AGROFORESTRY PRINCIPLES

BY DR. FRANKLIN W. MARTIN & SCOTT SHERMAN

Published 1992

ECHO TECHNICAL NOTE

INTRODUCTION

WHAT IS AGROFORESTRY?

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 which makes 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 plants that are useful. Emphasis is placed on perennial, multiple purpose crops that are planted once but yield benefits over a long period of time. Furthermore, systems of agroforestry are designed for beneficial interactions of the crop plants, and to reduce unfavorable interactions. They are designed to reduce the risks associated with agriculture, small scale or large, and to increase the sustainability of agriculture. Agroforestry practices normally help conserve, and even improve, the soil.

Agroforestry includes a recognition of the interactions of crops, both favorable and unfavorable. 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 systems. Interactions may be complementary, as in the case of trees, pasture, and foraging animals, where trees provide shade and/or forage, and animals provide manure.

Agroforestry systems are designed to produce a range of benefits including food, feed, fuels, often fibers, and usually renewed soil fertility.

ECHO, 17391 Durrance Rd., North Ft. Myers FL 33917, USA
Phone: (941) 543-3246; Fax: (941) 543-5317
e-mail: echo@echonet.org; website- http://www.echonet.org/

Agroforestry systems take advantage of trees for many uses, to hold the soil, to increase fertility through nitrogen fixation, or through bringing minerals from deep in the soil and depositing them by leaf-fall, to provide shade, construction materials, foods and fuel.

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.
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 as part of a trees-crop rotation system.
Individual Trees:	Trees occurring alone, whether spontaneously or planted.
Living Fences:	Fences in which the poles are living trees, or in which all of the fence consists of closely-spaced trees.
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 soils (especially when legumes are included) and of 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 it 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 the balcony nor for the greenhouse. It is a system to manage the agricultural resource, land, for the benefits of the owner, and the long-term welfare of society. While this is appropriate for all land, it is especially important in the case of hillside farming where agriculture may lead to rapid loss of soil. Normally land will be what the farmer owns (farmers that rent land may have little interest in the long term benefits of agroforestry), and thus farmers must think conservatively, how the land can be maintained over long periods of time.

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 foods.
- Sources of construction material, posts, lumber, branches for use as wattle (a fabrication of poles interwoven with slender branches etc.), 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 these trees in agroforestry systems considerable knowledge of their properties is necessary. Desirable information includes the uses described above, the climatic adaptations of the species, including adaptations to various soils and stresses, the size and form of the canopy as well as the root system, and the 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.
- Lines 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.

NON-TREE CROPS

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, certain other values should be pursued in the choice of crops, including:

- Crops for making money.
- Crops for feeding the farmer.
- Crops for good nutrition.
- Crops for self sufficiency.
- Crops for feeding the animals.
- Crops for protecting the soil.

Thus, selection of crops requires a judgement 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 such values as:

- Animals for making money.
- Animals for feeding the farmer.
- Animals for supplying labor.
- Animals for non-food products.
- Animals for using crop residues.
- Animals for furnishing 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 In Agroforestry
Anacardium occidentale	Cashew	flowers, seeds	garden, fence, pasture
Annona muricata	Soursop	flowers	garden, fence, pasture
Borassus aethiopicum	Borassus palm	multiple food uses	garden, pasture
Cajanis cajan	Pigeon Pea	seed, leaves	hills, nitrogen fixation, fuel, hedgerows
Carica papaya	Papaya	flowers	garden, quick shade
Cnidoscolus chayamansa	Chaya	leaves	rapid hedge
Cocos nucifera	Coconut	multiple food uses	pasture, roadside, construction
Coffea arabica	Coffee	seeds (bean)	hedges, hills, fuel
Gliricidia sepium	Mother of Cacao	flowers	living fence, feed, fuel
Leucaena leucocephala	Leucaena	leaves	hills, alley cropping, nitrogen fixation
Manihot esculenta	Cassava	roots, leaves	rapid hedge
Moringa pterygosperma **	Drumstick	leaves, flowers, pods	fence, garden
Theobrama cacao	Cocoa	pulp, seeds	understory tree, pasture
Psidium guajava	Guava	flowers	pasture, fuel
Sauropus androgynus	Katuk	leaves	hedge, alley cropping
Yucca elephantipes	Izota	flowers	hedge
Zizyphus mauritiana	Jujube	flowers	erosion control, fuel

*Any tree can be used in agroforestry systems, including all trees with edible products. In actual practice, very large trees are usually not used in agroforestry except casually, not by design

Table 2. **PRINCIPLE TREES FOR AGROFORESTRY SYSTEMS** (especially for hillsides)*

Species	Common Name	Principal Uses In Agroforestry
Acacia albida	Apple-ring acacia	terraces, dispersed trees, forage, nitrogen fixing
Acacia mearnsii	Black Wattle	terraces, borderlines, roads, fuel, nitrogen fixing
Bursera simaruba	Gumbo limbo	living fences, fuel
Calliandra calothyrsus	Calliandra	vegetation strips, fallows, windbreaks, fuel
Cassia siamea	Siamese acacia	terraces, fuel, nitrogen fixing
Erythrina berteroana	Dwarf machete	living fences, feed, rapid cover, nitrogen fixing
Gliricidia sepium **	Mother of Cacao	living fences, feed, fuel, hardwood
Leucaena leucocephala **	Leucaena	alley cropping, soil conservation, food, nitrogen fixing
Moringa oleifera **	Drumstick	living fences, rapid cover
Sesbania sesban	Sesban	planting stakes, quick cover, nitrogen fixing
Sesbania grandiflora	Agati	rapid cover, feed, nitrogen fixing

*Any tree can be used in agroforestry systems, including all trees with edible products. In actual practice, very large trees are usually not used in agroforestry except casually, not by design.
**See also Table 1

Table 3. **SOME EXAMPLES OF SUCCESSFUL USES OF TREES ON SMALL FARMS** (not necessarily in combination with other corps)*

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

* only a very small part of the potential uses.

Table 4. **SOME EXAMPLES OF SUCCESSFUL AGROFORESTRY SYSTEMS OF TREES AND CROPS.**

Location	System	Tree Crop	Benefits	Understory Crops
Costa Rica	dispersed trees	*Cordia almifolia*	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, *Acacia albida*	lumber, fuel, shade, special products, nitrogen	grains, pasture
Malaysia	dispersed trees	dwarf coconut	food, lumber	cacao
Tropics	dispersed trees	coconut	food, feed	pasture
Mexico	dispersed trees	Brosimim	food, lumber	wide variety of crops, pasture
Haiti	home garden	mango	fruit	rice
Sri Lanka	mixed perennials	many fruit trees	fruit, other products	spices, vegetables
Philippines	home garden	various fruit trees	fruits, edible leaves	many vegetables
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	*Grevillia, Albizzia, Leucaena*		

GETTING STARTED WITH AGROFORESTRY SYSTEMS

Steps in the decision-making process:

1. Decide whether agroforestry systems are appropriate
   - Describe family and community needs.
   - Find the limiting constraints in agriculture, including markets and marketing.
   - List the potential benefits of an agroforestry system in the region in question, and their relative importance.
   - Then decide if it is worth the effort to develop one.
   - Consider whether the people of the region are willing or capable of adopting a system.

2. Design a system
   - Select the area.
   - Characterize it (describe it, its strengths, weaknesses) with respect to existing soil, water, and crops.
   - List the needs that could be met with an agroforestry system.
   - Characterize the crops desired by minimum space requirements, water and fertilizer needs, and shade tolerance.
   - Select the trees, shrubs, or grasses to be used.

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 beginning with the most shade tolerant for the final years of intercropping.

   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.

4. In temporary and permanent systems:
   - Keep all ground in crops or protective covers at all times.
   - Try the system on a small scale first.
   - Measure the inputs and outputs of the system.
   - Evaluate whether the benefits expected have been achieved.
   - Look for the desired plant materials or for suitable substitutes locally (Table 5).
   - Expand or extend any new system cautiously.

SEED SOURCES FOR AGROFORESTRY TREES

Table 5. **SOURCES OF SEED OF MOST IMPORTANT TREE SPECIES.**

TREE SPECIES	ADAPTATION*	POSSIBLE SOURCE OF SEEDS
Acacia albida	hot, dry tropics	CATIE, ILCA, KI, SSC, TSP
Acacia mearnsii	hot, dry tropics	CSIRO, KFSC, KI, SSC, TSP
Bursera simruba	hot, dry tropics	FKNN, SFF
Calliandra calothyrsis	wet tropics	CATIE, TBAIF, TSP
Cassia siamea	intermediate tropics	CATIE, ILCA, KFSC, KI, SSC
Erythrina berteroana	intermediate tropics	CATIE
Gliricidia sepium	intermediate tropics	CATIE, ILCA, KI, TBAIF, TSP
Leucaena leucocephala	intermediate tropics	CATIE, ECHO, ILCA, KFSC, KI
Moringa oleifera	intermediate tropics	CATIE, ECHO, ILCA, SSC, TBAIF
Sesbania grandiflora	intermediate tropics	CATIE, ILCA, KI, SSC, TBAIF
Sesbania sesban	intermediate tropics	KI, TBAIF, TSP, UH

* Intermediate condition suggests a region of intermediate rainfall.

Source Abbreviations

ATSC- Australian Tree Seed Centre
CSIRO Division of Forestry and Forest Products, PO Box 4008 Queen Victoria Terrace, Canberra, ACT 2600, Australia)

CATIE- Centro Agromomico Tropical de Investigacion y Esperanza
Turrialba, Cartage, Costa Rica

ECHO- Educational Concerns for Hunger Organization
17391 Durrance Rd., North Ft. Myers, FL 33917, USA

FKNN- Florida Keys Native Nursery
102 Mohawk St., Travernier, FL 33070, USA
ILCA- International Livestock Center for Africa
P.O. Box 5689, Addis Ababa, Ethiopia
KFSC- Kenya Forestry Seed Centre
KARI, P.O. Box 74, Kikuyu, Kenya
KI- Kumar International
Ajitmal 206121, Etawah (UP), India
SFF- Southern Florida Forests
SSC- Shivalik Seeds Corporation
Panditwari, P.O. Prem Nagar, Dehra Dun - 248007 (UP), India
TBAIF- The Bharatiya Agro Industries Foundation
'Kamdhenu', Senapati Bapat Marag, Pune-411 016, India
TSP- Tree Seed Program
Ministry of Energy & Regional Development, P.O. Box 21552, Nairobi, Kenya
UH- University of Hawaii
Department of Agronomy & Soil Science, U. of H. at Manoa, 190 East-West Road, Honolulu, HI 96822, USA

RELATED RESOURCES & ORGANIZATIONS

Agroforestry Seed Information Clearing House (Pamela Fernandez, Department of Agronomy, University of the Philippines at Los Banos, College, Laguna 3720, Philippines). Information.

CARE (660 First Ave., New York, NY 10016, USA). Information.

Carter Seed Co. (475 Mar Vista Drive, Vista CA 92083, USA). Seeds.

Centro de Mejoramiento Genetico y Banco de Semillas Forestales de Nicaragua (Magaly Urbina M., Director, Km. 12 1/2 Carretera Norte, Managua, Nicaragua, phone; 505-2 31622, fax: 505-2 31623). Seeds.

DANIDA (Forest Seed Centre, Krogerupvij 3A, DK-3050, Humleback, DENMARK). A project of the Danish International Development Agency offering information and library service, publications and training to countries which Denmark renders support. Information.

Forestry Fuelwood Research and Development Project (F/FRED, Winrock International, 1611N. Kent St. Suite 600, Arlington, VA 22209, USA). Information.

Forestry Support Program (International Forestry, USDA Forest Service, P.O. Box 96090, Washington, DC 20090-6090). Provides technical assistance in forestry and natural resources to USAID and U.S. Peace Corps.

Henry Doubleday Research Association (Dr. Phil Harris, Overseas Projects Coordinator, HDRA, Ryton-on-Dunsmore, Coventry, CV8 3LG, UK). Information & seed for groups working in Africa and the Indian sub-continent, especially drought tolerant *Prosopis* species.

Inland & Foreign Trading Co. (Block 79A, Indus Road #04-418/420, Singapore, 0316. Information & Seeds.

Institute of Tropical Forestry (P.O. Box 25000, Rio Piedras, PR 00928-2500, USA). Information.

International Centre for Research in Agroforestry (ICRAF, P.O. Box 30677, Nairobi, Kenya, e mail: icraf@cgnet.com) Newsletter, Information & Seeds.

International Society of Tropical Foresters (ISTF, 5400 Grosvenor Lane , Bethesda, MD 20814, USA). Newsletter and Information.

J.R. Palmer, IUFRO (International Union of Forest Research Organizations, A-1131, Wien-Schonbrunn, Austria).

KENGO (P.O. Box 48197, Nairobi, Kenya). Information.

Kimseed (Australian Revegetation Corporation Ltd., 51 King Edward Road, Osborne Park 6017, Western Australia). Extensive inventory of arid land trees & shrubs and equipment for planting, harvesting etc.

The New Forests Project (731 Eighth Street, SE, Washington, D.C. 20003). Seeds & Information.

Nitrogen Fixing Tree Association (c/o Winrock International, Petit Jean Mountain, Morrilton, AR 72110-9537, Ph 501/727-5435, Fax 501/727-5417). Newsletter, Information.

NifTAL Project (Department of Agronomy and Soil Science, University of Hawaii, P.O. Box 0, Paia, HI 96779, USA). Rhizobia.

Oxford Forestry Institute (Plant Science Department, South Parks Road, Oxford OX1 3RB, UK). Seeds.

Peace Corps (Information Collection and Exchange, 1990 K Street NW, Room 808, Washington, DC 20526, USA). Information.

Petawawa National Forestry Institute (Chalk River, Ontario K0J 1JO, Canada). Seeds for research purposes.

Roy Danforth (Imeloko Agroforestry Project, B.P. 1377, Bangui, Central African Republic). Working to promote agroforestry as an alterative to "slash and burn" farming in Africa. Seeds (375+ species of tropical fruit trees).

RWEDP (Regional Wood Energy Development Programme in Asia). FAO/RAPA, 39 Maliwan Mansion Phra Athit Road, Bangkok 10200, Thailand. Information.

SETROPA (P.O. Box 203, 1400 AE Bussum, Holland). Seeds.

Tree Crops Centre (PO Box 27, Subiaco, WA 6008, Australia). Information.

BIBLIOGRAPHY AND USEFUL PUBLICATIONS

Buck, L. 1988. *Agroforestry Extension Training Sourcebook Cooperative for American Relief Everywhere*. (CARE) International New York, N.Y., 540 pp.

Fernandez, Pamela G., guest ed. *Sustainable Agricultural Newsletter* (September 1990 issue dedicated to agroforestry seeds with an extensive listing of suppliers around the world). CUSO, 17 Phaholyothin, Golf Village, Phaholyothin Road, Bangkhen, Bangkok 10900 Thailand.

Folliot, Peter F. and Thames, John L. 1983. *Environmentally Sound Small-Scale Forestry Projects, Guidelines for Planning.* Volunteers in Technical Assistance (VITA). Arlington, VA, 109 pp. $9.75 (see CODEL below)

Forestry/Fuelwood Research and Development Project. 1992. *Growing Multipurpose Trees on Small Farms*. Bangkok, Thailand: Winrock International. 195 + ix pp. (including 41 species fact cards). To order in the USA, call: 703/351-4006 and request book order no. PNABR667.

IITA. (no date) *Alley Cropping, A Stable Alternative to Shifting Cultivation.* International Institute of Tropical Agriculture, Ibadan, Nigeria, 25 pp. (available for $1.00 from NFTA, see resources).

IIRR. 1990. *Agroforestry Technology Information Kit*. The International Institute of Rural Reconstruction, 475 Riverside Drive, Room 1270, New York, NY 10115 ($20.00). Kits are probably available as well from their office in the Philippines: IIRR, Silang, Cavite 4118, Philippines.

MacDicken. 1988. *Nitrogen Fixing Trees for Wastelands*. FAO Regional Office for Asia and the Pacific, Maliwan Mansion, Phra Atit Road, Bangkok, Thailand.

Nair, P.K.R. *Classification of Agroforestry Systems*. Agroforestry Systems 3: 97-128.

National Academy of Sciences. 1980. *Firewood Crops, Shrub and Tree Species for Energy Production*, Vol I, Washington, D.C., 236 pp. (available free to those actively working in development: BOSTID (JH-217D), National Research Council, 2101 Constitution Avenue, Washington, D. C. 20418, USA).

National Academy of Sciences. 1983. *Firewood Crops, Shrub and Tree Species for Energy Production*, Vol II, Washington, D.C., 92 pp. (see vol I).

Rockeleau, D., Weber, F. and Field-Juma, A. 1988. *Agroforestry in Dryland Africa*. International Centre for Research in Agroforestry (ICRAF). Nairobi, Kenya, 311 pp. $31.00

Save The Children/US, Thailand. 1992. *Collection, Storage, and Treatment of Tree Seeds: A Handbook for Small, Farm Tree Planters*. The FAO Regional Wood Energy Development Programme in Asia, Bangkok, Thailand.

Shankarnarayan, R. A. (ed.). 1984. *Agroforestry in Arid and Semi-arid Zones*. Jodphur, India, ICAR Central Arid Zone Research Institute, 295 pp.

Teel, W.A. 1984. *A Pocket Directory of Trees and Shrubs in Kenya*. Kenyan Energy Non-Governmental Organization (KENGO). Nairobi, Kenya, 151 pp.

Thuvesson, D. (ed.). *Forests, Trees and People Newsletter*, Swedish University of Agricultural Sciences/IRDC, Box 7005, S-750 07 Uppsala, Sweden. (Quarterly publication distributed to those interested in and/or working with community forestry activities).

USAID. 1987. *Windbreak and Shelterbelt Technology for Increasing Agricultural Production*. United States Agency for International Development, Washington, D. C. 219 pp.

Liegel, Leon H., Venator, Charles R. 1987. *A technical guide for forest nursery management in the Caribbean and Latin America*, Gen. Tech. Rep. SO-67. New Orleans, LA: U.S. Department of Agriculture, Forest Service, southern Forest Experiment Station. 156p.

von Carlowitz, P. 1986. *Multipurpose Tree and Shrub Seed Directory*. International Center for Research in Agroforestry, Nairobi, Kenya. 265 pp. $24.00

VSO. (no date). *If a Tree Falls: A VSO Guide to Raising and Planting Trees in Kenya*. Voluntary Services Overseas.

Wesley, S.B. (ed.) *Agroforestry Today*, ICRAF. Nairobi, Kenya, quarterly.