siamea

intermediate tropics



Photo by Tim Motis

Sesbania grandiflora

intermediate tropics



Photo by Tim Motis

Sesbania sesban

intermediate tropics



Photo by Tim Motis

Photos courtesy of ECHO staff (photographer credited if known)

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