Planning for Agroforestry

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AGROFORESTRY

Susan Huke and June Plecan

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Planning for

AGROFORESTRY

With Special Reference to Low Rainfall Areas

An easy-to-use handbook for development workers interested in exploring agroforestry practices with their local communities.

Susan Huke and June Plecan

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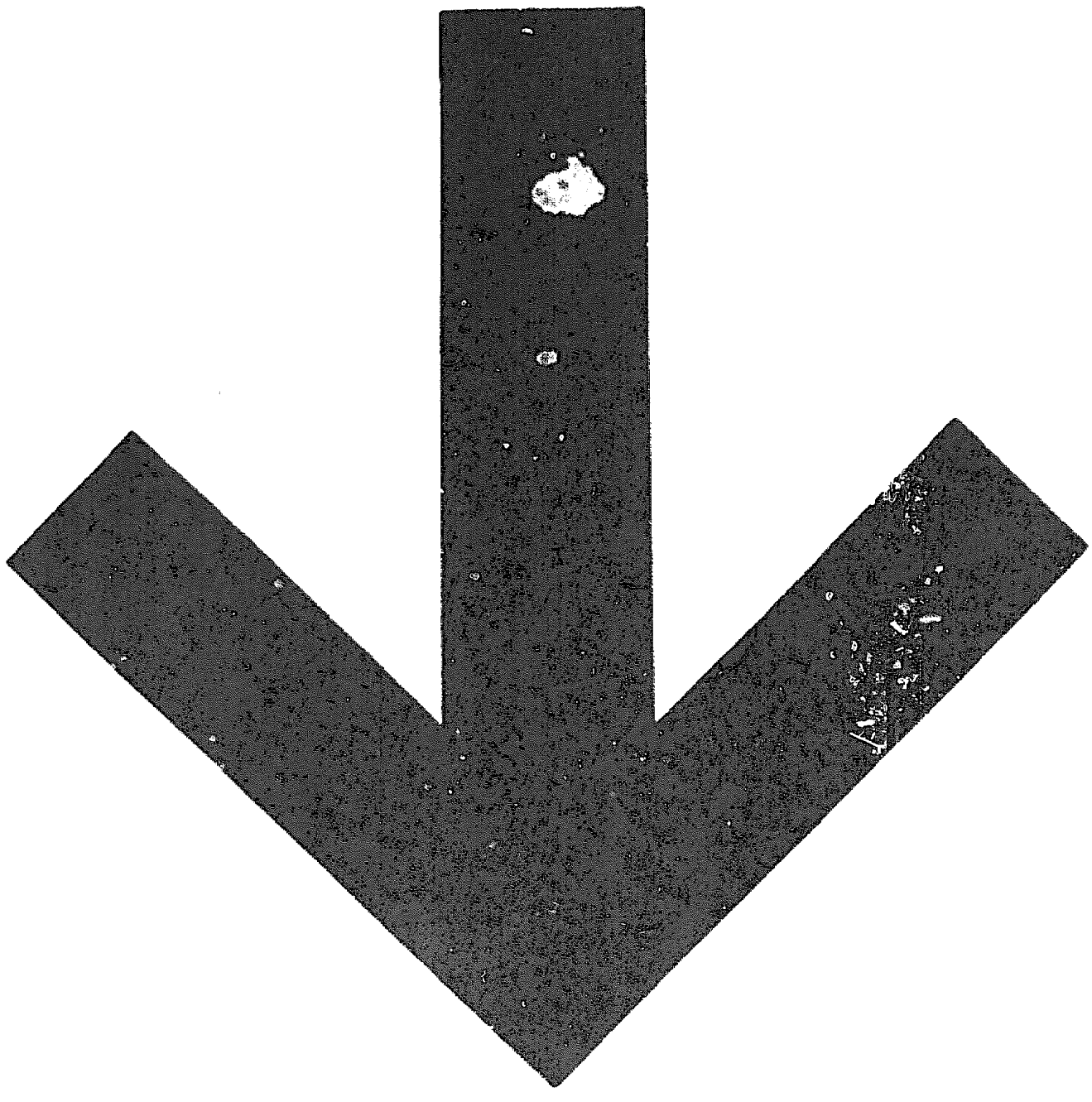


Contents

Mel McCaw

ONE

Introduction

What Is Agroforestry?

Agroforestry is the planned integration of agriculture and forestry. Examples of agroforestry include:

- Using the leaves from trees as fodder, to feed livestock;
- Grazing livestock under plantation crops such as coconut trees;
- Planting rows of trees across a farm to protect crops from the drying wind;
- Planting nitrogen-fixing trees in fields so that the tree leaves can add more nitrogen to the soil;
- Planting thorny trees close together around a home garden so that they grow into a protective "live fence."

Why Agroforestry?

Rural communities are increasingly affected by the tremendous pressures on their local forests. The forest and tree resources of many areas are becoming severely diminished by two major activities, both of which are essential to the well-being of many communities: farming and fuelwood collection. As population numbers increase, tracts of forest are being cleared for farming. Often the lands cleared are of marginal quality, located on steep, rocky hillsides or in dry, drought-prone areas. Such lands can become wastelands after only a few years of farming.

Additional reductions in forest cover can be attributed to decreasing fallow periods. In many rural areas, land was traditionally allowed to revert to bush or forest after a few years of farming. This provided a more sustainable supply of forest resources and allowed soil to regain lost fertility.

The demand for fuelwood and other tree products places even more pressures on forest resources.

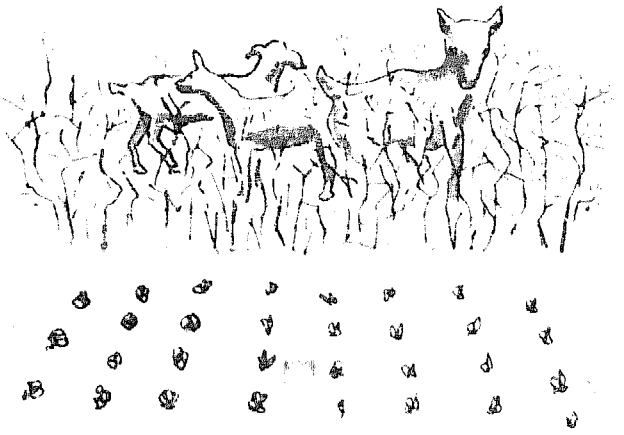
Rural communities can be greatly affected by these trends. More time and energy must be devoted to collecting the wood upon which they depend for cooking family meals, building homes, and carrying out other essential activities. The availability of fertile farmland is being reduced.

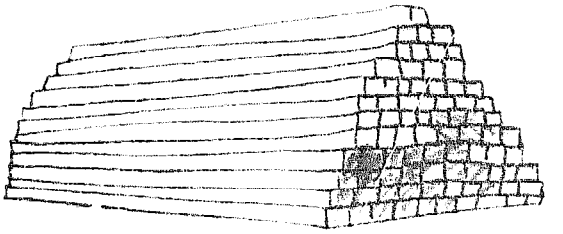
What can farmers and their communities do to address these forestry-related problems? Agroforestry is one potential solution. By planting trees on their land, farmers can boost local forestry resources. They can also improve the quality of their farmland and provide other benefits to the community.

Benefits of Agroforestry

Trees can provide numerous benefits to rural communities. Well-known benefits include the production of fuelwood and construction materials. Another benefit highly valued by families is the production of fruit which can add to the nutritional content of daily meals. Shade trees can serve as a focal point for community gatherings or market places. Trees and shrubs planted as "live fences" can prevent livestock from entering fields, home gardens, or compounds. The pollen from flowering trees can enhance local beekeeping activities.

Perhaps less obvious benefits but equally important are the land conservation benefits that trees can provide, such as the control of soil erosion and the improvement of soil fertility. Windbreaks can reduce the speed of wind flowing over crops and thus reduce crop desiccation and soil erosion. Trees planted on hillsides can reduce the amount of soil that is washed downhill by heavy rains. Alley cropping (see chapter 4) with nitrogen-fixing trees can improve soil fertility.





How Can This Handbook Help?

Planning for Agroforestry can help to guide the establishment and implementation of agroforestry projects. It has been written for community development agents, agriculture/forestry extension agents and other field workers who would like to integrate agroforestry into their organization's ongoing community development activities.

The recommendations presented here are based upon Save the Children's experience with agroforestry in Qorioley, Somalia, and upon many years of experience in community development throughout the world.

The handbook outlines basic steps recommended for establishing an agroforestry project in a rural community. We have emphasized working with individual farmers because our own experiences have taught us that farmers are more likely to make a commitment to the care and maintenance of trees if they own the land on which the trees are planted.

The handbook places an emphasis on low rainfall areas. This is primarily because we wanted to share the lessons that we learned in semi-arid Somalia where the average annual rainfall was 475mm, and where irrigation was seasonally available. However, we feel that many of our recommendations can be applied to other climatic conditions as well.

Susan Huke

TWO

Making Contact

If you decide that agroforestry may provide some useful benefits to local communities, what next? How do you begin to contact these communities and explore the possibility of working with them? Based upon Save the Children's experience in Somalia, we feel that the most important steps are:

- Identify potential communities;
- Contact local leadership;
- Survey agroforestry needs/potential,
- Introduce agroforestry to the community.

This chapter will present guidelines for carrying out each of these steps.

Community Identification

There are a number of factors to consider when identifying local communities that may benefit by participating in an agroforestry project. It is best to work in a community where one's organization has already established a presence, where people are familiar with the organization's goals and mode of operation, and where tree-related problems have been identified by the community as a major concern.

It is also important to consider the following factors:

Size of the Community

A new project is more likely to succeed in smaller villages where monitoring is generally an easier task.

Water Availability

It is important that water be available for seedling production and establishment. Communities selected to participate in an agroforestry project should therefore have access to wells, rivers, water catchments, or other water sources.

Proximity to Existing Tree Nurseries

If tree nurseries have already been established in a project area, one may want to give priority to communities located nearest to these nurseries.

Land Tenure

Priority should also be given to communities having legal rights to the land on which they farm. It is unlikely that communities or individuals who are farming land that they do not own will be interested in the long-term investment of time and effort that tree-planting entails.

Working with Local Leadership

Once potential communities have been identified, we recommend contacting government officials and other respected community leaders to discuss an agroforestry project. The importance of working closely with them cannot be overstated. Their understanding and support can really increase the chances of strong community interest. Moreover, failure to coordinate your activities with them can sometimes create problems!

In Somalia, Save the Children generally works closely with community leaders. However, in one case, we forgot to inform the local District Commissioner of a village meeting that we had called to discuss agroforestry. He chanced to visit the village earlier the same day and, upon hearing of the meeting through indirect channels, cancelled it. Fortunately, once properly informed of our intentions, he wrote a letter of support to the Village Chairman which facilitated our start in this village.

In addition to communicating with local leaders, we recommend that you contact any nearby government forestry or agriculture offices. Government administrators or extensionists may be good sources of information and may be able to assist in the supply of seedlings or technical knowledge.

Surveying Local Agroforestry Needs/Potential

Before you make a final selection of the communities with which you will work, survey community leaders and local households. The survey should give a strong indication of whether there is a need for agroforestry; whether

members of the community see this as a need and are willing to commit their time and resources to the project; and whether an agroforestry project has potential for success. We recommend that this survey be prepared and conducted in coordination with people who are familiar with each community.

Information to be collected from the survey should include:

Local Demand for Trees/Tree Products

This would include the need for such tree products as fuelwood, construction materials, fruit and fodder, as well as for trees which are used for shade, windbreaks, nitrogen fixation, and soil retention. The species commonly used for each of these purposes should be identified, if possible.

Availability of Trees/Tree Products and How Acquired

This would include investigating whether tree products are bought or collected, where they are collected, by whom, how often, and how much time is spent on collection.

History of Local Tree-Planting/Agroforestry Efforts

If any communities have tried to plant trees in the past, it would be most useful to understand the reasons behind any successes or failures. If past efforts have failed, it would be important to understand whether the causes of failure could be overcome.

Local Knowledge of Agroforestry

This would include local farmers' knowledge of actual agroforestry techniques as well as their benefits and disadvantages.

Seedling Availability

It would be very useful to investigate the availability of locally produced seedlings in order to determine if the community should establish additional nurseries.

Availability of Technical Resource People

Any local foresters, agriculturalists or other technical resource people should be identified. They may be able to participate in the agroforestry project.

Land Ownership

Who owns the land? Do the farmers who are interested in planting trees have complete, long-term control of the land? Experience has shown that land owners have much greater success with agroforestry projects.

Land Availability

Try to determine the amount of land owned by the average farmer. The extent of the land available to individuals may determine the agroforestry techniques promoted and the number of seedlings eventually needed for the area.

Water Availability

Young seedlings need water. Find out if there is a convenient source of water for farmers to use on seedlings.

If you have never conducted a community survey before, it would be wise to seek the assistance of a person experienced in planning and preparing questionnaires.

Ideas for preparing questionnaires:

- Before you write the questionnaire, carefully define the information that you wish to collect. Then, when you prepare the questionnaire, make sure that your questions will address this information. Also make sure that there are no unnecessary or ambiguous questions.
- Do not make the questionnaire too long. It's a good idea to keep questionnaires fairly short, so you do not lose the interest of the person or group being interviewed. We suggest that individual household interviews be designed to last about 15 to 20 minutes and that group interviews not last longer than one hour.
- Use open questions. It's very important not to ask "leading" questions, i.e. questions that may influence the answer of the person being interviewed. For example, if you would like to know whether the community's supply of fuelwood has decreased over the past 10 years, do not ask a leading question

such as, "Has your supply of fuelwood decreased over the past ten years?" Instead, it's better to ask: "How does your present fuelwood supply compare to the fuelwood supply of ten years ago?"

- Avoid asking questions that could have more than one meaning. The best way to check for this is to test your questionnaire before using it. You can test it out on another staff member, or a friend.
- Make sure your questions are culturally sensitive. The best way to ensure this is to prepare the questionnaires with someone who is from the region where you'll be interviewing. To give an example, the question, "How many children do you have?" would be perfectly acceptable in many cultures. In Senegal, however, this question would not be answered by many people because it is traditionally unacceptable to count people.
- Test the questionnaire in one community before surveying other communities. You may find that some questions are inappropriate or unnecessary. You may also decide that more questions are needed.

Introducing Agroforestry to the Community

Once the survey of local agroforestry needs/potential has been completed, the process of introducing the agroforestry project to each community can begin. We suggest that this be done through a series of community meetings. The community members that participate in the first meeting should include respected community leaders. As mentioned earlier, their understanding and support of the agroforestry project may serve to encourage the understanding and support of other community members. Local forestry or agricultural extension agents should also be included in the first meeting.

The number of meetings held in each community will depend upon the number of community members that are interested in agroforestry. We suggest that the size of the group attending each meeting be no larger than 15 people, in order to facilitate discussion among participants.

Those of you who have not had much prior experience in holding meetings may be asking such questions as:

"What can be accomplished in such meetings?"

"How much and what kind of information should be presented?"

"How should the information be presented?"

In order to answer such questions, we have prepared two sample introductory meetings, which are presented in Appendix 1:

Agroforestry Solutions to Community Problems is intended to encourage community members to explore ways in which agroforestry can address problems which the community is facing.

Tree Uses; Problem and Solution Identification is designed to involve community members in discussing ways in which they presently use trees or tree products and how, through agroforestry, the community can increase local forestry resources.

Working with Individual Farmers

While conducting the agroforestry survey and the group meetings, you should be able to compile a list of farmers who seem the most interested in participating in an agroforestry project. Guidelines for working with individual farmers will be presented in the next chapter.

A Note about Extensionists

At some point during the early stages of your project, you will need to recruit agroforestry extensionists or, at least, to train existing staff in agroforestry techniques. The timing and nature of this process will depend somewhat upon the present staffing of your organization and the proposed size of your agroforestry project.

In order to guide you in your recruitment or training of extensionists, we offer the following words of advice. Ideally, a community extension agent should possess the following qualities:

- Strong familiarity with the community: The extensionist should be from the community or be very familiar with it. Once hired, it is essential that the extensionist live permanently in the community. We also strongly recommend that the extensionist be available to work full-time on the agroforestry project.
- Experience: The extensionist should have had some experience and, if possible, training in agriculture or forestry as well as direct project experience. Past teaching would also be a real bonus.
- Communication skills: The extensionist should be someone who is able to communicate well with village leaders as well as other community members. The ability to listen and work *with* people is essential.

It is important that the project extensionists are given the support and guidance that they need. Those extensionists who lack past experience and/or communication skills will require training and technical support to "fill in the gaps."

Betty Woodward

THREE

Supporting Farmers in the Design and Maintenance of Agroforestry Plots

As mentioned in Chapter Two, the agroforestry meetings will expose each community to the potential benefits of the agroforestry projects and will allow you an opportunity to identify interested farmers.

Once these farmers have been identified, what next? What steps should be taken to prepare an agroforestry design that is appropriate for each farm? How can each farmer be supported in planting and maintaining their agroforestry plots? We recommend that the following steps be taken:

- Select farmers;
- Prepare agroforestry plans with each farmer;
- Provide on-going support through monitoring and additional training.

This chapter will provide guidelines for taking each of these steps.

Select Farmers

Although it will be tempting to enroll every farmer who expresses interest in your agroforestry project, this may not be wise. Three strong recommendations are discussed below.

Set Realistic Targets!

It is very important not to enroll so many farmers that you over-extend your project's resources. Careful consideration should therefore be given to the number of farmers to be enrolled each year of the program.

Look for Potential

Remember, during the early stages of your agroforestry project, the results will be under close scrutiny by the community. The farmers that you work with will, in effect, be setting an example for other farmers. It is therefore very important to work with farmers who show a strong potential for establishing a successful agroforestry plot. Farmers with good access to water, whose farms are easily accessible and who indicate a willingness to commit time and energy to maintaining their trees should be a priority during the project's first year. Once the project and the community have gained more expertise in agroforestry, the more difficult sites can be taken on.

Try for a Cross Section

Ideally, participating farmers should represent a cross section of the community in terms of land-type and farm-size. This will increase the chances of encouraging the interest of a wide range of farmers in future years.

Prepare Agroforestry Plans with Each Farmer

During the first few site visits with individual farmers, the extensionist can discuss various possible agroforestry designs and assist farmers in selecting the most appropriate one for their land. Chapter Four describes some of the possible designs.

It is important that the farmer make all final decisions regarding the use of his/her land. An extensionist's role should be that of an adviser, not a dictator.

When preparing an agroforestry plan, you will want to address the following issues:

- Tree Species to Be Planted
- Location of Trees
- Number of Seedlings to Be Planted
- Amount of Seasonal Timing of Labor
- Project Assistance

Tree Species to Be Planted

Selecting the appropriate tree species is essential to the success of an agroforestry project. This will depend primarily upon a) the specific needs expressed by each farmer; b) the community's forestry needs as revealed in the community survey; and c) site conditions.

a) *Needs expressed by each farmer:* This is, of course, a primary consideration. The preference of a farmer for growing trees for fruit, fuelwood, construction materials, fodder, or windbreaks will largely determine the tree species selected. It is important to be aware that the species preferences of each member of a farming family may not be the same. Men, for example, may prefer to grow poles for sale while women may prefer fuelwood, or fruit trees.

   The length of time that a farmer is willing to wait until he/she can harvest the trees will also determine the species chosen. For example, a farmer wanting to produce fruit for sale in local markets may want to plant papaya, which can be harvested within a year but which produces for under five years. On the other hand, he/she may prefer mango (or a combination of the two trees), which usually cannot be harvested for at least eight years but can bear fruit for over a hundred years!

b) *Forestry needs as revealed in your community survey:* The tree species which farmers first choose to plant may not always address the community's forestry needs. This was often the case in Qorioley, where fuelwood shortages were generally considered to be a problem. Most farmers we worked with initially wanted to plant only fruit trees. This may have been because they were very aware of the economic benefits that fruit trees could provide and were unfamiliar with the idea of planting trees for fuelwood. When this was the case, we often discussed the idea of planting fuelwood species as well as fruit trees. Many farmers decided to try it.

c) *Site conditions:* Obviously, you will want to recommend species that are best suited for a farm's soil type and water availability.

Appendix 2 presents information on rainfall, soil type and potential uses for species suitable for planting in semi-arid areas.

Location of Trees

The actual location and arrangement of the trees will depend largely upon the amount of land owned by a farmer, and upon land use. Farmers who own small plots of land (under one hectare) tend to choose agroforestry designs that occupy very little of their land (e.g. boundary plantings or live fences). Farmers owning larger farms can afford to experiment a bit more and often choose more "risky" designs, such as intercropping, alley cropping, or small woodlots. Each of these designs is presented in Chapter Four.

Another important consideration when determining location is land use. Trees planted along roads or pathways for example, can be trampled or eaten by grazing cattle. The importance of understanding land use was learned by Save the Children staff the hard way in Somalia. Seedlings planted along a secondary canal in a refugee camp were completely trampled by cattle. We had not realized that during the dry season the strip of land running alongside the canal was used as a pathway for cattle through the camps.

Number of Seedlings To Be Planted

When deciding upon the number of seedlings to plant, a farmer should be aware of the time that it takes to plant and maintain (e.g. water, weed, and protect) each seedling. In heavy clay soils, for example, the average farmer can dig between 30 and 50 seedling pits per day. This in itself represents a considerable workload. Watering, weeding and otherwise maintaining the seedling requires even more time.

We recommend that a farmer planting trees for the first time not plant more than 25 during the first year. After his/her experience with these trees, the farmer can decide upon the number to be planted the following year.

Other factors that will determine the number of seedlings planted include the availability of seedlings in the project area, the type of transport to be used, and the level of experience of the farmer. In order to increase the

chances that tree planting will be a positive experience for each farmer, it is better not to overwhelm him/her with too many seedlings and too much additional responsibility.

Amount and Seasonal Timing of Labor

Planting and maintaining seedlings can be a lot more work than it may seem. It is very important that each farmer (and each extensionist) has a good idea of the amount of work involved before deciding upon an agroforestry design. The primary labor-intensive stages of tree planting and maintenance are as follows:

- *Pit digging:* In the clay soils of Qorioley, seedling pits are generally easier to dig during the dry season, just before the rains begin. As mentioned earlier, in these heavy soils, between 30 and 50 pits can be dug each day.

- *Seedling transportation:* If the roads to a farmer's field are impassable during the rainy season, then the seedlings will have to be transported to the farm during the dry season. Transportation alone can be very time-consuming depending upon the type of transportation available and the distance of each farm from the nurseries.

  If seedlings are to be transported during the dry season, they will need to be watered until planting time. The amount of labor required for this will depend upon the distance between the planting site and the nearest water source.

- *Planting:* After a few good rains, the seedlings can be planted. Planting is less time-consuming than pit-digging but does occur at a time when farmers are busy preparing and planting their food crops.

- *Seedling maintenance:* Depending upon climatic conditions, the seedlings may need to be watered by hand or irrigated once the rainy season ends. They also will need weeding. In certain areas, where grazing animals may be a problem, seedlings should also be protected either by fencing or guarding.

George McRobie

Project Assistance

An important aspect of preparing an agroforestry plan is achieving a clear understanding between a farmer and the extensionist of the type of support to be provided by the project. There are several reasons for this, including.

- *Encouraging confidence:* A farmer may be more comfortable about trying out a new idea if he/she is aware that his/her efforts will be supported by your organization.
- *Avoiding unrealistic expectations:* Farmers sometimes have unrealistic expectations of the type of assistance that a project can provide and become disappointed if these expectations are not realized.

What type of support should be provided to each farmer? This is sometimes a difficult question to answer. Ideally, project support should be limited to training and technical assistance. Why? Two major reasons:

- The more material or financial support you provide, the more you encourage farmers to depend upon and expect benefits other than the trees themselves.
- By providing too much assistance in the form of labor (e.g. pit digging, transportation, or watering), you risk enrolling a farmer who will not see the necessity of commiting much time to maintaining his/her trees.

Provide Ongoing Support through Monitoring and Additional Training

Once an agroforestry plot has been established, unexpected complications can arise. If a farmer needs assistance and cannot find any, he/she may be tempted to let the trees die. It's very important, therefore, to maintain close contact with each farmer throughout the year and to monitor his/her progress.

Monitoring each agroforestry plot will enable you to lend assistance when needed and learn some lessons for the next growing season. We strongly suggest that an extensionist be on hand, living in each community throughout the year and that he/she make site visits to each farm at least once very two weeks.

In addition to site visits to each farm, an extensionist should support his/her farming community by providing training. These trainings can be presented to groups of farmers enrolled in the program as well as farmers interested in enrolling in the future. Potential training subjects include seedling maintenance; pruning; harvesting and in-depth training on particular species and their potential uses. We recommend that, whenever possible, a lesson be strengthened by visits to farms where the new techniques can be demonstrated. As we all know, "seeing is believing!"

Do not forget, the agroforestry plots established through your project will themselves be useful training sites. We strongly recommend that you arrange for group training sessions at some of these sites.

You may also want to grow trees around your office and staff homes and farms. This can be another effective way to introduce new species to local communities.

Don Kurtz

FOUR

Agroforestry Designs

This chapter describes seven basic designs for integrating trees into farm crops:

- Compound Plantings
- Canal/Boundary Planting
- Live Fencing
- Fruit Tree/Vegetable Intercropping
- Windbreaks
- Woodlots
- Alley Cropping

Please keep in mind while reading this chapter that it is meant as an introduction only. Before actually attempting the more complicated designs (e.g. windbreaks, woodlots, alley cropping), we strongly recommend that you consult other technical publications such as *Reforestation in Arid Lands*, Weber, Fred R. with Carol Stoney. Volunteers in Technical Assistance, Arlington, Virginia, 1986.

Compound Plantings

Although planting trees around homesteads and compounds does not fit into a strict definition of agroforestry, it deserves mention because it is practiced so widely by farmers. In many cases, farmers first start with planting trees around their homes and then after experiencing success, expand their tree-planting activities to their farmland.

Benefits

- Shade;
- Fruit;
- Beautification;
- Fuelwood/construction materials.

Design

There are no particular design requirements for compound plantings except that the trees' spacing requirements be met. Waste water from family chores can be used for watering.

Examples from Somalia

Compound plantings are particularly striking in the refugee camps of Qorioley, Somalia. Before the establishment of the SCF nursery, the camps were almost devoid of trees. Now, four years later, there are so many trees that, as one visitor put it, "You can hardly see the refugees' homes." Species planted here include fruit tree species such as papaya, lime, mango and grapefruit, and fuelwood/construction species such as eucalyptus, casuarina, parkinsonia and cassia. It appears that the cassia and parkinsonia have been the most hardy survivors. Both are drought-resistant and cassia is not particularly vulnerable to grazing.

Canal and Boundary Planting

Often farmers experimenting with agroforestry for the first time and/or those with small farms will plant trees along the boundaries of their farms or along canal banks. This is seen as a much lower "risk" than intercropping

trees in a field. Just about any species is suitable for a boundary planting: leucaena, fruit trees, casuarina, cassia, eucalyptus and other species have been used.

Benefits

- Use of idle land;
- Production of fuelwood, construction materials, or fruit;
- Shade;
- Beautification;
- Reduction of wind erosion.

Restrictions/Problems

Trees planted on farm boundaries are often difficult to protect from grazing animals and therefore may require fencing or guarding during the first few years.

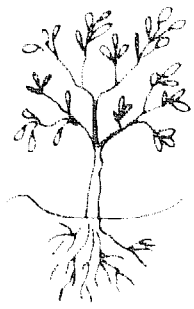
When planting trees along canals, it is important to place them far enough away that their roots do not crack the canal banks or interfere with dredging/cleaning operations.

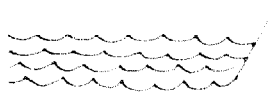
Examples from Somalia

There are several examples of canal and boundary plantings in this area. Many different species have been used although casuarina and fruit trees (particularly bananas) are the most common.

One method of boundary planting used in Somalia was to mix tree species which require different spacings. For example, one farmer planted the boundary of his farm with several different species: casuarina, cassia, eucalyptus, mango, lime and leucaena. The leucaena had been planted between the other species that require spacing of two meters or more. Leucaena only requires a spacing of one meter to produce a reasonably sized pole.

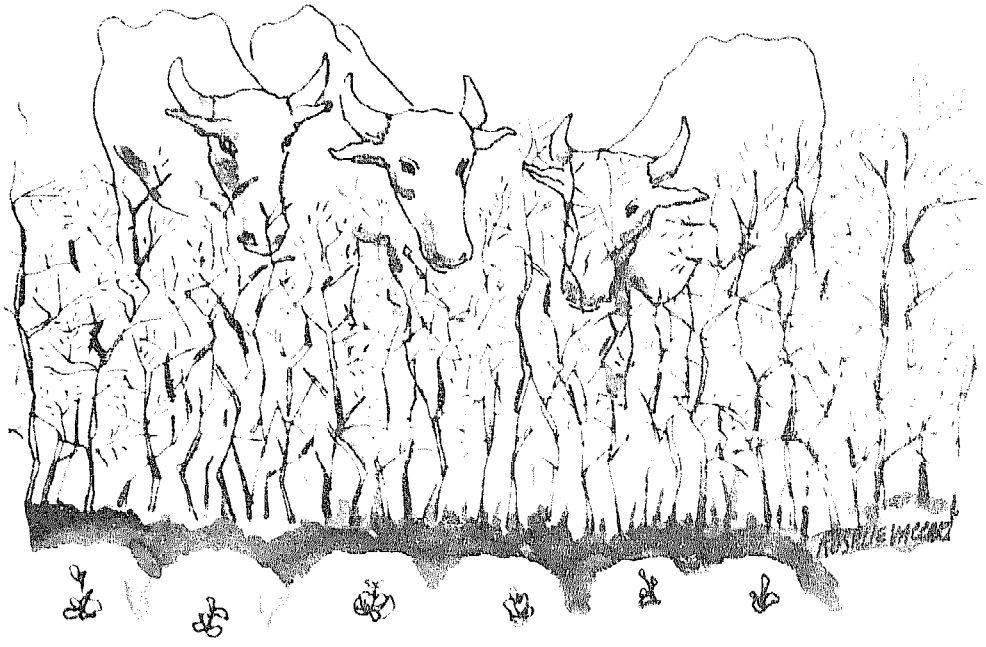
Planting leucaena between other tree species during their first few years of growth, when competition is minimal, allows for a more intensified utilization of the farmer's boundary. As the other trees mature and begin to compete with the leucaena for light, water, and soil nutrients, the leucaena trees can be harvested, leaving the other trees at a correct spacing for optimal growth.





On a reservoir in the irrigation system, trees were planted in microcatchments to hold rainwater for the trees and retard soil from running into the reservoir.

Live Fencing



A live fence is a very thick planting around the perimeter of a field, a home garden, or any other area from which animals should be excluded. The trees or shrubs used usually have thorns or intertwining branches.

Benefits

- Protection of cropland, woodlots and nurseries from grazing animals;
- Reduction of money, labor and material required for other types of fencing;
- Production of wood or fruit;
- Beautification.

Design

A live fence should be very closely spaced so that animals (and people) cannot walk between the trees. Close spacing can be achieved by direct seeding (i.e. sowing seeds directly in the ground) or by planting seedlings or cuttings close together (approximately 15 cm apart).

Restrictions/Problems

If a live fence is being planted to protect an area from grazing by animals, it may be necessary to construct a temporary fence to protect the young seedlings of the live fence. This problem can sometimes be avoided by planting a species which animals do not like to browse. Live fences may also require periodic pruning to keep them thick and low enough that they do not shade out crops.

Examples from Somalia

During a walk through refugee camps or local villages of the Qorioley area one can see many examples of live fencing.

One of the most commonly used species is euphorbia ("ano" or "milk" is the local name because the leaves contain a milky substance inedible by animals).

Euphorbia cuttings are collected from the bush and planted during the dry season. The cuttings lay dormant until the rains come and then send out roots and new shoots. As one man pointed out, "This plant is not like the ones you grow in your nursery. They require seedling bags, mixtures of soil, and lots of watering. I just plant this and it grows." Euphorbia is very drought resistant. One euphorbia fence we saw, which was four years old, had gone through several drought periods and was still a healthy 2.5 meters tall.

The owner of this fence has pruned it several times so that his friends could have cuttings for their own compounds. He strongly recommends euphorbia as a live fencing for a family compound because it does not have thorns, its dense growth prevents intruders, it can grow very tall (and thus serve as a windbreak or as shade) and it is an attractive addition to the compound. One disadvantage of this plant is that the milky substance can irritate the skin if not washed off immediately.

Other species often used as live fencing are *Parkinsonia aculeata*, a very drought-tolerant species, *Ceselpinae pulcharina, Prosopis juliflora*, and various *acacia* species. These can be grown by direct seeding before the rains begin. Some farmers prefer planting seedlings instead of direct seeding so that they can take full advantage of the rains.

Fruit Tree/Vegetable Intercropping

Fruit tree/vegetable intercropping refers to the association of fruit trees, grains, or vegetables in a field.

Benefits

- Intensified use of farm land;
- Production of fruit;
- Shade;
- Soil conservation/improvement;
- Erosion control.

Design

The design and spacing chosen will depend upon the spacing required for the tree species being planted and upon the farmer's long-term plans for his land. For example, if a farmer would like to eventually establish a fruit tree orchard, he will plant his trees according to the minimum spacing required and stop vegetable production once the trees produce too much shade. However, if he would like to continue vegetable production indefinitely, he could plant his fruit trees far enough apart so as not to shade out all crop land.

Restrictions/Problems

Most fruit trees have high water requirements. Those planted in low rainfall areas therefore need to be located on irrigated land or near a water source so they can be easily watered.

Examples from Somalia

A number of irrigated farms have intercropped fruit trees and vegetables. One farmer, for example, is intercropping grapefruit trees, bananas, papaya, and vegetables on a one hectare plot. The grapefruit trees were planted throughout the plot three years ago at a spacing of

6m × 6m. They are still very small (about 2 meters tall) and therefore do not yet shade out vegetable production. Eventually, however, vegetable production will be shaded out.

The banana trees were planted along the banks of the farm's main canal and alongside a casuarina windbreak on one side of the farm.

One section of the farm has undergone a rotation of papaya and vegetables. Three years ago it was planted with papaya (2m × 2m) and intercropped with vegetables during the first rainy season. For several

seasons after that, the shade from the papaya prevented vegetable production, but the papaya did produce fruit. Once fruit production dropped off, the papaya were cut down, and vegetables were again planted. The farmer was pleased with this system and plans to plant more papaya next season.

Windbreaks

Windbreaks are rows of trees planted in strips across fields so that they reduce the speed of wind flowing over fields. In countries such as Somalia, which have very strong seasonal winds, plants can be severely desiccated without such protection.

Benefits

- Reduction of damage to crops caused by wind;
- Reduction of wind erosion;
- Production of wood for fuel or construction;
- Production of fruit;
- Beautification.

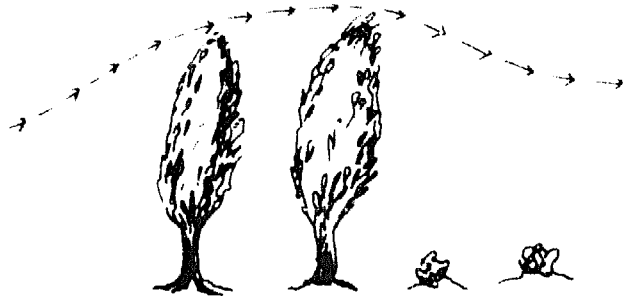
Design

Ideally a wind break should be

- Tall;
- At least two rows of trees;
- Alternating rows (see diagram);
- Evergreen.

A tall windbreak can protect a larger crop area than a short windbreak. Casuarina are ideal for windbreaks because they can grow up to 20 meters tall. The area protected by a windbreak can be up to 10 times the height of its trees, if at least two rows of trees of different heights are planted. Therefore, a windbreak 15 meters tall could potentially protect an area 150 meters wide.

Windbreaks can be designed with up to four rows of trees: two inside rows of tall trees and two outside rows of shorter, bushy trees. However, in hot, arid climates, only the two rows of tall trees are recommended. Too dense a windbreak increases temperature immediately to the lee of the windbreak and causes crops to die.

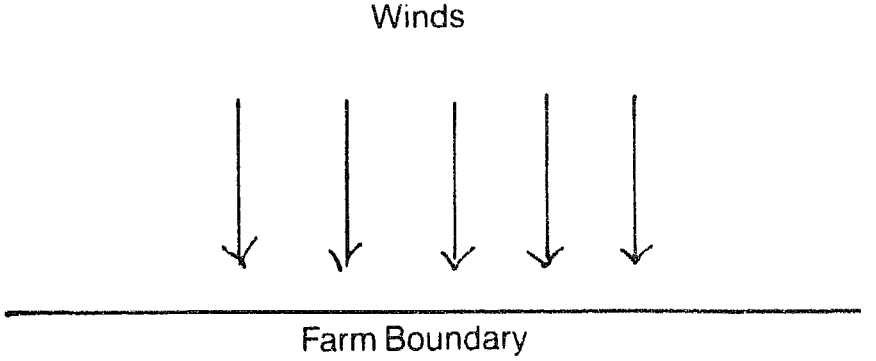


If two rows of trees are planted, they should be alternating. This will allow the windbreak to close up faster.

The spacing of the trees depends upon the tree species being used in the windbreak. Casuarina, for example, are normally grown two meters apart.

Location

Windbreaks are most suitable along farm boundaries which are perpendicular to prevailing winds.



Restrictions/Problems

Windbreaks, especially those with four rows of trees, require a large strip of land. Some farmers, especially those with small farms are therefore hesitant to grow windbreaks. Windbreaks have also been known to shade out adjacent crops, although we did not see examples of this in Somalia.

Examples from Somalia

Most of the windbreaks in Somalia consist of one or two rows of casuarina trees and are located on seasonally irrigated land. Many of the older windbreaks were planted by Italian farmers to protect and beautify their banana plantations. Since the establishment of the SCF seedling nursery three years ago, many more farmers have planted windbreaks on small farms and larger plantations. Those on small farms (under 10 hectares) usually consist of one row of leucaena trees and sometimes, one row of banana trees. One larger farm has one row of casuarina and a second row of mango.

Woodlots

Farmers owning large parcels of land may be interested in planting woodlots to produce fuelwood or construction materials. Some tree species, such as leucaena, will also produce fodder and increase soil fertility through nitrogen fixation and mulching.

Benefits

- Production of fuelwood and construction poles;
- Productive use of idle land;
- Erosion control.

Design

The most successful woodlots in low-rainfall areas are those located on irrigated land. It is possible to establish

dryland woodlots but only if water, manpower and the materials necessary for supplementary watering (e.g. by donkey carts or buckets) are available. CARE/Somalia has established some very impressive dryland plantations in Beletweyn, Somalia. It is doubtful however, that most private farmers would be able to invest the time or money required to establish a dryland plantation.

The spacing chosen for a woodlot depends upon the tree species to be planted, climate, and desired use of the tree (e.g. trees intended for small poles would be more closely spaced than those intended for larger logs).

Examples from Somalia

The first woodlot to be established on a farm in Qorioley, Somalia was planted in July 1985, after the owner visited another private woodlot located in a nearby town. In both woodlots, leucaena was planted at a spacing of 1m × 1m, on irrigated land. The woodlot located in Qorioley was intercropped with maize. During its first season, the farmer noted no decrease in yields on this plot as compared with other maize plots and in fact observed that yields were higher on the leucaena plot. During the next season, the farmer decided not to intercrop because the trees were producing too much shade.

Alley Cropping

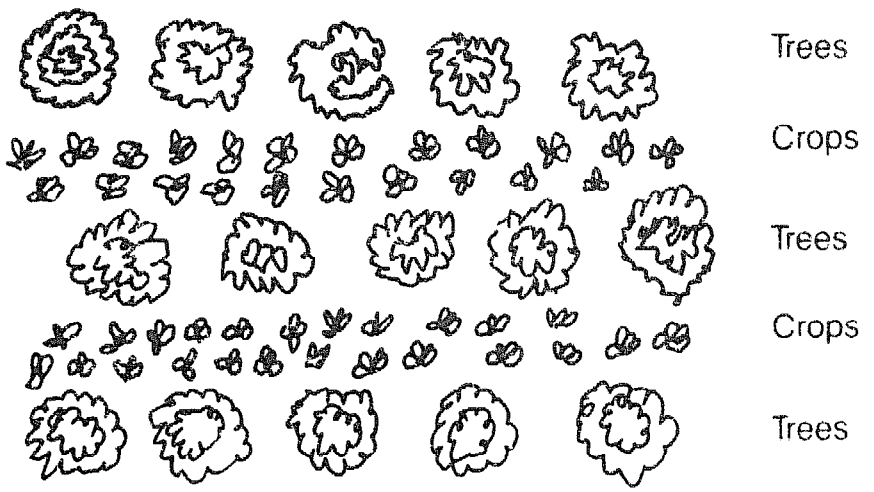
Alley cropping is an agroforestry system which alternates rows of trees with rows of crops directly in the field. This design is also referred to as hedge rows.

Benefits

- Nitrogen fixation;
- Mulch production;
- Fodder production;
- Wood production;
- Protection of crops from wind and sun;
- Soil conservation.

Design

The basic design of an alley cropping system is alternating strips of agricultural crops and trees.



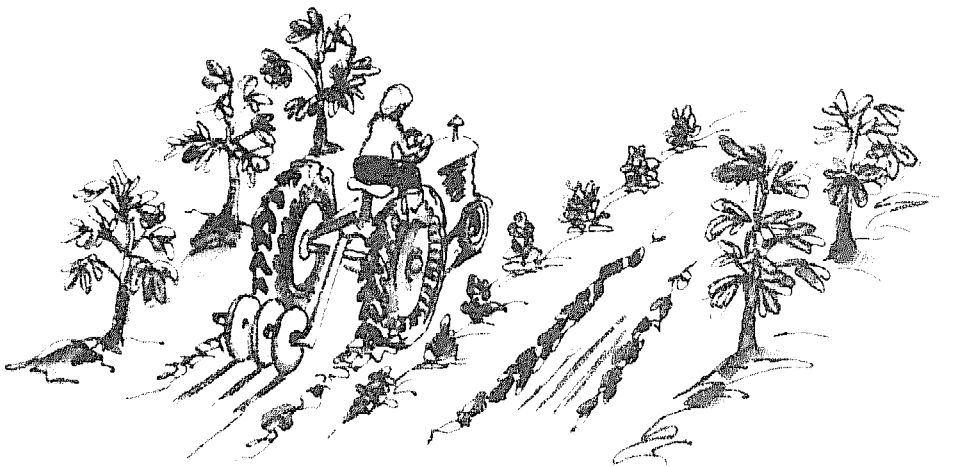
Restrictions/Problems

One potential restriction in semi-arid areas may be the low rainfall and subsequent water competition between trees and crops. It is likely that competition could be reduced by planting trees with deep tap roots.

Another potential problem is that of competition for sunlight. This can be reduced by coppicing (harvesting trees which regenerate quickly) or pruning the trees before they reach a height that shades out the crops. Cuttings could be used for fodder or fuelwood depending upon the species planted.

Examples from Somalia

The first alley cropping plots in this area were established in May of 1986. One farmer planted alleys of casuarina and eucalyptus between rows of maize. The alleys are 5 meters apart (to facilitate the use of a tractor for plowing the soil) and the trees in each alley are 2 meters apart. Once the trees begin to shade out the crops over the next few years, the farmer plans to discontinue crop production, wait until the trees are a harvestable size, harvest them and then begin again.



John Nittler

FIVE

Establishing a Nursery

If farmers are interested in planting trees but cannot easily obtain seedlings from a government or local nursery, they may want to start a nursery of their own.

This chapter will present the basic steps needed to establish a small group nursery.

Save the Children has organized small groups of five farmers each to establish nurseries in five Somali villages. Each group began with a nursery of 5,000 seedlings. This was a manageable size and provided enough seedlings for each farmer to use on his own farm and to sell or give away. The size of a nursery should be adjusted to the size and needs of the group and the availability of water, labor and other resources. For example, our groups needed to bring two barrels of water per day to the nursery by donkey cart.

The following chapter outlines methods for establishing a community nursery. It is organized into four sections:

- Site Selection
- Equipment Needed
- Layout
- Operations and Maintenance

Site Selection

There are six factors to consider when choosing a site for a community nursery: land, water, soil, access, shade and fencing.

Land

For a nursery of 5,000 seedlings, an area of approximately 15m × 15m is needed. The site should not be dramatically sloped. A gentle slope however, will facilitate drainage of excess water.

Water

Water availability is crucial. Since full-grown seedlings should be ready by the start of the rainy season, the

seedlings must be watered during the dry season. The daily water requirements may be as high as 30 liters per thousand seedlings. The problem of water availability should be thoroughly discussed and analyzed with the nursery group. If the nursery cannot be located next to a permanent water source then a means of transporting water must be devised.

In order to meet one group nursery's water needs, Save the Children loaned the group money to purchase a donkey and donkey cart. The loan was paid back within six months. The group was able to transport water for their nursery as well as for their personal use.

Soil

Since it is difficult to transport large quantities of soil long distances, it is best to locate the nursery in an area that already has suitable soil.

Access

It is important that the nursery be accessible to the workers maintaining it and to the people who will eventually plant the seedlings. An ideal location is close to a group member's home and near a good road or path.

Shade

When seedlings are very young, they should be in full shade. Either shade trees or shading structures can be used for this purpose.

Fencing

The nursery site must be protected from grazing animals. If a fence is built of dry woody materials, a living fence can be planted to replace the dead fence as it decomposes. (see Live Fencing)

Equipment Needed

Polyurethane Plastic Bags

We commonly use black bags 10cm × 25cm in size when laid flat.

Seedlings can also be grown in fine soil (usually sand) without containers but management is more difficult and the seedling survival rate is generally low.

Digging Tools

Soil will have to be dug both to fill bags and to level the land where seedlings are kept. Shovels or other local tools can be used.

Screen

The soil for the seedling bags will have to be sifted in order to break up large clods and remove stones. We recommend a wire mesh of 1cm × 1cm.

Water Apparatus

Either watering cans with a nozzle to create a spray or a water container and a short broom can be used. In the latter case, the water is poured through the broom to create a soft sprinkle. The water can also be poured through baskets.

Poles and Wires

These are needed to construct a shading structure for seedlings.

Transportation

A donkey cart, wheelbarrow, or other instrument will be needed to transport soil, water and seedlings.

Water Cistern

The co-op members may want to store water on site in a barrel, cistern or other container.

Layout

Work Area

It is a good idea to choose a shady spot for the place where the nursery group members will be mixing and bagging soil. This area should be close to the nursery beds.

Bed

The bagged soil can be placed in rectangular beds approximately 1 meter wide and as long as desired. The bags should be placed in a completely upright position.

The ground under the beds should drain well and should be weeded and leveled by hand before the bags are placed. After the bags are in position, dirt can be push-

ed up around the perimeter of the beds to keep them in an upright position and to conserve moisture.

Paths

The paths or rows between the beds should be wide enough for people to walk through comfortably.

Shade

If nearby trees do not provide adequate shade, a shading structure will have to be constructed to protect seedlings during initial stages of growth. This can be made with sturdy poles and strong wire. The structure should reach approximately 50cm above the top of the seedling bags. The poles should be placed at each corner of the bed at 1 to 2 meter intervals and should be buried deeply for strong support. Wire can then be run around the perimeter of the poles to support the shading materials such as corn stalks, palm leaves, grass, etc. You may want to use shade nets if your project is able to afford them and has access to them.

Cistern

A central location which minimizes the carrying of water is best if the group decides that they need a cistern. Oil drums are commonly used for this purpose. If you decide to build a cistern, take into consideration any possible future expansion of the nursery and how/if the cistern will be used for the expansion. We strongly recommend that you do not spend a lot of time or capital building a large, permanent cistern until the nursery group has been in operation for at least one year. It would be better to wait until the nursery group has indicated that it will be sustainable.

Operation and Maintenance

This section will consider the following aspects of operating and maintaining a nursery.

- *Timing*
- *Mixing soil and filling bags*
- *Seed gathering*
- *Seed pre-treatment*
- *Sowing*
- *Shading and watering*

- *Weeding*
- *Root pruning*

Timing

It may take as long as 7 months to produce certain varieties of seedlings. Therefore, the nursery should be started well in advance of planting time. The nurseries which we helped to establish were started 7 months before the planting season.

If a nursery is not started far enough in advance of the rainy season, the nursery group should be encouraged to sow only the faster-growing species such as papaya, mango, leucaena and cassia, which only take 3-4½ months to develop.

It is also important to remember that fast growing species should not be sown too early, or the seedlings will become too big by planting time. Refer to Appendix 4 for species-specific information on timing.

Mixing Soil and Filling Bags

As mentioned earlier in the section on nursery site selection, the ideal soil for a nursery is a light sandy loam. In Qorioley, Somalia, the soil tended to be a heavy clay, so our nursery members used a mixture of 3 parts soil, 2 parts river sand and 1 part composted (old) manure. This made a fertile soil which held water but drained well.

Before using, the soil must be sifted through a 1cm × 1cm mesh screen. This should be done while the soil is dry to remove stones, dirt clods, and large pieces of plant material. The soil can then be mixed and the bags filled to within 2cm of the top. Filled bags are then moved to the seedling beds.

Seed Gathering

Our village nurseries were started with seeds donated by a government nursery. However, for the nurseries to be self-sustaining, it was important that the members learn when and how to collect their own seeds.

Seeds should be collected from healthy, good looking trees. Seed, fruit, cones or pods should always be collected after they are fully ripe. Seeds should be sun-dried if necessary and stored in a cool, dry, pest-free place. Seeds that are not stored under these conditions are less likely to germinate once planted.

Fruit seeds should be taken from the largest, best fruit available. Care should be taken when collecting citrus species as many citrus trees have been grafted and will not breed true.

Seed Pre-Treatment

If the seed coat is soft (ex. citrus or papaya seeds), there is no need to pre-treat the seeds before planting. If the seed coat is hard (ex. leucaena or acacia seed) the seeds can be easily treated with boiling water to increase germination rate. Refer to Appendix 4 for pre-treatment requirements for selected species.

Seeds can often be pre-treated by the simple method described here:

On the day before sowing, bring a pot of water to a boil. Put the seeds into the boiling water and immediately remove the pot from the fire. Let the seeds soak in this water overnight. The water will have started the germination process, so seeds must be planted soon afterwards. It is important not to let the seeds soak for too long or dry out after they have been treated. The former will cause seeds to rot; the latter will prevent germination.

Sowing

After the bags are filled with soil, 2-3 holes can be made in the soil surface. A seed should be placed flat in each hole and then covered. If more than one seed germinates, the extra seedlings should be thinned out. For large seeds such as mango, it is best to use one seed per bag. Care should be taken not to plant the seeds too deep or too near the soil surface as this will affect the germination rate. One basic rule of thumb is to plant seeds at a depth of 2-3 times their width. For example, if a seed is approximately 1cm wide, it should be planted 2 to 3cm deep.

Shading and Watering

There are two methods for shading young seedlings:

a) Shade trees: The seedling beds can be placed under the deep shade of a large tree. The seedlings should be watered morning and evening so that the soil stays moist but is not waterlogged. Water should not be applied during mid-day as sunlight reflecting off water droplets may burn the seedling leaves.

After the seedlings are approximately 5cm high, they should be moved to an area of light shade. In another 2 weeks, the seedlings should be moved to full sunshine. A few weeks before planting time, watering should be reduced to one time per day.

This process of reducing shade and water is called "hardening off." It is a process which encourages the quickest growth of a seedling yet also prepares it for the harsh conditions of the field.

b) Shading structures. If there are no shade trees at the nursery site, a shading structure can be built (see section on nursery "layout"). When the seedlings are approximately 5cm high, the shading material should be removed during the morning and evenings and used only to protect seedlings from the hottest mid-day sun. During the last few weeks, the structure should be removed completely and the watering reduced to finish the hardening off process.

Weeding

If weeds are observed in the bags, they should be gently pulled out. Weeding should be done when weeds are small and the soil is moist so that the seedlings' roots are disturbed as little as possible.

Root Pruning

It is important not to let the seedling roots grow through the bags and into the ground. If this is allowed to happen, the seedlings will be stressed because their roots will break when they are removed from the nursery for planting.

The best way to avoid this problem is to simply lift the seedlings and move them a few centimeters, at regular intervals (about once every two months). This task should be started when seedlings are approximately 5cm tall or when it is noticed that roots are growing through the bottoms of the bags. Any roots that do grow through the bag should be cut. The seedlings are ready for transplanting when they are the same height as the bag (approximately 25cm).

John Nittler

SIX

How to Plant a Tree

One of the easiest and most enjoyable aspects of training farmers in agroforestry is teaching them how to plant a tree. Save the Children's forestry and agricultural extensionists have taught many farmers and hundreds of children to plant trees using the following method:

Step 1: Digging The Pit

We recommend digging a pit that is about 30 to 40cm deep and 20cm in diameter. It is important that the pit be large enough for the seedling bag and for a few inches of loose soil around the seedling. The loose soil will facilitate root growth.

Most of the people we work with do not know the meaning of "30cm" or "20cm" so, instead of using these measurements we tell adults to dig the hole until it can hide at least half of an outstretched forearm. Young children are told that they should be able to hide *all* of the forearm. The hole should be at least as wide as 1½ extended hands.

Pits can be dug using one of the following tools:

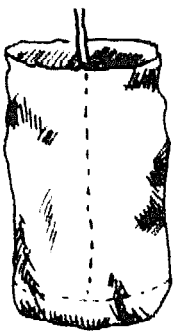
- shovel
- rebar (an iron bar approximately 1.5m long with a sharpened end)
- hoe

Fill the pit with water and let it soak into the soil. After the tree is planted, give the seedling another three liters of water.

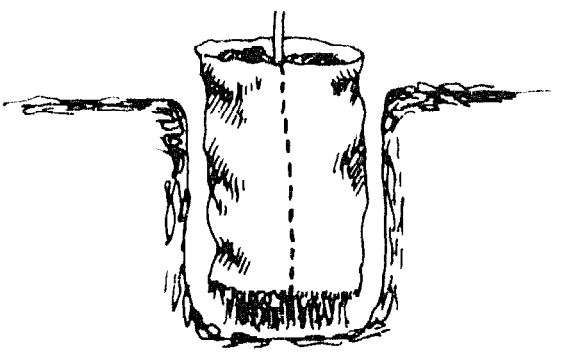
Step 2: Removing the Seedling Bag

Ideally the seedling bag should be removed with a razor blade in the following manner:

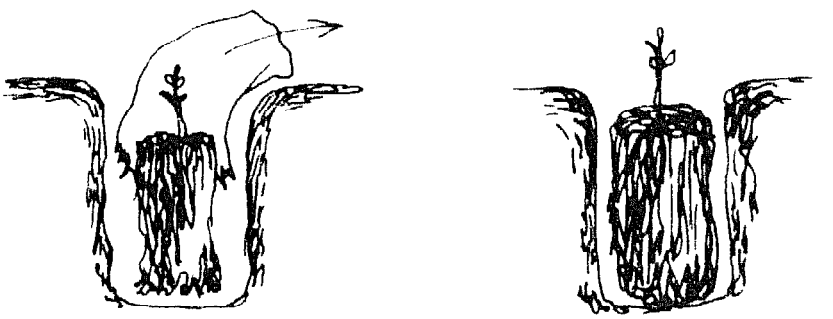
Make one slit along the entire length of the bag and another slit around the bottom.



Remove the bottom part of the bag and gently place the seedling in the hole.



Carefully remove the remainder of the bag.



Step 3: Filling in the Pit

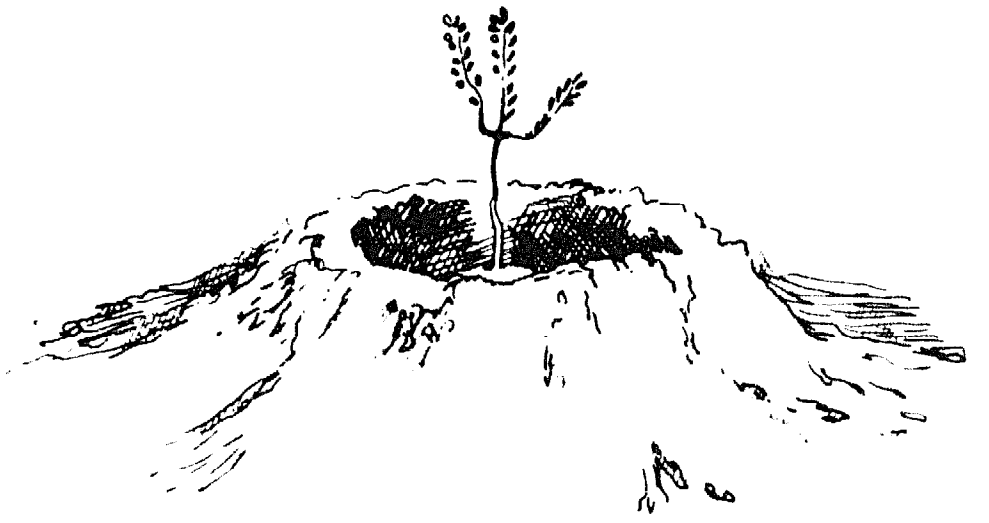
Hold the seedling gently so that the roots dangle and the "root collar" (i.e. the section where the stem and root meet) is at ground level. Care must be taken to make sure that once the hole is filled in and the tree watered, the top roots remain covered with soil. It is also important not to put the seedling too deeply into the pit or part of the stem will be covered. Burying the stem can make seedlings vulnerable to disease.

Push the soil back into the pit around the seedling and step firmly but gently upon the soil to compact it. Failure to compact the soil properly may later cause holes to form in the pit.

Step 4: Making a Water Catchment

Making a water catchment in arid and semi-arid areas is advisable so that rainwater can be held longer and conserved. This is done by forming a ridge of soil around the seedling.

The size of the catchment can vary depending upon rainfall and soil type. In areas where the soil has a high clay content and slow drainage, it is advisable to make small catchments.



Step 5: Watering the Seedling

If the soil is dry, water the seedling with about 5 liters of water. We normally wait until the rainy season has started before we plant any seedlings so that this supplementary watering is not necessary.

Appendix 1: Introductory Agroforestry Meetings

As described in Chapter Two, "Making Contact," this appendix contains two outlines for introductory meetings on agroforestry. The main purpose of these meetings is to encourage community members to identify ways in which agroforestry can address community needs. Additional benefits include: 1) introduction of the project to the community, 2) increased awareness by the community of the potential benefits of agroforestry, and 3) preliminary identification of potential participants in the agroforestry project.

The design of each training session is influenced by our experience in Somalia and by ideas gathered during a tour of agroforestry projects in Kenya. The designs may require some modification for use in other countries or by other organizations.

Meeting 1

Purpose: Agroforestry Solutions to Community Problems

We suggest that the first meeting organized by an extensionist focus upon the ways in which agroforestry can address the needs of the community. It is recommended that a leading public figure, such as a village chairman, preside over the meeting. This person can start the meeting by introducing the extensionist who will lead the meeting and by briefly describing the purpose of the meeting. The extensionist can then present the agenda.

Introduction (5 - 10 min)

- Introduction of any other extensionists participating in the meeting
- Presentation of project's activities and goals
- Review of topics to be covered
- Time frame

Problem Identification (20 min)

The purpose of this exercise is to allow farmers to identify any major needs they have or problems that they face. The extensionist should start off the discussion with a general question such as, "What do you see as the greatest needs of people in this village?" If the group is having difficulties in expressing their opinions, they may have to be prompted with more specific questions, such as, "How are your crop yields?" or, "How do they compare with yields of 10 years ago?"

We suggest that the extensionist emphasize each need as it is identified by drawing a symbol on a flip chart or, if the audience is literate, by writing a list. As a survey will have been previously carried out in the community, the extensionist may already know what to expect. Possible needs include:

- Money
- Better nutrition
- More farm land
- Higher crop yields

Identification of Agroforestry Solutions (30 min)

The purpose of this exercise is to suggest ways in which agroforestry can help farmers to address their needs. Obviously, agroforestry alone cannot satisfy all of the needs that farmers will voice, but it can address some of them.

We suggest that the extensionist begin the exercise by asking the farmers if they think that planting trees on their farms can help to satisfy some of their needs.

The extensionist can list or draw symbols of their answers. Following this, he can add to the farmers' list with his own suggestions. Possible suggestions include:

Need	Suggestion
Money	Growing trees to sell as poles or firewood.
	Growing fruit for sale.
Better Nutrition	Growing fruit trees to increase vitamin intake (we cannot say that eating fruit satisfies all nutritional needs, but it can help).
Higher Crop Yields/ More Crop Land	Planting nitrogen-fixing trees can increase soil productivity and thus produce a higher crop yield. Plus, harvest of fodder or wood can increase the overall farm production.

Questions/Answers (10 - 20 minutes)

Once the extensionist has finished presenting the above information, time should be allowed for questions.

Summary/Conclusions (15 minutes)

At the end of the meeting, the extensionist can briefly summarize the major points and ask the farmers if they are interested in learning more about agroforestry. For those interested, Meeting 2 can be scheduled.

Tree Planting Demonstration

We encourage you to include a tree-planting demonstration at the end of this first meeting. Your audience is

more likely to be enthused and supportive of tree planting if they are able to participate from the very beginning. Please refer to Chapter 6 on "How to Plant a Tree."

Meeting 2

Purpose: Tree Uses; Problems and Solutions

The suggested group size is 3 to 25. If the group is expected to be much larger, it may be necessary to make modifications on this meeting.

Introduction (5 - 10 minutes)

- Introduction of extensionists
- Purpose of meeting
- Review of topics to be covered
- Time frame

Exercise 1: Identification of Tree Uses (10 - 15 min)

Pose this question to the group: "How do you use trees in your life?" We have found that farmers are usually quite willing to speak up and answer questions. After each farmer has spoken, the extensionist should try to pull out *key ideas* in order to make them clear to the group.

For example: A farmer may answer by saying, "I have a guava tree in my backyard from which I sell the large fruit, and my family eats the bruised and smaller fruit."

The extensionist could note the key ideas of:

- Income generation
- Family food

These key ideas should be repeated or re-emphasized as the other farmers continue to answer the question and more key ideas are brought forth. These key ideas can be emphasized verbally or, for fun, you may want to try pictures. If the group members know how to read, the key ideas can be listed on a flip chart.

Some key ideas to anticipate are:

- Fuelwood/charcoal
- Construction
- Shade

- Income generation
- Family food/nutrition
- Erosion control
- Soil fertility
- Wood products
- Beekeeping
- Wind protection
- Fodder
- Fencing
- Medicinal uses

Farmers may not come up with all of these ideas or they may have others. Encourage all responses within the time allowed.

Exercise 2: Problem/Need Identification

This exercise is done through a series of open-ended questions* to determine if the community is experiencing tree-related problems and what they might be.

An open-ended question is one that requires an explanation, that cannot be answered by yes or no. It is designed to encourage training participants to better express their own opinions.

Divide the farmers into small groups of 3-5, depending upon the number of participants. Give each group the following two tasks.

Task #1 (15 - 20 min)

Have the small groups discuss among themselves the question, "What do you see as tree-related needs and problems of families in this village." The extensionist should be observing the groups and if necessary, prompting discussion if a group is having considerable difficulty.

Task #2 (10 - 15 min)

Each group should present their findings.

At this point the extensionist will listen to the needs stated by the farmers and determine if these needs are adequately met. If not, the extensionist should identify

the key problems (i.e. those which are repeated) and summarize them for the group.

These are examples of some of the problems identified by farmers.

Need	Problem
Fuelwood	Shortages, time consuming to collect, expensive, poor quality, hard to transport
Construction materials	Expensive, poor quality, hard to transport
Fruit trees	Shortages, cannot get seedlings, fruit is expensive

Exercise 3: Identifying Solutions (5 min)

Bring the participants back to a large group and pose the question, "What do you propose from your experience as a solution to these problems?"

The extensionist should highlight any agroforestry solutions given by the farmers.

Short Presentation on Agroforestry Techniques (15 - 20 minutes)

Suggested topics to be covered (see Chapter 4):

- Boundary planting
- Live fencing
- Windbreaks
- Alley/intercropping
- Woodlots
- Fruit orchards
- Amenity plantings (e.g. for shade or beautification)

During these explanations, show diagrams and pictures or use examples of farms with which farmers may be familiar.

Discussion of Agroforestry Solutions (20 minutes)

The extensionist should now ask if the group has any questions or comments about the agroforestry techniques

just described. Farmers should be encouraged to voice any doubts or discuss any disadvantages.

For example, in one of our meetings, a farmer stated: "I know that fuelwood is a real problem for me, but my farm is too small for planting trees." Our response was, "We recognize this to be a problem, but you may want to try planting a fast-growing species such as leucaena on a boundary of your farm. We know a farmer who planted this tree and in two years had poles to sell , which everyone here knows brings in good money. If you like, we can take you to see this farmer." (After we took a group on this farm visit, one man was so impressed that he planted a leucaena woodlot on a section of his land).

Conclusion (5 minutes)

The extensionist should briefly summarize the meeting. Following this summary he/she can ask how many people are interested in knowing more about agroforestry. Depending on the response, the extensionist can decide to either hold another large meeting, set up individual appointments, or arrange for farm visits.

Suggestion for following meetings:

a) Describe government seedling distribution services.
b) Tree planting demonstrations.
c) Farm visits, survey and analysis of possible agroforestry sites (see Chapter 4).
d) Describe how to set up a nursery (see Chapter 5).

Appendix 2: Planting Information for Selected Species

In order to assist you to determine what tree species may be most appropriate for your agroforestry needs, we are providing the attached table "Planting Information for Selected Species." The information was compiled by Dague Clark, who works with Save the Children in Sudan. As you will note, the tree species listed here are all suitable for low rainfall areas.

Of course, nothing is better than first-hand experience. One excellent way to identify tree species suitable for your area is to visit other sites where trees have been planted, talk to people who can tell you about the establishment of these trees, and see for yourself what works and what does not!

Appendix 2: Planting Information on Selected Species (1)

Species (2)	Rainfall (3)	Direct Seeding	Soil Type	Comments and Uses
Acacia sieberiana	(150) 400-800 mm. (1,200)		Alkaline, low-lying, heavy to sandy. Can stand periodic flooding. Grows well in shallow soils.	Fuel fodder, construction, gum, tannin, medicines, windbreaks and soil improvement
Adansonia digitata **(Baobab)**	250-1,000 mm. (1,500)		Most soils	Fruits, edible leaves, fodder, soil improvement, dye, and medicines
Albiza lebbeck **(Lebbek)**	500-2,500 mm.	Yes	Various but prefers moist sand. Grows in laterite. Needs a high water table. Supports up to 0.11% salt and pH of 8.7	Fuel, construction, tannin, fodder, medicine, soil improvement or protection, shade and ornamental. Wood is very susceptible to insect attack.
Anacardium occidentale **(Cashew Nut)**	100-2,000 mm. (optimum: rainy season of 4 to 7 months)	Yes Plant seeds with the convex side up. Cover with 3 cm of soil.	Various, but roots should be able to reach water table	Valuable fruit and nut. Seeds remain viable for at least two years if they remain dry. Very susceptible to fire. Rodents love the seeds. Weeding is important. Fuel, fodder, medicine, soil improvement and tannin
Anogeissus leiocarpus, A. schimperi or Conocarpus leiocarpus	(250) 400-1,200 mm.	No	Low lying, can stand flooding and needs a high water table	Slow growth usually discourages artificial propagation. Fuel, construction, fodder, medicine, dye and tannin

Appendix 2: Planting Information on Selected Species (1)

Species (2)	Rainfall (3)	Direct Seeding	Soil Type	Comments and Uses
Acacia albida or Faidherbia albida **(Apple Ring Acacia)**	(100) 350-800 mm. Water table should be within 15 m.	Possibly	Sandy "millet" soils. Can support flooding for short periods	Very useful for agroforestry: soil improvement, fodder, fuel, medicines and construction
Acacia caffera or campylacantha	Needs a high water table	Yes	Fertile	Fuel, gum, tannin, medicine and fodder
Acacia mellifera	(75) 400-750 mm.	Yes	Clay/heavy but adaptable-alkaline	Fuel, fodder, medicines and soil protection. Tolerates floods.
Acacia scorpiodes or nilotica **(Egyptian thorn)**	(100) 250-1000 mm.	Yes 1,000 mm. Plant where the water table is near to the surface	Clay/heavy. Can withstand flooding	Forage, fuel, tannin, medicines, soil protection and thorn fences
Acacia raddiana or tortillis **(Umbrella thorn)**	50-1,000 mm.	Yes Very drought-resistant	Sandy-gravel	Can stand flooding. Thorn fences and soil improvement
Acacia senegal	(100) 300-400 mm.	Yes	Sandy, well-drained	Very useful, particularly for the gum. Fuel, fodder, medicines and soil improvement
Acacia seyal	(100) 250-1,000 mm.		Most soils. Low lying, heavy. Can withstand flooding. Rich in humus or stony.	Wood is very resistant to insects. Fodder, medicines, soil improvement, construction, fuel and gum

(1) The information included in this table was compiled by Dague Clark, now working in Save the Children's Sudan Field Office. References are included at the end of the table.

(2) Common English names are in parenthesis.

(3) Numbers in parenthesis show minimum or maximum rainfall where species have been seen.

Appendix 2: Planting Information on Selected Species [1] (continued)

Species (2)	Rainfall (3)	Direct Seeding	Soil Type	Comments and Uses
Azadirachta indica **(Neem)**	150-1,500 mm. (Optimum: 450-750 mm.). Very drought resistant	Yes	Various	Seed viability drops to near zero within a few weeks. Fuel, construction, medicine, shade and windbreaks. Insect repellent and toothpaste made from extracts.
Balanites aegyptiaca **(Desert Date)**	100-1,000 mm	Yes	Sandy but adaptable Very drought resistant	Fuel, construction, fruit, fodder, medicine, soil improvement and the seeds yield oil Natural molluscicide (i.e. kills mollusks)
Bauhinia reticulata		Possible	Wide variety	Usually poor germination Fuel, fodder, construction, medicines, soil improvement and tannin
Borassus aethiopum **(African Fan Palm)**	500-4,200 mm.	Yes	Low lying: needs a high water table	Fuel, construction, fruit, fodder and medicines
Butyrospermum parkii or Butyrospermum paradoxum	750-1,250 mm.	Yes	Moist Medium Heavy. Sandy, laterite or rocky, rich in humus	Plant the seed with the white point down. Susceptible to fire. Fuel, construction, fruits, nuts make shea butter, fodder and medicine

Appendix 2: Planting Information on Selected Species [1] (continued)

Species (2)	Rainfall (3)	Direct Seeding	Soil Type	Comments and Uses
Carica papaya (Papaya)	Will probably have to be watered, therefore it is good to plant the trees near to the house or in a vegetable garden	Yes	Various as long as it is well drained. Very acidic soils are unsuitable; ideally the pH of 6.0 to 6.5	Need both "male" and "female" trees to produce fruit. Viability of the seeds drops rapidly with age. Not very wind tolerant. Very fast-growing but short-lived. Start bearing fruit at 9 to 14 months and a tree can produce up to 150 fruits. Fruits and enzyme papain from unripe fruit.
Cassia siamea (Yellow Cassia)	700-1,500 mm	Yes	Deep and moist. Reported to grow poorly in areas with Imperata cylindrica grass.	Susceptible to fire in early stages of growth. Fuel, construction, wind-breaks, live fence, fodder, medicine, soil improvement, and shade
Casuarina equisetifolia (Whistling Pine)	(200) 700-2,000 mm.	No	Deep sands to clay with a high water table. Tolerates calcareous and slightly saline soils.	Monoecious. Seeds remain viable for a few years if kept dry and cool. Very susceptible to fire. Fuel, construction, medicine, soil protection, wind-breaks, tannin, honey and dune stabilization
Ceiba pentandra	Moist areas	No		Source of kapok fiber, shade and ornamental

Appendix 2: Planting Information on Selected Species (1) (continued)

Species (2)	Rainfall (3)	Direct Seeding	Soil Type	Comments and Uses
Combretum glutinosum	300-900 mm.	Yes	Sandy, gravel to laterite	Fuel, construction, medicine, soil protection and tannin
Combretum micranthum	250-1,200 mm.	Yes	Gravel	Usually poor germination in the nursery. Fuel, construction and medicine
Commiphora africana	(100) 250-700 mm. Very drought resistant	Yes	Many soils but prefers fine-sandy	Very good for live fencing, construction, fodder and medicine
Conocarpus lancifolius (Damas)	50-400 mm.	Yes	Adaptable, but needs deep soils	Construction
Dalbergia sissoo	500-2,000 mm.	Yes		Fodder and construction
Eucalyptus camaldulensis (Red River Gum)	700-1,200 mm.	No	Heavy but adaptable. Supports short periods of inundation	Transplant into pots when the plants have four to five leaves. Fuel, construction, medicine, tannin and wind-breaks
Euphorbia balasamifera	150-500 mm.	N/A	Sandy or rock, but adaptable	Very good live fence. Plant 50 cm. long; cuttings 20 cm. deep during the dry season (April-June). The sap is caustic to skin. Medicine and protection.
Ficus gnaphalocarpa	200-2,000	N/A	Sandy-rich	Fruit, fodder, medicine and shade
Ficus irgens	150-800 mm.	N/A	Rocky	Fruit, medicines, fodder and shade

Appendix 2: Planting Information on Selected Species (1) (continued)

Species (2)	Rainfall (3)	Direct Seeding	Soil Type	Comments and Uses
Ficus platyphylla	Medium to high with a high water table		Low areas but also sandy to laterite	Fruit, medicines, gum, tannin, dye, fiber and shade
Gmelina arborea	750-4,500 mm. (Does not stand inundations)	Yes	Good/well drained. Adaptable, acidic, calcareous loams and laterite	Wood used to make matches. Honey, fuel and timber
Grewia bicolor	400-900 mm. (supports inundations)	Possible	Sandy to gravel	Soap, fruit, construction, fodder, fiber and medicines
Guiera senegalensis	400-800 mm.	Yes	Sandy	Forage, fuel, soil improvement, construction and medicines
Hyphaene thebaica	(100) 200-600 mm.	Yes	Sandy to gravel with a high water table	Very resistant to fire. Medicines, fiber, construction, fodder and fruits
Khaya senegalensis	(400) 500-1,000 mm.	No	Deep with laterite during 4 to 7 months. Does not tolerate stagnant water	Good source of wood for mortars and boats. Fuel, fodder, medicines, soil protection and improvement, windbreaks, and shade
Lannea microcarpa	700-1,000 mm.		Deep sand to gravel	Fuel, construction, fruits, fodder and medicines
Leptadenia pyrotechnica	100-400 mm.		Sandy-deep	Forage, dune stabilization and medicines

Appendix 2: Planting Information on Selected Species (1) (continued)

Species (2)	Rainfall (3)	Direct Seeding	Soil Type	Comments and Uses
Leucaena leucocephala **(Leucaena)**	400-3,000 mm.	Possible	Various, prefers alkaline but grows in acidic deep soils. Grows best at pH 6.0-7.7.	Not tolerant of weeds in early growth. Agroforestry, fuel, fodder, construction, medicines, soil protection and improvement, shade, wind-breaks and live fences
Mangifera indica **(Mango)**	300 mm.	Possible (should be irrigated for the first year) can not support stagnant water or long periods of flooding	Grows well in deep soils, without a hard pan	Fruit, fuel construction, shade, fodder, medicine, dye and wind-breaks
Moringa oleifera	300 mm.	Yes	Well drained	Medicines, fuel, construction, fodder, fiber, gum and leaves used in sauces
Parkia biglobosa	500-700 mm.	Yes	Deep gravel to sand	Fruits used in sauces, construction, fuel, medicine, tannin, dyes and soil improvement
Parkinsonia aculeata **(Jerusalem thorn)**	(200) 350 mm.	Yes	Sand. Can stand some salt but not waterlogging	Excellent live fence. Used to regenerate soils, fuel, fodder, ornamental wind-breaks and medicines
Phoenix dactylifera **(Date Palm)**	50-300 mm.	Possible Very drought-resistant	Sandy, but needs a high water table	Plants have 6 meter roots. Dioecious. Fruits, fuel, construction, ornamental and fiber
Prosopis african	200-400 mm.	Yes	Sandy-clay to laterite	Forage, food, fuel, construction, tannin and medicine

Appendix 2: Planting Information on Selected Species (1) (continued)

Species (2)	Rainfall (3)	Direct Seeding	Soil Type	Comments and Uses
Prosopis juliflora **(Mesquite)**	150-700 mm. Very drought resistant	Yes	Sandy-rock, well drained	Can plant stumps. Forage, fuel, construction, live fence, food, shade, soil protection and improvement, medicines, windbreaks and dune stabilization
Psidium guajava **(Guava)**	Can withstand temporary inundations	Yes	Adaptable but does best in deep fertile soils	Fruits very rich in vitamin C. Seeds remain viable for about one year
Sclerocarya birrea, Spondia birrea, or Pourpartia birrea	200-700 mm. (1,100)	Yes	Sandy valleys to gravel	Fruit, fuel, construction, fodder and medicines
Tamarindus indica **(Tamarind)**	400-1,500 mm.	Possible	Various	Fruit, fuel, construction, shade, fodder (except sheep), medicines, windbreaks (very wind resistant) soil protection, dye, tannin and ornamental
Ximenia americana	500 mm.	Yes	Clay-gravel	Fruits, fuel, construction, medicines, tannin and live fences
Ziziphus mauritiana **(Indian Jujube)** **(Indian Plum)**	150-500 mm. Very drought-resistant	Yes	Sandy but adaptable. Can stand flooding	Fruits, windbreaks, fuel, construction, fodder medicines, soil protection, tannin, and live fences
Ziziphus spina-christi **(Christ Thorn)**	150-600 mm. Can withstand flooding	Yes	Low lying, with deep soils but extends into dry desert areas	Fruits, fuel, construction, soil protection, dune stabilization, windbreaks, forage and medicines

Appendix 3: Additional Readings

As international interest in agroforestry increases, so does the availability of technical materials. We provide here references to a few of what we found to be the most useful publications:

Agroforestry

East-West Center, Napoleon Vergera (Ed). *New Directions in Agroforestry: The Potential of Tropical Legume Trees*, 1982.

Economic Evaluation of Agroforestry Projects

Initial Tasks in Agroforestry Projects

Selection of Legume Trees for Agroforestry

Sustained Outputs from Legume-Tree-Based Agroforestry Systems.

Fillion, Jacob, and Weeks, Julius. *Agroforestry in-Service Training, A Training Aid for Asia and the Pacific Islands*. Peace Corps, 1984. This document presents the proceedings of a training workshop on agroforestry. This workshop could easily be adapted for use in other regions of the world.

Peace Corps, Buck, Louise (Ed.). *Kenya National Seminar on Agroforestry*, 1981.

Weber, Fred, and Hoskins, Marilyn. *Agroforestry in the Sahel, A Concept Paper Based on the Niamey Agroforestry Seminar*. Virginia Polytechnic Institute, 1983.

In addition to the above references, you may also be interested in CARE's upcoming publication titled "Agroforestry Extension: The Training Sourcebook," which will be published in three volumes. Intended as a tool for project managers and their designated trainers, it provides specific guidelines for formulating and implementing extension staff training curricula for agroforestry or related natural resource projects. The first volume contains 11 training modules. The remaining two volumes contain technical support materials.

Forestry

Folliott, Peter F. and Thames, John L. *Environmentally Sound Small-Scale Forestry Projects, Guidelines for Planning*. Arlington, Virginia; Coordination in Development/Volunteers in Technical Assistance, 1983.

National Academy of Science, *Firewood crops: Shrubs and Tree Species for Energy Production, Vol. 1.* Washington, D.C.; National Academy Press, 1980.

National Academy of Science, *Firewood Crops: Shrub and Tree Species for Energy Production, Vol. 2.* Washington, D.C.; National Academy Press, 1983.

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

Weber, Fred R., with Stoney, Carol. *Reforestation in Arid Lands*. Arlington, Virginia; Volunteers in Technical Assistance, 1986. We highly recommend this book. It is a very useful, comprehensive publication dealing with the design and implementation of forestry projects in arid lands. It includes one chapter specifically devoted to agroforestry. Information presented in the other chapters would also be very helpful in planning for an agroforestry project.

Agriculture

Action Peace Corps, *Soils, Crops & Fertilizer Use*, Program and Training Journal Reprint Series #8.

Peace Corps, Gibbon, Michael and Schroeder, Richard. *Agricultural Extension*. Peace Corps Information Collection & Exchange, 1983.

Benor, Daniel, *Agricultural Extension: the Training and Visit System*. Washington, D.C.; World Bank, 1984.

Halpin, Anna, *Guide to Vegetables and Fruits*, Emmaus, Pennsylvania; Rodale Press, 1982.

Stroskopf, Neal, *Cereal Grain Crops*. Reston, Virginia; Reston Publishing Company, 1985.

Yepsen, Roger B., *The Encyclopedia of Natural Insects and Disease Control*. Emmaus, Pennsylvania; Rodale Press, 1984.

Appendix 4: Summary of Nursery Management Information for Selected Species [1]

Species (2)	Seed Maturity Date	Number of seeds per kg.	Pre-Treatment (3)	Propagation Method	Length of Time in the Nursery
Acacia albida or Faidherbia albida (Apple Ring Acaria)	Dec-Feb	11,500-19,000	Soak over-night, hot water. Scarify or pass through the gut of an animal	Pots	10-14 weeks
Acacia caffera or campyla-cantha	Jan-Feb	11,000	Soak overnight, hot water.	Pots	12-18 weeks
Acacia mellifera	Dec-Apr		Soak overnight, hot water.	Pots	
Acacia scorpiodes or nilotica (Egyptian Thorn)	Nov-Apr	4,000-7,000	Soak overnight, hot water.	Pots	14-18 weeks
Acacia raddiana or tortillis (Umbrella Thorn)		15,000-20,000	Soak overnight, hot water.	Pots	14-18 weeks
Acacia senegal (Gum Arabic)	Nov-Jan	12,000-18,000	None needed	Pots	14-18 weeks
Acacia seyal (Whistling Thorn)	Nov-May	20,000-22,000	None needed	Pots Trunch-eons (large) Cuttings	12-16 weeks
Acacia sieberiana	Nov-Jan	4,500	Soak overnight, hot water.	Pots	18-24 weeks
Adansonia digitata (Baobab)	Dec-Feb	2,000-3,000	Immerse in boiling water, allow to cool and soak for 24 hours	Pots and bare-root	Some seeds take up to a year to germinate

(1) The information included in this table was compiled by Dague Clark, now working in Save the Children's Sudan Field Office. A list of references is provided at the end of Appendix 2.
(2) Common English names are in parenthesis.

Appendix 4: Summary of Nursery Management Information for Selected Species [1] (continued)

Species (2)	Seed Maturity Date	Number of seeds per kg.	Pre-Treatment (3)	Propagation Method	Length of Time in the Nursery
Albizia chevalieri		13,000	Soak overnight, hot water	Pots	10-14 weeks
Albiza lebbeck (Lebbek)	Oct-May	7,700-10,000	Soak overnight, hot water.	Pots and Bare-root	10-14 weeks for pots
Anacardium occidentalis (Cashew Nut)	Feb-Mar	150-200	None needed. (Sun dry fresh seeds at least two days)	Pots	14-18 weeks
Anogeissus leiocarpus. A. schimperi or Conocarpus leiocarpus		140,000-150,000	None needed. Low germination	Bare-root	
Azadirachta indica (Neem)	Dec-Feb	1,800-4,000	None needed	Bare-root But pots also possible	Bare-root at least 8 months; pots 12-18 weeks
Balanites aegyptiaca (Desert Date)	Sept-Dec March-July	500--1,500	Soak overnight, warm water	Pots or bare-root	18-24 weeks
Bauhinia reticulata	Oct-Jan	11,000-14,500	Soak overnight, hot water	Pots	
Borassus aethiopum (African Fan Palm)	Apr-July	Fruits contain 3 seeds			Usually not raised in nurseries
Butyro-spermum parkii or Butyro-spermum paradoxum	April-Sept	150-300	None needed	Pots	14-24 weeks

Appendix 4: Summary of Nursery Management Information for Selected Species [1] (continued)

Species (2)	Seed Maturity Date	Number of seeds per kg.	Pre-Treatment (3)	Propagation Method	Length of Time in the Nursery
Carica papaya (papaya)			None needed but soaking seeds for 24 hours in a dilute solution of cow dung improves germination. Germination, if soaked, 10 days; otherwise about 3 weeks	Pot or bare-root (seeds should be sown about 5 cm. deep)	Three months
Cassia siamea (Yellow Cassia)	Dec-March	35,000-40,000	Sacrify and soak in warm water, cuttings	Bare-root, Pots or	30 weeks to one year for bare-root
Casuarina equisetifolia (Whistling Pine)		760,000 (616,000) — 1,488 million	Place cones in the sun 2-3 days to release seeds. Germination in 2-3 weeks. Should be inoculated with Frankia actinomycete	Pots, vegetative or bare-root transplant when 30-50 cm.)	
Ceiba pentandra	June-July Dec-Jan	17,000-27,000	None needed	Bare-root	
Combretum glutinosum	Oct-Feb	20,000		Pots	20-24 weeks
Combretum micranthum	Nov-Feb	13,500-30,000	None needed		
Commiphora africana	N/A	8,000	N/A	Cuttings	20-24 weeks or plant directly at site
Conocarpus lancifolius (Dama)			None needed	Pots, bare-root or cuttings	20-24 weeks for pots

Appendix 4: Summary of Nursery Management Information for Selected Species [1] (continued)

Species (2)	Seed Maturity Date	Number of seeds per kg.	Pre-Treatment (3)	Propagation Method	Length of Time in the Nursery
Dalbergia sissoo			Soak overnight, warm water	Pots or cuttings	
Eucalyptus camaldulensis **(Red River gum)**	Jan-April	200,000-1,000,000	Use Nobila mthod (4)	Germinator and then pots	18-24 weeks
Euphorbia balasamifera	N/A	N/A	None needed	Cuttings directly at planting site	Plant
Ficus gnaphalocarpa	Dec-March			Cuttings	
Ficus ingens	March-May			Cuttings	
Ficus platyphylla	Oct-Jan Apr-May			Cuttings	
Gmelina arborea **(Gmelina)**	Jan-Apr	700-1,300	Soak in water 48-72 hours (seeds lose viability within a year)	Bare-root or cuttings	10-12 months
Grewia bicolor		15,000			
Guiera senegalensis	Oct-Dec		None needed	Pots or cuttings	12-18 weeks
Hypaene thebaica	Nov-onwards	20-50			Usually not raised in nurseries
Khaya senegalensis	Nov-March	4,500 7,000	Soak overnight, warm water	Pots or bare-root	12-18 weeks for pots up to 3 years for bare-root
Lannea microcarpa	July-Sept Apr-May	5,000			

Appendix 4: Summary of Nursery Management Information for Selected Species [1] (continued)

Species (2)	Seed Maturity Date	Number of seeds per kg.	Pre-Treatment (3)	Propagation Method	Length of Time in the Nursery
Leptadenia pyrotechnica					
Leucaena leucocepha-la **(Leucaena)**	Oct-March	22,000	Soak 2 minutes in water at 80° and 2 days in cold water, treat with Rhizobium. Seeds lose their viability in 4-5 months.	Pots	2 months
Mangifera indica **(Mango)**	Oct-Dec and March-June		Clean the fruit from the seed	Bare root and pots	2-3 months in pots and up to a year for bare root
Moringa oleifera	April-May	4,000		Pots, bare root and cuttings over one meter long	
parkia biglobosa	April-June	5,000	Scarification (5)	Pots	10-14 weeks
parkinsonia aculeata **(Jerusalem Thorn)**	Dec-Jan but the seeds remain on the tree much longer	12,000	Scarification	Bare root or pots	6-10 weeks
Phoenix dactylifera **(date Palm)**	Feb-May			Transplant shoots or seed	
Prosopis african	Feb-Aug	7,500-8,000 mm.	Scarify or boil seeds	Pots	14-18 weeks

(5) Scarification involves scratching or nicking the seed coat. Various methods include: the use of sandpaper; fingernail clippers; immersion in acid for a few second; and shaking seeds in a container with wet sand.

Appendix 4: Summary of Nursery Management Information for Selected Species [1] (continued)

Species (2)	Seed Maturity Date	Number of seeds per kg.	Pre-Treatment (3)	Propagation Method	Length of Time in the Nursery
Prosopis juliflora **(Mesquite)**	Feb-March	8,000-15,000	Scarify or cover with boiling water, allow to cool and cuttings soak for 24 hours	Bare roots, cuttings	12-13 pots or weeks
psidium guajava **(Guaba)**	Ripe fruits		None needed or soak overnight cold water	Pots, bare root possible but it is difficult to transplant. Root cuttings	
Sclerocarya birrea. Spondia birrea. or Pourpartia birrea	Feb-June	400	Soak overnight, warm water (high germination)	Bare root, pots or cuttings	
Tamarindus indica **(Tamarind)**	Nov-Jan	2,000-2,500	Soak 24 hours, hot water	Pots or cuttings	18-24 weeks
ximenia americana	Apr-June	1,400	None needed	Seed or cuttings	
Ziziphus mauritiana **(Indian Jujube) (Indian Plum)**	Nov-Feb	3,600-7,000	Crack seed coats	Pots or cuttings	18-24 weeks
Ziziphus spina-christi **(Christ Thorn)**	Oct-Jan		Crack shells and soak overnight, warm water	Pots or cuttings	18-24 weeks

References

The following references were used in the preparation of Appendixes 2 and 4:

Clark, Dague B. *Fiche Technique d'Amenagement d'une Pepiniere.* Mopti, Republic of Mali; Unpublished document for the Regional Direction of Water and Forests, 1985.

Garner, R.J., Chaudhri, Saeed Ahmed. *The Propagation of Tropical Fruit Trees.* Farnham Royal, Slough, SL2 3BN, England; Commonwealth Agricultural Bureau, 1976.

Ibrahim, Fouad N. *Ecological Imbalance in the Republic of the Sudan - with Reference to Desertification in Darfur.* Germany; Druckhaus Bayreuth Verlasgesellschaft mbH, Bayreuth, F.R. 1984.

Little, Elbert L., Jr. *Common Fuelwood Crops.* Morgentown, West Virginia; Cummuni-Tech Associates, 1979.

von Maydell, H.J. *Arbres et arbustes du Sahel - Leurs caracteristiques et leurs utilisations.* Eschborn/Ts.1, Federal Republic of Germany; Deutsche Gesellschaft fur Technische Zusammanarbeit (GTZ) GmbH, 1983.

Firewood Crops, Shrub and Tree Species for Energy Production. Washington, D.C.; National Academy of Science. 1980.

Firewood Crops, Shrub and Tree Species for Energy Production. Vol 2, Washington, D.C.; National Academy of Science, 1983.

Agroforestry in West African Sahel. Washington, D.C.; National Research Council, National Academy Press, 1983.

Environmental Changes in the West African Sahel. Washington, D.C.; National Research Council, National Academy Press, 1983.

References (continued)

Thitakul, Souane. *Manual of Dendrology.* Quebec, Canada; Groupe Poulin, Theriault LTEE, Consultants, 1984.

Weber, Fred R. *Reforestation in Arid Lands.* Mt. Rainier, Maryland; VITA Publications, Manual Series No. 37 E, Volunteers in Technical Assistance, 1977.

Weber, Fred R. and Hoskins, Marilyn W. *Soil Conservation Technical Sheets.* International Training Division, Office of International Cooperation and Development of the USDA, 1983.