SOURCEBOOK SUPPORT MATERIALS

CARE

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FSP

SOURCEBOOK SUPPORT MATERIALS - MODULE 1

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1.1 BREAKING THE ICE 1

1.1.1 "Breaking the Ice" 1

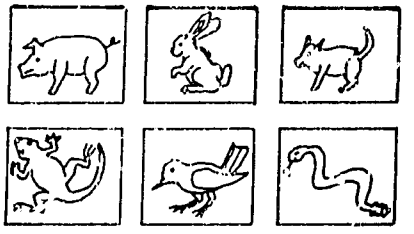
'BREAKING THE ICE'—methods to help a new group meet each other, relax, and start talking

When a group comes together for the first time, some people may already know each other, but many may not. Often those who are already friends will sit and talk with each other, but feel uncomfortable about speaking with those they do not yet know.

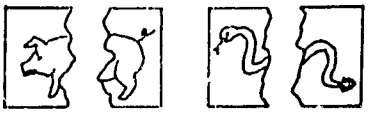
Various games or 'tricks' can be used to help people get to know one another and feel comfortable about taking part in a meeting or a class:

1. PAIRING OFF FOR INTRODUCTIONS

Draw hearts, animals, or other figures on slips of paper. (Draw one figure for every 2 people.)

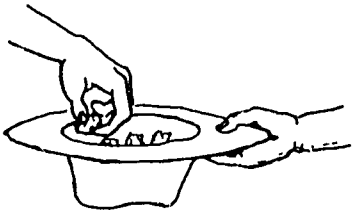


Tear each slip in two.

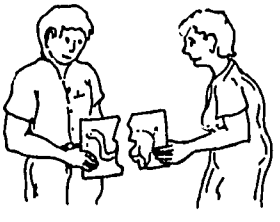


Crumple the pieces into balls.

Put them into a hat and let each person pick one.

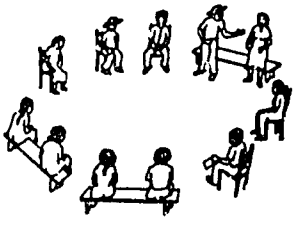


Now each person tries to find his 'other half'.



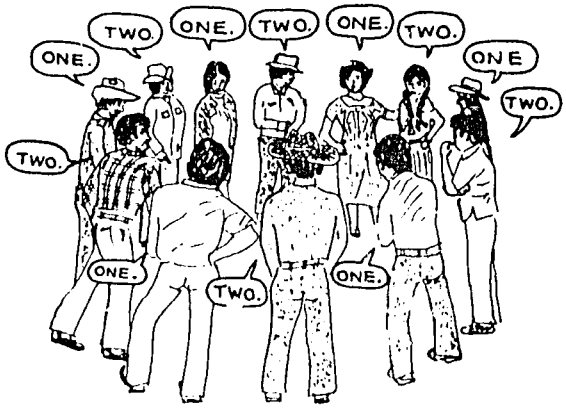
Each pair of people with matching halves spends 10 or 15 minutes getting to know each other.

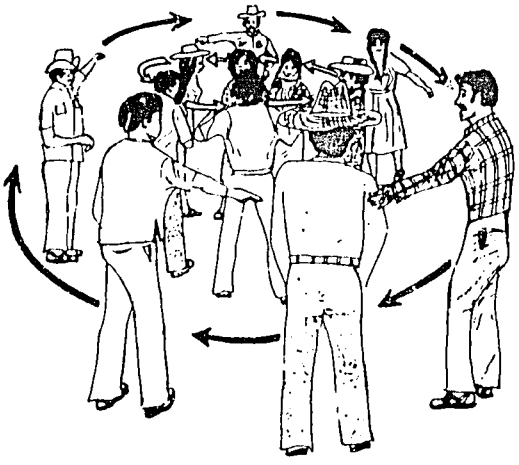
At last the group meets again, and everyone takes turns introducing his partner to the group.



2. MERRY-GO-ROUND OR 'TRAINS'

The group divides into two halves by counting off—ONE, TWO, ONE, TWO—around the circle.





Then all the ONE's form a circle, and all the TWO's form another circle around them.

When the leader says "GO," circle ONE runs in one direction and circle TWO runs in the other—whistling and puffing like trains.

When the leader shouts "STOP," each person turns to the nearest person in the other circle and introduces himself or herself. Each pair talks together about a topic the leader or someone else has suggested.

After a minute or two, the leader shouts "GO" again, and each circle at once begins to run as before until the leader again cries "STOP." This can be repeated 4 or 5 times.

Afterwards the whole group can meet to discuss what they learned.

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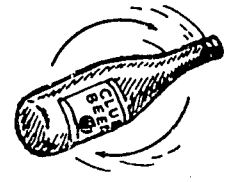
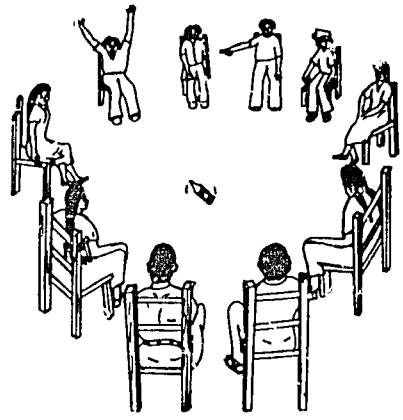
3. SPIN THE BOTTLE



This simple game is a fair way to pick one member of a group to answer a particular question, start off a discussion, or do a certain job. If more than one person needs to be picked, the bottle can be spun as many times as necessary.

Everyone sits in a circle. One person spins an empty bottle on the floor in the middle of the circle.

The person the bottle points at when it stops is the one who is picked.



After he answers the question or does the job, the person who was picked spins the bottle again to see who will be picked next.

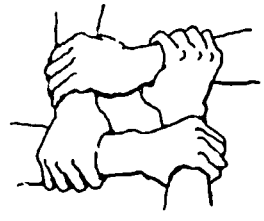
Silly? A waste of time? Yes, but . . .

'Ice-breaking' games may seem ridiculous. In fact, they often are. Some people may not like them or may feel they are a waste of time. Sometimes they are. But sometimes they can help a group that is too serious or stiff, to loosen up and begin to enjoy each other.

A friend who has worked for many years in community health says: "To waste time is to save time." Taking time to 'break the ice' and help people begin to relate to each other openly can make a big difference in what people learn from the course.

We must never forget that, although latrines and medicines and vaccines are important, the most important factor that determines human health is how people work and live and share and learn together.

If we can all learn to work well together in our training program, perhaps we can do so with those in our villages or neighborhoods. And this would be a real step toward health! So remember . . .



To 'waste time' getting to know and like each other may save time later.

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1.1.1 Werner, D. and B. Bower. 1983. Helping Health Workers Learn. Hesperian Foundation, Palo Alto, California. pp.4-6 - 4-8.

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Lesson code: AAK/T/1a

Series: Trees

Lesson title: **THEIR IMPORTANCE TO THE LAND**

Aim: To enable the trainees to understand and appreciate the importance of trees in their environment.

What you will need for this lesson:

1. An area where a nu of different types of trees are growing
2. An area where trees have been cut down indiscriminately
3. An area where there are a lot of old tree stumps
4. An area on the edge or bank of a river or gulley or anywhere else where tree roots are exposed
5. An umbrella
6. A plan of which places you will visit in a proper sequence to match the steps of the lesson

Notes: You do not necessarily need assistants for this lesson but ensure that the group of trainees is not too big.

The lesson is going to be a practical "walk around the area" lesson to familiarise the trainees with the trees around their school and what the trees contribute to the area and the people in that place.

The lesson:

Begin the meeting outside in the school compound under any trees. There is no classroom section to this lesson so discuss the few theory parts as you walk around with the trainees.

Follow these steps:

1. Tell the trainees that it is very important to have trees on our land because they help to conserve (i.e to hold or retain) our soils from being washed away when it rains.

2. Tell the trainees that this is because the roots help to hold the soil together in one place.

3. Tell the trainees that when trees are planted in and around our compounds the wind will not blow so fast and this can prevent the roofs of classrooms and houses from being blown away.

4. Move with the trainees to a place where the roots of trees are exposed.

5. Show the trainees how the roots are holding the soil.

6. Ask the trainees what would happen if the soil was not being held by the tree roots.

7. Move with the trainees to another area where there are strong mature trees which provide good cover and shade.

8. Tell the trainees that the leaves of the trees reduce the amount of water being taken away when the sun is shining.
   Explain to them that it is cooler below the trees so less water evaporates.

9. Ask the trainees to handle and study the soil in this place.

10. Move with the trainees to a place where trees have been cut down.
    Using the umbrella, explain how making a shade makes a place cooler.

11. Let the trainees try standing under the umbrella to feel cooler.

12. Let the trainees handle and study the soil in this place to find out if it is different to the soil under the trees.

13. Ask the trainees if the soil where there are no trees is different from the soil where there are trees.

    (the soil in the open may be hotter, drier, have less plants growing on it and have less organic matter. There may be some surface or sheet erosion as well).

14. Tell the trainees that because there are no trees (or all of the trees have been cut down) a lot of soil is (or can be) carried away by rainwater, and by the wind.
    More water will also be lost by evaporation, because the bare earth is exposed to the sun.

15. Tell the trainees that they should not destroy trees.
Tell them that they should tell their parents and colleagues about the importance of trees and also that they should plant more trees to help to keep the land fertile.

16. Summarise the lesson by asking a number of questions, including:

    a. Why should we encourage the planting of trees?
    b. Why shouldn't we cut down all of the trees in a particular place?
    c. How do the roots of trees help the soil?
    d. What do the leaves of trees do to help the soil below?

17. Tell the trainees their home assignments:

    a. To identify the places in their home area where soil has been lost because trees have been cut down.
    b. To look to see how many young trees are growing in the area.
    c. To look to see how many mature trees have been cut down.

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Lesson code: AAK/T/2a

Series: Trees

Lesson title: **THEIR USES**

Aim: To enable the trainees appreciate the importance of trees to man and to know some of their uses.

What you will need for this lesson:

1. The position of trees which have different uses or which have been planted for different purposes (e.g fruit, timber, fodder, shade, fence, medicine, food).
2. A kitchen where sticks and logs have been collected for a fire.
3. A place where timber is being lumbered.
4. Some articles/items made from wood/timber.
5. Some branches from a browse tree.
6. Some goats.

What to brief your assistants about:

1. Tell the assistants the steps to be followed in the lesson.
2. Each assistant must stay with his group throughout.

Notes: It is best to have a small group with each assistant i.e you need 3 or 4 assistants. The trainees will only break into the small groups for the practical activities i.e they will be in one large group for the questions and the main steps.

This lesson will be a "walk around the area" session with lots of questions.

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The lesson:

Begin the lesson out of doors in an area where different types of trees are growing.

Follow these steps:

1. Take the trainees to a place where you can stand between different types of trees.

2. Ask the trainees to tell you as many uses for trees as they can think of.

3. Take the trainees to a fruit orchard.
   Ask the trainees what they do with the fruits.

4. Take the trainees to the school kitchen.
   Ask them what the sticks and logs in the kitchen are used for.
   Ask them what the kitchen is built from.

5. Move with the trainees to any building e.g classroom, office, house.
   Ask them to tell you anything in the building which is made from trees.

6. Move with the trainees to the compound.
   Ask them to tell you the purpose of those trees in the compound.

7. Move with the trainees to a tree nursery.
   Ask the trainees why somebody should grow young trees for transplanting.

8. Move with the trainees to an area where either of the following are growing (pawpaw, castor, rubber).
   Ask the trainees what products are derived from these trees.

9. Move with the trainees to a place where trees are flowering and ask them why bees are visiting those trees.

10. Tell the trainees to pick some tree branches they think can be eaten by sheep/goats.

11. Move with the trainees to a place where you have tethered the animals and let them feed the animals.

12. Ask the trainees why trees are important to animals.

13. Summarise the lesson by asking the following questions

    a. What food can man get from trees?
    b. What other products can be derived from trees?
    c. What other uses do trees have?
    d. Why do bees visit trees?
    e. What other animals that man needs, use trees?

14. Tell the trainees their home assignment:
    To look at the trees within the families boma and discuss with their brothers or sisters how these trees are useful to man.

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Useful information:

These are some notes to help you and your assistants prepare the lesson and make the activity more effective. For translations of the tree names see the table provided with this series of notes on trees. The vernacular names are shown in this table.

1. What can trees be used for?
   - Fuelwood. Man uses trees for burning to cook food and to make heat. Before fossil fuels became common, trains burned wood. Charcoal is made from wood to make a good fuel for burning in jikos.
   - Foods. Many human foods are collected from trees, particularly fruits e.g. mangoes, pawpaws, oranges, lemons, apples, plums, ovacados and leaves are also eaten sometimes.
   - Timber. Some trees provide good timber which can be used for building, making furniture, fencing posts and even pencils and matches. Good timber trees include Eucalyptus, Camphor, Olive.
   - Decoration. Some trees can be planted just for beauty and to provide shade. Some are good for making fences as well. These trees include Jacaranda, Silky oak, Palm, Euphorbia, Cypress.
   - Soil Erosion. By reducing the energy of rain drops and by roots and trunks getting in the way of surface water, trees can be very important in preventing/controlling soil erosion.

2. Other products from trees:

   - Sap. This is the liquid in the tree trunks. Rubber comes from the sap of trees and is used to make a whole range of products including tyres for vehicles. The sap from pawpaw trees is also extracted and is used to season/soften meat before it is cooked.
   - Oil. The seeds of a number of trees can be crushed or processed to extract the oil. e.g cashew nuts are used to produce an oil used in brake fluid. Castor oil is extracted and used in industrial machinery, and in the past people used it as a body lotion. The oil extracted from the fruit of the coconut palm is used for cooking and is used on hair.
   - Medicine. A lot of medicines are made from plants. Some of these are used traditionally and some plants are grown so that the dawa companies can use them to make medicines commercially. It is mainly the leaves or the bark which are used. e.g. the Quinine tree for dawa for malaria.
   - Beverages. Tea leaves, coffee and cocoa berries are sold to factories where they are processed.

3. What do other living things derive from trees?
   - Pollen. Bees collect pollen and use it to make honey which is later harvested by man.
   - Many animals eat leaves of trees.

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C. The Actual and Potential Role of Trees

The roles that trees can play in an agroforestry system are numerous and include:

- Providing fuel and wood products
- Providing animal fodder
- Providing shelter and shade
- Increasing soil friability and increasing water retention in the soil
- Providing nutrients and organic matter
- Producing cash crops

1. Fuel and Construction Wood Production

A shortage of fuelwood is common in most of the drier parts of Africa and in some of the more humid areas as well. Virtually all cooking is done using wood as the fuel. In Tanzania, for example, fuelwood accounts for over 90% of all wood used. Natural forests and woodlands are able to provide fuel in perpetuity when demand is low; but the annual growth yield of naturally occurring vegetation is often lower than that of manmade plantations, and in many parts of Africa the natural vegetation has virtually disappeared. Although rural communities generally use more fuel than any other forest product, the need for construction materials (poles especially) is important. Rural people often see fuelwood as a "free good" for which they are reluctant to pay a market price, whereas poles are frequently traded and regarded (by the male) as more valuable.

Under conditions of low or stable population, governments traditionally set aside areas of trees as "forest reserves" in order to

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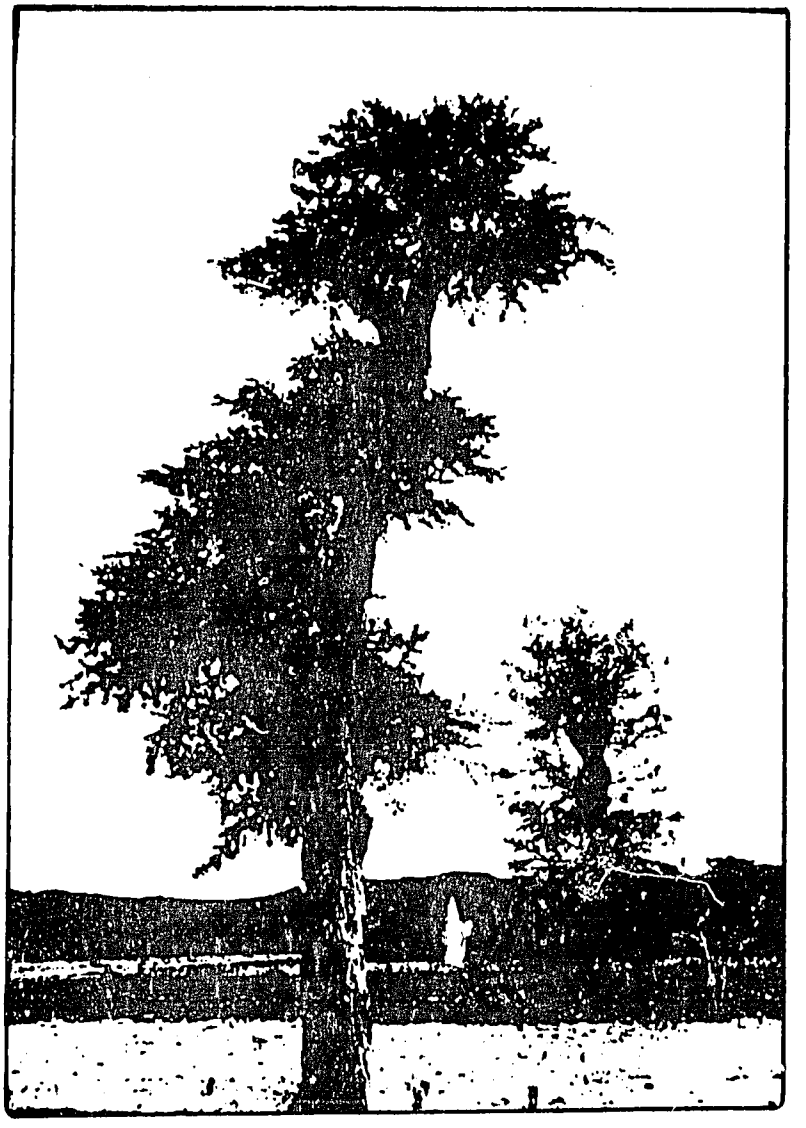
protect the environment and to supply the country with a never-ending supply of forest products. In many countries today, the non-reserved forests are being destroyed wholesale and even the forest reserves are disappearing. In any case, most of these are needed for the supply of industrial wood for national development. Such production systems hardly meet any rural (or urban) needs for fuel and poles, which for most rural people should be within walking distance of the farm or on the farm itself.

Agroforestry is an excellent way of helping meet these needs, especially if multipurpose trees are used. Many of these trees are well known, and others are continually being identified as having potential for agroforestry and farm woodlots. They provide a wide range of possible products. A particularly well-known example is Leucaena leucocephala, which is frequently grown in lines associated with food crops (alley cropping); it provides fodder and green manure from its leaves and fuel from its branches, and it helps control erosion. In addition, Leucaena fixes atmospheric nitrogen.

2. Animal Fodder Production

In many highly populated areas of Africa, arable food crop farming is gradually being introduced in farming systems which previously had been dominated by animal production. However, in most cases there is still a strong preference for animal husbandry; and frequently, there is a need to combine arable farming with animal production. Here again this can be made possible by introducing multipurpose trees of which one output is fodder. Generally, such fodder trees occupy less area than pasture, and in many cases they can be planted in fields primarily used for arable crops. In the subhumid savannah, a tree such as Leucaena will produce about 20 to 50 kilograms of dry fodder per tree per year. In the humid secondary savannah, the production of Calliandra calothyrsus will be in the range of 30 to 60 kilograms of dry matter per tree. In both cases, the protein content of the fodder will be between 10% and 15%. On an arable farm of two hectares, between 500 to 1,000 trees can easily be planted without significantly affecting the production potential of annual food crops. The total fodder production from these trees is capable of



Acacia albida is used as a source of fodder (note cut branches).

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closing an average feed gap of two to three months annually for between four and eight head of livestock. Even in areas of very high population pressure and shortages of land, a few fodder trees make it possible to raise five to ten rabbits, which may keep an average family supplied with a reasonable amount of animal protein. In drier areas, fodder trees include Acacia albida, A. senegal, and A. tortilis.

3. Shade and Shelter

Where wind, high temperature, and high evaporation rates adversely affect farm yields, wisely planted trees can mitigate these adverse effects. The shelterbelt is an excellent example. Properly designed shelterbelts increase crop production substantially; and at the same time, both wind and water erosion is reduced, thereby improving the sustainability of the farming systems. There are two effects of shelterbelts and windbreaks: direct effects, such as obviating physical wind damage to plants, and indirect effects, such as changing the microclimate, particularly the water balance. On the whole, shade and shelter reduce excessive evapotranspiration over short periods, thereby relieving water stress, which in turn leads to the more efficient use of water for the duration of the crop.

Establishing shelterbelts has become a particularly promising agroforestry intervention in the Sahel. In protected fields in Niger, net grain production increases of over 30% have been reported. Similarly, in Nigeria peanut production in protected fields was double the average of the unprotected fields.

Here also it is possible to use multipurpose trees. A common approach in the Sahel is to have a mixture of rapidly growing species for immediate protection; slower growing trees that eventually become quite tall, thus extending the wind-shielded area; and smaller trees and bushes that partially close the spaces near the ground. At the same time, these trees can produce a variety of by-products, such as pods from Acacia nilotica, which may be used by local tanneries. An example of the design of a shelterbelt is given in Figure 4, and tree and shrub species which

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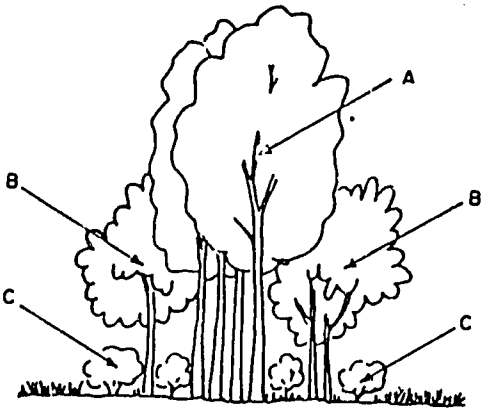

(A) Large trees in the center

(B) Smaller species for the next two rows

(C) Low shrubs, bushes, and grasses on the outside

Figure 4

CROSS SECTION OF A SHELTERBELT

may be planted in such a shelterbelt in dry and moist tropical areas are given in Table 2.

An important feature of shelterbelt development is that, although farmers are reluctant to plant blocks of trees, they are less opposed to taking a strip of land out of farm production to establish shelterbelts.

Shade trees used to be important in the production of plantation crops, such as tea, coffee, and cocoa. However, with the development of new varieties of these crops and improved crop husbandry, shade trees are no longer as important. Nevertheless, they are still widely used, particularly when these crops are grown under low levels of farm inputs. There is still, however, a very important role for shade trees in animal production systems, as well as in shading compounds, meeting sites, etc.

4. Production of Cash Products

It is often difficult to introduce trees or shrubs into a farming system that is primarily needed for a service function, since it is hard for farms to see the long-term benefits. Farmers more readily adopt new technologies when early cash returns can be demonstrated. There are many trees and shrubs which have a service function as well as provide a relatively quick cash return. For example, with the rapidly spreading fuelwood shortage all over Africa and an increasing commercialization of firewood and charcoal, many farmers are ready to adopt fast-growing fuelwood species, which also have soil-improving qualities. The example of *Acacia nilotica*, whose pods can be used for tannin production, is pertinent. Other examples are trees whose by-products are honey (principally legumes); medicinal extracts (quinine); nuts (cashew, coconut, ye-eb, palm); fruit (jack fruits, pears, avocado, mango, peaches); resins (gum arabic, pine, frankincense); and spices (cinnamon, cloves, nutmeg).

Table 2

EXAMPLES OF TREES AND SHRUBS
THAT COULD BE USED IN SHELTERBELTS

	Dry Tropical Areas	Moist Tropical Lowland Areas	Moist Tropical Highland Areas
A) Large Trees	Acacia species Acacia alba Acacia tortilis Caratonia siliqua (Carob) Dalbergia sisso Tamarindus indica (Tamarind)	Acacia auriculiformis Afrormosia elata Afzelia species Af. africana Af. quanzensis Casurarina equisetifolia*	Acacia Mearnsii (Black wattle) Acrocarpus fraxinifolia Alnus acuminata Cordia alliodora
B) Medium Trees	Acacia victoria Cassia siamia Dalbergia melanoxylon (Blackwood) Prosopis species Prosopis alba P. chilensis	Albizia guamifera Gliricida sepium Leucaena leucocephala Sesbania grandiflora	Erythrina poepigiana Gleditsia triacanthos Leucaena leucocephala Mimosa scabrella
C) Small Trees and Shrubs	Acacia species Acacia horrida Acacia saligna Cassia sturtii Cordeauxia edules (Ye-eb) Lablab purpurens (Lablab bean)	Cajanus cajan (pigeon pea) Calliandra callothyrsus Desmodius gyroides Sesbania bispinosa	Cajanus cajan (pigeon pea) Crotalaria spp. C. agatiflora C. laburnifolia Tephrosia species T. interupta T. holstii Sesbania sesban

NOTE: All species have been chosen from nitrogen fixers (mainly legumes).

*These species fix nitrogen but are not legumes.

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The Relevance of Tree Planting

WHY PLANT trees? Since the earliest time, man has maintained a close relationship with trees. Early man derived his livelihood from forest products, such as fruits, nuts, roots, leaves and shoots. Even today trees provide large quantities of the dietary requirements of humans and livestock. People have also depended on trees for shelter as well as for numerous other purposes.

Trees play an important role in our daily life - no wonder a tree has been termed the best friend of man on earth. However, due to the population explosion and the expansion of land under agriculture, the economic demands on forest products have been enormous. Man has deforested large areas of indigenous forest cover leaving bare earth behind. Desert encroachment in Africa is now seen as a reality and the only practical way to combat desertification is to plant appropriate trees using appropriate techniques.

Most African governments are striving to raise the standard of living of some 90% of their rural populations through rural development programmes. One way of alleviating poverty is to undertake projects that will generate local employment opportunities and which are locally self-supporting.

The benefits accruing from rural development also flow to urban areas, especially to the majority of urban poor who depend on rural products for daily subsistence. In a way, then, employment in rural areas permeates the broad spectrum of the society.

Apart from employment, the benefits of trees to mankind are otherwise too many to enumerate. Below are but a few examples:

a) There is the provision of timber for construction and joinery, plywood, pulp for paper, posts and poles;

b) pharmaceutical oil and medicine;

c) some minor products such as honey, fodder, fruits, resin, gum, fibre, rubber, and myriads of food products, all play a very important role in some communities (Kamweti). For example, in Sudan, gum Arabic from *Acacia Senegal* and other species produce an annual income of about 4 million US Dollars (Amin).

There is also the all important issue of biomass energy. Fuelwood and charcoal are increasingly becoming very important sources of energy not only for domestic use but also for various industrial uses. While the fossil fuel price continues to

escalate, it is comforting to bear in mind that fuelwood is a renewable resource, provided it is harvested in a sustainable way. Woodfuel plays such an important role in Africa that in some countries like Kenya nearly 100% of rural people depend on fuelwood for domestic energy and in urban areas 80%, mainly in the form of charcoal (Kamweti).

Elsewhere in Africa, the same general trend exists. In fact it has been estimated that at least half the timber cut in the world still serves its original role for mankind - as fuel for cooking and heating (Spears). In most of the West African countries, 80 - 85% of wood harvested is used as fuelwood (Okigbo). In Africa as a whole, it is estimated that woodfuel accounts for 66% of total energy (Burley). In absolute terms, it is estimated that about 300 million cubic metres of fuelwood is consumed annually (Poulsen). The percentage share of wood consumed in the form of energy in Africa is impressive - as can be inferred from the following sample countries (Ishengoma):

- Kenya 75%
- Malawi 89%
- Tanzania 96%
- Uganda 90%

Woodfuel is no longer a poor man's commodity. As consumption continues to rise above supply, planting of trees must be done close to population centres, otherwise situations will arise where, for example, a housewife spends the equivalent of a full work-year gathering wood for fuel. In other cases woodfuel has become very expensive. In Niger, for example, an average manual labourer spends one fourth of his income on firewood and charcoal.

Firewood is indeed an essential commodity in life just as food is. To minimize fuelwood shortage, it is important to apply good tree planting techniques to avoid high rate seedling mortality. In helping to solve energy problems, experimental results from Ghana suggest that 40,000 ha. of plantation of fast growing species can produce the equivalent of 50,000 tons of coal per year without unusually large inputs of capital-intensive technology (Myers).

Trees are also capable of providing many indirect benefits, some of which may not be quite obvious at the first instant but are nevertheless important:

a) Trees do improve microclimate; they provide shade for livestock and people. It has been observed that temperature in the sun can be greater than that in the shade by as much as 10° centigrade (Norman et al).

b) Trees are effective tools for water and soil conservation, a major issue in most of the African countries.

c) Trees also provide a habitat for wildlife - an important consideration for genetic conservation (Myers).

d) Tree play a major role in protecting, maintaining and improving the environment. Trees, especially in the form of forests, because of their sponge effect on rain water, play a critical role in regulating the flow of water and trapping any suspended matter which would otherwise pollute water.

e) As for land degradation, there is no better cover for soil than trees. Some experiments in USA have demonstrated that volumetric loss of top soil (15 cm deep) under tree cover has been 1% and under concentrated vines 20% in the same period (Norman et al). In many African areas, soil losses from erosion have been estimated at between 200 and 2,000 tons per square kilometre per year. In terms of value, it is the greatest per capita loss in most African countries, especially in sloping areas denuded of trees. The prevention of soil erosion by the use of tree cover in turn means minimizing siltation of rivers, canals, and dams (World Bank).

f) Also for combating and even reclaiming deserts, tree planting is the best tool. It is one of the recurring recommendations since the U.N. Conference on Desertification held in 1977 in Nairobi. The Conference noted that on the Southern edge of the Sahara alone 650,000 sq. km. of once-productive land has become desert within the last 50 years. This is an annual loss of 13,000 sq. km.

g) The air people breath is purified by trees as they exhale oxygen - no wonder forests have rightly been called "Nature's Lungs" (Douglas & Hark). An acceptable environment without trees is unimaginable. Indeed one can say that agriculture in marginal lands may be disastrous but trees are the only solution (Douglas & Hark).

h) Trees are usually not depletive on the earth in which they are growing; they tend to enrich soil by their nutrient recycling effect. A number of trees, such as the *Acacia* species, have a fertility effect by their ability to fix atmospheric nitrogen (Wilson). It is known that if one plants legumes it may not be necessary

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to add fertilizer to improve the nitrogen content in the soil. Leguminous crops can add up to 500 kg of nitrogen to the soil per hectare per annum (National Academy of Science). Indeed any substitute for fertilizer is most welcome in Africa, bearing in mind the cost of fertilizer and also the energy needed to make it. Trees are a partial solution to this problem which is often associated with foreign exchange expenditure. Hence, besides ameliorating the site for themselves, trees also nurse other economic crops.

It is necessary to keep in mind the above-mentioned uses of trees because, if tree planting is looked at from one angle only, it may be discarded because it does not meet some economic criteria. It should be emphasized that a number of trees have many advantages, or rather they play a multi-purpose role in rural development. In fact it is common knowledge that forestry supports agriculture.

In view of the above advantages of trees, it is a logical conclusion that, for those African countries with a deficit of wood, massive planting programs should be undertaken. There are essentially three categories of areas where such planting should take place.

a) Land devoted to afforestation or forest reserves where large plantations could be created.

b) Farm land where agroforestry could be practised.

c) On roadside reserves, in towns, and on any unused land earmarked for such tree planting.

Whatever category of the area to be planted there are essentially four categories of plantations (Lundgren):

i) The eucalyptus species.

ii) The tropical hardwoods.

iii) The softwood, mainly conifers.

iv) The legume species.

The concept of tree planting is simple if the techniques are well understood.

Tree planting programmes have failed for many reasons, such as bad planting methods, improper ground preparation and inadequate care at the early stages of growth.

To have a successful tree plantation, the people need to be trained in basic skills that would help them to look after their plantations successfully. To achieve community participation, they must be made aware of the economic values of trees as relates to their daily lives.

For people providing the plants, some silvicultural knowledge of the behaviour of different species is essential. It is most unlikely that the local community will reject a tree unless it is obviously unsuitable for the particular end-use in mind. There are a few cases when there is a belief that some species will take too much water e.g. *Eucalyptus* species. But in most cases people will plant what is made available by the relevant authority issuing seeds or seedlings. It is therefore of paramount importance that suitable species which have been tested and appropriately selected are used as much as possible. Local species which may have withstood burning, overgrazing, pests, and diseases are likely to be successful candidates in planting for that particular locality.

If growth performance of a species is known and a knowledge of appropriate planting methods, considering climate, soil, and locality, are well communicated to the people involved, then planting of trees is likely to succeed. It is the aim of this booklet to analyse the relevant factors and current planting methods which have been used in Africa with some success. There are a lot of local variations for which local experience is necessary. In an attempt to increase productivity per unit area (in most countries suitable land for tree planting is definitely very limited), most people are inviting failure by planting exotic species without a proper provenance trial. It is common knowledge, and indeed a reasonable precaution, to plant those trees which have done well in other areas with similar or almost identical growing conditions such as climate, soil and altitude.

Trees

In many parts of the Tropics people produce their food on land that is best suited for forests. Long-term preservation of the land and its fertility is especially important in such areas because destroying the forest frequently destroys the capacity of the soil to support agriculture. What is needed there are food production systems that combine forest preservation with agriculture.

There are production schemes (called agrisilviculture) that yield wood, foodstuffs and animal products from the same management unit (farms, small communities, or portions of watersheds). In these schemes, good agricultural practices and judicious use of arborescent vegetation are combined. Of course, cooperation among land users is essential; it enhances the potential of the scheme, and helps maintain the productive capacity of the management unit.

Trees offer many benefits. They protect the soil, ameliorate soil microclimate, enhance infiltration of air and water into the soil, improve water quality and regimen, recycle nutrients that would otherwise be lost to percolation, and provide shade, food, forage, fuelwood, and (sometimes) timber. Food production can be added to the forest system without making destructive changes, and degraded agricultural lands can be rehabilitated by interplanting with aborescent vegetation.

Several stable agri-silvicultural systems have been developed in the Tropics that combine production of annual plants, bushes, trees, vines, and livestock to yield a combination of useful seeds, flowers, fruits, vegetables, leaves, medicines, resins, forage, firewood, lumber, and meat. In the simplest systems, trees are used chiefly for wood, fruits, shade, or wind protection. Windbreaks are important, especially where there are strong, dry winds that dessicate the soil. Planted along plot boundaries or among cultigens, windbreaks minimize erosion and regulate water supply. Also, living fenceposts bordering pastures can enclose livestock, yield forage, provide firewood, and eliminate the need to cut small trees to replace fenceposts.

Forest blocks can be scattered among agricultural lands, as they are among rice paddies in the Philippines, to help stabilize the soil and cycle nutrients. When the forest blocks are upper slopes and hilltops (usually in areas of recurrent drought), the trees impede water loss, increase percolation into the soil, and may even increase the productivity of adjacent lower slopes and bottomlands by prolonging the growing season.

Shifting cultivation is a particularly important system for the Tropics, in which trees are used to regenerate the soil over long periods of time. When the forest is cut, trees are burned and crops are planted on the site for 1 to 3 years. When weeds become too competitive, the fields are abandoned, and new (secondary) forests are allowed to develop. During this time (the fallow period) the land is not used.

Land clearing in tropical forests leads to a series of alterations in the soils. Burning adds mineral nutrients to the soil, but these are soon used or leached away. Some soils are hardened when exposed to strong light and soon become infertile. The available minerals (and total fertility) decrease during agricultural use and gradually increase during fallow.

Shifting cultivation works very well where populations are dispersed. In areas of high population density, farmers must resist the temptation to prolong cultivation, clear too large an area, or cultivate steep slopes; soil deterioration and erosion soon follow.

Two modifications and extensions of shifting cultivation, the corridor system in Africa (Coene 1956, Newton 1960) and the Tuangya system from Burma (King 1968), contain specific prescriptions for rotational sequences and choice of crops.

Casual intercropping is a system in which naturally regenerated secondary species (volunteer trees) are allowed to remain in fields used for pasture or other crops, or trees that are rem-

nants of previous forest are deliberately planted. The trees are retained as shade for animals and sources of fruits, edible leaves, firewood, or even timber. But casual intercropping is not a systematic use of trees to contribute to the farm.

Simulation of succession has been suggested as still another alternative to intercropping in the American Tropics. This system consists of cropping sequences that simulate natural succession (such as leafy, stem, and root crops, followed in order by bananas and plantains, palms, and productive forest). In one example (Holdridge 1959), successional phases included subsistence crops, and the terminal stage had capa (*Cordia alliodora* Oken) and pejibaye (*Bactris gasipaes* H.B.K.) as the dominant and codominant vegetation, cacao (*Theobroma cacao* L.) as a suppressed crop, and root and tuber crops scattered on the ground. In fact, polyculture systems with several crops have resulted in greater yields than monoculture rotation systems (Hart 1975).

Several multiple-cropping schemes that consider specific crops can be found in the literature (Holdridge 1951, Hunter and Camacho 1961, Espinosa-Caballero 1976, Peck 1976, and Aguirre 1977).

FRUIT TREES

Among the best trees for the subsistence farm are fruit trees, because they can provide food. They often require little special attention and, if carefully managed and pruned, they can also serve as a source of wood fuel for the farm. The space used by them need not be great: they can be located near buildings, as shade for cages as part of fencing, in areas that are difficult to farm, or as part of the landscaping of the house and farm. They should not take up space that could be used for intensive production of vegetables, cereals, legumes, or roots and tubers, which merit the bulk of the available land.

The best fruit trees for small tropical farms (table 12) are those that are well known in the area of the farm for their productive ability. Local farmers will know what plantings have worked best for them, but there are often new, highly productive trees that are known only by a few people. Since the people or facilities necessary to produce, graft, and distribute high-quality trees are often lacking, special attention should be given to acquiring trees known to be useful.

There are a large number of fruit trees suitable for the subsistence farm. Many also have edible leaves (including cashew, coffee, papaya, mango, and tamarind). Others have special, little-known edible uses. It is best to select a combination of trees with different nutritional values. For example, vitamins A and C can be obtained from a wide variety of fruits, oils for cooking from coconut or oil palms, and protein from nuts. A few fruits of exceptional value are discussed below.

The canistel or eggfruit [*Pouteria campechiana* (H.B.K.) Baehni] begins to bear when quite small, and is among the most versatile of fruits; it can be used fresh, dried, or cooked to add color and flavor to puddings, ice cream, or baked products (Martin and Malo 1978).

Citrus fruits (*Citrus* spp.) are very popular and usually contain useful amounts of vitamin C. There are varieties available for almost all tropical climates, and the trees usually require little care and take up comparatively little space. The fruits keep well, and the juice, pulp, and rind can all be used. Grafted varieties that have proved suitable in the farmer's locale are worth the initial expense because they are likely to yield heavily.

The guava (*Psidium guajava* L.) is also outstanding; it will bear almost year round in some areas. Its highly nutritious fruits have a wide variety of uses. Its pruned or dead wood is especially good for the cooking fire because the dense wood burns with a high heat and without noxious fumes or sparking.

Mangos (*Mangifera indica* L.) contain useful amounts of vitamins A and C, and are widely appreciated. The trees bear heavily while young but tend to occupy disproportionately large areas when they are older and less fruitful. The wood is good for furniture construction and fuel.

Tall palms that bear edible fruits that can be used as staples are recommended. The best of these are the coconut (*Cocos nucifera* L.) and the pejibaye. These trees furnish food for years, and need little space or attention.

Papaya (*Carica papaya* L.) is an excellent fruit tree even though it is short lived (3 to 4 years). Its leaves, pith, roots, seeds, and flowers can be eaten if they are cooked 10 minutes or more. The fruits are edible when ripe and even (if cooked) when immature.

Tamarind (*Tamarindus indica* L.) is highly nutritious and is more versatile than most people

Table 12.—Fruit trees recommended for tropical subsistence farms

Common name	Species	Climate preference	Nutritional contribution	Notes
Avocado	*Persea americana* Mill.	Somewhat dry Tropics	Oil, vitamins B_2, B_3	Short life span.
Banana	*Musa* spp.	Humid Tropics	Carbohydrates	Readily accepted, widely adapted, heart and inflorescence also used.
Barbados cherry, acerola	*Malpighia glabra* L.	Somewhat dry Tropics	Vitamin C	Widely adapted, small fruit.
Canistel, eggfruit	*Pouteria campechiana* (H.B.K.) Baehni.	Tolerant	Sugars, vitamins	Widely adapted, versatile in use.
Cashew	*Anacardium occidentale* L.	Dry Tropics	Protein, B vitamins	Also has juicy fruit, tolerates drought and poor soils.
Cocoa	*Theobroma cacao* L.	Humid Tropics	Oil, protein	Very wide variety of uses.
Coconut	*Cocos nucifera* L.	Tolerant	Oil, protein	Widely adapted; heart, inflorescence also used, as is sap (for wine).
Coffee	*Coffea arabica* L.	Humid Tropics	None	Used only as a stimulant.
Guava	*Psidium guajava* L.	For all tropical climates there are tolerant varieties.	Vitamin C, calcium	Widely adapted, versatile in use, bears over long season, limited by disease in some areas.
Key lime	*Citrus aurantifolia* Swing	For all tropical climates there are tolerant varieties.	Vitamin C	Widely adapted, versatile in use.
Macadamia	*Macadamia integrifolia* Maiden et Betche.	Dry to moderate Tropics	Oil, protein, minerals, B vitamins.	Underutilized but readily accepted.
Mango	*Mangifera indica* L.	For all tropical climates there are tolerant varieties.	Vitamins A, C	Productive; widely accepted; leaves, seeds also used; trees tend to get too large for small farm.
Oil palm	*Elaeis guineensis* Jacq.	Humid Tropics	Oil, vitamin A	Extremely productive, easy to manage source of cooking oil.
Orange	*Citrus sinensis* Osbeck	Somewhat dry to humid Tropics.	Vitamin C	Widely adapted.
Papaya	*Carica papaya* L.	Dry Tropics	Vitamins A, C	Fast growing; green fruit leaves, heart, roots also used.
Soursop	*Annona muricata* L.	Tolerant	Vitamins B_2, B_3	Very popular, useful as fresh fruit or in drinks.
Tamarind	*Tamarindus indica* L.	Dry Tropics	Sugars, vitamins B_1, B_2, minerals.	Widely adapted, seeds and leaves edible as well as fruit pulp.

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realize. The pulp around the seeds is used to flavor chutneys, drinks, and other foods, and both seeds and tender leaves can be cooked and eaten.

VEGETABLE TREES

There are a few trees and a number of large woody shrubs that produce vegetables for the small farm (table 13). These are extremely useful because they produce a great deal of food and require only a minimum of attention; they can be used to diversify food production while conferring the same benefits as other trees.

Bananas and plantains (*Musa* spp.), although really large perennial rhizomes, offer the small farm many of the protective features of trees. The fruits of all varieties can be used as vegetables either green or ripe. After fruit production ceases, the remaining flowerbuds can be cooked; the bases of the bracts are delicate vegetables.

The breadfruit (*Artocarpus altilis* Fosb.) is known for its seedless forms, whose fruits are used as starchy vegetables. The seeds of seedy forms (often called breadnuts) are also edible. They are boiled in saltwater, and their flavor resembles that of chestnuts.

The small palms known in Spanish as pacaya (*Chamaedorea* spp.) are grown widely in Central America. Palm flowers, the unopened spathes or inflorescences are considered a delicacy and are boiled or cut into pieces and fried in batter.

The pejibaye is also very versatile (Almeyda and Martin 1980). It will grow well under conditions of low fertility, and its starchy fruits are nutritious and appealing. The palm has multiple trunks; old trunks can be cut, used for timber, edible hearts eaten, and they may be replaced by new shoots.

Several species of vegetable trees are used chiefly for their edible leaves, which are highly nutritious as well as good tasting. These include sunset hibiscus, chaya, Indian mulberry, and katuk (see "Leaves"). The drumstick tree (*Moringa oleifera* Lam.) is perhaps the best, because of the diversity of its edible products (table 13). Cassava, while often grown as an annual, can be left as a shrub or small tree, harvested for its leaves, and its tubers used when needed.

LEGUMINOUS TREES

Leguminous trees (table 14) afford several benefits to subsistence farmers in need of multipurpose crops on limited plots of land. Many are rapid-growing colonizers that produce a low- to intermediate-density wood, and are adapted to several environmental conditions. They are usually fertile at an early age and often produce seed copiously. Many add nitrogen to the soil and produce protein-rich foliage and seeds that serve as excellent forage and, in some instances, as food for man. The terminal branches of some can be cut and used as hay.

Mesquite [*Prosopis juliflora* (Sw.) DC.] is a drought-resistant species that can be planted in dry lowlands through montane habitats. It provides a heavy wood that is resistant to decay and is used in rural carpentry, for fuel, and to produce high-quality charcoal. The bark is used in tanning and the leaves and pods serve as forage. Children sometimes eat the sweet, nutritious pods, which were once a staple of Indians in what is now the southwestern United States. The tree also functions as a honey plant (its flowers attract bees that make honey from its pollen).

Mother of cocoa (*Gliricidia sepium* Steud.) is especially useful as living fenceposts. Stakes up to 2 meters long are capable of sprouting after being "planted" in the ground. The species grows fast, fixes nitrogen; and is good for windbreaks and foliage is plowed into the ground as fertilizer), and serves as an excellent nurse crop in multiple-cropping schemes with cacao, vanilla, and coffee. The wood is hard; it is used in construction and cut branches are used as fuel. The flowers and flowerbuds are edible, and the leaves serve as forage for cattle (but are poisonous to horses). It too is a honey plant.

Sesban (*Sesbania grandiflora* Pers.) is another fast-growing multipurpose legume that serves as a source of fuelwood and pulp. Tender green pods, young leaves, and flower parts are eaten in salads, curries, and soups. The leaves have a high protein content, making them an excellent forage or green manure. The bark yields a useful fiber, and dyes can be extracted from the sap. Other extracts from the plant have been used medicinally.

Tantan (*Leucaena leucocephala* de Wit.) is one of the most promising multipurpose trees; it

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Table 13.—Tropical trees and large shrubs that can be grown for vegetables

Common name	Species	Climate preference	Uses	Notes
Breadfruit	*Artocarpus altilis* Fosberg	Tolerant of most tropical climates.	Fruits, seeds of seedy varieties.	Widely adapted; long, prolific bearing season; propagated from shoots, roots, or seeds.
Cassava	*Manihot esculenta* Crantz	Tolerant of most tropical climates.	Tubers, leaves	Widely adapted, propagated from cuttings.
Chaya	*Cnidoscolus chayamansa* McVaugh.	Tolerant of most tropical climates.	Leaves, growing tips	Propagated from cuttings.
Drumstick tree	*Moringa oleifera* Lam.	Dry Tropics	Leaves, young pods, roots	Propagated from seeds or cuttings.
Indian mulberry	*Morinda citrifolia* L.	Tolerant of most tropical climates.	Leaves, unripe fruits	High nutritional value prefers seaside environment, propagated by seeds.
Katuk	*Sauropus androgynus* Merr.	Tolerant of most tropical climates.	Leaves	High nutritional value, used as hedge, propagated from seeds or cuttings.
Millionairs' salad	Palms of many genera especially *Palmus*.	Varies with species	Heart	Palm trunk must be opened to obtain this vegetable.
Palm flowers	*Chamaedorea* spp.	Tolerant of most tropical climates.	Unopened inflorescence	Propagated from seeds.
Pejibaye	*Bactris gasipaes* H.B.K.	Tolerant of most tropical climates.	Fruits, heart	Widely adapted, propagated from seeds or shoots.
Plantain	*Musa* spp.	Humid Tropics	Green or ripe fruits, heart, inflorescence.	Widely adapted, readily accepted.
Sunset hibiscus	*Abelmoschus manihot* (L.) Medik.	Humid Tropics	Leaves, tender shoots	Short lived, propagated from cuttings.

Table 14.--Leguminous trees of special value in the tropical subsistence farm

Common name	Species	Climate preference	Uses
Acacia	*Acacia* spp	Moderate to dry Tropics	Forage
Bauhinia, poor man's orchid	*Bauhinia* spp	Moderate to humid Tropics	Forage, fuel
Blackhead	*Pithecellobium dulce* Benth	Tolerant	Forage, hedges, pulp of fruits edible.
Cabbage angelin	*Andira inermis* H B K	Moderate to humid Tropics	Shade, hard wood used for furniture.
Cassia	*Cassia* spp	Tolerant	Forage, green manure.
India padauk	*Pterocarpus indicus* Willd	Humid Tropics	Timber, shade.
Machette	*Erythrina* spp.	Moderate to humid Tropics	Forage, living fence, fuel edible leaved.
Mesquite	*Prosopsis juliflora* (Sw.) DC.	Dry Tropics	Leaves and pods for forage, fuel.
Mother of cocoa	*Gliricidia sepium* Steud.	Tolerant	Forage, fencing, hedge, flowers edible.
Sesban	*Sesbania grandiflora* Pers.	Dry Tropics	Forage, edible young pods.
Spanish oak	*Inga* spp	Humid Tropics	Fuel, shade for multiple cropping, edible fruit pulp.
Tantan	*Leucaena leucocephala* de Wit.	Moderate to dry Tropics	Forage, fuel, young leaves and small pods edible.
Tibet tree	*Albizia lebbeck* Benth.	Moderate to dry Tropics	Leaves and pods for forage, fuel, wood for construction.

yields nutritious forage, firewood, and timber; it fixes nitrogen; and is good for windbreaks and shade. Timber production has ranged from 30 to 40 cubic meters per hectare per year. The variety 'Acapulco' has been used to provide overstory for coffee, cocoa, peppers, and vanilla in multiple-cropping schemes, and a Hawaiian variety yields up to 8 tonnes per hectare per year of edible dry forage that contains 25% crude protein. Young leaves and small pods serve as human food, and the pods also yield a dye. Tantan should not become a large part of the diet because it contains a toxic substance, mimosine, but there are cultivated varieties whose mimosine content is low.

Tibet tree (*Albizia lebbeck* Benth.) is a fast-growing species that provides a coarse-grained, strong, long-lasting wood used for furniture, paneling, veneer, turnery, posts for general construction, and fuel. It is tolerant of salt spray and drought, and is widely naturalized throughout the Tropics. The leaves and pods also serve as forage.

TREES FOR WOOD

Trees grown for timber should be tall, fast-growing species with straight stems, and have strong, fine-grained, woods with good machining characteristics. Fuelwoods, should have a high specific gravity (thus a high calorific value), dry fast or have a low greenwood moisture content, be easy to harvest and transport, regenerate easily by coppice or seedling, and exhibit favorable burning characteristics they should not smoke, spark, or release toxic substances when burning). Fence or hedgerow species may be like either of the above, but primarily, they should be easy to establish (preferably by stakes), grow fast, and should not corrode nails or wire. Trees that are good for timber, fuel or fence are listed in table 15.

Australian beefwood (*Casuarina equisetifolia* L.) is adaptable to a wide range of sites, grows fast, and is excellent as a windbreak. It also fixes nitrogen, and its wood is dense enough to make it a good fuelwood.

Capa (*Cordia alliodora* Oken), found between lat. 15° N. and 15° S., is a fast-growing, valuable wood prized for furniture, cabinetwork, millwork, and general construction. It has been used for shade in a multiple-cropping scheme with pejibaye and coffee, and suggested as a timber crop in a scheme with cacao, pejibaye, and tubers (Holdridge 1959).

Rose apple (*Syzigium jambos* Alston) is a hedgerow plant that provides edible fruit, firewood, posts, and charcoal. The trunk sprouts

Table 15.—Tropical trees of special value for forest products

Common name	Species	Site preference	Uses	Notes
Alder	*Alnus* spp.	Cool, moist, montane habitat.	Construction timber	Fixes nitrogen.
Australian beefwood	*Casuarina equisetifolia* L.	Dry to moist lowlands and foothills.	Windbreaks, hedges, fuel	Dense wood, can be propagated from cuttings, fixes nitrogen.
Balsa	*Ochroma* spp.	Moist to wet lowlands or foothills.	Construction of lightweight objects.	Very light wood, grows fast.
Burma toon	*Toona ciliata* Roem.	Moist to wet foothills and mid-altitudes.	Furniture.	
Cape	*Cordia alliodora* Oken	Dry to wet lowlands and foothills.	Timber, furniture, posts.	
Caribbean pine	*Pinus caribaea* Morelet	Lower elevations with high summer rainfall.	Timber.	
Coffee colubrina	*Colubrina arborescens* Sarg.	Dry to wet lowlands and foothills.	Construction timber, shade for other crops.	Water-resistant wood.
Eucalyptus	*Eucalyptus* spp.	Individual species adapted to variety of climates.	Timber, fuel	Grows fast.
False cedar	*Bombacopsis quinatum* Dug.	Dry to wet lowlands	Construction timber.	
Honduras mahogany	*Swietania macrophylla* King	Dry to wet lowlands	Timber, furniture.	
Kadam	*Anthocephalus chinensis* A. Rich. ex Walp.	Moist to wet lowlands and foothills.	Timber, veneer, cabinetwood	Grows fast.
Kapok	*Ceiba pentandra* L.	Dry to wet lowlands and foothills.	Boxwood, fiber, edible leaves.	
Melina	*Gmelina arborea* Roxb.	Moist to wet lowlands and foothills.	Pulp, posts	Grows fast.
Mexican cypress	*Cupressus lusitanica* Mill.	Foothills to montane habitat with high summer rainfall.	Timber, pulp.	
Monterrey pine	*Pinus radiata* Don.	Areas with winter rains and dry summers.	Timber, pulp.	
Ocote pine	*Pinus oocarpa* Schiede	Higher elevations with high summer rainfall.	Timber, pulp.	
Paradise tree	*Simaruba glauca* DC.	Lowlands, monsoon climate to rain forests.	Living fence, fuel, oil for soap.	
Rose-apple	*Syzygium jambos* Alston	Low to medium elevations, humid forests.	Charcoal, hedgewood	Edible fruit, heavy yield.
Spanish cedar	*Cedrela odorata* L.	Dry to wet lowlands	Furniture, fine construction	Fragrant, durable, termite-resistant wood.
Teak	*Tectona grandis* L.f.	Deep soils at low elevations, dry to moist climate.	Furniture.	

after cutting or pruning, and its wood production on poor soils has reached more than 15 square meters per hectare per year basal area.

Species of eucalyptus (*E. globulus*, *E. grandis*, *E. robusta* and *E. deglupta*) are quite adaptable, and they have been planted widely. They grow rapidly and are a good source of timber, posts, and fuelwood.

Spanish cedar (*Cedrela* spp.), mahogany (*Swietenia* spp.), oak (*Quercus* spp.), Australian cedar (*Toona* spp.), muskwood (*Guarea* spp.), and species of *Carapa* are good species to grow for timber because they have high-quality woods used in general construction, carpentry, and cabinet and furniture making. Many of these species are resistant to decay and drywood termites. Coniferous trees, such as pine (*Pinus* spp.), cypress (*Cupressus* spp.), and Norfolk pine (*Araucaria* spp.) are valuable sources of sawtimber and pulp.

The following species are good sources of shade, fodder, fuel, and construction timber: acacia (*Acacia* spp.), Tibet tree (*Albizia lebbeck* Benth.), poor-man's orchid (*Bauhinia* spp.), shower tree (*Cassia* spp.), mesquite [*Prosopsis juliflora* (Sw.) DC.], powderpuff (*Calliandra* spp.), and immortelle (*Erythrina* spp.). Less common species that are also good sources of timber, fuel, and pulp are Mayan breadnut (*Brosimum* spp.), jacaranda (*Jacaranda* spp.), nutmeg (*Myristica* spp.), pui (*Tabebuia* spp.), almond (*Terminalia* spp.), trema (*Trema* spp.), goldenfruit (*Virola* spp.), and prickly-ash (*Zanthoxylum* spp.), and species of *Apeiba* and *Dalbergia*.

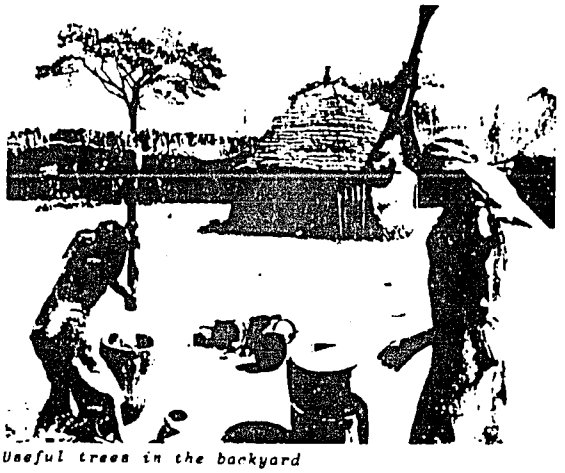
1.1 The Importance of Trees

The world's forests have an undisputed and vital role in sustaining natural and human environments. They protect watersheds, provide habitats for wildlife and help to stablize otherwise fragile ecosystems. They provide many essential products for rural and urban dwellers. They also play an economic role, with the commercial extraction of timber and pulpwood producing significant amounts of national income and foreign exchange in a number of countries.

Trees provide wildlife habitats

In addition, forests provide a home and a means of livelihood for large numbers of people, both traditional forest dwellers and those who find employment in extracting and harvesting commercial forest products. Forests also play a vital role in agricultural production. Although shifting cultivation has been a cause of the deterioriation of much forested land, when it is practiced in an environmentally sustainable way, the natural process of regrowth and regeneration of the forest restores the fertility of fallow land.

Although not as well documented, the role trees play outside established forested areas and reserves is also critical. Trees, dotted about the rural landscape, around houses, along field boundaries and roadsides, and in communal grazing areas, are seldom recorded in the formal statistics of forested lands. But for the majority of the rural population, living away from the immediate vicinity of forested lands, these trees have an even more significant role than the forests themselves. Therefore, policies and programmes intended to improve access to wood resources and other tree products must be based on a recognition that the trees which will be most useful to these rural people will not be found growing in the forests, but in their own backyards, on smallholdings and on communally held lands.



Useful trees in the backyard

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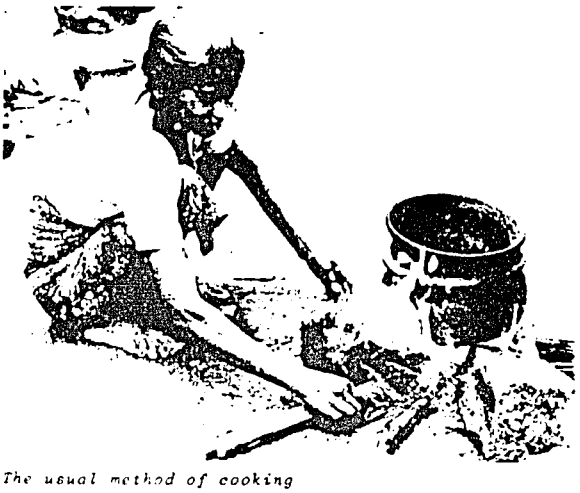
In farmlands and grazing areas, trees also play a vital environmental role. They act as windbreaks, protecting crops from wind damage and the soil from erosion. Their shade helps to reduce the temperature of the soil. Tree litter slows down the run-off of rain, thereby protecting the soil and increasing the infiltration of water so that groundwater stores are replenished. Trees also redistribute nutrients, drawing essential minerals from the subsoil and making them accessible, through their leaf-fall, to other plants. In many countries, tree litter is collected in large quantities for composting and mulching in order to maintain soil fertility.

Trees have a valuable social function. They provide shade for people and animals in hot climates, and are sometimes a focal point for family and community gatherings and activities. There are many places where trees are grown and protected for their shade and beauty; sometimes they are treated as sacred.

1.2 Tree Products



The usual method of cooking

Wood is the most widely used household fuel in non-industralized areas of the world where supplying energy, in fact, constitutes the greatest demand for wood, far exceeding that of commercial timber. Wood is by far the most important energy source in many countries, accounting for up to 90 percent of the total fuel used in some of the poorest. In many countries, virtually every rural family uses it for at least some cooking and food processing and for heating. In many cities, charcoal and wood remain the predominant cooking fuels. Some industrial processes such as tobacco and tea curing, brick firing and beer brewing often rely entirely on wood for process heat. Restaurants, tea shops, bakeries and other commercial enterprises add to these demands.

However, the dominant role of wood in rural energy supplies should not be allowed to obscure the fact that other traditional fuels are often important. Use of agricultural residues and animal dung is extremely widespread, though since it is poorly understood it is not given the attention it deserves. The result has sometimes been that the case for fuelwood programmes has been overstated because the contribution that other traditional fuels make has not been taken fully into account.

The dominance of woodfuel demand in quantitative terms has also tended to obscure the vital importance of other tree products to rural people. Animal fodder is perhaps one of the most significant of these, especially at certain times of the

year when grass and other feed sources are unavailable. In arid areas, trees often provide regular supplies of fodder in the form of edible seed pods and leaves. During times of drought, these become especially important sources of animal feed.

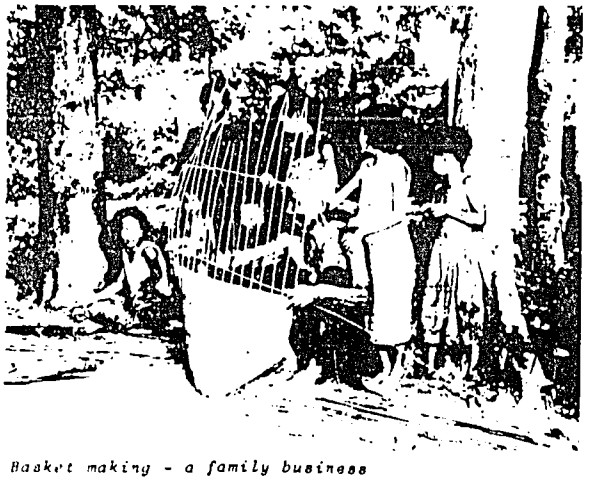
Trees can provide fodder

A wide range of human foods are also obtained from trees and from forested areas. Some of these are extremely important in preserving the nutritional balance in traditional diets. They include edible leaves and pods, roots, fruits, nuts, honey, insects, and game. Trees may be a source of food condiments, such as spices, and sap from some trees is used to make wine. Mushrooms and other forest funghi are also collected for certain types of dishes.

Mushrooms can grow on trees

Trees produce a large number of what are often referred to as "minor" forest products. The importance of these products should not be underestimated. They make a vital contribution to the needs and general living patterns of large numbers of rural people.

Many communities rely on trees to provide fibre to make ropes, mats, baskets, snares, coverings, woven goods and even musical instrument strings. Trees are an important source of many herbal remedies and traditional medicines. Tannins and dyes extracted from tree bark and seed pods are used to cure leather and colour fabrics. Oil from the seeds of certain trees can be used as a substitute for paraffin in hurricane lamps. The leaves and twigs of other trees have good insect repellant qualities, are used to stun fish or serve as natural livestock dewormers. Some resins can be used as glues.



Basket making - a family business

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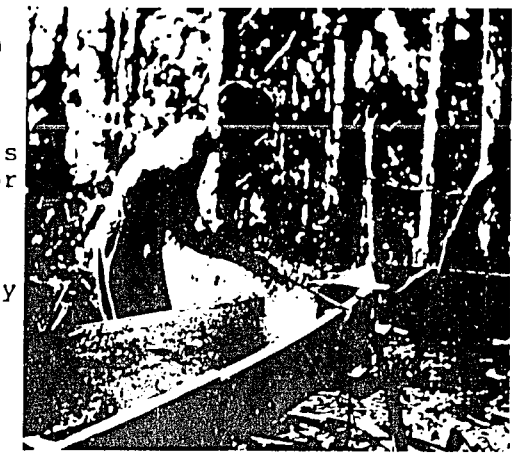
Agricultural implements, bullock carts and boats are often crafted out of wood, and certain varieties of wood are highly-valued for their tool-making qualities. The trunks of some trees are hollowed out for water storage. African woods are used to make camel bells.



A boat crafted from wood

Trees also supply a variety of commercial construction materials. Building poles, for example, are widely needed for a variety of purposes. In rural areas, they are used in construction of many traditional types of dwellings; in cities, poles are used by the poor in constructing low-cost housing, and larger poles are extensively used for scaffolding and for props by the building industry.

Harvesting and distribution of these tree products is an important income-generating activity in many areas. Charcoal production and fuelwood vending, for instance, are a vital source of income for many poorer rural households. Other jobs are generated by pitsawing, operation of sawmills, woodworking, tree farming, and the gathering and selling of fruits, timber, resins, gums and other forest products both for cottage industries and for larger scale commercial concerns. The significance of small-scale rural enterprises which process forest materials is gradually becoming better documented. In a recent survey, FAO has shown that such enterprises are often one of the largest sources of off-farm employment and income. Further work is now in progress to determine the key characteristics of such enterprises and to formulate ways to enhance their economic contribution (FAO, 1985a).

The role of trees in the patterns of rural living is thus both complex and diverse. Focusing on one aspect, even such a major one as fuelwood, at the expense of others can be gravely misleading. So much of the fabric of rural domestic and farming life relies on trees that any diagnosis of the problems arising from the depletion of tree cover which does not take into account the full complexity of this dependence is likely to be inadequate.

RURAL DEPENDENCE ON FOREST OUTPUTS

The importance of forests and the goods and services from the forests to the rural peoples in developing countries is mainly threefold. Forest trees provide fuel and other goods essential to meeting basic needs at the rural household and community level. Forests and forest lands provide food and the environmental stability necessary for continued food production. Forests and forest products can generate income and employment in the rural community. Some of the benefits which forestry can bring to rural communities are summarized in Table 1 and are discussed more fully in the following sections.

FUELWOOD AND TIMBER

Wood is the dominant domestic fuel for rural people in developing countries, and for many of the urban poor as well. In many parts of the developing world, wood is also the principal structural material for constructing shelter and housing.

More than 1.5 thousand million people use wood daily for cooking their food and for maintaining essential levels of warmth in the home. Wood is the preferred fuel because it can be used without complex equipment, both for use and distribution, and can be acquired at little cost, often no more than the cost involved in gathering it. For the poor there is often no alternative to wood fuel or other locally available organic materials. Commercial fuels, even where they are available, require cash outlays on stoves and related equipment which are generally beyond the reach of the rural poor. One consequence of growing rural populations is, thus, an inexorable growth in the pressures on locally available forest resources and other sources of woody material. The source of wood fuel extends progressively from collecting deadwood to the lopping of live trees, the felling of trees, the total destruction of tree cover, the loss of organic matter to the soil, and eventually to the uprooting of stumps and removal of shrubs. Subsequent to this there is the diversion of agricultural residues and animal dung to fuel use, to the detriment of soil structure and soil fertility.

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TABLE 1

BENEFITS OF FORESTRY TO RURAL COMMUNITIES

Output	Beneficial Characteristics
Fuel	Low cost in use Producible locally at low cash cost Substitutes for costly commercial fuels Substitutes for agricultural residues Prevents destruction of protective ground cover Prevents diversion of household labour Maintains availability of cooked food
Building materials	Low cost in use Producible locally at low cash cost Substitutes costly commercial materials Maintains/improves housing standards
Food, fodder, grazing	Protection of cropland against wind and water erosion Complementary sources of food, fodder and forage (e.g., in dry periods) Environment for supplementary food production (e.g., honey) Increased productivity of marginal crop land
Saleable products	Raising farmer/community incomes Diversifying the community economy Additional employment
Raw materials	Inputs to local handicraft, cottage and small-scale industries (Plus benefits as from saleable products)

At the same time the steady disappearance of wood in the vicinty of the community means increased social hardship. Progressively, more of the time of household members must be devoted to gathering fuel. It has been estimated that fuelwood gathering now requires 360 man days annually per household in the Gambia and 250 - 300 man days in central Tanzania. As the situation deteriorates further, and the household is forced to purchase its wood fuel, a heavy burden is placed on the household budget. It is reported that up to 15 percent of household income is spent on fuel in the highlands of the Republic of Korea, and up to 25 percent in the poorer parts of the Andean Sierra and the Sahelian zone.

Eventually, this shortage of wood fuel can affect the nutritional well-being of the people. In parts of West Africa, people have been reduced to one cooked meal a day. In the uplands of Nepal only vegetables which can be eaten raw are grown. In Haiti, a principal impediment to the introduction of new food crops with better nutritive value into the wood-poor hills is that they would require more cooking.

FOOD AND THE ENVIRONMENT

There are now perhaps 200 million people living in the tropical forest areas and practising 'slash and burn' farming (shifting agriculture) on perhaps 300 million hectares (ha) of forest lands in order to provide their daily food. In parts of south and southeast Asia this form of land use occupies some 30 percent of the officially designated forest area. Traditional systems of shifting agriculture, which employed a lengthy fallow period under forests to restore the fertility of soils which were capable of supporting

agricultural crops for only a limited number of years, have largely broken down. Growing population pressures, and migration into the forest areas by landless people from elsewhere, have forced a progressive shortening of the fallow period to the point where it suffices neither to restore soil fertility nor to recreate a useable forest crop. Similar trends are discernible in the more open savannah woodlands of more arid areas. The problems of the gum arabic system of Sudan described in Appendix 2 are largely a result of pressures to cultivate more land, at the expense of the fallow period under Acacia. The future of such areas on which productivity cannot be maintained indefinitely under crop production calls for systems of joint production of trees and other crops.

In addition to crop production there are many other ways in which rural communities can draw upon the forests for food in one part of the world or another. Bush meat and honey provide supplementary food sources, as do a wide variety of tubers, fruits and leaves. Fish production in swamps or mangrove forests can also be an important protein source, for mangroves and swamp forests offer a most valuable protective and productive habitat for fish.

In many areas trees are a source of fodder. In Nepal, leaves make up about 40 percent of the annual feed of a buffalo and about 25 percent for a cow. In dry forest areas, livestock often cannot survive without forest grazing. In the Sahel, leaf fodder is the principal source of feed in the dry season, and the excessive grazing of trees during the recent lengthy drought contributed significantly to the large-scale destruction of the vital tree cover.

Concurrent with the pressures on the forest from within from shifting cultivation are the pressures for alienation of forest land which arise from the need of expanding rural populations for more land on which to grow food. In most areas, forests are the largest remaining land-bank -- the one land cover which can absorb large-scale further extension of the area under crop production. It has been estimated that the existing area of forest in developing countries is being reduced annually by 5 - 10 million ha in Latin America, 2 million ha in Africa and 4 million ha in Asia. To the extent that this process releases to food production land which can sustain the growth of crops, this is logical and to be planned for. But over large areas, the pressures of growing populations force landless farmers onto soils which cannot sustain crop production and onto slopes which cannot be safely cultivated — at least with the techniques and resources available to these farmers. The consequences of these practices in terms of wind and soil erosion, silting, flooding and drought, are well known. Some 10 percent of the world's population live in mountainous areas, but another 40 percent live in adjacent lowlands, so that fully half of mankind is directly affected by ravages of the watershed environments.

It is reported that in India, 50 percent of the total land area is seriously affected by water and wind erosion. Indeed, displacement of fertile top soil is estimated to be around 6 000 million tons a year. In Pakistan, erosion affects 76 percent of the total land area. Nepal is perhaps one of the most dramatic cases of its kind in Asia. In many parts of Nepal the forests have been cleared up to 2 000 metres (m). Slopes of 100 percent are under cultivation. Huge landslides occur during periods of continuous rain. These landslides, which destroy lives and crops and remove the necessary humus, occur more and more frequently throughout the Nepalese hills, in part because ground-holding trees are disappearing fast. At present, the washing away of top soil is a threat to agricultural productivity in the remaining fields. Similar landscapes, perhaps to some extent less pronounced, can be found everywhere in the hilly areas in other parts of the world.

The erosion of agricultural soils often results in the siltation of rivers and water reservoirs. Thus, the river bed of the Nepalese Terai is rising between 15 - 30 cm a year. This rising of river beds, which occurs because of accelerated soil erosion and siltation, is a major cause of the more frequent and dangerous floods in all regions. But sedimentation also causes loss of reservoir water storage capacity. In the Indian subcontinent the Mangla reservoir is estimated to receive every year 100 million tons of sediment, of which the Jhelum river, due to indiscriminate felling and burning of the forest in the catchment area, contributes about 80 percent. The Mangla reservoir was built to last 100 years or more. Sediment measurement after a few years of operation indicates that most of the reservoir's capacity will have gone in 50 to 75 years. These are illustrative of many similar examples.

The process of environmental degradation following destruction of the tree cover is often accelerated by the pressures of fuelwood harvesting. These tend to be most pronounced in the neighbourhood of large towns and cities. Wood is the preferred fuel not only of the rural poor but also of many of the urban poor as well, who use it principally in the form of charcoal. The large concentrated demands that ensue have led to treeless wastes in peri-urban areas in many parts of Africa, Asia and Latin America, with the areas affected often growing at frightening speed.

INCOME AND EMPLOYMENT

Forests and trees can give rise to cash crops such as mushrooms, chestnuts, walnuts and pine kernels. Bamboo can be cultivated for shoot production, as is done in Japan. In many countries trees are grown at the smallholder level, to provide fuelwood for sale to the urban and semi-urban areas. In India the income from gathering and selling fuelwood is an important part of the economy of forest villagers, especially for the poor in these villages. Tree farming can also provide profitable industrial wood crops, such as the pulpwood grown by farmers in the Philippines. Among non-wood products, the gum arabic produced as a farmer crop in Sudan is one of the more important export commodities of that country.

In addition to the income and employment generated by their industrial exploitation, forests also provide timber and other raw material for local craftsmen and small-scale artisan and processing activities. Throughout the developing world, doors and other builders' woodwork, furniture, tools and other agricultural inputs such as fence posts are made locally within the community. These products, together with wooden handicrafts, and other products of non-wood raw materials such as 'tasar' silk, can also be marketed outside the community.

Forestry can also contribute to rural incomes in less direct ways. If other alternatives for raising the incomes of the rural poor are not promising, the establishment of fuelwood lots may provide a means to raise their incomes by releasing dung and agricultural residues for reworking into the soil, so increasing crop yields. In this way forests may also contribute to a more equitable distribution of income. It might be easier to help the poor by providing them with fuel in the form of wood than with similar benefits provided through taxation and redistribution.

OUTLINE OF THE AGROFORESTRY CONCEPT

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Department of Silviculture

Introduction: the role of forestry in rural communities

Historically, many traditional farming-systems consisted of an integration of agricultural and tree crop production, sometimes with animal husbandry also included. In these systems not only final products for human consumption were produced,but also the inputs for further production were generated in the system (subsistence farming). Such combined agricultural and forestry practices were formerly practised both in temperate regions and in tropical regions, where they formed a stable form of land-use for many centuries. In temperate regions, these systems have gradually been replaced by more specialized farming systems by which a maximal production of only one or a few products is obtained. Such specialization was possible through the development of an open-market economy and good transportation facilities, by which industrially produced inputs for agricultural production, and outputs, could be obtained from, or sold to, distant markets. Furthermore, with increased development more and more labour became absorbed in industries and services, and labour costs increased, necessitating farm rationalization, which is possible in monocultures.
During the last decades it has generally been assumed that such development would also take place in tropical regions and also here a separation between agriculture, animal husbandry and forestry was envisaged. Indeed, in many tropical countries the growing population resulted in an increased pressure on the land which resulted in diminishing forest areas. The following factors contributed to this decrease of forest area:

- Competition for land between agriculture and forestry; forestry is often not able to withstand the pressures for more agricultural lands because priority is given to agricultural food production, and because trees are a less intensive form of land-use.
- Various timescales in production cycles; agriculture mostly gives (semi)-yearly yields, but forestry gives mostly delayed returns. Consequently, yields from trees will not meet the immediate needs of the local population, while there is also a risk that the initial planter cannot profit from future yields.

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- The benefits of forests are often dispersed and may accrue in part outside the direct forest area. Such dispersed distribution of benefits can be observed in the protection offered by forests by maintaining good hydrological conditions for downstream areas.
- Insufficient knowledge about the possibilities of forestry and lack of attention for improved management techniques for tree crops which are of importance to farmers. Consequently often insufficient institutional framework for forestry development are present.
- Sometimes substitution of forest tree products by industrial products takes place.

For a more extensive discussion, see FAO (1978).

Because of these reasons, many tropical forests were changed in agricultural lands. Too often, the agricultural techniques employed are not suited to the local conditions and they resulted in environmental deterioration (soil degradation, erosion, etc.) or poor or uncertain yields as a result of diseases or variable climatic conditions. In other cases, especially in densely populated areas, the decrease in forests resulted in a severe wood shortage as, due to the poor socio-economic situation, not much substitution of wood products to industial products (e.g. fuelwood) took place.

Thus, gradually it appeared that, due to different environmental and socio-economic conditions, it is not possible to transfer the agricultural techniques of temperate regions to all tropical regions. As a result, during the last decade the understanding of the importance of forestry for local communities in tropical countries has been recognized more and more. Also, it became apparent that in order to stimulate forestry and tree crop production in rural communities, new approaches should be worked out to overcome the various obstacles which have limited the acceptance of forestry by local communities in the past. Gradually several responses to the limiting factors for forestry development in rural areas have been recognized, see table 1.

One of the main basic principles in reconciling forestry and agriculture is the development of integrated agricultural and forestry production. Especially during the last five years the possibility of sustained production of such combined agro-forestry systems has been recognized by a steadily increasing number of people and institutions. Fortunately, in many tropical countries many traditional integrated agricultural and forestry systems

Tabel 1 Factors to be taken into account in analysing the place of forestry in a rural economy (from FAO, 1978).

Factors	Possible Response
Competition for land (trees are a less intensive use of land than crops)	
- Competition for forest land	- Intercrop trees and crops - Allocate forest land rationally between trees and crops - Improve non-food benefits to forest communities: forest/forest industries employment; secondary forest product income; social infrastructure, etc.
- Competition for crop/grazing land to afforest	- Plant trees on: roadsides, river banks, field boundaries and other unused areas marginal for crop production; erodable areas unsuitable for crop production or grazing. - Improve productivity on the more arable areas in order to release land for tree growing. - Plant multiple-use species or mixtures of species to increase productivity. - Intercrop trees with other crops or combine with grazing. - Introduce additional sources of income (e.g. beekeeping).
The timescale for forestry (delayed returns from tree growing)	
- Output from trees will not meet immediate needs	- Plant multiple-use species, or mixtures of species, which give some early return. - Provide financial support during the establishment periods: low-interest loans, grants, subsidies, wage employment, etc.

Tabel 1 continued.

	- Introduce or expand complementary non-forestry sources of income.
- The risk that the producer will not benefit	- Ensure security of tenure of land used for tree crops.
Dispersed distribution of benefits from forestry	
- Benefits from protection forests or from timber production may accrue in part outside the community	- Provide compensation for those benefits foregone, or inputs provided, by the community, which generate benefits elsewhere.
Seasonal shortage of labour	- Adopt forestry systems which do not compete with peak demands for labour
Lack of a tradition of forestry (unfamiliarity with the necessary techniques, lack of understanding of cause and effect, behavioural patterns inimical to forestry, inappropriate institutional framework)	- Provision of guidance and support through extension services: education of the people, technical advice and technical inputs, grass-roots training. - Demonstration projects. - Encourage producer groupings (cooperatives etc.). - Legislation and regulation.

still exist, which can be used as examples and starting-points for the development of new integrated systems suited to the present situation. Such systems can be adapted to situations of subsistence farming or to situations of cash-crop farming. Whatever the case, the cultivation of tree crops is an essential part of the agricultural system and their functions are both productive and protective. Many different combinations of tree crops and agricultural crops and also animal production are possible, which

- make an optimal use of the soil production capacity,
- ensure a multiple-use of natural resources,
- provide multiple and sustained yields,
- are socially acceptable.

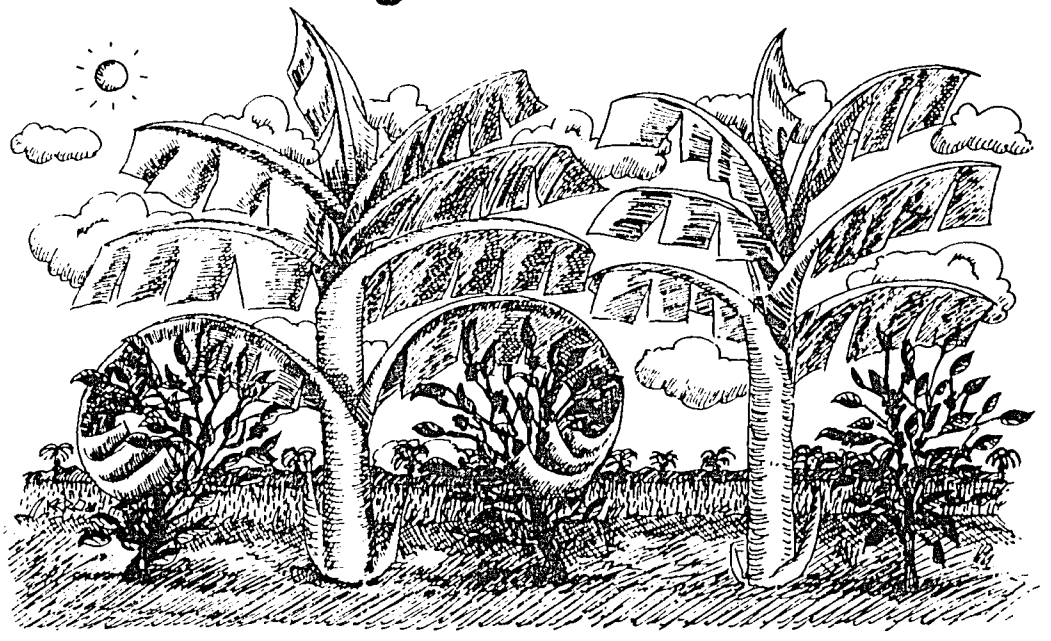
With agroforestry the general concept for such integrated land-use systems is indicated.

Development of the agroforestry concept

Although agroforestry is an age-old practice, modern concepts for this kind of land-use are only being developed now. The main impuls for its development was provided by the study "Trees, food and people: land management in the tropics" (Bene, et.al., 1977). Based on this publication in 1978 the International Council for Research on Agroforestry (ICRAF) was established to stimulate research in agroforestry; at the moment it is based in Kenya. Further international activities on agroforestry are undertaken by the International Union of Forest Research Institute (IUFRO) and the United Nations University (UNU), while added stimulus is provided by the FAO programme on "Forestry for local community development". Also several conferences have been devoted to this subject, the main ones are:
several sections of the 8th World Forestry Congress at Jakarta, which had as theme "Forestry for the People",
the workshop "Agroforestry systems for Latin America" (De las Salas, 1979) and the symposium on "International Cooperation in Agroforestry" (Chandler & Spurgeon, 1979).

As the modern concepts for agroforestry are still being developed, a commonly accepted understanding about its exact meaning is still evolving. Consequently, depending on a wide or more restricted vieuw of its meaning and different emphasis being given to its various attributes, several definitions can be encountered, see appendix 1 and also Combe & Budowski (1979).

Intercropping: Farming for the future?



Until recently, intercropping has received relatively little attention from agricultural scientists, even though it has been practised for centuries by millions of farmers in the tropics and is a system which can be particularly beneficial to farming families short of cash or credit.

Intercropping involves the growing of two or more crops in the same field - in sequence, in combination, or both. This includes the practice of relay cropping - when a second crop is planted between the rows of a first crop which is nearing maturity. Crop and animal production may also be mixed in even more complex, ecologically sound systems designed to maximize production.

Studies of agricultural systems throughout the tropics indicate that farmers prefer, where possible, to plant at least two crops in the same field. This helps to minimize the risks of crop failure, which can prove disastrous if the farmer devotes all his resources to growing a single crop.

In Africa, for example, 98% of the continent's most important legume crop - cowpea - is grown in combination with other crops. In Nigeria, over 80% of the cropland used is given over to polyculture (mixed cropping). A Nigerian farmer may typically grow up to eight crops, including bananas, beans, cassava, melon and yams, in a variety of mixtures. In India, more than 80 crops are utilized in mixed-crop combinations.

Over the last 15 years, agricultural scientists have turned their attention to intercropping in order to determine the reasons for its success. Species compositions have been studied together with spatial and temporal arrangements of crops, with a view to finding ways of improving mixed-cropping procedures and tailoring them to specific purposes and conditions.

It was soon discovered that, in many instances, crop mixtures produce more than individual crops grown alone. Where the crop species complement each other with regard to such parameters as growth rhythms, rooting depths, nutrient uptake and use of water and light, production is maximized. In Trinidad, for example, intercropping maize and pigeon pea increases the efficiency of nutrient uptake, primarily as a result of differences in nutritional requirements and root depths between the two crops. The polyculture makes use of up to twice the level of nutrients from the soil than does the monoculture.

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Optimizing resources

Investigations to establish how well crop mixtures utilize available resources have included an analysis of the land equivalent ratio (LER). This is the amount of land planted in monoculture that would be needed to achieve the same yield produced by a mixture. Researchers in Mexicu found that 1.73 ha of land would have to be planted with maize to produce the same amount of food as one hectare planted with a mixture of maize, beans and squash. Measured in terms of total biomass produced, the ratio increased (1.78 ha). In the majority of cases where comparisons have been made, polycultures outperformed monocultures.

Efficiency of use of local resources is one of the major advantages of intercropping. Short-term crops planted with others that take a year or more to mature (such as sugar cane or cassava) can use land, water and light while the main crop is still small. Planting both early and late maturing crops together helps spread the harvest throughout the year. This can be particularly valuable where a crop does not store well or storage facilities are inadequate or lacking. In Mauritius maize, groundnut and vegetables are grown and harvested in-between sugar cane before the cane grows high enough to shade the row spaces. Similarly, tall growing crops can be combined with short-growing, shade-tolerant crops. Furthermore, some crops, such as maize, respond to increases in row spacing by raising the yield per plant but do not increase their leaf area. Consequently, crops such as sweet potato can be raised between the maize rows, thereby increasing and diversifying production with no additional input.

Intercropping is not confined to annual crops. Among other examples, Pacific islanders grow cocoa under coconut and in East Africa bananas are interplanted with coffee, the bananas providing shade and material for mulching.

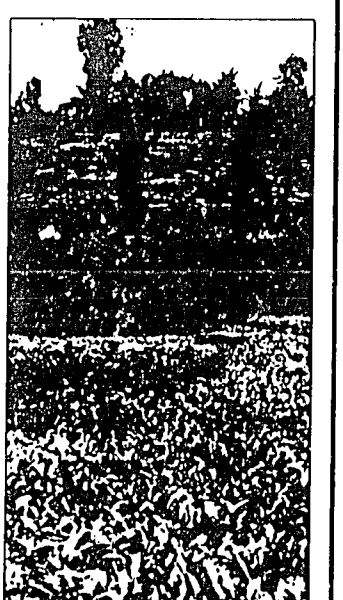
Temporal and spatial variants in crop preference have traditionally been exploited by tropical farmers to the full. Multi-storey crop combinations - such as coconut-black pepper-cocoa-pineapple - are now becoming more commonplace in the effort to produce as much as possible from a unit of land, preferably without the need for expensive inputs.

Another advantage of intercropping lies in the value of increased crop residues, measured in terms of what nutrients they return to the soil and how they improve tilth. In rubber-tea intercrops, plant debris was found to provide soil with the equivalent of 813 kg/ha of ammonium sulphate (nitrogen fertilizer), 65 kg/ha of calcium superphosphate and 146 kg/ha of potassium sulphate. Livestock fed on crop residues also produce additional fertilizer in the form of dung, providing a further reason for planting mixed crops.

In Cameroon, mixtures of maize and groundnuts yielded more food than monocultures, and did so irrespective of whether fertilizers were used or not. Comparisons of productivity with and without fertilizers showed increased yields of 21% and 11% respectively for unfertilized and fertilized mixtures than for monocultures receiving the same treatment. LER's ranged from 1.24 in the unfertilized mixtures to 1.49 in the fertilized areas.

Intercropping can provide several other benefits to help improve farm performance. Rubber-tea intercrops not only have a good rate of return of nutrients to the soil, they can raise ambient temperature by 2° C - limiting the chances of frost damage to the rubber trees - and reduce soil erosion by up to 70%. The increased rooting of mixed crops, usually extending to deeper levels than would be seen with single crops, helps to hold soils together.

Moreover, by choosing a mixture of crop species, farmers can ensure that leaf coverage of their land is expanded to try and use what solar radiation and water are available to the full. The change from monoculture to polyculture marks a notable shift in water balance - from evaporation from the soil to transpiration from the leaves. However, the overall water loss (evapotranspiration) is little changed and so water and irrigation requirements of monocultures and polycultures do not differ significantly and production can be increased without the need for improving water supplies.



Panscope

Food crops being grown alongside tea crops in Kenya

Fewer pests and diseases

Farmers who intercrop are able to introduce a means of controlling crop pests - at virtually no cost. The effect of viruses, fungi and nematodes can all be diminished just by planting more than one crop. A study of plant-feeding insects has found that 60% of the species tested were less abundant in mixtures than in monocultures. What is more, this simple method of biological control works even on a small-scale.

Several disease-resisting crop combinations have already been identified. Cassava and bean mixes reduce both incidence and severity of powdery mildew on cassava and angular leaf spot on beans. Cowpea viruses have also been found to be diminished when cowpeas are grown with cassava or plantain. Other beneficial combinations include, maize - sunflower - oats - sesame, potato - mustards, and okra - tomato - ginger - mungbean grown under coconut trees. Cowpeas appear to be protected from insect attack by interplanting with sorghum or other cereals, and okra protects cotton from flea beetles.

Even simple physical characteristics of individual crops, when combined, can provide protection, disrupting the visual or olfactory processes by which insect pests home in on their food or deterring colonization by weeds. Laboratory experiments showed that merely by interplanting kale with tomato and tobacco, leaf damage from cabbage-eating beetles was reduced by 75%.

Throughout the tropics maize is frequently planted with another crop. In the Congo basin it is cucurbits, in the Philippines sweet potato and in Colombia beans. In each case the maize has to compete with fewer weeds. The combined vegetation leaves little room for weeds to either invade or survive, and the efficiency with which the crop mix uses light, water and nutrients leaves precious little for the weeds.

Using this knowledge, some crops are now being used as 'barrier' crops to protect another. For example, soybeans planted around pigeon pea prevents the passage of hairy caterpillars which thrive on the peas.

Mixed-crop systems meet more of the annual needs of subsistence farming families than monocrops, and with less risk. In areas where hunger and malnutrition are endemic the evidence is hard to ignore. Trials of sorghum/pigeon pea mixtures showed that, for a given 'disaster' level, sole pigeon pea crops would fail one year in five, sole sorghum one year in eight, but that intercrops would fail one year in 36.

Technique for the future

Intercropping offers definite potential for the future. But, as recently as 1985, reviews of the scientific literature devoted to intercropping were bemoaning the lack of published information on the subject.

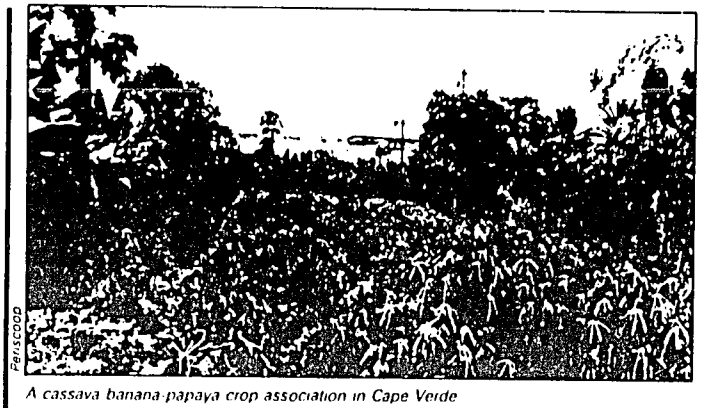
The direction and scope of institutionalized agricultural research has been governed by the desire to maximize production per unit of land and per unit of labour. This has resulted in an historical bias toward advancement and development of agricultural machinery and chemicals in monoculture systems. But now many of the international research centres are following research programmes on multiple cropping systems with the overall aim of improving low- or no-input agriculture.

The International Rice Research Institute (IRRI) has developed a strain of rice that matures in 100 days. In Nigeria, the International Institute for Tropical Agriculture (IITA) has produced a variety of cowpea that matures in 65 days, and trials are underway to investigate the possibilities of combining the two. The cowpeas, which are also resistant to several major diseases, have already been found to yield well when grown with maize - and to flower and begin to pod before the maize gets too tall.

Some High Yielding Varieties (HYV) bred for use in high-input intensive farming programmes fare well in mixed-crop systems as well, especially the less competitive varieties. But new varieties will need to be tested in typical mixtures and specific environments.

Over the centuries some mistakes with crop mixture choices or husbandry have been made. In Trinidad, for example, interplanting of coffee and cocoa led to coffee being pruned in the same way as cocoa, which is incorrect and counter-productive.

Mistakes will continue to be identified or made but the drawbacks associated with intercropping have - so far - been few and far between. Weeding cannot be mechanized because of the close proximity of crops of different physical characteristics and demands. But this is not a major disadvantage because intercropping tends to prevent weed invasion and growth. Nevertheless, any weeding that has to be done has to be carried out carefully and this is thus time consuming. The problem is compounded because, at present, there are very few herbicides that can be used on mixed crops.


Panscoop

A cassava banana-papaya crop association in Cape Verde

Similarly, harvesting has to be carried out carefully so as not to damage the standing crops. The main problem of intercropping identified thus far is that it is labour intensive.

The usual model for agricultural research has tended to be one of Technology Transfer, which favours resource-rich farmers who can afford expensive agricultural inputs or capital investments, and which, historically, concentrated on agricultural production in temperate climates. The exploration of tropical-zone farmers' choices of technology, cropping patterns and other factors of their food production has only recently begun in earnest.

The emerging model is one which relates agriculture to the world's differing ecosystems. This involves a holistic and interdisciplinary appraisal of farming families' needs, resources and problems, where scientists and research stations have a consultancy role. The new model, incorporating the socio-economic and agro-ecological conditions of tropical farmers, and developed with a view to long-term viability, is envisaged to have a much better chance of alleviating rural poverty than any that have gone before.

Intercropping

Benefits:
- Crop yields increase, total farm output is generally raised and varies less from year to year.
- Harvests are spread, extending food supply over a longer period.
- A variety of food is produced reducing the risk faced by farmers who rely on single crops.
- Weed invasion is reduced.
- The damage done by pests and diseases is reduced.
- Soil fertility is improved for future crops.
- Environmental resources (solar radiation, soil nutrients, water) are maximized.
- Soil erosion is reduced through better cover from sun and rain.
- Space is provided for crops required in small quantities (plants for sauces, medicinal herbs, gourds) and for fuel and fodder crops.

Disadvantages:
- Weeding cannot be mechanized, and has to be done more carefully.
- Husbandry is labour intensive.
- There are few herbicides that can be used on mixed crops.

MAJOR SOURCES

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AGROFORESTRY

Background

Traditional farming methods used in tropical countries were developed to reduce the risk of crop failures more than to provide maximum production. As a result, the traditional cropping and grazing systems used on relatively infertile, dry, or erosion-prone sites often involve multiple crops, intercropping, and complex crop rotation schedules. However, the traditional systems are not productive enough to provide for the rapidly expanding populations of the Tropics. They need to be modernized and further developed.

On fertile and well-watered alluvial soils where traditional farming was based on monocropping of rice or wheat, it has been possible to increase yields by adapting modern temperate-zone technologies, including applications of fertilizers and pesticides. But in the less well situated sites, many attempts to replace complex, traditional farming systems with modern monocrop agriculture have failed, apparently because of high risks from climate, pests, and difficult soils and because of the complex socioeconomic conditions that often prevail. So, in recent years, some scientists have begun developing modern technologies to improve, rather than replace, the traditional farming systems (26). This approach to tropical agriculture development is still promoted by only a small number of agricultural scientists.

Agroforestry is a name for a collection of land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately grown on the same land with agricultural crops and/or animals in either spatial arrangements or temporal sequences. Agroforestry is a new word, not a new concept. The novelty lies in formally recognizing that many different tree-based land-use systems possess certain common features that hold great promise in the Tropics.

On fertile lands, intensive agroforestry systems, like intensive agriculture, can support dense populations. Agroforestry, however, is probably more important for improving and sustaining the productivity of the lands with soil fertility and soil moisture problems, and where lack of rural infrastructure and cash make it necessary for people to produce most of their own basic needs for food, fodder, fuel, and shelter.

Agroforestry Systems

Description

Agroforestry encompasses many well-known and long-practiced land-use systems on cultivated or grazed lands in the Tropics (table 29). Traditional shifting cultivation, bush fallow systems, and all forms of "taungya" afforestation* fall under this term, as do the home gardens of the wet tropics and the use of fodder trees and shrubs in the dry Tropics.

*Taungya: Burmese for hill cultivation. Agricultural crops are planted with trees used for wood production.

Table 29.—Some Prominent Agroforestry Systems in Developing Countries

Southeast Asia	Southern Asia	Mediterranean and Middle East	Eastern, Central, and Humid West Africa	Arid and semiarid West Africa	American Tropics
1. Agro-silviculture					
1. Commercial trees among crops 2. Fruit/shade trees among crops 3. Live fences 4. Shelterbelts 5. Taungya 6. Shifting cultivation systems 7. Intercropping in plantation crops (rubber, oil palm, coconut)	1. Taungya 2. Plantation crops + arable crops 3. Commercial trees and fruit trees with crops 4. Live fences + shelterbelts 5. Various trees on farmlands for productive functions 6. Various forms of shifting cultivation 7. Medicinal plants + agriculture species	1. Olive + cereals (on terraces, 'banquettes', 'cuvettes', etc.) 2. Poplars along irrigation canals 3. Trees for sand dune reclamation 4. 'Huertas' – small plots irrigated crops + fruit trees 5. Aromatic, medicinal and fruit trees with crops	1. Taungya 2. Cacao/food crops/forest complex 3. Plantation crops (oil palm/rubber) and root crop complex 4. Coffee + banana 5. Mixed perennial crops 6. Gum arabic + millet 7. Shifting cultivation/bush fallow systems	1. Use of trees on farmlands for protective role (windbreaks, dune fixation) 2. Productive + protective role of trees on farms (*A. albida/Leucaena* + agriculture crop systems)	1. Trees in perennial cash crops (coffee, cacao, tea) 2. Trees for organic matter and mulch with annual crops 3. Tree live fences 4. Windbreaks and shelterbelts 5. Trees as support for climbing commercial crops 6. Taungya 7. Shifting cultivation systems
2. Silvo-pastoral					
1. Pasture in forest plantation 2. Pasture in secondary forests 3. Commercial trees in pastures 4. Fruit/shade trees in pasture 5. Fodder trees 6. Coconuts + pasture	1. Pasture under trees 2. Plantation crops + cattle grazing 3. Fodder trees and shrubs 4. Fruit trees and commercial trees in pastures	1. Oak forest + grazing 2. Pig breeding and forestry 3. Range land improvement	1. Gum arabic + livestock 2. Plantation crops (coconut/cashew) + pasture	1. Nomadic/semi-nomadic/transhuman 2. Sedentary livestock grazing systems/browsing systems 3. Fodder tree/shrub systems	1. Trees in pasture 2. Pasture in natural regeneration forest 3. Trees lopped for fodder 4. Trees used for browsing
3. Agro-silvo-pastoral					
1. Crops and grazing in plantations 2. Agriculture tree crops + grazing in forest plantation 3. Multipurpose trees with crops/animals 4. Integrated farming systems with agriculture plantation crops (rubber, coconut, oil palm)	1. Plantation crops + arable crops + livestock 2. Agriculture tree crops + grazing in forest	Range land management	1. Coconuts/other plantation crops + food crops + grazing 2. Coffee + banana + dairying 3. Horticultural complex systems 4. Plough culture complex systems	1. Forestry dominating (forest lands) 2. Agriculture dominating (crop lands) 3. Livestock dominating (crop lands)	1. Agriculture plantation crops (coconut, rubber, fruit, trees) with crops and pastures

Table 29.—Some Prominent Agroforestry Systems in Developing Countries—Continued

Southeast Asia	Southern Asia	Mediterranean and Middle East	Eastern, Central, and Humid West Africa	Arid and semiarid West Africa	American Tropics
4. Home gardens					
Various forms of multispecies combination	1. Multistorey plant canopies in humid regions 2. Aridisemiarid systems	Mainly in large cities	Various forms	Various forms	Various forms
5. Others					
1. Silviculture in mangrove forests 2. Agri-silvi-fishery 3. Trees on bunds in fish breeding ponds 4. Swidden farming 5. Fuelwood agroforestry	1. Mixed perennial cropping 2. Irrigation systems 3. Various site-specific systems 4. Fuelwood systems	1. New system in Morocco (spice plantation for erosion control) 2. Agriculture + forestry 3. Fruit trees in deserts 4. Mushroom cultivation in forest	1. Pastoral systems with corral farming (highland/lowland) 2. Mixed perennial cropping	1. Oasis 2. Irrigation systems 3. Various site-specific systems	Mixed perennial cropping

SOURCE: Anonymous, "A Global Inventory of Agroforestry Systems," *Biomass* :241-245, 1983.

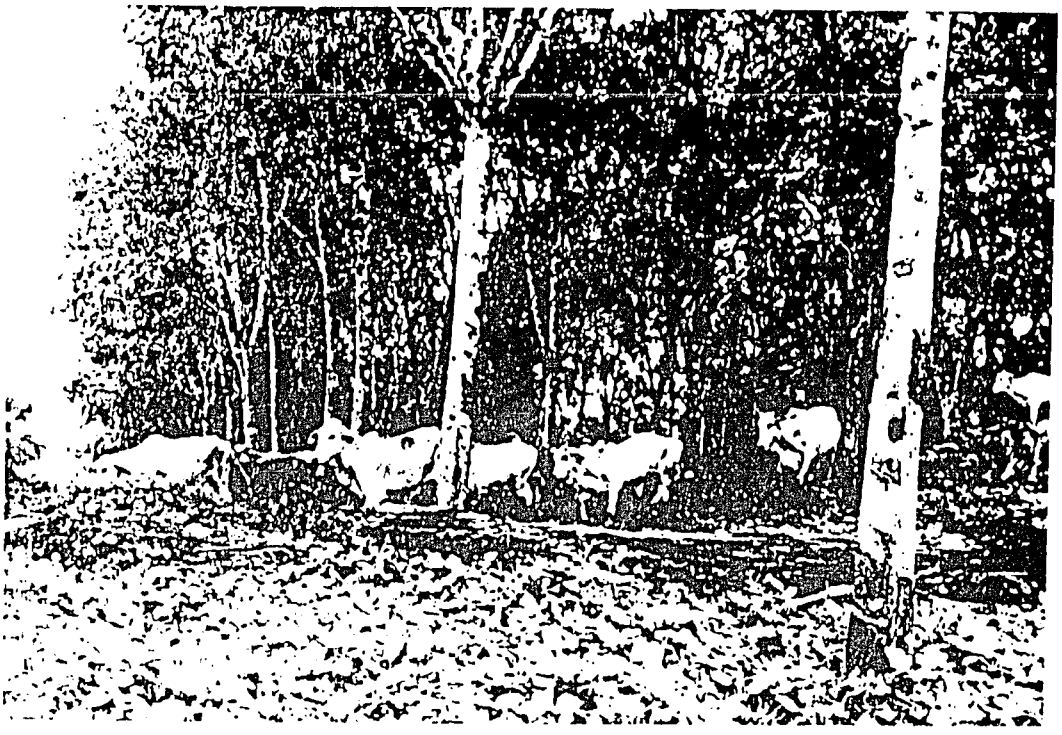

Photo credit: S. Hecht

Rubber trees interplanted with a cover crop of *Pueraria phaseoloides* and grazed by cattle is one type of agroforestry system

Agroforestry systems attempt to optimize ecological and economical interactions between various components (trees and shrubs/crops and animals) to obtain a higher, more diversified, and/or more sustainable total production than is possible with any single land use. Typical characteristics of such systems are: 1) two or more species of plants (or plants and animals), at least one of which is a woody perennial; 2) two or more outputs; and 3) a production cycle of more than 1 year.

Agroforestry can provide many goods and services. Depending on the particular situation, it may:

- increase and improve food production yields;
- produce firewood and a variety of other raw materials from shrubs and trees for farmers' subsistence, for local sale, and sometimes for export;
- protect and improve the soil's productive potential;
- improve social and economic conditions in rural areas by creating jobs and income and reducing risks; and
- develop land-use systems that draw on both modern technologies and traditional local experience and that are compatible

with the cultural and social life of the people concerned.

Classification and Assessment

Many reviews of traditional agroforestry systems and practices in the Tropics and subtropics have been published,* but most are only descriptive accounts. Rarely are any quantitative data included on the number of people or areas involved. Nor have many in-depth analyses of the environmental and economic advantages or disadvantages of the systems been conducted. The reviews do show, however, that agroforestry has been practiced for a long time with apparent success in almost all parts of the dry and wet tropical and subtropical worlds.

Agroforestry systems have been classified in different ways according to 1) physical structure, 2) temporal arrangement, 3) relative importance and role of components, 4) production aims/outputs, and 5) social and economical features (see 11,19,24,41,42). The following discussion of agroforestry is based on three socioeconomic production categories: commercial, intermediate, and subsistence (26). The divisions among categories are not discrete; rather they represent a continuum of production systems. Nevertheless, it is a suitable basis for discussing potentials and problems of further development and large-scale implementation of agroforestry.

Commercial agroforestry systems typically have as their aim the production and sale of crops, often a single commodity. These systems have been the object of systematic development efforts by horticultural, agricultural, or silvicultural institutions. Commercial tree crops (e.g., coconut rubber or oil palm) are interplanted with food crops or forage crops, or the understory is grazed by animals. The use of commercial timber species in conjunction with cacao is better developed than with almost any other cash crop system. Grazing cattle under plantation trees has attracted much attention as a promising way of increasing total yield from the land. An example is the Jari Project in Brazil, where seeding the pine plantation (*Pinus caribea*) with forage grass (*Panicum maximum*) reduced the need for weed control. The cattle then increased the total income from the system (21).

Many commercial timber and pulpwood plantations in the Tropics have been established through the "taungya" system. Farmers or forest laborers are allowed to grow crops for a few years during land preparation and early plantation phases. In exchange, they weed and care for the young trees. After an agreed-upon period, the farmers move on. Taungya has been used for more than a century and has been applied throughout the Tropics. Although well-planned taungya can provide a sequence of new ground for shifting cultivators, it removes the land from agriculture for a period dictated by the biology and economics of the forest crop and not by the needs of farmers or forest laborers.

The widespread use of this system and its many local variations is a clear indication of its success (25). The practice has been successful with *Terminalia*, *Triplochiton*, and several *Meliaceae* in West Africa; *Cordia* in Surinam; *Tectona* in Trinidad; and *Swietenia* in Puerto Rico (45). In Nigeria, the system has been applied in both wet and dry zones for tree and food production. In that country, it has been credited with providing enough food for about 700,000 people, or about 1 percent of Nigeria's food needs (13).

The increased use of commercial, commodity-oriented agroforestry is attractive in theory. However, the areas under perennial agricultural tree/shrub crops occupy about 8 percent of total arable area in developing countries today (27). Of this, only a minor part is used for intercropping or grazing. Another 2 million hectares of perennial agricultural tree plantations could be established by the year 2000 without encountering serious marketing problems (38). But this approach has limited potential for substantially alleviating land problems. Since commercial agroforestry will be intro-

*For Latin America see Budowski (7); Weaver (46); Ampuero (2); de Las Salas (12); Wilken (47); Budowski (8). For Africa see FAO (14), von Maydell (43); Seif el Din (36); Okigbo (30); Iyamabo (23); IITA (22); Poulsen (33,34). For Asia see Atmosoedarjo and Wijayakusumh (4); Generalao (18); Ahmad (1); FAO (15).

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duced only where opportunities for profits are clearly perceived, it is unlikely to be used on infertile land or by people who are not entrepreneurs. This objection applies less to timber plantation land, where small improvements in taungya could produce significant increases in food production. Forest plantation lands could then support considerably more people than they do now.

Intermediate agroforestry systems are where farmers with small to medium sized landholdings combine production of perennial crops for cash with annual crops for subsistence. Some of these systems are oriented toward commercial production, but they are small and the land is operated by individual farmers. Others are similar to subsistence systems. An example is the combination of gum arabic trees (*Acacia senegal*), which can provide good cash income to farmers, with millet in the Sudan. Another intermediate level agroforestry system occurs when commercial firms enter into contracts with small- and medium-scale farmers to produce raw materials. The British-American Tobacco Co. in Kenya has contracts with farmers who grow tobacco and the fuelwood needed for curing it, together with their own food crops.

Coffee forms the economic basis for many integrated land-use systems in this category, particularly on fertile soils in tropical uplands. In the East African highlands, multistory production is common. Timber trees such as *Albizzia* and *Grevillea* shade coffee interplanted with bananas and beans (33). Similarly, in Costa Rica coffee is grown under the shade of both timber trees (*Cordia alliodora*) and multipurpose trees (*Erythrina* spp.) (7,8). Another important crop in tropical small-holder agroforestry is coconut. Planting food crops and grazing cattle under coconuts are common practices in the wetter parts of Sri Lanka, India, Southeast Asia, and the Pacific regions (28).

Most of the economically and ecologically successful examples under this category are found in areas having relatively fertile soils, good communications, and existing market infrastructure. But many obstacles can be encountered when expanding permanent cash crops into less favorable areas, where infrastructure and markets are underdeveloped, where land tenure is uncertain, or where the environment imposes serious restrictions on intensive land use. Still, there is promise for improving existing systems through the introduction of improved varieties of tree crops, fruit trees, and compatible food crops, as well as application of fertilizers.

Subsistence agroforestry systems are oriented toward satisfying the basic needs of farmers for food, fuel, and shelter, with some products sold for cash income. Such systems are practiced by a large portion of the population of the tropical world, from livestock herders in semiarid areas to shifting cultivators in rain forests. These systems usually are practiced where serious ecological and/or socioeconomical constraints exist. Infertile soils, erosion, and/or drought can be major physical limitations. Insecure land tenure and lack of infrastructure, capital, extension services, and education are common socioeconomic constraints.

Many different subsistence agroforestry systems exist. Shifting cultivation and bush fallow are practiced in many forms throughout the tropical world. One well-known form of permanent traditional agroforestry is the home gardens of Southeast Asia, characterized by a multistory mixture of many species of trees, shrubs, climbers, palms, tubers, and often animals (pigs and poultry) (16). Other agroforestry in Asia integrates rice production with trees for windbreaks, boundary demarcation, and fuelwood production (6,16).

Oases are a prototype of agroforestry in arid lands. They contain ponds to water livestock as well as an upper story of multifunctional trees and a lower story of agricultural or horticultural plants. Though only comprising a small area endowed with water and fertile soils, they can be extremely well-balanced human ecosystems with species mixture, multistory structure, and near-perfect recycling processes (44).

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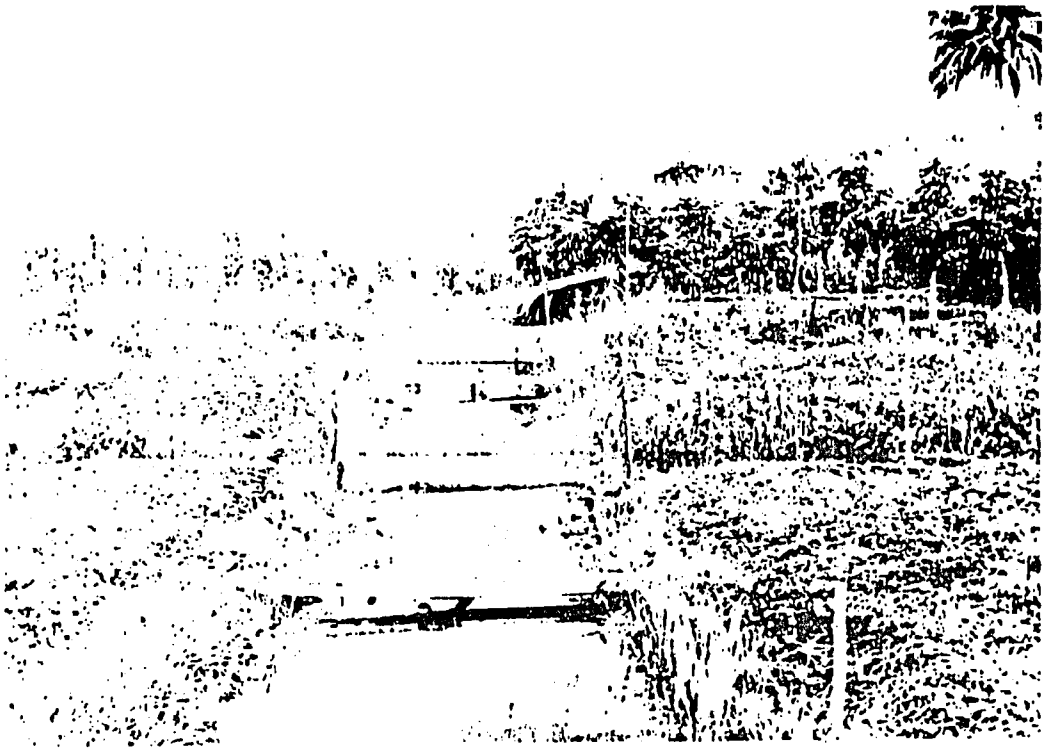

Photo credit: K. Parker

Chinampas in Mexico are centuries-old food production systems used where water is available year round. Narrow irrigation/drainage canals surround the plot and control water supply; mud dredged from canals serves as organic fertilizer; aquatic vegetation serves as "green manure;" fish that colonize the canals provide additional protein; trees planted along the canals hold the soil in place as well as providing other products

Millions of people practice agroforestry in areas with serious physical and socioeconomic constraints. The problem of improving the productivity and sustainability of these people's agriculture and agroforestry methods is of an entirely different magnitude than that of improving commercial and intermediate agroforestry systems. Reaching farmers can be difficult, and where subsistence farmers can be reached, they need to be convinced that the costs, risks, and benefits of new technologies are favorable. The time between planting a tree and achieving significant yields may involve risks that subsistence farmers cannot take. It also can be difficult to convince land users to make long-term investments when land tenure is uncertain. Subsistence agroforestry holds great potential for improving land use but has urgent need for technology improvement.

Technology Issues

In general, the concept of agroforestry as a sustainable approach to land use is sound. The aim is to create productive farming systems able to supply an increasing and sustainable output of basic needs, including cash. Maintaining soil fertility, preventing erosion, moderating microclimate, and other environment-enhancing roles of the tree/shrub component apparently do help sustain production.

A growing body of information exists on the various agroforestry technologies, but this is mainly descriptive and qualitative. Most scien-

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tists' interest has been in the tree/shrub component (e.g., potential tree species, their use, and management) because of the novelty of using trees and shrubs in agricultural and pastoral lands.

During the last 5 years, many agroforestry research projects have been initiated at university forestry departments and forestry research institutes. These generally study the long-term economic and ecological productivity of various trees, planted at different spacings, and combined with a food crop, which is often used as a "test" crop to quantify the competitive or soil-improving influences of the tree.

Only certain trees and crops prove to be compatible. Rubber trees, for instance, produce so much shade that underlying pasture often becomes useless within 3 years. Oil palm soils are often clayey and wet and animals tend to compact the soil and damage tree roots (17). Some crops such as sorghum, millet, and pigeon pea are highly competitive with other plants and, thus, may not be suitable for intercropping. Other crops—maize, cotton, and dry rice—are less competitive and can be intercropped. Each system has complex problems of intraspecific and interspecific competition. The aim of experimental research is to optimize combinations of agriculture, pastoralism, and forestry over space and time.

Tropical research and development organizations have become much more interested in multipurpose trees. The legume family has attracted particular attention. In general, legumes, through their bacterial relationship, can improve soil fertility and produce good-quality fuelwood as well as leaves and pods with fodder and food value. Different legume species also are adapted to a wide range of ecological conditions. Many multipurpose species are found in the legume genera *Acacia* and *Prosopis*. Several nonlegume multipurpose species are equally interesting because of their general versatility, adaptability to less favorable sites, and yield of valuable products. An example is the neem tree (*Azadirachta indica*) which originated in the dry zones of Asia. It is an excellent timber, fuelwood, and shade tree and produces tannins, insecticidal chemicals, and fuel/lubricant oil (35).

The greatest potential for improving agroforestry systems lies in the practically unexplored field of genetic improvement of multipurpose trees and shrubs (26). Selecting the species and varieties that are best adapted to particular purposes and site conditions for which the agroforestry systems are intended is the first step. Traditional agroforestry systems have been doing this gradually for centuries, but now with modern communications and techniques for reproducing, transporting, and testing varieties, it is possible to greatly accelerate the process.

Because the scientific attention to multipurpose trees is so new, examples of the gains that can be achieved by this selection and matching process are rare. The interest in single-purpose use of trees is older, and gains with these illustrate the potential for multipurpose trees. For example, results from 32 sites in 18 countries show that productivity gains of several hundred percent could be achieved in eucalyptus trees simply by selecting the best-adapted provenances for prevailing conditions (31).

The second step, which can begin before the first is completed, is tree breeding—crossing plants to combine particular desired characteristics, such as fodder and fuel production quantity and quality, rooting characteristics, phenology favorable for interplanting with annual crops, nitrogen-fixation, pest resistance, drought resistance, or the ability to withstand other stresses.

The potential for agroforestry systems improvements to be adopted on a large scale by farmers and pastoralists is difficult to assess. If the relevant land-use problems have been identified and an ecologically, economically, and socially well-adapted agroforestry solution is demonstrated to be feasible, then agroforestry improvements may be adopted. However, finding locally acceptable solutions to problems that are perceived by farmers is crucial. Sophisticated trials on the best spacing of trees over crops are, for example, not particularly

relevant if farmers are not interested in that particular tree species.

The constraints and problems encountered in developing and disseminating agroforestry systems are many. Millions of farmers and landless people are spread over vast expanses of tropical lands. Rapid population growth, insecure land tenure, erosion, droughts, floods, declining soil fertility, lack of infrastructure, political instability, illiteracy, and other development problems often characterize those broad regions where agroforestry approaches have a potential role to play. Therefore, agroforestry development cannot occur in isolation from general social and physical constraints on rural development.

Constraints and Opportunities

Agroforestry techniques can be used to address particular land productivity problems. However, most information on the technique is qualitative and advocative. Present research and field implementation efforts are more ad hoc than systematic.

Critical analyses of agroforestry's constraints and opportunities must be made if it is to benefit from application of the scientific method. Systematic quantitative information can provide a basis from which researchers can formulate hypotheses and design efficient research strategies to develop new agroforestry systems, refine old ones, and adapt proven ones to other areas. This is necessary to ensure that only technologies with high probability of success are brought to large-scale field implementation.

The effort to organize and assess existing national and international experience in traditional agroforestry technologies and to identify promising technologies for further development is under way at the International Council for Research in Agroforestry (ICRAF). Technologies that need refinement and farm validation include alley cropping, improved fallows, live fences, contour hedges, mulch production with tree species, and fodder production. Some such programs already exist, but efforts should be made to strengthen these (table 30).

Table 30.—Organizations That Work on Agroforestry Systems

1. International Council for Research in Agroforestry
2. Centro Agronomical Tropical de Investigacion y Ensenanza (CATIE)
3. International Tree Crop Institutes (U.K., U.S.A., and Australia)
4. Nitrogen-Fixing Tree Association
5. National Academy of Sciences (fuelwood and legume tree species)
6. Commonwealth Forestry Institute (information, research, and training)
7. East-West Center (dissemination and exchange of agroforestry information)
8. United Nations University (workshops and research programs at cooperating institutions)
9. Some components of UNESCO/MAB research program
10. Some developed country universities
11. Some CGIAR institutions (e.g., IITA in Nigeria on alley cropping and CIAT in Colombia on *Leucaena* and *Erytherina*)
12. FAO's Panel of Experts on Forest Gene Resources (data collection and assessment)

SOURCE: B. Lundgren, "The Use of Agroforestry to Improve the Productivity to Converted Tropical Land," OTA commissioned paper, 1982.

Since agroforestry cuts across several disciplines, it requires an integrated and multidisciplinary approach. Agronomists, foresters, ecologists, sociologists, anthropologists, and experts in other related disciplines have accumulated much data on various tropical mixed-cropping systems. Such information can become the foundation for research programs to explore ways to integrate sustainable production of food, forage, and fiber needs on appropriate lands. However, too little communication or coordination occur among these disciplines to formulate a strategy for development of agroforestry technologies. This constraint would be alleviated if interdisciplinary teams were established to conduct research on integrated land-use systems (26).

Agroforestry needs an institutional home to ensure its implementation. It is considered a subdivision of forestry, but forestry institutions deal with forest land. They seldom address the problems facing individual users of small and medium size holdings of cultivated lands. Forestry institutions, in general, do not have the range of expertise needed to develop agroforestry's full potential. The major potential for agroforestry lies in the integration of trees into

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agricultural and pastoral lands. The development of these lands is the mandate of agricultural institutions, which are not explicitly mandated to deal with agroforestry.

Rigid boundaries between disciplines affect funding of agroforestry research, development, and implementation. Forestry and agriculture often compete for both funds and land. In international agencies, agricultural divisions are better institutionalized, more prestigious, and, thus, better funded than forestry divisions. The forestry funds that do exist usually are channeled to conventional forestry activities.

The ratios of international financial support for research in tropical agriculture, forestry, and agroforestry, respectively, are about 200:10:1 (26). This may underestimate the relative magnitude of agricultural research support. Although the importance of research is clearly recognized in agriculture, the attitude of development assistance donors toward research in forestry is cool. Thus, as long as agroforestry funding is channeled through forestry departments, little hope exists that sufficient research funds will be available. A thorough rethinking and revision of the appropriate institutional home for agroforestry is needed.

The large-scale promotion of agroforestry would require incentives to encourage farmers to adopt practices that involve initial risks and delayed returns. Integrating trees into agricultural or pastoral systems is unlikely to succeed where short-term, insecure leases for use of land are prevalent, where trees automatically become the property of the government, or where nonrestricted communal grazing or tree cutting rights exist. Neither are farmers likely to achieve large-scale cash crop production of wood (i.e., fuelwood, poles, pulpwood, etc.) where prices are set so low that growing trees is not profitable.

To alleviate these constraints, tropical governments will need to identify and remove constraints in land tenure and provide incentives and extension services. Incentives may take the form of credits and loans that reduce initial capital outlay and minimize risk of failure. Extension services can facilitate supply of materials, train farmers, and make followup visits to monitor progress of agroforestry development. Unfortunately, forestry and agroforestry extension efforts often suffer from: 1) lack of staff with adequate training, 2) lack of networks of on-farm demonstration plots, 3) inconsistent efforts, 4) difficulty obtaining good seeds of multipurpose tree species for mass distribution to farmers, and 5) lack of infrastructure.

As institutional interest and support for agroforestry increase, it is necessary to take steps to ensure that the enthusiasm does not lead to disappointment and a sharp reduction of support. Development assistance agencies and research institutions have not begun, collectively or individually, to formulate a strategy to assure that the necessary and sufficient steps are taken to develop the potential of agroforestry.

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AGROFORESTRY: CONCEPTS AND PRACTICES

*Dr. Filemon Torres**

1. *Introduction*

Woody components have traditionally been included in small-holder management systems of the American, African and Asian Tropics as a source of fuel or food, and to restore soil fertility, particularly in the so-called shifting cultivation areas.

The traditional use of land by the small-holder of the tropics has been particularly affected by demographic pressure, leading to an increase in the proportion dedicated to cropping (either for household consumption or marketing the latter to meet higher cash needs), with corresponding shortening of the fallow period necessary to restore soil fertility (Fig. 1).

As a consequence, food production *per capita* in developing countries with a market economy has been kept almost constant, leading to an increase in the food deficit over time (Fig. 2).

The high input requirements of temperate zone tech ology (high-yielding varieties & fertilizers) and their detrimental effect upon natural renewable resources and social equity have tempered the enthusiasm initially aroused by their application.

These circumstances have led to the revival of an old practice, now called agroforestry, based upon the development of the interface between the agricultural and the forestry use of the land.

*Senior Research Scientist (Range Management & Livestock Production) at ICRAF.

FIG. 1: *Land Pressure and Land use*

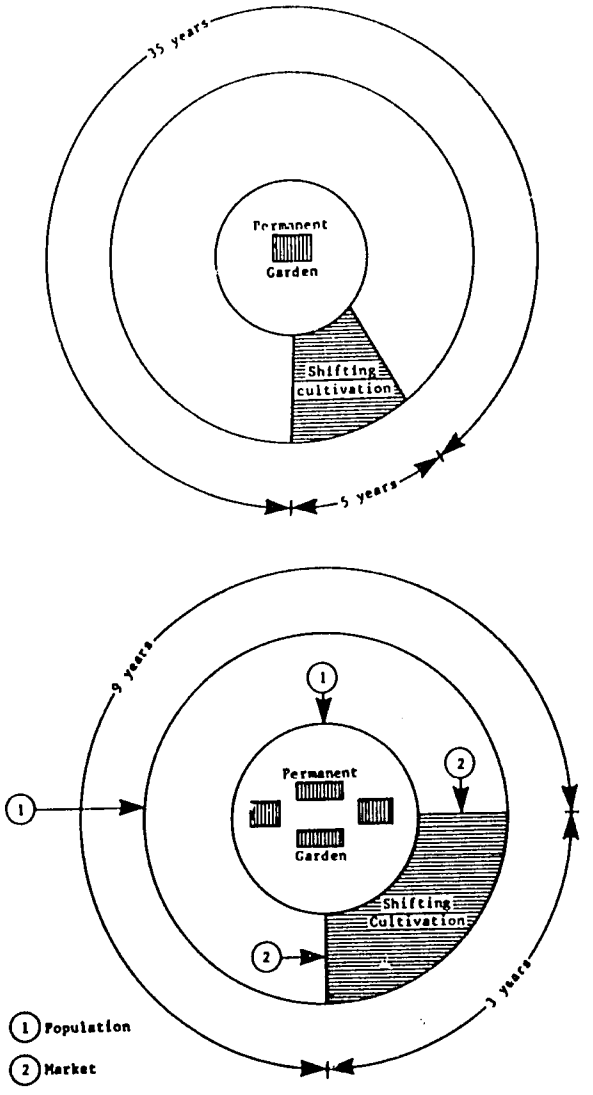

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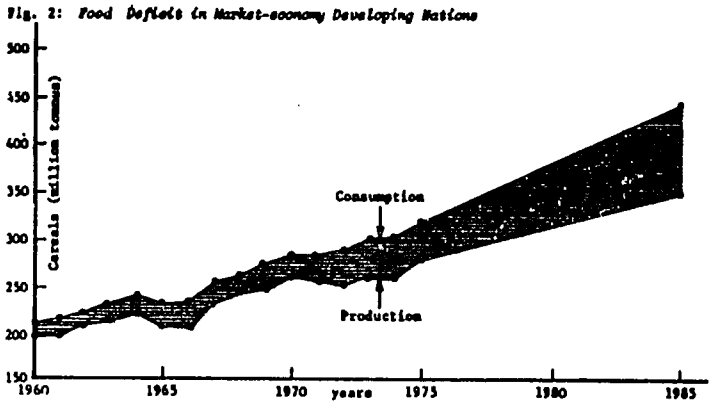
Fig. 2: *Food Deficits in Market-economy Developing Nations*



2. *The biophysical potential of agroforestry*

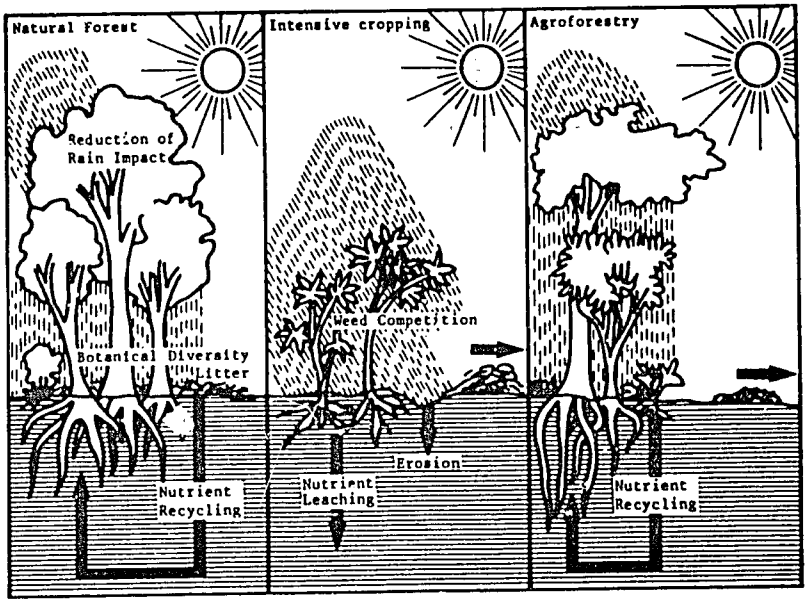
Agroforestry can be defined as the deliberate combination of trees with crop plantation or pastures, or both, in an effort to optimize the use of accessible resources to satisfy the objectives of the producer in a sustainable way.

The principle behind the development of an agroforestry technology is that of creating an architecture of the above-ground biomass that imitates the climax vegetation of the tropics, i.e., the one of the multi-strata forest. Fig. 3 tries to represent schematically the capability of the conventional and the agroforestry systems to achieve such imitation.

Such systems could improve *productivity* in quantitative (through supplementary relationships between herbaceous and woody components) and qualitative (by producing outputs that satisfy most of the operator's needs) terms.

But they are also meant to be *sustainable* over time, in terms of both their ability to satisfy basic needs under extreme circumstances and to reduce system "leakiness", by enhancing nutrient recycling, preventing soil erosion, conserving soil moisture, etc.

Fig. 3: *Comparison of an agroforestry system with other systems*



The amplitude of that definition implies that several agroforestry systems can be generated according to the components included in the combination, the role of the indispensable component in the system (the woody one), the type of interaction between these components and the others in the system (spatial or temporal), and the way in which the woody component is distributed in space (Fig. 4).

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Fig. 4: *Agroforestry systems*

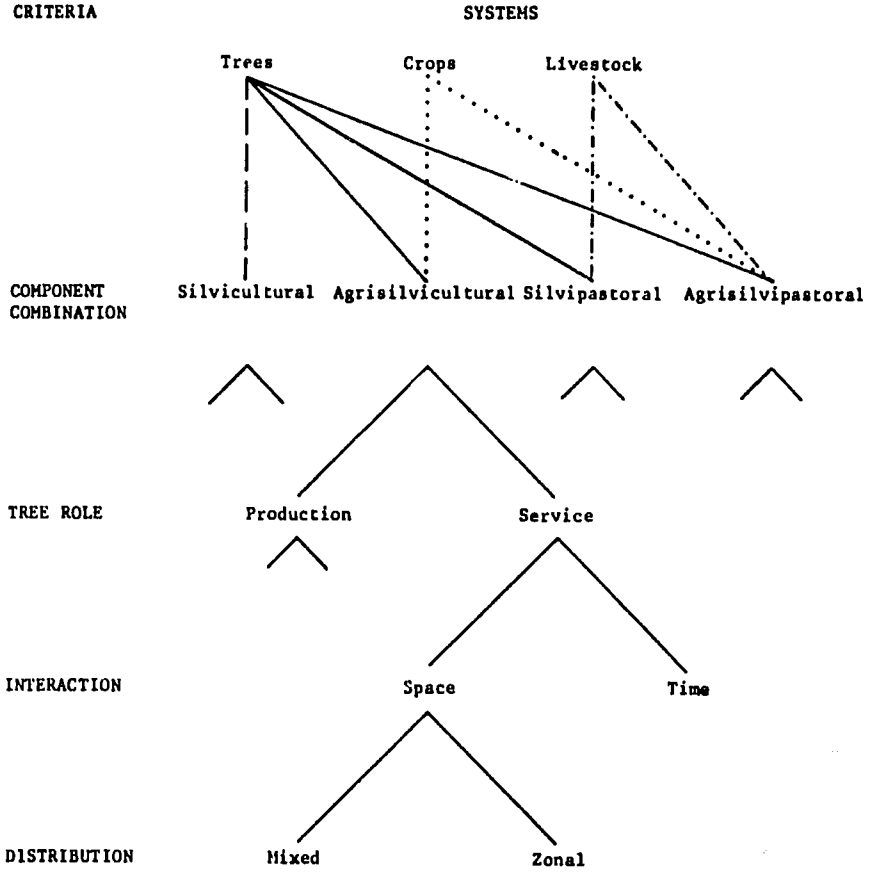

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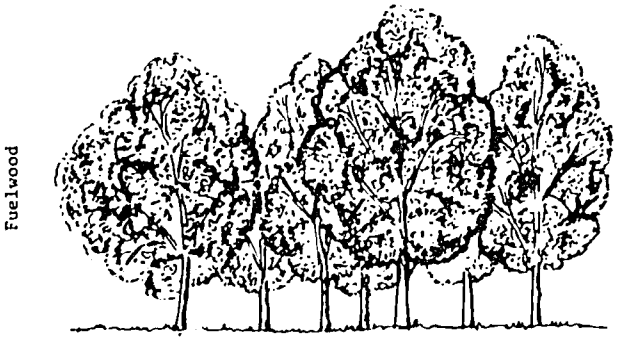
Fig. 4 (b): *Silvicultural systems*

System	Tree role			Distribution	
	P	S		M	Z
Fuelwood	✓	✓			✓



3. *Agroforestry systems*

3.1 Agro-silvicultural systems are those dealing with the concurrent production of food crops and either forest (with a "productive" and/or "service" role) or tree crops. Fig. 5 systematically represents the architecture of some conceptual system of the agro-silvicultural type, and its "classification" according to the criteria mentioned in Fig.4. Fig. 6 and 7 indicate the effect that woody species could have upon soil fertility, as components of potential "improved fallow" systems, or when combined in space. Fig. 8 shows the "service" effect of an alley cropping system upon maize production, as compared with fertilizer application.

3.2 Silvo-pastoral systems integrate trees (timber, food or fodder producing ones) with pasture and livestock. Fig. 9 is an attempt to represent the architectural profile of conceptual combinations of the silvo-pastoral type, and its corresponding "classification".

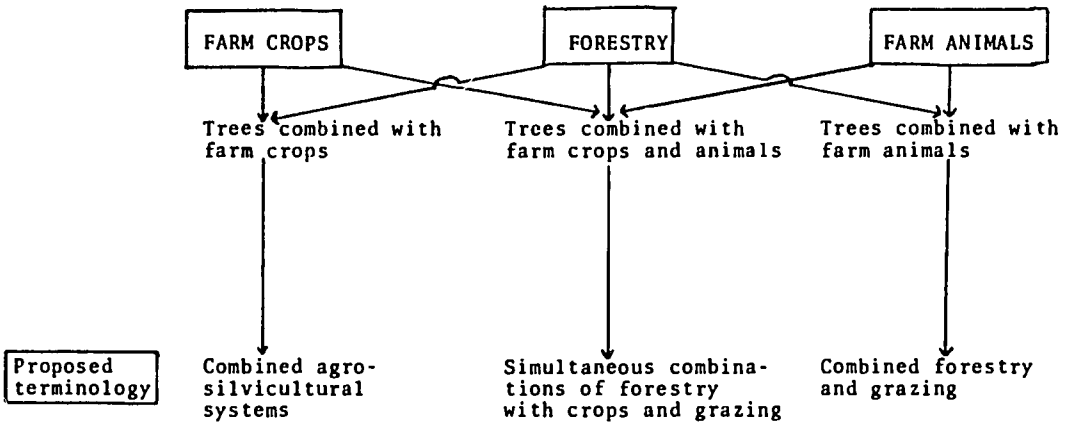
4. PROPOSED CLASSIFICATION AND TERMINOLOGY OF AGRO-FORESTRY TECHNIQUES

4.1 French

Applying the foregoing concepts, we propose the term agro-forestry for the general concept. This includes all techniques wherein forest production is associated with farm crops and/or animals.

4.1.1 Classification by Types of Agricultural Output. An initial level of classification is proposed covering the types of agricultural products combined with forestry under various systems. For this purpose, we repeat the items in Diagram 1 in the Introduction.

Diagram 2. Classification of agro-forestry systems by kind of agricultural output.



4.1.2 Classification by major function of the forest component. A second level of classification is proposed according to the function of the forest component within the system. By this we mean the principal objective behind the establishment of this component in a non-forest environemnt. The main functions are: Production; Protection and services.

The main agro-forestry techniques, which are discussed in the following chapter, are classified as indicated in the following pages.

Table 1. Classification of major agro-forestry techniques by function

	SILVO-AGRICULTURAL SYSTEMS		SILVO-PASTORAL SYSTEMS	
PRINCIPAL FUNCTIONS	PRODUCTION	PROTECTION AND SERVICES	PRODUCTION	PROTECTION AND SERVICES
	Agro-silviculture (Taungya systems)	Live fence posts Windbreaks	Forest grazing Grazing in young forests	Live fence posts Windbreaks
	Commercial trees combined with crops	Shade trees among crops	Commercial trees combined with grazing	Shade trees in pasture
	Fruit trees combined with crops	Trees to conserve and improve soil (climate, water, etc.)	Fruit trees combined with grazing	Trees for soil conservation and improvement (climate, water, etc.)
	Pisciculture	Trees grown on bunds in fish-breeding ponds	Fodder trees	

Table 1 calls for three important observations:

1. Agro-silvo-pastoral systems are not mentioned. This is because such systems are much more complex than the two-component systems. The large number of possible combinations makes it difficult to evaluate them. Generally speaking, these systems are marked by a close correlation of objectives. The forest component has a productive as well as a protective function. Concrete examples are given in Ch. 6.

2. We classify agro-forestry techniques by the major function of the forest component, though well aware that functions are usually combined and vary in importance according to stage. The two functions have been connected by horizontal arrows so as to take these variations into account.

3. Lastly, several types of forest components with the same or distinct functions may well be seen in the same area. For example: Shade trees and live fence posts in pasture; shade and commercial trees among permanent crops; others.

For this reason, vertical arrows have been drawn to indicate the relationships between the techniques of each system in terms of possible combinations.

4.1.3 Classification by distribution in time and space. Lastly, at the third level of classification we consider the distribution of the forest component in time and space.

As to time, the combination of a forest component with farm crops and/or animals may be either temporary or permanent. Strictly speaking, a combination is only permanent when the rotation of the species combined in the operation is of the same duration. This is rarely the case an so we shall not retain this criterion. In practice, the proposed distinction is the following:

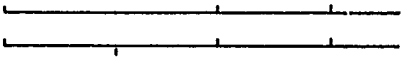
Proposed definitions: The combination of permanent, when maintained during one or more rotations of the forest component. This includes the continuous renewal of the crop grown in combination.

The combination is temporary when it does not last for the length of one rotation of the forest component. This includes sequential agricultural and forestry productions, with the temporary combinations being repeated several times.

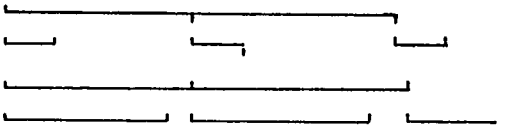
These two definitions are given schematically as follows:

Diagram 3: Temporal distributions of agro-forestry combinations

1. Permanent combinations



2. Temporary combinations



Looking at this latter diagram of temporary combinations, it appears probable that certain techniques will have to be considered as limiting cases with regard to classification in time.

Spatial distribution of the forest component in combination with farm crops and or animals can be regular (homogeneous) or irregular (heterogeneous). In the latter case we also speak of adjacent combination.

Proposed definitions:

Distribution is regular when the forest component is grown plant by plant in association with the farm crop, or rather scattered regularly among it. This includes natural regeneration as well as the planting of forest trees.

Distribution is irregular when the forest component is placed alongside or around the farm crop with which it is associated. This is particularly true of trees planted in rows or strips.

Diagram 4. Spatial distribution of agro-forestry combinations

(Each x stands for a tree)

1. Regular distribution

```
x  x  x  x  x
x  x  x  x  x
x  x  x  x  x
```

2. Irregular distribution (adjacent combinations)

```
xxxxxxxxxxxxxxxxx

xxxxxxxxxxxxxxxxx
```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4.1.4 Practical applications. The foregoing proposals on classification and terminology allow an exact description of the main characteristics of agro-forestry systems, namely:

a) Kinds of agricultural products combined with forest trees; b) Major function of the forest component; c) Duration of the combination and spatial distribution of the forest component.

These three levels of classification are represented in the following table with which we propose to classify all presently known agro-forestry techniques.

Under this third level of classification, the most frequently used agro-forestry techniques can be broked down as in the following table.

Table 2. Distinction between the major agro-forestry techniques by spatial and temporal distribution.

SPACE	TIME	
	TEMPORARY COMBINATION	PERMANENT COMBINATION
Regular distribution	Agro-silviculture (Taungya reforestation system) Grazing in plantations	Commercial trees in crops Fruit trees in crops Grazing (or fodder production in secondary forests) Fodder-producing trees Pisciculture in mangrove forests Shade-producing trees in crops or pasture Trees improving soil fertility
Irregular distribution		Live fence posts Windbreaks Trees on bunds in fish-breeding ponds

4.2 Translation

The same principles of translation can be repeated in other languages. Since this work is appearing in both English and Spanish there is no need to make a word-for-word translation of the terminology utilized herein. The main synonyms and some translations are listed in the following table.

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Table 3. Classification of Agro-Forestry Techniques

1. Kinds of associated agricultural product	Trees and crops COMBINED AGRO-SILVICULTURAL SYSTEMS				Trees and farm crops and animals SIMULTANEOUS COMBINATIONS OF FORESTRY WITH CROPS AND GRAZING				Trees and grazing COMBINED FORESTRY AND GRAZING			
2. Major function of the forest component	Product. Protect. + services				Product. Protect. + Services				Product. Protect. + Services			
3. Distribution in terms of time	Temporal	Permanent	Temporal	Permanent	Temporal	Permanent	Temporal	Permanent	Temporal	Permanent	Temporal	Permanent
Regular												
Spatial distribution												
Irregular												

5. REMARKS

Our concept of agro-forest is unusually vast, as shown by the definition given in the Introduction and the proposed classification in the preceding chapter. For some authors (and in the strictest sense of the term "agro-forestry"), the only combinations which ought not to be included are those where the forest component is of permanent duration and which are regularly spaced. Below we give our reasons for accepting temporal and spatial variations.

5.1 Timing

The justification for the inclusion of temporary combinations as part of agroforestry is as follows. It is quite rare to find a combination where the forest component and the agricultural component (s) have rotations of equal duration. Our investigation therefore has to take into account the following combinations: a) permanent, where the duration of the rotations coincides; b) permanent, where one or even all components are renewed from time to time; c) temporary, where the agricultural component is not renewed.

We note great variations in length of combination among the temporary combinations, ranging from a few months to years or even decades, depending on the crops grown together. This leads to the following conclusions:

1. Temporary as well as permanent combinations mean that the objective set forth in the definition -- optimize production whilst respecting the principle of sustained yield -- can be met.

2. The forest component calls for a particular silvicultural treatment whether in temporary or permanent combinations.

For these two reasons we are also impelled to include under the heading agro-forestry all those combinations which are characteristically planted in staggered fashion.

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SOURCEBOOK SUPPORT MATERIALS - MODULE 3

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Identifying strategies for communal and farm forestry

Over the past decade, a large number of programmes have been launched to promote tree growing by rural people. Although many of these field projects are still in their early stages, much has already been learned about the potential of various types of programmes and the problems of introducing them.

Objectives set for programmes and methods of implementing them have varied widely. Some programmes have placed tree growing objectives within a broad and ambitious social and environmental framework. Others have been intended to encourage tree growing by individual farmers, and the primary objective has been to increase the production of wood and other tree products for household consumption or for commercial markets.

Community involvement often has been seen as a means of widening the range and distribution of tree growing benefits by bringing public and community land into productive use and by involving landless people and the poor. Strengthening local institutions and generating employment have also been among the explicit objectives of many programmes.

A joint effort for trees

The differences between programmes have thus been considerable. Even so, from the experience to date, distinct strategic approaches can now be identified, each with its own specific potential and limitations. At the same time, these should not be construed as mutually exclusive. Combinations of various basic strategies can be, and often are, developed within a programme or a region.

4.1 Identifying Programme Objectives

Any strategy which is intended to stimulate tree and forest management by local people must, of necessity, be based on a well-defined and consistent set of objectives. In the past, many rural tree growing schemes have been launched under the name of "social forestry" or "forestry for local community development."

Generally, social forestry is a term used for any type of industrial, conservation or community forestry project which tries to maximize benefits for residents. Community forestry falls under this umbrella. The term community forestry was defined in 1978 by a group of international experts in a way that continues to be accepted.

> "Community forestry has been defined ... as any situation which immediately involves local people in a forestry activity. It embraces a spectrum of situations ranging from woodlots in areas which are short of wood and other forest products for local needs, through the growing of trees at the farm level to provide cash crops and the processing of forest products at the household, artisan or small industry level to generate income, to the activities of forest dwelling communities. It excludes large-scale industrial forestry and any other form of forestry which contributes to community development solely through employment and wages, but it does include activities of forest industry enterprises and public forest services which encourage and assist forestry activities at the community level. The activities so encompassed are potentially compatible with all types of land ownership. While it thus provides only a partial view of the impact of forestry on rural development, it does embrace most of the ways in which forestry and the goods and services of forestry directly affect the lives of rural people." (FAO, 1978)

Gradually it has been recognized that even the community forestry label is generic and that the social development norm of such forestry projects does not refer to one specific objective, but rather to a group of objectives. A number of broad aims can be distinguished. Generally, these projects have been intended to:

-- provide the means so rural families can supply, or have better access to, certain basic needs in the form of essential forest and tree products;

-- increase the participation of the rural people in managing forest and tree resources as a means of increasing their self-reliance;

-- use human resources to better manage degraded and marginal lands thereby counteracting the process of deforestation and environmental degradation;

-- contribute to the general socio-economic development of rural people through employment generation, institution building and promoting economic growth;

Seedlings to meet people's needs

-- help meet the needs and aspirations of both women and men in specific underprivileged groups within the rural population, such as subsistence farmers, migrant herders and the landless;

-- increase the overall production of wood or other tree products to counter growing deficits.

It should be recognized that although some of these different objectives may be congruent or may reinforce each other, at times they may be conflicting. For instance, when denuded and over-utilized agricultural lands are reforested for environmental improvement, the production of tree products may well be limited by poor growing conditions. Consequently, such schemes may not be financially attractive for smallholders interested in the production of commercial tree products. Even if smallholders do involve themselves in growing trees to meet specific market demands, it may be difficult to achieve participation, especially of poor and landless people. As a result, a given project may have an inconsistent impact among different sectors of the rural population.

It should be realized, as well, that some objectives can be met by planting individual trees in backyards while other objectives require establishing forested areas as complete and well functioning ecosystems. For example, the production of wood or fodder or fruit takes place in individual trees, even if they are standing alone; in contrast, the environmental value of a forest depends on the proper functioning of a concentrated stand of trees as an ecological unit. Even planting trees on private fields may require community agreement for the community-wide control of animals or fire.

Planting together

Thus, in identifying the objectives and strategies for programmes which involve rural people in forest and tree management, it is essential that project outputs and intended beneficiary groups be identified and linked in an internally consistent project design. Under many circumstances there may be trade-offs between effective contribution of tree management schemes to general socio-economic development and efficient creation of specifically needed forestry outputs. It is essential that each proposed project component also be analyzed separately in terms of the objectives it can realistically be expected to meet.

The relative importance of multiple objectives of local tree management schemes will, in the end, be determined by various socio-economic, political and environmental conditions. A proper

analysis of these factors is a prerequisite for developing strategies which stimulate local tree growing. The role of policy makers and planners is to establish broad development objectives as well as clear-cut priorities for the use of capital and labour resources for rural forestry so that programmes can be developed which have underlying and basic consistencies. Programmes must identify issues of vital concern to rural people - how land is to be used and protected, what sectors of society should benefit from development activities, and how forest-based needs of rural people are to be met - and then must provide adequate support to address these issues.

4.2 Types of Community Forestry Development Strategies

In addition to the proper identification of programme objectives, several other factors must be considered before developing strategies which encourage local tree growing or other social forestry activities (see Figure 4.1). Closely connected with the identification of a project's objectives are two related questions. First, who are the individuals or institutions with primary management responsibilities? Second, how is the control, use or ownership of trees and of land resources defined and organized?

Broadly speaking, the control of tree and land resources belongs either to the community (including communal groups), to private groups such as households and individuals or to the public sector. The extent to which any of these groups have control is defined by complex legal and institutional arrangements, traditions, cultures, conditions of class and systems of tenure.

Ultimately, a programme's design will define tree management responsibilities. These responsibilities will characterize the type of development strategy which is pursued, although they will likely be affected by characteristics of land and tree ownership and control. Outside of public sector managed activities, primary responsibility for land management and for tree planting will lie with the community or communal groups and with individuals and households.

4.3 Definitions and Strategic Approaches

From the experience to date, three broad approaches to community forestry activities can be distinguished. These can be classified under the following headings:

- Communal forestry
- Farm forestry for household use
- Farm forestry for the market

Within each of these categories there is a considerable range of flexibility in goals and operating methods. Nevertheless, each has important distinctive features.

Table 2.1

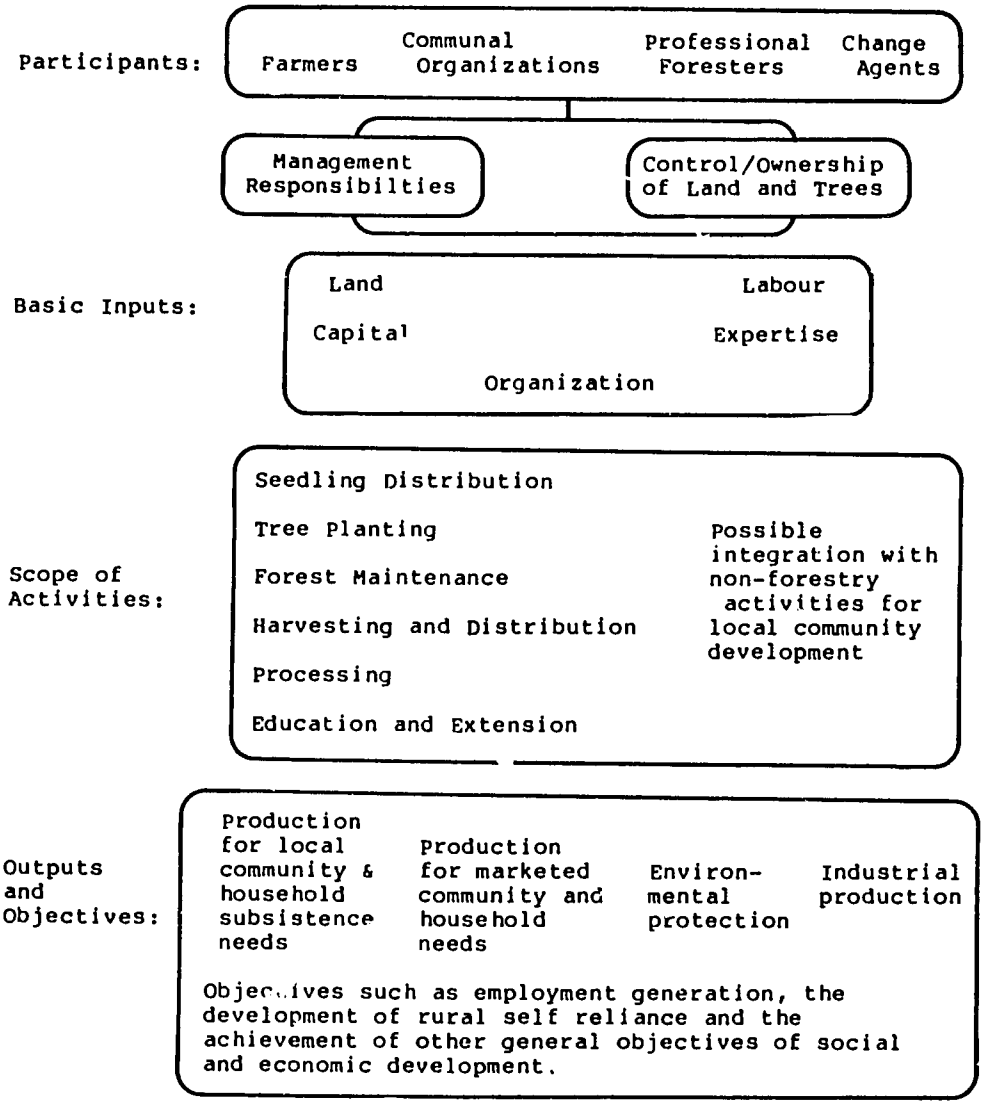
Possible Social Forestry Development Strategies

		Control/Ownership of Land		
		Private	Communal	State
Management of Tree and Land Resources	Communal	1.	2.	3.
	Private	4.	5.	6.

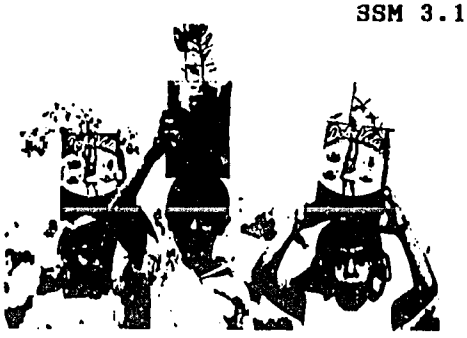
Social Forestry Management Strategy	Characteristics
Communal and Community-based Forestry	1. Tree growing on private lands organized by community institutions 2. Communal tree growing on community lands 3. Public land allocated for communal and community-based forestry projects
Farm Forestry	4. Privately managed tree farming and tree planting around households 5. Privately-managed tree growing on communal or community lands 6. Public land allocation schemes for private tree growing

Table 2.2

Developing Social Forestry Strategies



Communal forestry refers to progammes in which rural communities, or user groups, cooperatively participate in project planning and implementation. This category also includes projects based on the activities of community organizations such as schools or cooperatives which may establish nurseries or plant trees in small or fragmented private woodlots. Communal forestry may involve projects on community lands, on land which has been allocated by the state for the purpose of tree growing or on private land being managed collectively.



Proud of the school nursery's plants

Farm forestry for household use covers programmes which promote tree growing by individual farmers for their own family use. In some cases, these programmes may have the objective of increasing the supplies of fuelwood, building poles, animal fodder or other tree products; in others, the aims may be primarily environmental with trees being planted to control erosion or to increase soil fertility.

Farm forestry for household use

Farm forestry for the market refers to programmes in which the primary aim is to encourage farmers to grow trees as a cash crop. In the majority of cases, the trees are grown on private lands, but public or common lands may be used where usufruct rights have been allocated to farmers.

Teak for the market

But whatever the distinctions between approaches, the unifying factor in all programmes is that they actively involve rural people and are responsive to their ideas, needs and aspirations. It is this, more than anything else, which should distinguish community forestry approaches from conventional forestry activities.

To the extent that goals encouraging rural participation and management are successful, the forestry service will find itself able to focus on its role as a technical and supportive service rather than as an executing agency. Different services may be needed in the various strategies selected, depending upon the local constraints to tree planting.

Approaches to Farm and Community Forestry

Over the past two decades, programmes to encourage tree growing by rural people have been launched in over 50 developing countries. Though many of these are still in their early stages, much has already been revealed about the potential, and limitations, of the different approaches being used.

In some cases, programmes have relied primarily on the incentive provided by the commercial wood market. Farmers are helped and encouraged to grow trees for sale. By doing so, they increase the availability of wood products to meet the demands of the market, and provide themselves with a source of income.

Other programmes have placed tree growing within a broader and more ambitious framework of social and environmental goals. In particular, community involvement has been sought in many programmes as a means of widening the range and distribution of benefits, bringing public and community land into productive use, and involving landless people and the poor. Local institution-building and employment generation have also been explicitly stated objectives of some projects.

The differences between individual programmes are thus considerable. But a number of broad approaches can now be distinguished. These can be classified under the following four headings:

* farm forestry
* tree growing for family uses
* community forestry
* land allocation schemes

Within each of these categories, there is a considerable range of flexibility in goals and operating methods, and many programmes have used a combination of approaches in parallel. Nevertheless, each programme approach has its own distinctive features which make it suitable for particular circumstances or permit it to meet certain objectives. At the same time, the intrinsic characteristics of each approach impose quite definite limits on what it can achieve.

In programme planning, it is important that the potential and limitations of these different programme approaches are clearly recognised. In the following chapters, the four programme categories are discussed in detail, using examples from a countries where they have been tried.

The Small Scale Farmer

First and foremost, each farmer and family is individual, uniquely struggling to respond to the various factors which affect their success in the process of adaptation called farming. Despite rich personal, local and regional diversity, however, these people share a number of important characteristics:

They are much more than just farmers. For example, they may be parents, religious or community leaders, masons, carpenters, healers, blacksmiths, truck drivers, etc. In these diverse roles, small-scale farmers participate in complex local religious, social and economic patterns and are subject to a wide range of demands from them. Due to influences from beyond the village, these farmers also have changing aspirations for material well-being, status, etc. Many have changing social identities too, moving from family, village and tribe or region membership toward national citizenship. They all are cultural beings and family members first.

Secondly, these are skilled and experienced farmers. They are experts in the local conditions affecting agriculture. They are practitioners of local agricultural and other technologies (e.g.-hoeing, plowing with oxen, making tools, etc.) In the face of change, they are also farmers in transition between traditional and newer agricultural practices. They are aware of outside inputs and new techniques. They seem to be open to producing a marketable or barterable surplus once family food needs are met.

Finally, small-scale farmers have economic concerns. They participate in local barter or subsistence economies, in which goods are either exchanged among neigbors or grown to be used at home. In these self-contained economies, farmers are not in the habit of investing in outside inputs or of using credit, except for meeting home needs. These farmers are usually limited to the family labor supply, or to a communal exchange of labor among neighbors. Most small-scale farmers operate as if they own or rent their land, as independent farmers, even though some are subject to tribal or community controls or to insecure tenancy.

Small-scale farmers share a village agricultural point of view. It is characterized by:

- <u>A holistic outlook</u> - Agriculture is a central activity, but it is only part of a whole, connected way of life. For example, things which can be contributed to farm work like money and labor are constantly required to meet other family needs as well. The village family allocates these resources by looking at the whole.

- o Environmental Sensitivity - All farmers have to be extremely sensitive to their environments in order to survive. They sense from collective and individual observation what elements of the environment are critical to their success as farmers. They are particularly sensitive to cyclical things like rainfall and storm patterns. More than any one else, they know the mini-environments of their individual farms intimately.

- o Local Focus - Small-scale farmers especially know alot about local things and much less about regional, national or global things. Most of these farmers interests are local as well.

- o Self Interest - Each small-scale farmer has a list of priorities that helps her make decisions. This list defines a farmer's self-interest, which is a central part of her worldview.

- o Farmer's Bias - A farmer's view of things is colored by the physical and economic realities of farm work. These practical preoccupations are uppermost in a farmer's mind.

- o Tradition, Fatalism and Adaptability to Change - Carrying out the tradition of farming is a normal and reliable habit of mind. This unchanging habit of mind is negatively reinforced by adverse outside opinions about village people like small-scale farmers. It has also been reinforced by the inability of tradition to contend with the new problems brought on by accelerated change. As a result, one of the extremes of a small-scale farmers point of view is a kind of fatalism and feeling of impotence amid rapid change. The other end of the spectrum is a real, though often latent openness and adaptability to change, for farming is a constant process of successful adaptation. Like other people, small-scale farmers are ambivalent towards change.

For small-scale farmers with all the above characteristics, change is not worthwhile unless it is:

- o culturally appropriate
- o in agreement with self-interest
- o respectful of tradition
- o clearly benficial
- o not economically risky

Elaborating on economic risk, John Guy Smith offered this description in 1970:

> "Farming is subject to numerous risks from weather, pests, diseases, price flunctuations and other uncertainties. For the small-scale farmer, these risks are accentuated by her precarious economic condition. Much of a small-scale farmer's supposed conservatium is really a very shrewd attempt to avoid or minimize risk.

For example, Yigi Kamara grows rice in Sierra Leone. Every year, he grows his crop during May to September, the rainy season. In August and September, while waiting for the harvest, the stores from the previous year dwindle, and there is a "hungry season". Yigi plants millet and cassava on a hillside in March and April to deal with this. In order to grow rice year round and perhaps even grow a surplus, Yigi is thinking of building gravity-fed ditches and dikes in a swamp near his hill farm. The work will take four months, from January to May. Is it worth the effort? If he doesn't plant millet or cassava, will there be enough food this "hungry season"? Can he afford a shovel? Will his family be able to harvest, thresh, store and grind all the expected new rice? Can he sell some to make it worthwhile? What will his neighbors say? What about the old stories about the dangers of working in the swamp?

Small-scale farmers like Yigi confront change as individual cultural beings, as practical farmers, and as economic producers. They have considerable resources which they bring to bear on the problems of agricultural production and livelihood in developing countries:

- o Expertise in local technologies and a variety of practical skills (e.g. - masonry, carpentry, etc.)
- o Expertise regarding local conditions affecting farming
- o Status as independent economic units
- o Experience as farmers (tradition)
- o A practical, critical viewpoint
- o Adaptability
- o Openness to producing a usable surplus

Their limitations include:

- o Lack of capital beyond family supply
- o Habit of not investing in or using credit or outside inputs.
- o Interests and roles which compete with agriculture
- o Little access to outside agricultural support services
- o Reluctance to take risks

Along with these, however, there are factors from beyond the village which also limit the small-scale farmer's ability to deal with change. Most directed technological change, like the promotion of new practices, is based on the priorities and interests of development planners and leaders. This may exclude small-scale farmers or be irrelevant to their needs. Governments, development agencies and private businesses promote change this way. Examples may be mechanization or mono-cropping (cacao or sugar cane) which benefit large-scale farmers and foreign markets more than small-scale farmers.

Like Yigi, these small-scale farmers are the special clients of Peace Corps agricultural extension work. Given the unique nature of the problems they face, their strengths and their limitations, Peace Corps promotes a specific kind of agricultural extension designed especially to help small-scale farming families participate in the development process.

SOME PRINCIPLES OF AGRICULTURAL EXTENSION

1. Agricultural extension is an educational process that should serve all elements of rural society and all members of the family.

2. Extension builds self sufficiency in CLIENTS and AVOIDS building dependencies. Thus it stresses education rather than provision of services.

3. Extension is a Two-Way Process in which research findings are communicated to farmers and farmers needs, situations, opinions, attitudes and beliefs are communicated to researchers.

4. Extension is based on existing conditions (is realistic for the situation).

5. Extension is based on peoples interests and needs. it considers their felt needs and their real needs.

6. Extension leads people to more fully understand their real needs and opportunities.

7. Extension workers recogonize and use the knowledge which experience has imparted to farmers. They learn from farmers.

8. Extension is usually most effective when it uses democratic processes.

9. Extension is a two-way learning process between farmers and extension workers.

10. Extension workers who are skilled practically inspire confidence in farmers.

11. To gain the legitimacy which is needed to influence farmers, extension workers must learn the ways of the villagers and associate with them as equals.

12. Learning lasts longer and is better utilized by farmers when it emphasizes "doing" as opposed to "hearing" and "seeing".

13. Extension is a process in which adoption of new practices often comes slowly; requiring extension workers to make many contacts and provide considerable evidence of the superiority of improved practices.

14. Extension workers know where and how to obtain resources,technical advice, administrative support, printed information, physical inputs, management support, organizational support. They are not so much a source of information as a conduit for information flow, both to and from farmers.

15. Extension best convinces farmers of the superiority of recommended practices by allowing them to see the results on their own land.

10. Extension work is most successful when extension workers start by winning the confidence and support of leaders, thereafter working through them and with them.

17. People participate best when they help plan the activities they are sked to carry out. Thus farmers as well as leaders should be involved in planning, implementation and evaluation of programs.

18. Extension work is most productive when it concentrates on a few important problems/programs which have the best potential for good results and high impact.

19. Extension work is most effective when several reinforcing and complimentary activities are aimed at reaching an objective.

20. Reliable and effective Exztension Programs can only be developed after a through job is done on collecting and analyzing relevant information obtainable from village leaders, farmers and agriculturalists.

A new Extension worker should strive for some quick visible results after a new assignment in order to establish early credibility with farmers. Such projects should be simple-Ex-designing and building a simple village grain storage facility.

22. Extension workers must understand that farmers have reasons for behaving as they do, including reasons for not adopting new practices. They must learn what these reasons are and make use of them.

23. Village verification is necessary for many of the improved practice recommendations coming from research stations. What works on a station may not work well in a village, or even if it works well, it may not be acceptable for various reasons. Recommendations often need modification to be acceptable in villages.

Extension work is: Teaching, advising, learning, leading, helping, organizing, planning, supervising, training, evaluating, cooperating, expediting, facilitating, complementing, managing, collecting, monitoring, diagonosing. It includes planting ideas which in time will take root in the minds of farmers. Most experts agree that enforcement is not a desirable role for an extension worker.

Personal Characteristics Related to Extension Success:

- Resourcefulness, creativeness, innovativeness.
- Good common sense
- Proud of being an Extension Worker.
- Willingness to invest his/her life in the betterment of rural people through extension.
- Good listener.
- Willingness to learn from farmers.
- Confidence in own knowledge and skills.
- Intelligence
- Concientiousness
- Ability to organize self and activities.
- Willingness to prepare far in advance.
- Ability to speak clearly and simply.
- Good stage presence (as a public speaker)
- Dresses neatly but simply.
- Understands and likes people.
- Understands and applies the principles of Extension.

ACTIVITY T : HOW FARM PEOPLE ACCEPT NEW IDEAS

SUGGESTED TIME : 2 hours

RATIONALE

Trainees who appreciate how rural adult learners accept new innovation will be better prepared to engage in information collection and program planning activities in the village.

OBJECTIVES

Trainees will understand the significance of the adoption process in adult education.

CONTENT

Notes on How Farm People Accept New Ideas

This session usually requires about 1 - 1/2 hours to conduct. It has stimulated rather lengthy discussions at the conclusion and is rated high by trainees.

One instructor opens with a story to establish an idea:

There was an up and coming extension agent who had outstanding success in getting farmers to his meetings with the exception of one holdout. He was old Joe. Joe had never attended a single one. This bothered the ambitious extension agent to no end. One day he thought; "I will drop by and see Joe today". Arriving at the farm, the worker was faced with a completely rundown yard and house. The agent explained that he wanted to have a talk with Joe about his farm. Joe seemed agreeable and asked him what he would like to see. The extension worker said "Let's have a look at your cows". Joe replied: "They are right over there in the shed. Come along and we will have a look". The cowshed looked even more rundown than the house. A good puff of wind might easily have flattened it, but Joe still used it. Standing at the stalls were two very scrubby looking cows and a bull which had an ancestry of several different breeds. Being the diplomat the young agent said: "How much milk do you get from these two cows, Joe?" "Oh, about two quarts I guess, but it's enough for me". "You know", the agent said "if you would get rid of these two animals and buy one good one, you could get six times as much milk and have some left over to feed a couple of pigs. And that bull there, you don't need him at all. Farmers are using artificial insemination these days so a bull is not needed by every farmer. Besides that, you get much better grade calves." "No," said Joe, "both my father and grandfather kept animals like them, they were good

enough for him, so they are good enough for me".

The agent was not about to give up at this point. Viewing the maize field he saw a miserably poor stand. There was no uniformity, the plants looked diseased and there was just about everything a good farmer would not want in a maize field. "Joe", he said "Why don't you get some hybrid seed and grow a real crop of maize"? "Well", said Joe, "My father planted this kind of maize and my grandfather did before him, so it is good enough for me".

A visit to the poultry coop and the pig pen resulted in the same wall of resistance. Finally, the extension worker was ready to call it a hopeless endeavor. He attempted to excuse himself by mentioning an appointment he had to keep. Joe said "Mr. Agent, you have been kind enough to pay me a visit, the least I can do is to have you in for a cup of coffee". "O.K." said the agent, "but I have only a few minutes". The house inside was a real mess. Dirty dishes were on the table and in the sink. Joe had to wash out the coffee pot and two cups before he could make and serve the coffee. As a last effort the agent made one last try. "Joe", he said, "Why don't you get married? A wife could tidy up the house and give you more time on the farm". "No" said Joe, "my father never got married nor did my grandfather, and that's good enough for me".

Although we have not expereinced an uproar from trainees in most cases, the point is well taken. When they are asked if there are any "old Joes" in their districts there is a unanimous "Yes". There are Old Joes in every country. This story leads into the talk on <u>How Farm People Accept New Ideas</u>.

<u>How Farm People Accept New Ideas</u>

Before an individual will adopt a new idea - whether it is a new practice, or a new crop variety, or a new food dish, he goes through an evolution of five stages:

Awareness This is his exposure to a new idea. He may see it, or hear about it from friends, or on the radio, or read about it in a magazine, newspaper or extension bulletin.

Interest At some later time he relates the idea to his own situation and becomes curious about its possiblities.

Evaluation Before he will try the new idea, he asks questions of himself, of his neighbor, or of the agricultural field man. What is the value of the new idea for me? How much will it cost in money, time and work? What are the risks involved? Have any of my

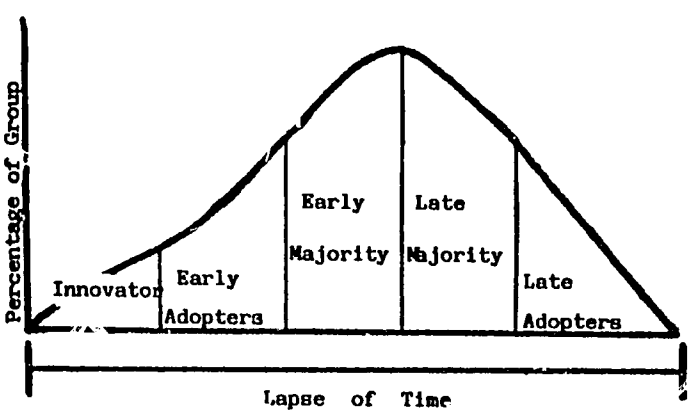
friends tried it? If the answers do not satisfy him he may never go beyond this stage. If his curiosity persists he will go on to the next stage.

Trial He indicates his willingness to try the new idea on a small scale. It may mean trying it on a very small part of his shamba, or on part of his herd, or by tasting just a little bit of a new food at a home demonstration.

If the trial is satisfying, that is, if it promises something better than he has had in the past (in terms of higher yield, or lower cost, or better quality, or less work, or some other type of satisfaction) he will probably move to the final stage.

Adoption At this stage the new idea is incorporated into the persons regular routine. He is also likely to try to sell the idea to others.

The speed with which people move from the awareness stage to the adoption stage varies from person to person and depends upon many factors. Some people may have more exposure to the new ideas through radio, newspaper and meetings. Some may be in a better position economically to try something new. Some people are more receptive or eager to try new things.



In general, the normal curve of adoption looks like this for large groups of people under average circumstances. The curve shows approximate divisions of adoption groups. In small groups, segments may merge and it may be impossible to identify clearly separate classes of adopters.

The innovators are the small percentage of a group who are

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willing and able to try something new. They should be sought out by the agricultural instructor, and encouraged in the initial stages.

These "pioneers" open the door for the subsequent adopters. Innovators usually have one or more of the following characteristics: more education, more widely traveled, more contact with agricultural institutions and specialists, higher social status in the community, more access to the mass media, belong to several organizations.

For every new idea there is a time lag before it is adopted by farmers. It was at least 14 years before the idea of hybrid maize was adopted in the United States. Soil testing for fertilizer needs required 20 years. Many farmers have not adopted the idea yet.

Extension workers are change agents. You work to change farmers to adopt new ideas. This discussion is about How Farm People Change. Two processes work to help bring about change:

1) Diffusion - The period during which the idea is being spread.

2) Adoption - The period between the time people hearof the idea until they put it into practice.

Before people adopt a new idea they pass through a series of stages.

The five stages can be nicely developed using an analogy. These are underlined on the board as it is developed. To explain these stages the story of a farmer will assist.

A part-time farmer lived just outside a small village. He worked several hours each day for a shopkeeper. Each day he traveled the same route to and from work. One day he noticed his neighbor giving his cow a bath. It seemed an unusual thing to do, but made no difference to him. Again on the next saturday the farmer was bathing the cow. Out of curiosity our farmer called out and asked the other farmer why he bathed the cow every saturday. The farmer explained that he was not bathing his animal, bit spraying for ticks. This was the first time that our man had been aware that cows are sprayed for ticks. He had now reached the first of five stages necessary for adoption of an idea - <u>awareness</u>. It was no concern of his that his neighbor sprayed his cow for ticks and he knew nothing else about it, but he was now aware that people spray their cattle. The picture changed when this man's daughter was married. As a bride price he received some good grade milk cows. On the following saturday he again saw the farmer spraying his cow. This time he stopped to talk. He enquired about the cow, the ticks and the reason for spraying them. His neighbor explained that ticks carry sickness that either kills cows or makes them so sick that they produce little milk. This information gave our man a start. "What if my cows get sick"?

"What if they should die"? These and many other questions ran through his mind. He had now reached the second stage of adopting - interest.

He was interested because it could seriously affect his wealth.

Returning from work that afternoon he stopped again to talk to his neighbor. He had many questions to ask his neighbor. "How much does the spray material cost"? "From where do I get it"? "What does the spray pump cost"? "How do you mix the material"?

He had now progressed from the stage of awareness to that of evaluation. He was trying to make up his mind. During the conversation his neighbor had offered to lend him the spray pump. The farmer got the name of the spray material and decided to buy it the next day. That afternoon he stopped again at his neighbor's house to borrow the pump. With the instructions for using it he set off home. As tired as he was from the long walk home, he was in no mood to wait any longer. Without any delay he mixed the spray as he had been instructed. He felt a bit clumsy at first, but he did a rather thorough job of it. The farmer had now reached the next stage towards adoption - trial. Returniing from work the next evening he walked somewhat faster than usual. He had one thing in mind. "Had the spray killed the ticks"? He hurried to see the cows. In looking at them, he noticed that almost every tick had dropped off. There were a few in some rather hidden places. He asked where he could get help and was told of the local agricultural instructor (often known as the extension agent in some countries). The next day he looked up the instructor who went with him to his farm. The instructor gave him more complete information on how to spray the cows. The next day there was not a tick to be found on the animals. He had now tried the skill.

He knew he could do the job, but wondered how it would affect his animals. After several weeks of spraying, he was convinced that the animals looked better. They had increased their milk production - enough in fact to more than pay for the cost of the materials. He concluded that it is not only important to spray, but it is essential. When he received his next pay, he bought a spray pump. When the agricultural instructgor dropped in to check the results of the spraying, the farmer said: "I think this is a good idea of mine to start spraying my cows". When he saw other cattle owners after that, he would stop to discuss cattle problems with them. Somehow he would manage to bring up the subject of the importance of spraying them for ticks. Now he had reached the fifth stage known as adoption. He was completely sold on the idea and wanted to tell others about it. He had truly adopted the idea.

This little story clearly points out the five stages of adoption.

1. awareness
2. interest
3. evaluation
4. trial
5. adoption

FIVE WAYS TO SUCCEED IN EXTENSION WORK

There are many principles of extension which, when applied, improve one's success in Extension work. In this paper, the author discusses five approaches which he believes may be especially important to successful Extension work in Tanzania. If these approaches interest you, discuss them with your supervisor. Hopefully, he will support your trying them.

1. Make your usual approach to the farmer one of learning from each other, one of shared reflection on problems and of joint action to solve them, rather than one of you (the informed) giving knowledge and advice to the farmer (the ignorant). It simply is not true that farmers are ignorant and extension workers well informed. In a survey in Afghanistan a counterpart and I found farmers to know many things that our college graduates did not know. From centuries of tradition they knew when to plant each crop and how much yield would be lost by delaying planting 2-4 or 6 weeks, they knew the good land from the bad, knew the signs of a good rainy season and who to see to get things done in the village, etc.

In Tanzania, Devries described several specific cases where farmers rejected extension worker's recommendations because the farmers realized that for their specific situation, the broad approach by the Extension worker will bring such errors to light, compromises can be reached, both parties (people) will be smarter than before, and the extension worker will be welcomed back. The farmer who is

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* Tutor in Extension and Coordinator of Studies, MATI Mpwapwa. Formerly an Extension Supervisor working with American Indians.

1 "Extension or Dialogue", a paper presented at the National Conference for Agricultural Education, 1977; and other papers.

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involved in analyzing his problems and in planning courses of action will feel good and will have grown a little personally, the importance of which will be discussed later.

For emphasis, I repeat, the farmer is not an empty, ignorant, inferior person. He is a proud man filled with the knowledge begotten by a lifetime of experience.

Neither is the extension worker filled with unlimited knowledge. As an extension agent myself, some years ago, I was not able to offer sound advice for even half of the farmers' problems and I had a fresh M.Sc. degree. As extension workers, you do have important ideas to offer, but, offer them at the right time in an atmosphere of mutual respect and idea sharing. Through discussion and questioning, lead the farmer in a critical examination of his problems and their solutions. Listen to him and heed his advise and his reasoning where he is experienced. Be a good listener and a good learner yourself. We are all ignorant in different ways.

2. Follow-up again and again to bring about changes in peoples practices.

A new idea or a new practice is seldom accepted or adopted (used) the first time a farmer hears about it. People accept ideas and adopt new practices gradually, step by step. Confidence must be developed in the idea or practice and often, fears of bad results or social pressures must be reduced. A new practice may at first only gain a farmers attention; as it is heard again (follow-up) his interest increases; if he sees the practice demonstrated (another follow-up) he may develop a desire to try the practice; and after trying it (a trial) he may become convinced and fully adopt the new practice. In this often long-series of events, the farmer's interest and confidence in the new practice increases and his fears decrease each time an extension worker talks with him, demonstrates to him, takes him on a field trip, brings a successful user of the new practice to talk with him and his neighbours, etc. Follow-ups should cease only when a farmer or group of farmers have fully accepted and mastered a new practice. Even after they agree to try a new practice, extension follow-up is necessary to ensure that the practice is properly followed and will yield a good result.

It is obvious that such a series of contacts between an Extension worker and a group of farmers is possible only if the extension worker lives and works in a relatively limited area, preferably in one village. Other people in

each village should be trained and motivated to make follow-ups (Ex. C.C.M. workers), so that Extension work goes on all the time with a maximum of manpower. This brings us to the next point.

3. A successful Extension worker works with and through other people and organizations.

A first step for a new extension worker is to gain the confidence and support of existing leaders, agencies and organizations. Extension work is everyone's work. It requires legitimacy and organization in order to gain the attention of the masses, to lead them to new practices & to harness their energies in community-wide Projects.

Once an idea or proposal affecting an entire community has been thoroughly studied for its feasibility and it has been approved or legitimized by the appropriate leaders, it should be taken to the people for their information, reaction and hopefully for their commitment to actively support it. If the people support the idea, it is very important that they participate in selecting the goals of the project and in planning the action project designed to solve their problem. Such involvement in planning makes people more willing to work on the Project. It ensures that planning oversights are not made and it develops the people themselves.

Involvement in successful projects makes people feel good about themselves, more wiling to tackle another project, more confident of their ability to change their situation. It promotes cooperative spirit, develops leadership skills and group planning skills. Their agricultural and livestock knowledge may increase through the discussion of alternative solutions and their consequences. They learn to help themselves and develop the confidence to do so through democratic involvement. People development through involvement is much of what Extension work is all about.

4. Plan and Carryout "Programs of Work" rather than just doing what people request of you day by day or doing what pops into your mind day by day.

It is not efficient use of time to solve isolated problems one by one nor is it effective in many cases. Program Planning should normally start with discussions with local leaders and organizations. They can express their goals, their problems and needs while you can help them to understand which of the agricultural and livestock problems mught have the most potential for solution, and

which projects muight have the most impact on the community. Then jointly set some tentative priorities and plans. The next step preferably will be that of involving more people as already discussed.

From this approach, a few carefully selected and well planned "Extension Programs" take shape. Each program calls for many coordinated activities by the extension workers, by leaders, by individual people and by organizations, all aimed at achieving a single broad goal. Suppose a goal selected is "To reduce the deaths of village livestock due to tick-borne diseases, from 240 per year to 50 or less". Some of the necessary activities will include getting financial assistance from KILIMO, conducting a public education campaign (meetings, farm visits, field trips to villages new dipping, etc.) building a number of dips, training dip attendants, and procurring dawa. Note that this program has the potential for assisting all villagers and thus for providing an efficient use of the Extension Worker's time. It requires many activities and events for success, making careful step by step planning and organization necessary. It requires the good will and participation of all people for success and thus the involvement of many people in planning. Each step is a follow-up to an earlier step, each reinforces the other and moves individuals closer to adoption (dipping his animals). The program is a package, an integrated whole. It has, or can have, impact. It involves people, leading to Personal growth and development. It engages the energies of many people in extension work for maximum impact.

Compare the type of Extension work just discussed with that of a vety extension worker whose habit is to go where he is called to treat sick animals. The number of people he can help will be very few. As his visits to individual herds may turn-up anything, he is often unprepared in drugs, equipment and knowledge. Any educational effect he has is limited and accidental. He is "helping people" not "helping people to help themselves". The people are robbed of an opportunity for personal growth and development, and he must return to "help" year after year. the benefit is that a few sick animals may get well and a few people will gain respect for the extension worker. But how shall this respect benefit him or the extension program? If he is only asked to cure more sick animals, there is little value, but if he uses it as a base from which to launch major coordinated extension programs then let him start in this manner. This leads us to the final point of the paper.

5. Stress prevention rather than cure

Preventative disease measures are comparatively easy and inexpensive - they allow the mass handling of stock and the participation of many people in a coordinated action program. Curative measures comparatively are difficult, inefficient, and costly. It would require an army of advisory service staff to treat the nation's sick stock. Maybe more important, it is not realistic to expect certificate holders to be able to diagnose and cure sick animals beyond first aid and common problems.

Further, it is this writer's opinion that in terms of Tanzania's overall development, whether one or a hundred separate sick animals live or die, matters little. The food these dead animals don't eat becomes extra food for other animals, or, the reduced feeding will lead to range improvement.

I leave you with this rather strong (dogmatic) statement in the hope that some of you readers will write PS your ideas on the subject. We would like to have some discussion in future issues.*

*In agroforestry terms; stress known and adapted systems rather than new or introduced ones. Work with what is known, and adapt to suit changing circumstances! (LEB)

WHO IS BWANA SHAMBA?

The ideal **BWANA SHAMBA** is one who has:

1) **These personal characteristics (somewhat trainable);**

Is resourceful, creative, innovative,

Has good common sense,

Is proud and happy in his role as a Bwana Shamba,

Is willing to invest his life in the betterment of rural people through extension,

Is a good listener,

Has confidence in his knowledge and skills but fully recognizes its limits. One who recognizes and uses the knowledge which experience has imparted to farmers,

Is willing to learn the ways of the villagers and to associate with them as equals,

2) **This Extension knowledge and Understanding;**

Realizes that his technical recommendations will likely be judged and accepted more on the basis of whether he is a trusted person than on whether he has a scientific degree,

Understands that the extension role is a leadership role in that the Bwana shamba must be actively involved in the purposeful creation of change,

Feels responsible for the end result of programs and projects even though village leaders and others are very involved,

Understands that extension programs often fail because people fail,

Knows that the process by which people adopt new practices is usually a slow one requiring many Bwana shamba contacts and considerable evidence of superiority of recommended practices to bring about volunteered change of adoption,
Knows that because there are usually many steps in the adoption process and many resource inputs needed, that mass adoption can only be brought about through a "program" encompossing a series of reinforcing and mutually supporting activities,

Can lead people to more fully understand their needs and opportunities,

Knows that a leader whose authority or leadership is threatened, even by the Bwana shamba being active on his own, will become a bloker of extension efforts, while a leader who views the Bwana shamba as a person whose efforts can make him successful will become a supporter of extension efforts,

Knows tha appointed leaders are not always true leaders of the people and knows how to deal with unrespected leaders,

Realizes that his own effort will be forever modest unless he multiplies them through the involvement of others and quickly builds self-sufficiency in others,

Realizes that there is constant threat of developing dependencies in his clients rather than self sufficiency,

Knows that he should strive for some quick visible results after a new assignment to establish early credibility with farmers,

Knows that farmers are best convinced by seeing the results of a recommended practice on their own shamba,

Knows how to conduct a good demonstration, make a forceful farm visit, gets the most out of a meeting, etc.,

3) **Competence in Technical Fields;**

Knows not only the basic principles of crops and livestock production but how they relate to his country; which principles are being violated, where, why, and how to improve the situation,

Has mastered the essential agricultural skills to a degree that he inspires confidence in farmers,

Can recognize agricultural potentials but is cautious to check out the validity of his assumptions and observations,

Knows where and how to obtain resources-technical advice, administrative support, printed information, physical inputs, management support, organizational support,

Knows that the collection of voluminous information must be the first step in planning programs and recommending practices,

Has the necessary skills to conduct appropriate field surveys and to build programs for the data,

Knows the Limitations of general recommendations and knows that unsophisticated adaptive or verification research is needed for each unique agro-ecological area,

Knows how to conduct verification trials.

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FIELD TRIP OBSERVATION GUIDELINES
(Prototype...adapt for each trip)

1. Project Personnel contacted during visit.

2. Project Objectives.

3. Describe the key activities and/or services of the project or facility. (Research, Demonstration, Training, Production, Distribution, Information)

4. Describe the project or facility's relationship with the farming community in the key activity areas discussed above.

5. What does the project consider to be its main achievements and/or findings to date, especially as they relate to our own project plans/activties?

6. What can we learn from the project that may help us in our own project context?

7. What cautions should we apply in interpreting or adopting activities and/or findings from the project visited, to our project situation? (What are key differences, and what do they imply?)

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SOURCEBOOK SUPPORT MATERIALS - MODULE 4

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2. THE GROUP LEADER AS FACILITATOR

a) Introduction

Group leadership approaches generally range from the dictator to the passive sleeper and somewhere in our own background we have probably experienced leaders or teachers who fit either extreme. We have also experienced leaders or teachers who we can call facilitators, and probably remember those most positively.

The facilitator is a group leader who encourages a group to be alive, active, productive and at the same time to feel good about itself and what it is accomplishing. S/he makes a group session something to look forward to, rather than to be avoided. How does one gain this skill? Some say it is a natural talent and that only a few people can really possess the skill. Yet, it has been shown frequently that it simply takes some knowledge on how to facilitate, some practice at working with groups, some exercises that encourage facilitation and probably most importantly, the will and motivation to perform the facilitator's role in a group.

The following section provides some suggestions on how to act as a facilitator. Subsequent sections provide sample exercises that encourage the use of participatory approaches. We hope that the reader will provide the essential final practice ingredient by using some of the exercises and suggestions in working with groups in the future.

b) The Facilitator

A facilitator essentially has two major roles when working with a group. S/he thinks about:

- The content of the session: the groups' reasons for meeting and the results expected at the conclusion of the session, and

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- The support or maintenance of the group: how it is interacting to reach its goal.

Content Management

The group sets its objectives and interacts to reach them. The facilitator can help the group to do this in some of the following ways:

- Identify clearly what the group's objectives or reasons for meeting are: Statements of objectives should be clear, simple and should always be reachable by the group. In one village seminar, the group had the objective of developing a concrete action plan for a project by the time the seminar was completed. By considering this objective at the outset of the seminar, all of their activities during individual sessions could relate to this objective. By considering this objective as they interacted, they were able to develop their concrete action plan as they had set out to do. Other examples of objectives could be: "to practice new methods of communication", or to make a plan for our village LG 17 project, or "to select committee members for our village". We could not expect villagers or even extension staff to achieve the objective of determining whose picture should be seen on the Pula or when the Gaborone Trade Fair should take place. The facilitator can help the group to develop objectives that are reasonable and reachable.

- Stay with the group objectives: The facilitator must always remember the objectives of the group and remember especially that these objectives belong to the group. They developed them. The responsibility of a facilitator is to keep these objectives in front of the group, and constantly and consistently encourage movement towards attaining the objectives. One way to achieve this is to simply write the group's objectives on newsprint or a chalkboard when the objectives are initially developed. These objectives are then to be literally "in front of the group" throughout the group session, and constantly referred to during discussions. This tangible reminder assists the facilitator and the group in working toward its objectives.

Bring out the varied information, ideas and opinions of all group members: When discussing a topic, it is important to bring out all of the information necessary for clear understanding. When attempting to plan it is important to bring out all the varied opinions. If a village group was planning a vegetable garden, those villagers who have experience with village gardens should be consulted; if a District Extension Team was planning a consultation, the schedules of each member should be considered. The facilitator ensures that all participants have been consulted both for information and/or opinion on a given topic. This widespread consultation often prevents complaints when a project is implemented, or an action is taken.

Allow the group to discuss controversial topics openly: A facilitator does not want to encourage useless arguments, but s/he does want to encourage an atmosphere that permits open discussion of opinions. A group should be permitted to work out a controversy until a conclusion is reached. What is important to remember is that all participants are equal and that every idea, no matter how odd it may seem, should be given equal respect by the facilitator. If the facilitator insults someone's idea, no matter how antagonistic or ridiculous it may seem, the rest of the group will probably become afraid to speak, wondering whether his or her idea will result in the same reaction from the facilitator. When an unrelated or extremely argumentative statement is made, the facilitator could simply suggest that the statement may be taking the group away from its objectives; point out once again to the objective and then ask someone in the group to take the group back to the topic at hand. For example, the facilitator could say, "We all know that this topic is extremely controversial, that we all have strong opinions about it; therefore, we must respect each others strong opinion, learn from it and eventually, as a group, come to some kind of consensus. Now, let us look at our objective once again. Who can add a point that will help us to get closer to it?"

Give equal time and respect to all group members: This point follows the previous one in that what is being encouraged is respect for every group member and respect for the ideas/opinions of every group member. Everyone's ideas should be given equal time and equal respect. This encourages active participation by all. Yet at times it is obvious that one member is leading the group away from the topic or that another member is developing a plan that is totally removed from the group's plan. The facilitator usually can see when the group is becoming annoyed with a member or frustrated with his or her diverse ideas or pressure to accept them. In this case the facilitator must again remember to respectfully respond to a person, as the other group members will be observing this response and will eventually react to it themselves. In a situation like this, the facilitator can use the group for support. For example, "Now, Thabo seems to be emphasizing a particular point. Let's ask some other group members for their opinion, briefly, and see if in fact this idea is supported by others. We must again remember our group objective when considering Thabo's point".

Explain and clarify ideas to the group: Use examples frequently to further describe ideas. For example, the facilitator could say, "Your idea is really important and it is supported by an experience I had in another district in the same area . . .", or "That is an excellent point. An example of that approach was developed in Kweneng with their VET and proved to be very successful." The group members can also be assisted in explaining what they mean by encouraging their own use of practical examples. "That is a very relevant idea. Do you know of any areas where it has been implemented?" "What you are advocating is interesting. Have you had experience in doing this yourself, or do you know someone with relevant experience?". Examples take the group from theory to the reality of daily life. They provide the concrete situations necessary to make a discussion believable and real to a group.

Summarise ideas: This is probably one of the most important tasks of a facilitator, to take all of the information being given by a group and provide a summary. This requires active listening and active involvement in all discussions. When a summary is presented, it should always be presented to the group in a way that encourages the group to comment on its accuracy. For example, "In my opinion, this is the summary of what we have been saying. This is my opinion, do you agree with me or do you disagree?" "Would any group member like to summarise the ideas of the group this far?" "What are the group's ideas on this summary?" "This is what I hear being said . . . does the group agree?" "Are all the points here in the summary? What do we need to add if anything? What do we need to delete?" When the group has developed its summary, it is best to write it on newsprint, or on a chalkboard. (See Section 5. (h) on Materials).

Assist the group in its own plan development: The role of the facilitator is NOT to influence the content, not to set the objectives, not to develop the plan, but to assist in achieving the objectives of the group. The facilitator must never offer his or her opinions in a conclusive manner. S/he must never say, "Well, this sounds like the final decision, doesn't it?" or "This certainly is the best conclusion for us." "We should certainly adopt this idea". Rather, the facilitator again reviews the ideas of the group and re-offers them for concensus or conclusions. S/he says, "These seem to be the ideas of the group. What do you think? Do you agree? Do you disagree?"

In all cases the facilitator assists the group in reaching its own conclusions. In planning activities the facilitator helps the group achieve its objectives in group sessions, the facilitator helps the group develop it's own ideas, theories and information. The facilitator is the group's guide to decision making - never the final decision maker.

Encourage the group to develop its own theories and answers: The facilitator does not have all of the answers. His or her role is to encourage active participation in problem-solving thinking

by the group. The facilitator should therefore never present all of the information necessary either for problem solving or content development, but should consistently encourage group development of ideas. All members of the group come with knowledge and experience and this should be respected. The process is similar to constructing a building. The ideas and knowledge of the members are the blocks and mortar that must be joined to develop, to build the final product. We can visualise in our minds what the final building will look like, we can even draw plans (set objectives), but the actual construction process must take place before one can move into the building. Now sometimes some of the materials are not good, they are flawed. Then the builder must carefully replace these with new materials so that the end product will be the safest and strongest. It is the same in a group. Sometimes in the development of ideas or theories, opinions or knowledge that is flawed is given by a group member. In cases like this the facilitator can often ask the group for assistance in improving an idea or correcting information, e.g. "What does the group think about this information. Is it correct?" "What about this idea?" "Will it help us to achieve our objective?" In the end the facilitator works with the group to develop and build its own theory or programme.

A FACILITATOR

Identifies the group's objectives

Stays with the group's objectives

Brings out varied information, ideas and opinions

Allows the group to discuss controversial topics

Gives equal time and respect to all group members

Explains and clarifies ideas

Summarises ideas

Assists the group in plan development

Encourages the group to develop its own theories and answers

The energy of the group is related to the actions of the facilitator. If the facilitator is lively, the group members stay involved and active.

Providing Support

In addition to assisting with content development, the facilitator has the major responsibility of helping the group to achieve its objectives in a democratic participatory manner. Some important support tasks for a facilitator include:

Be lively and energetic: The energy of the group is directly related to the actions of the facilitator. If the facilitator is lively, talking with the group, drawing out ideas, walking around the room when necessary, reacting openly to comments, the group stays involved and active. A group leader who sits behind a desk passively reading or barely communicating will probably put a group to sleep. At the same time, this does not mean that a leader should be so active that s/he does not allow the group to participate. The energy should be put into encouraging participation.

Develop a climate of trust: A facilitator is friendly, open and always respects the ideas of every group member. Support and encouragement of one group member encourages others to participate. Building on the contribution of one member in a positive way enables other members to feel interested in contributing. The facilitator can say, "Now that was a good idea. Can anyone add specifically to that?" or "That seems to be very important. Do other members want to add something?"

Develop group procedures: A facilitator is never a passive leader, but someone assisting the group in reaching its goal. This means that at times the facilitator will need to set time limits for discussion, to give direction, to consult the group for methods, to encourage all to participate, or to develop small group activities that encourage active participation by all.

Work with group tension: Very often controversial topics result in group tension. The facilitator relieves this tension by making the group aware that such tension in fact does exist and could lead to productive conclusions. By putting a problem in a wider

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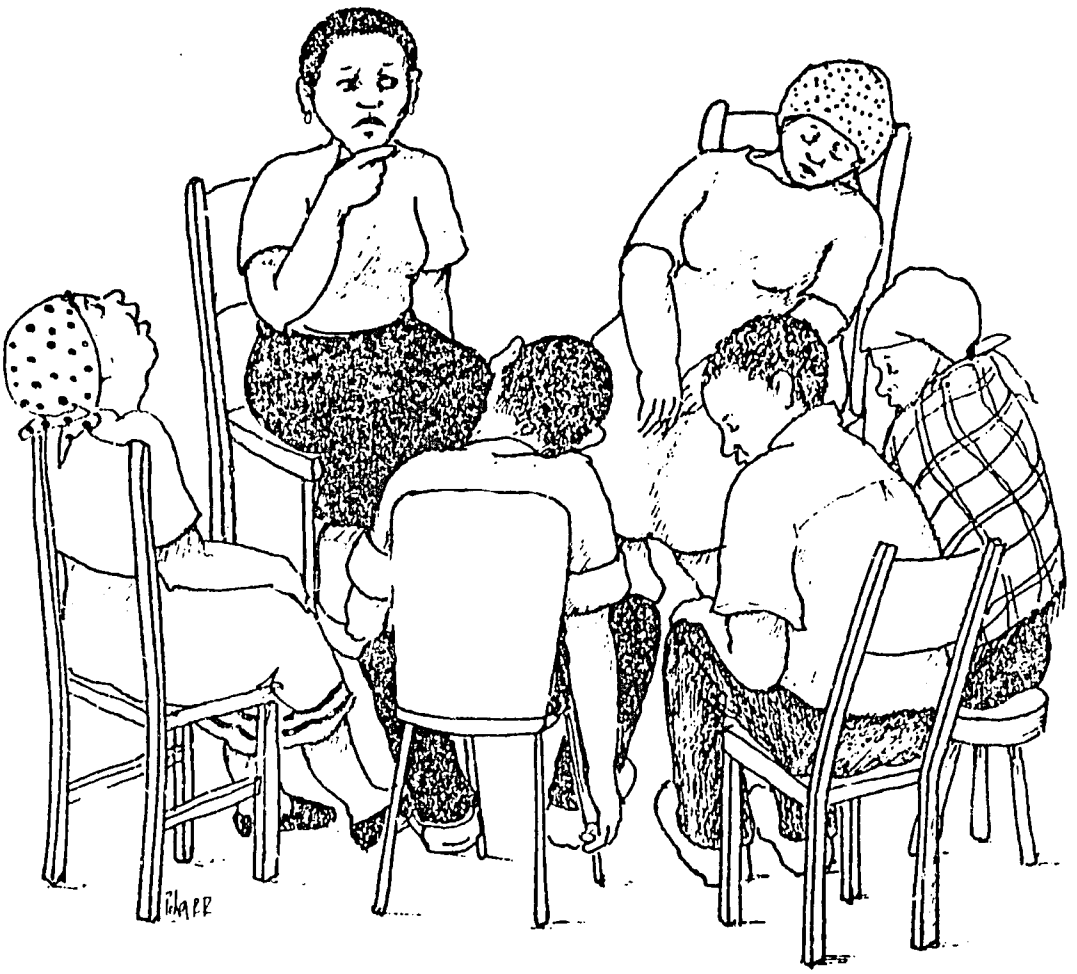
context, and by reminding the group that the goal is to reach productive conclusions, not to get stuck in internal arguing, the tension could have a good result. Very often a facilitator can help relieve unnecessary tension by restating argumentative comments in less threatening ways: S/he could say, "I think the point Esther was making primarily deals with . . ."; "If we concentrate on this issue of . . ."; "let's try to look more closely at this specific point from your statement . . .".

Developing conclusions: It is very different to say "We all agree now, don't we?" than to say, "Does everyone agree with this statement, conclusion?" The second question allows the participants to answer as they feel. The first question usually leads to much head nodding and little real consent.

Eye contact: A facilitator looks directly at the person s/he is talking with and listens actively to each participant as s/he speaks. A group member is always very aware of whether or not a leader is listening and feels little reason to participate if the facilitator is not paying attention actively.

Encouraging participation by all: This can be done in several ways. One good way is to have large groups break into small groups in circles. This allows the quiet ones to participate without the threatening experience of speaking in front of a large group. This also ensures the development of various group opinions and the sharing of much more information. Another way is to be constantly aware of who is and is not participating and to ask the quiet ones for their opinions: For example, "Thabo, we haven't heard your ideas yet. Do you have anything to add?" At the same time this means asking the very active participants to give the quiet ones a chance to talk. For example, "We have heard many good ideas from you Chedza. Maybe some of the other group members would like to comment on these" or, "You have provided us with good insights. Do you agree, Lesedi?" At all times the facilitator must remember that members need to be encouraged to participate and even the very active participants need to be quietened in a respectful way so that they will not stop.



Being conscious of group feeling: Are participants getting bored with a topic or are they too tired to proceed? Generally, if the facilitator is getting bored or tired, the group probably feels the same. Express this to the group; ask them for ideas on how a session could move along; change the topic if necessary or postpone the discussion to a time when members are more likely to be active.

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DISCUSSION QUESTIONS

1. Should a facilitator concentrate more on con ent (i.e. reaching objectives) or support (i.e. encouraging a good discussion atmosphere)

2. What are some things a good facilitator can do to prepare for a session?

   - to ensure the group reaches its objectives?

   - To ensure the group is active and productive?

Use Audiovisual Aids*

Roughly, a person remembers 10% of what he has heard, 50% of what he has seen, and 90% of what he has heard, seen, and done.[5] This means that if all we do is talk, we are wasting 90% of our time. World Neighbors personnel frequently remind people: "What I *heard*, I forgot. What I *saw*, I remember. But what I *did*, I can do!" Audiovisual aids have proven themselves effective to entertain, to stimulate people's interest, and to make ideas more concrete. They help explain, illustrate, and communicate information and ideas. They are particularly useful for preparing people to learn and for reviewing material already taught. Virtually no class should ever be given without the use of visual aids.

Audiovisual aids are not, however, a substitute for competent, well-informed, and enthusiastic teachers. They are marvelous tools, but, like a shovel, they can do nothing if a person does not know how to handle them.

When we think of audiovisual aids, we should not think only of movies and filmstrips. Audiovisual aids also include demonstrations, sociodramas, puppets, flipcharts, flannelgraphs, and any other object or action that illustrates the point at hand. Probably the most effective motivational visual I ever saw was one used by a villager extensionist to promote a new bean variety. He had a single dried and varnished bean plant taken from his own field with over eighty pods and five to six beans in each pod.

The same criteria can be used for judging the appropriateness of an audiovisual aid as for that of an agricultural technology: it should be simple, effective, inexpensive, easy to operate, and, most important, easy for villagers to continue making after the program is terminated. Chart No. 6 can be used in selecting the audiovisual aids most appropriate for any given situation. In addition to those listed, we should also consider the area's traditional media puppets, songs, games, drama, dance, town criers, etc. Nor should we use only one audiovisual aid at a time. The most

*For a discussion of audiovisual aids and their use, see *World Neighbors in Action* Vol. 4, Nos 1E and 4E on "Nonprojected Aids" and "Projected Aids." These newsletters can be ordered from World Neighbors.

CHART NO. 6. Selecting the Tool You Need

VISUAL AID	ADVANTAGES	DISADVANTAGES
Chalkboard Audience size: 5-30 people	Inexpensive, can be homemade, easily maintained, minimum preparation. Enables audience participation. Easy to continue using after program ends.	Limited to the user's artistic ability.
Flannelboard Audience size: 8-25 people	Inexpensive, easily made with rough cloth or a blanket, glue, sand, and paper. Difficult drawing could be drawn by an artist and duplicated. Ideal for showing sequence of events and reviewing lesson, as figures can be brought back on the board. Often humorous.	Requires considerable advanced preparation. Cannot be used out of doors if there is any wind. Some artistic ability is required if making homemade figures. Easy to get figures out of sequence.
Flip charts Audience size: 8-30 people	Inexpensive, can be homemade. Good way to give information in sequence because they are bound, illustrations stay in sequence and help the extensionist remember the order of ideas in his class.	Deteriorate with constant use. Some artistic ability required if making homemade flip charts.
Flash cards Audience size: 5-15 people	Inexpensive, can be homemade, very easy to transport. Good way to give information in sequence to small groups.	Deteriorate with constant use. Some artistic ability required if making homemade flash cards. Easy to get out of sequence. Limited to small groups.
Demonstration Audience size: 1-30 people	Excellent way to use materials in a real situation. Uses local materials. Easy to understand by people not accustomed to looking at illustrations. Good way to get audience participation. Is impressive, convincing to the skeptical. Replication after program ends is easy.	Takes a lot of planning and preparation, and perhaps transportation of students to demonstration site. Most demonstrations can only be done during the daylight hours.
Sociodrama Audience size: 15-40 people	No transport problem. Is graphic. Shows motion and therefore can explain step-by-step sequences. Draws audience's attention. No equipment needed. High audience participation. Often humorous. Replication after program ends is easy.	Requires good advanced preparation. Some people cannot do sociodramas.
Slides Audience size: 10-30 people	Dramatic, less expensive than cinema film, excellent way to bring distant things to audience and to show time sequence. Battery-operated projectors available. Local slides easily made.	Easy to damage, easy to get out of sequence and project upside down or sideways. Requires projection equipment, electricity or batteries and a camera to make slides. Used only at night or in a darkened projection area.
Filmstrips Audience size: 10-30 people	Dramatic, less expensive than cinema film and slides. Once inserted correctly in projector, impossible to get out of sequence. Can show photos of the real thing and shows sequence in time. Battery-operated projectors available. Relatively easy to transport.	Requires projection equipment, can be damaged, requires either electricity or batteries. (Sometimes batteries are expensive.) Limited appropriate filmstrips available. Used only at night or in a darkened projection area.

Film Audience size: 25-100 people	Dramatic and gets the audience's attention. Shows motion and therefore helps explain step-by-step and time sequence very well.	Requires expensive equipment, electricity. Difficult to transport and operate. Very easily damaged. Attracts too many people. Beware of people going for entertainment only. No possibility of replication after program ends. Limited appropriate movies available. Allows no dialogue. Used only at night or in darkened area.
Radio Audience size: 1,000's	Covers large area and many people. Good for testimonials.	Too expensive, creates dependency on outsiders. Only good for simple message. No personal contact. No discussion. No participation. Use after program ends very difficult.

effective teachers will, for example, use a flipchart, a chalkboard, and a walk through a successful field all in the same class.

The content of audiovisual aids should also be appropriate to the local setting. Those used repeatedly should be field-tested with villagers who will provide candid feedback about the aid.

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THE DISCUSSION METHOD

Characteristics

The discussion method involves one, or often more, carefully planned meetings in which students pool ideas in order to solve collective or individual problems. The instructor does not present theory, principles, doctrine or ways of handling problems. Rather, the group is presented with a topic or a problem and members draw upon their own experience and opinions for possible ways of handling it. Therefore, if the method is to be used successfully, group members must have a background of experience or information pertinent to the topic or problem. In discussion, the instructor encourages students to interact with each other. The instructor does not supply answers or information, but helps the group to define problems and develop solutions by guiding the discussion. Ideas and solutions evolve from the experience and thinking of group members and not the leader.

Discussion is often confused with recitation. Recitation is a sequence of "rapid-fire" questioning which the instructor initiates and controls. In discussion, the instructor is a moderator and does not control each interaction. Recitation also focuses on students' recall and reciting of subject matter content. In contrast, discussion tends to focus on higher co nitive objetives.

When to use

The best opportunities to use discussion are when:

-The group size is from 7-25 people
-The students already have been introduced to the theme and have a strong background on the subject to be discussed.

Merits

The discussion method is effective in:

-Utilizing the resources of group members
-stimulating critical thinking
-assisting students in formulating and becoming aware of problems
-developing motivation for further learning
-allowing students to apply previously-learned principles
-providing students with the opportunity to express their ideas and explore their own and the others' belief.
-giving instructor feedback on how well objectives are being met.
-helping students analyze and evaluate opinions
-helping students articulate their views

Limitations

Although the discussion method is remarkably versatile and effective, it has a few limitations which cause instructors to be reluctant to use it:

- many students clam up when invited to participate in a discussion. Some participants feel unable to say what they mean and are afraid of being wrong if they contribute. Others are intimidated by the dominant participants.

- the discussion moves slowly and is easily sidetracked.

- When different discussion groups are formed, large and embarrassing differences may result when groups are requested to present their findins.

Effective discussion techniques

Seating Arrangement. The traditional classroom seating arrangement students in rows facing the instructor- severely restricts participation in a discussion. A circular arrangement, where instructor and students can see each other, is much more effective. Members of the group are more likely to interact with other members of the group if they can see as well as hear the others. The instructors should sit in the circle same as the students.

Initiating the discussion. There are several techniques for starting a discussion. An open-ended question, carefully phrased, is more likely to elicit responses than are questions of fact. Questions which have no "right" or "wrong" answers are often successful cues to initiate discussion. Presenting a common experience often puts people at ease, an important consideration for group interaction. Role-playing, case studies, and audio-visuals provide a common experience to draw from.

Let's look at an example of initiating a discussion. We'll assume that the discussion follows a brief lecture on the applicability of agroforestry systems and that the course participants have already had considerable exposure to agroforestry systems and monocultures.

"After hearing about the applicabilityt of agroforestry systems, let's now discuss the advantages and disadvantages of agroforestry systems as compared with monocultures of the same crops or pastures. It will not be easy to compare the systems since often the monocultures have no parallel in agroforestry or vice versa; or if they exist, they may not be found side by side under comparable conditions. Such comparison is also complicated by various short and long term economic projections and by the appraisal of social and cultural factors. Scientific data are still scarce to evaluate many agroforestry practices. But based on our own experiences let's discuss amongst ourselves the advantages and disadvantages of the biological, economical, and social aspects of a well known agroforestry practice such as...., when compared to monocultures of the crop component. Let's start with the biological aspects. What are some

biological advantages of agroforestry systems?". The ideas and contributions of the participants are then transcribed in telegram style on the blackboard or on sheets of paper with marking pencils, that can if necessary be pegged against the wall for future consultation.

Stimulating Participation. Many students are reticent during discussion. During these situations, the instructor must create an expectation of participation and develop positive attitudes regarding the values of participation. Positive reinforcement or encouragement in the form of a nod, a smile, or an acknowledgement, may help allay some fear. The instructor must exercise a high degree of support of students when their ideas are incongruent and must help them formulate more appropriate responses. The instructor's failure to be supportive and helpful when inaccurate or inappropriate ideas are offered might cause students to alienate themselves and reduce or eliminate their participation. Differences of opinions, for instance: "should a certain factor be included or not", may result and may be favored... to a point. Such discussions should not degenerate or consume too much time. A concluding statement to stop a futile discussion may be in order.

Keeping the Discussion on Track. Too often discussion are sidetracked to different themes. It is the responsibility of the instructor to keep the discussion focused. The issue should be clearly stated at the beginning of the discussion, and during key points within the discussion. Students' contributions should be monitored to relate each new bit of information to the whole problem while, at the same time, helping the class to discard those ideas which are irrelevant or inaccurate.

Maintaining impartiality. One tendency to guard against is exposing the instructor's personal opinion on the subject prematurely; he should avoid performing too much of the analysis. When students ask any questions the should be directed back to the group. The purpose is of course to formulate questions and probe the responses of students, not to verify the instructor's authority by giving the "final word" on each issue.

Analysing the problem. The first consideration in making the analysis is to define the terms and limits of the problem. Then, the class members can begin to identify each of the issues connected with the problem. Discussion should elucidate each of these factors. It is imperative that the basic assumptions which are associated with each consideration be identified and their validity checked. Our example of agroforestry vs. monoculture is a good illustration: The terms and limits of the problem are established at the begining. Then class members begin to identify each issue (advantages and disadvantages) and elaborate on the issue. When possible, the students and instructor can validate their assumptions through personal experiences or research, or cite literature.

Reaching a consensus. Because it is sometimes desirable to reach a consensus, it is necessary that criteria for making judgements be evolved in the discussion process before conclusions are reached. Frequently, a decision cannot be reached by the group because the advantages and disadvantages weight evenly against one another. In order to avoid this, it may be useful to establish criteria in terms of priority. Then the solution which best satisfies prior criteria can be selected with less difficulty.

References: 3, 4, 7, 8, 9, 11

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GROUP EXERCISE METHOD

Characteristics

In this method, real or hypothetical problems are assigned to small groups of students who work together toward a single, final group product. This method stresses joint effort and collective decision making in group problem solving and research. Problems that are assigned may be completed in one class session or in several days. The groups are normally required to make a presentation of their findings. This requires that they participate actively and strive to do a good job. The method is used to parallel or to illustrate ongoing instruction. At CATIE, this method has been successfully used in a series of activities involving either discussions of the same theme by different groups (allowing comparisons and lively discussions) or division of the general theme in supplementary subthemes that allow a broad and comprehensive coverage (see "suggested uses" further below).

When to Use it

The group exercise method works best when there is ample time and the main group is large enough (more than 20) to be subdivided. It should only be used when participants already have some experience or knowledge of the theme. It can be used with three purposes: 1) to train groups of individuals who must work together on a daily basis, 2) to train students to solve problems relevant to a particular content area, and 3) to expose students to information and information sources.

Merits

The major strenght of this method is that it gives course participants an opportunity to work together on a meaningful problem. It is a highly active learning environment requiring direct involvement of course participants. The method invites students to participate in an environment where they feel free and confident.

The participants contribute their own experiences and learn from each other. Some members of the group stimulate others to think and produce a chain reaction of thoughts. Participants learn to work toward a common goal and look for solutions by themselves. Their learnings, therefore, become more valuable than information merely told to them.

Finally, group exercises are quite effective in motivating students and raising their interest levels.

Limitations

Group exercises normally requiere an extensive time commitment. Much of this time may be devoted to group organization. Also, the value of the learning process is determined, to a very large extent, by the nature and quality of the problem and by the way in which the group organizes itself and the way it functions. Furthermore, the instructor plays a relatively limited role in the process -providing only organizational and directional assistance- and has only indirect control over the learning environment. This makes it far from easy to ensure that the important points of the exercise are being absorbed by all the participants. Moreover some participants may assume a particularly dominant role opaquing other more timid members of the group.

Techniques for Using the Group Exercise Method

Selection of theme. Consider these factors before selecting a theme:

1) Is the theme relevant to the needs of the participants? The learning process will be enhanced if the theme is related to the participants' daily working conditions.

2) Is it feasible? Will the group be able to reach a conclusion within the set time?

3) Does the group have all the necessary information or can it be easily obtained?

4) Will the theme keep all the members of the group occupied?

Orientation of Group. It is of extreme importance to state the objectives of the exercise carefully and delineate the theme. Offer suggestions to structure the group's time. It should be made very clear what the expectations for their presentation to the class are. A one or two page handout which states this information should be given to students (see example at the end of this chapter).

Division of Groups. Our experience at CATIE shows that rather than allowing participants to break into groups that they select, the course organizers should themselves form the groups. After carefully studying the list of participants, divide them into groups with an equall share of different experiences and disciplines, i.e. foresters are mixed with agriculturalists, and technicians with many years of experience with nocives -the latter are explicitly requested to participate actively, regardless of their "green" condition. Five to seven people seem to be the optimal size for small groups.

Consolidation of Groups. After the groups have had sufficient time to discuss the issue, they should be called back to the classroom to the to present their findings.

Procedure for Using Group Exercises

1) Introduce the method, describe objetives, expectations for presentations (time limits, required visual format, etc.), and procedures for its implementation.

2) Assign students to groups.

3) Assign a problem or topic to each group. If comprehensive coverage of a theme is desired, assign a different problem to each group. If the focus is upon problem-solving skills and quality of group results, assign the same problem to all groups to facitate later comparisons.

4) Hand out information sources and written guidelines.

5) Assign groups to work areas.

6) Alert each group before end of work period (this may be done twice at reasonable intervals).

7) Recall groups and reassemble class.

8) Collect group reports, if written, or require the group's recorder to briefly summarize his group's work.

9) As instructor lead class discussion of findings and of problems encountered during group deliberations.

Note: Some flexibility may be necessary in certain cases, particularly concerning the time allowed for each group during discussion. A coffee break between group discussion and reassembling into room may be handly to allow some groups a few more minutes to finish.

Use of the Group Exercise Method in Agroforestry

The group exercise method can be used to:

-Discuss terminology, classification and concepts of agroforestry.
-Analyze case studies of agroforestry projects.
-Discuss advantages and drawbacks of selected techniques (as compared with alternative land use schemes).
-Divide general theme in subthemes to bring out a comprehensive picture (for instance to discuss the a) biological, b) social, and c) economic features of certain agroforestry practices).

-Develop project work plans.
-Discuss proposals for experimental design.
-Develop criteria for planning and evaluating agroforestry projects.

An example of a well-written guide for a group exercise is presented here. Note that the guide clearly indicates the following points:

.Relation of exercise to course
.Value of exercise
.Structure of groups
.Expectations for presentations
.Outline for plan preparation.

ROLE PLAYING

Characteristics

Role playing is a method of portraying human interaction in situations, in such a manner that realistic behavior is elicited. A situation is presented to the group and some members are asked to assume roles and to enact the situation toward some resolution. Other students observe the behavior of the actors. The scene may be carried to a resolution or the instructor may stop at some critical point in the action. Following the scene, observations of the audience, as well as thoughts and feelings of the actors, are reported and discussed by the group. In this way, faulty diagnoses and actions can be identified. Alternative ways of handling the situation may be tried by replaying the scene. Role playing is an exceptionally flexible method which can be used for a variety of purposes under many different conditions.

Uses

The objective of role playing is to give the participants insights into human relationships and problems, which, when they return to their normal lives, will be reflected in their behavior. It offers an opportunity to experience behavior from a point of view that they might not otherwise experience. It is a technique designed to change attitudes and influence behavior rather than to communicate ideas by concepts. Role playing may be used to:

- Provide insights on why individuals, organizations and nations behave as they do.
- Provide experience in diagnosing interpersonal behavior.
- Test different alternative strategies for managing a situation and provide a manner to improve methods and techniques used in interpersonal relations.
- Learn what behavior is effective in dealing with other people.

Merits

The principal benefits of role playing derive from its highly participative nature.

- It allows individuals to practice different roles and experience different behavior without the risks normally inherent in real life. Mistakes can be tolerated.
- It enables individuals to react to conflict or stress situations without the fear that their actions may have adverse results.

-Role playing puts students in the shoes of others which permits individuals to guess how others will behave in different situations and to appreciate and understand their point of view.

-It provides the group with a common experience to base discussion. In most discussions, much time is lost when students speak and think of their own experience. After participating in role playing, students can focus their comments on what occurred in the dramatization.

-Finally, role playing is fun. It is a pleasant yet educational break from the routine classroom activities.

Limitations

There are several criticisms of the technique. Some observers feel that it is often too artificial, resulting in little transfer of behavior change to real situations and that the very theatricality that makes it engrossing for participants may lead them to forget the problem with which they are dealing. Others consider the technique to be too timeconsuming. They argue that role playing can only focus on a relatively limited number of issues and thus students have a tendency to find it boring.

Conducting a role-playing demonstration

Although role playing is often most effective when it occurs spontaneously, the following steps should be followed:

1) Select a situation that relates well to the interest, needs, experience and knowledge of the participants. The more relevant the situation is to the participants, the more they will learn.

2) Describe the objectives of the activity, the reason for using role playing to attain the objectives, the situation and the roles of each character. If you are using role playing for the first time in the course you should carefully describe it. As an example of an introduction to a spontaneous or impromptu dramatization you could say: "In our discussion this morning, we talked about the various socio-cultural aspects of dealing with small farmers in the implementation of agroforestry alternatives. We suggested a number of techniques to overcome these socio-cultural barriers. Nevertheless, we often, learn something and forget it before applying it. Therefore in order to complete our discussion on this theme we are going to practice some of these techniques so that you can apply them better. Rather than goin out to the field and talking to farmers we are going to simulate the action here in the classroom in a dramatization. In this way we can test our new strategies without the fear of saying something wrong as well as analyze the behavior of both the agroforester and the farmer. It will also illustrate some common problems encountered in dealing with small farmers which we will discuss afterward. Let's see what happens in this scene.

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Mr. Ted Poroski, an agroforester from an agricultural center, has come to the farm of Mr. Manuel Tristán, to discuss the possibility of introducing leguminous trees in his pasture. Although Mr. Poroski has data that clearly shows better profit margin by using leguminous trees, Mr. Tristán is extremely reluctant based on his lack of faith in experiments and on the fact that he has always raised cattle with good results without leguminous tre s.

Let's have two volunteers to play the roles of Mr. Poroski and Mr. Tristán. Act and say what comes naturally to you and the rest of us will observe. And remember the objective of this dramatization is to gain new insights, so please, do not feel hesitant to try new techniques.

Another scenario could be a coffee farmer and a fertilizer salesman. The latter will of course convince the farmer to buy fertilizers for the coffee although the farmer tries to convince the salesman that his shade trees which he prunes regularly every six months, have kept up productivity over many years.

3) Choose your actors with caution. Different organizations have had different experiences in terms of composition of the role-playing groups. Some have found that bringing together people of different levels in an organization, (i. e. a heterogeneous group) tends to reduce the effectiviness of role playing. On the other hand, this could be an effective way of sensitizing both levels to the problems of the other. Role playing is probably most effective when individuals of a similar level, but from different organizations are brought together, since it enables them to see how other individuals and departments tackle the sort of problems with which they are faced.

Many students who are normally shy will feel hesitant or reluctant to participate. Rather than forcing these students into an uncomfortable situation, it is preferable to use volunteers.

4.) In dramatizations which are less spontaneous, give participants 10-15 minutes to prepare their act. Prepare cards which detail the role of each character and give them to the actors.

5) While the actors are preparing the dramatization invite the audience to participate by asking them to select a character and study it to see if they are in agreement with the interpretation of the role. You can assign a particular detail to each observer.

6) Commence the dramatization.

7) Continue the action until the different characters have had an adequate opportunity to develop their role. Normally you will have to

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cut the action before it drags on.

8) Follow the dramatization with a discussion and analysis of what occurred. It is generally better to allow the actors to discuss the situation before the audience. Some possible questions for discussion would be:

-Did the actors play within their roles? In what other way could they have interpreted their roles?

Did they miss some classic points or arguments?

-Why did certain characters behave as they did?

-How did the actors feel when reacting to the situation?

-How would the audience feel in such a situation?

-What principles of human relations can be deducted from the conduct that was observed?

-Which of the alternative methods demonstrated worked best? Why?

-Did underisable responses occur and why?

-What could have been done to avoid such problems?

Or should they be accepted as "normal" risks?

9) In some cases, the dramatization can be repeated after discussion. Often role playing incidents bring out the wrong way of doing things. After discussion, during which correct principles are suggested, a new group of actors can try to show the group the right way the incident should have been handled.

Role of the Instructor

In role playing the role of the instructor is very similar to his role in a case study discussion, i.e. of a moderator or conductor. Once the individual roles have been clearly delineated no more active participation is warranted. Involvement of the instructor in the discussion is only justified if for instance:

-the discussion appears to be going off track or getting out of hand, e.g. tempers become heated;

-certain premises are being introduced which do not match factual information or could lead to improductive discussions not clearly

related to the exercise, such as political or certain land tenure aspects;

-key points or concepts are not being clearly or appropriately identified and discussed;

-there is a need for an external analysis either of the participant's behavior or of the key points arising during the discussion.

Suggested Uses in Agroforestry

The role playing method is used when there is an element of interpersonal relations. Some themes which could be strengthed by using role playing are:

-introducing agroforestry alternatives to small farmers

-testing agroforestry alternatives with agronomists (including animal husbandry), and forest production oriented specialists, who may have a certain inheritent resistence to accept the multidisciplinary aspects.

-conducting surveys

-interviewing farmers

-argumenting with conventional "extensionists" on the validity of "traditional systems" or conversely the introduction of novel agroforestry practices.

-selling a project proposal to your boss or funding agency

-Trying to involve researchers to test certain agroforestry practices (i. e. arguing over plot sizes, statistical methods or yard sticks against which to compare the practices).

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A METHODOLOGY FOR DIAGNOSIS AND DESIGN OF AGROFORESTRY LAND MANAGEMENT SYSTEMS

*Dr. J.B. Raintree**

Agroforestry, the new interdisciplinary science dealing with the age-old practice of combining trees, in space or time, with herbaceous crops and/or animals on the same unit of land, has recently come into international prominence as a potential source of solutions to many interrelated problems of production and conservation troubling land use systems in the tropical and sub-tropical regions of the world today. If the fledgling interdisciplinary science is to live up to the world's expectations with regard to its problem-solving capabilities, it will have to improve significantly on the methodology for targeting research and development efforts to the actual needs and potential of tropical land use systems.

With the promotion of research and development of improved agroforestry land use systems to enhance the social, economic and nutritional well-being of the people of developing countries as its goal, ICRAF's research strategy places a major emphasis on the development of a "diagnostic and design methodology" to guide agroforestry RAD toward relevant and adoptable solutions to location-specific land management problems.

A preliminary version of this methodology (Torres, 1981) was used as a framework for the collection and analysis of data for the case-studies presented at an agroforestry planning seminar held in Venezuela. A more detailed preliminary working manual is available from ICRAF under separate cover (ICRAF, 1982a). The purpose of this brief introductory paper is to highlight the principal features of the evolving methodology and to explain something of its internal logic and rationale.

**Ecological Anthropologist / Senior Research Scientist at ICRAF.*

1. *Why is diagnosis necessary?*

The ultimate practical aim is to develop agroforestry land management systems and technologies with specific capabilities to solve land management problems in areas where agroforestry is deemed to have a role. When confronted with an ailing land use system, the task facing agroforestry planners and practitioners is to identify and prescribe relevant treatments. The nature of the task is analogous in many respects to that of the medical practitioner confronted with an ailing human organism.

The rule of procedure in the medical profession is that "diagnosis should precede treatment". There are exceptions to this rule in practice, of course, but it would be unthinkable that medical professionals could ever simply ignore the diagnostic process altogether and prescribe treatment without due regard to the specific nature of the illness. We would never tolerate a haphazard, hit-or-miss approach to treatment from professions dealing with human pathologies. How strange that we have come to accept such an approach when it comes to treating pathologies arising from man's use of the earth!

Is this not, in fact, what happens in many cases when a traditional agricultural or forestry research station develops a new technology and recommends it for dissemination? In how many cases is the treatment preceded by an adequate diagnosis of the actual and perceived problems confronting the majority of land users in the recommendation domain? The answer given by many researchers that they *already know what the problems are"* without the complications of a formal diagnostic procedure would be analogous in the medical profession to a) the patently absurd assumption that all patients are the same, or b) the arrogant assumption that well-trained medical doktors could treat patients without recourse to an examination.

No wonder the cure rate for land use problems is so low! Technologies implicitly designed for conditions which prevail on research stations

and "high access" farms (Rolling, 1980) and forest management units are often abysmally inappropriate when extended to the majority of land users in the agroecological zone. The problem is not that the biophysical parameters of the zone have not been taken into account - on the contrary, these are usually well understood - but that discipline-oriented researchers often fail to perceive that the "patient" in the final analysis is the *existing land use system*, which has its own internal organisation and its own unique set of operational constraints and potentials.

The problem with an *ad hoc* approach to technology generation is that researchers are rarely equipped to address the *full set of relevant design criteria*. It was never a very effective strategy to design technology on the basis of only a partial set of design criteria and then to treat the non-adoption of the resulting technology as an "extension problem". It will almost always be more useful to place the onus of responsibility for relevant technology squarely on the technology-development professionals, recognizing that the problem is, in the first instance, *a design problem*. There is simply no substitute for good design. To achieve this objective will normally require coordinated inputs from an interdisciplinary team of professionals as well as from the intended users of the eventual technology product.

A problem-oriented diagnostic approach to agroforestry design is believed to be the most direct and logical route to effective and adoptable agroforestry technologies and land management systems. In developing its diagnostic and design methodology, ICRAF recognizes that a quick turn-around on diagnostic and design activities is absolutely necessary in order to have a timely influence on the project-planning cycle. It is not envisaged that a long-drawn-out survey process will be either necessary or useful. Rather, the aim is to develop a practical, effective, and quickly accomplishable D&D protocol which can prove its usefulness by the results it obtains in a wide range of environments around the world.

Basic procedures

The basic logic of the D&D discovery procedure is displayed in the following table. The process can be subdivided into smaller steps (e.g. pp. 8-14) and used selectively for varying purposes, but the hierarchical logic of D&D is quite robust and generally applicable to virtually any problem in technology design. The more detailed procedural suggestions are best thought of as optional steps for collecting and processing the information needed to answer the basic questions shown in the table below. If at any time you feel you are getting "lost in the details," simply return to this outline of basic procedures for a reorientation to where you are in the process.

D&D STAGES	BASIC QUESTIONS TO ANSWER	KEY FACTORS TO CONSIDER	MODE OF INQUIRY
PREDIAGNOSTIC	DEFINITION OF THE LAND USE SYSTEM AND SITE SELECTION (which system to focus on?)	DISTINCTIVE COMBINATIONS OF RESOURCES, TECHNOLOGY AND LAND USER OBJECTIVES	SEEING AND COMPARING THE DIFFERENT LAND USE SYSTEMS
	HOW DOES THE SYSTEM WORK? (how is it organized, how does it function to achieve its objectives?)	PRODUCTION OBJECTIVES AND STRATEGIES, ARRANGEMENT OF COMPONENTS	ANALYSING AND DESCRIBING THE SYSTEM
DIAGNOSTIC	HOW WELL DOES THE SYSTEM WORK? (what are its problems, limiting constraints, problem-generating syndromes & intervention points?)	PROBLEMS IN MEETING SYSTEM OBJECTIVES (production short-falls, sustainability problems)	DIAGNOSTIC INTERVIEWS AND DIRECT FIELD OBSERVATIONS
		CAUSAL FACTORS, CONSTRAINTS AND INTERVENTION POINTS	TROUBLESHOOTING THE PROBLEM SUBSYSTEMS
DESIGN & EVALUATION	HOW TO IMPROVE THE SYSTEM? (what is needed to improve system performance?)	SPECIFICATIONS FOR PROBLEM SOLVING OR PERFORMANCE ENHANCING INTERVENTIONS	ITERATIVE DESIGN AND EVALUATION OF ALTERNATIVES
PLANNING	WHAT TO DO TO DEVELOP AND DISSEMINATE THE IMPROVED SYSTEM?	RESEARCH AND DEVELOPMENT NEEDS, EXTENSION NEEDS	RESEARCH DESIGN, PROJECT PLANNING
IMPLEMENTATION	HOW TO ADJUST TO NEW INFORMATION?	FEEDBACK FROM ON-STATION RESEARCH, ON-FARM TRIALS AND SPECIAL STUDIES	REDIAGNOSIS AND REDESIGN IN THE LIGHT OF NEW INFORMATION

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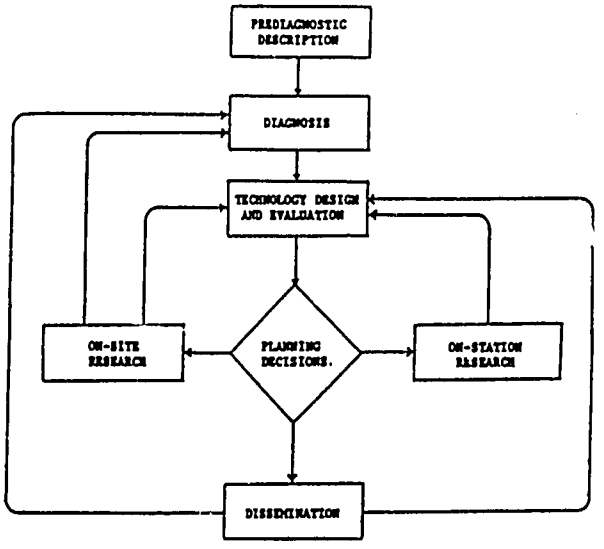
D&D IS AN ITERATIVE PROCESS

The basic D&D process is repeated throughout the project implementation stage to refine the original diagnosis and improve the technology design in the light of new information from on-farm research trials, more rigidly controlled on-station investigations, and eventual extension trials in a wider range of sites. As shown in the following flowchart, the iterative D&D process provides a basis for close feedback and complementarity between different project components. By adjusting the plan of action to new information, the D&D process becomes self-corrective. In an integrated agroforestry research and extension programme, the pivotal decisions are taken in periodic meetings which evaluate new results and revise the action plan accordingly. The process continues until the design is well optimized and further refinement is deemed uneccessary. You can enter the cycle at any point, but the ultimate fine-tuning and dissemination of the technology will most likely be accomplished by the farmers themselves.

FLOWCHART OF REPETITIVE ACTIVITIES AND FEEDBACK IN A D&D-BASED PROJECT



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Key concepts

D&D IS SYSTEM SPECIFIC

The focus of D&D is the **land use system.** Since different systems are likely to have different problems and potentials, it follows that each distinctive land use system must have its own diagnosis and corresponding design.

This does not mean that D&D results are 'site specific' since the same basic land use system may exist in many sites. The selection of sites representative of important land use systems is an essential aspect of the art of D&D.

DEFINITION OF "THE SYSTEM" FOR D&D PURPOSES

For the purposes of a D&D exercise, a land use system is defined as a distinctive combination of three interrelated factors: the **land resources** exploited by a particular **technology** to satisfy the production objectives of a particular type of **land user.**

This definition contrasts with other commonly used definitions which do not formally recognize the land user as part of the system. The difference is more than just semantic, since all three elements are essential to a functioning land use system. If the human element is left out of the picture it becomes too easy to overlook the objectives around which the existing land use system is organized. By consciously attempting to design with the grain of the existing system rather than against it, the D&D methodology helps to avoid the kind of design error that results in technically and environmentally feasible but somehow "non-adoptable" agroforestry technologies.

THE DIAGNOSIS LEADS TO 'SPECIFICATIONS' FOR INTERVENTIONS

The *end-product* of the diagnostic procedure is a set of functional specifications which tell what the system needs and, in a general way, how these needs can best be satisfied.

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SPECIFICATIONS SUGGEST 'CANDIDATE TECHNOLOGIES'

This is basically a matching exercise which narrows down the range of technical choices to those prototype technologies which are hypothetically capable of meeting the specifications.

'TECHNOLOGY SPECIFICATIONS' COMPLETE THE DESIGN

The design is not complete until the "nuts and bolts" of the selected technologies have been specified, i.e. the actual choice of component species, spatial arrangements, management practices, etc.

THE DESIGN REVEALS RESEARCH NEEDS AND EXTENSION OPPORTUNITIES

The attempt to arrive at an agroforestry design relevant to the needs of the diagnosed system is a practical way of exposing the gaps in technical knowledge. Research and extension programmes designed to develop and implement the envisaged technical solutions are likely to be more relevant and cost-effective.

IF AT FIRST YOU DON'T SUCCEED, TRY AND TRY AGAIN

Complete success on the first round of D&D is an unrealistic expectation. There is a saying in the engineering profession that "the first one never works." There are exceptions to this facetious generalization, of course, but it is true that prototype technologies can almost always be improved. The aim of the initial round of D&D is not to arrive at the "perfect solution," but simply to start the research and development process moving in the right direction and to provide a concrete focus for further design improvements.

The very act of introducing a new technology changes the diagnosed situation and necessitates at least one more round of diagnosis to evaluate the impact of the intervention on the system. In most cases this will suggest ideas for design improvements. Longer exposure to the land use system in the course of the project will inevitably result in a deepening of the initial diagnosis and may even suggest a whole new approach to design. Creative inputs from farmers may not be forthcoming until after they have been exposed to the experimental technology for some time.

Suggested procedures for national research programmes

This section presents a schematic overview and a detailed step-by-step outline of the full set of D&D procedures for formulation of coordinated national research and extension programmes.

Since the implementation of such programmes may involve multi-institutional collaboration and long term committment of significant financial and institutional resources, a more elaborate and formal version of the D&D methodology is usually required. Although the procedures outlined in this section follow the logic of the "basic procedures" shown on pages 6-7, they represent a more detailed subdivision of the basic stages into steps with additional subroutines for collecting and processing the information needed to answer the key decision questions of each stage.

This outline is best thought of as a of a "prototype methdology" or provisional blueprint for large-scale, nationally coordinated D&D activities. As with all D&D applications, the suggested procedures should to be used selectively and adapted to fit the requirements of particular programmes. Adapted versions of these guidelines are currently being implemented by participating countries in ICRAF's Agroforestry Research Network for Africa (AFRENA).

For a closer focus on community-based D&D activities, see "**The view from the village.**"

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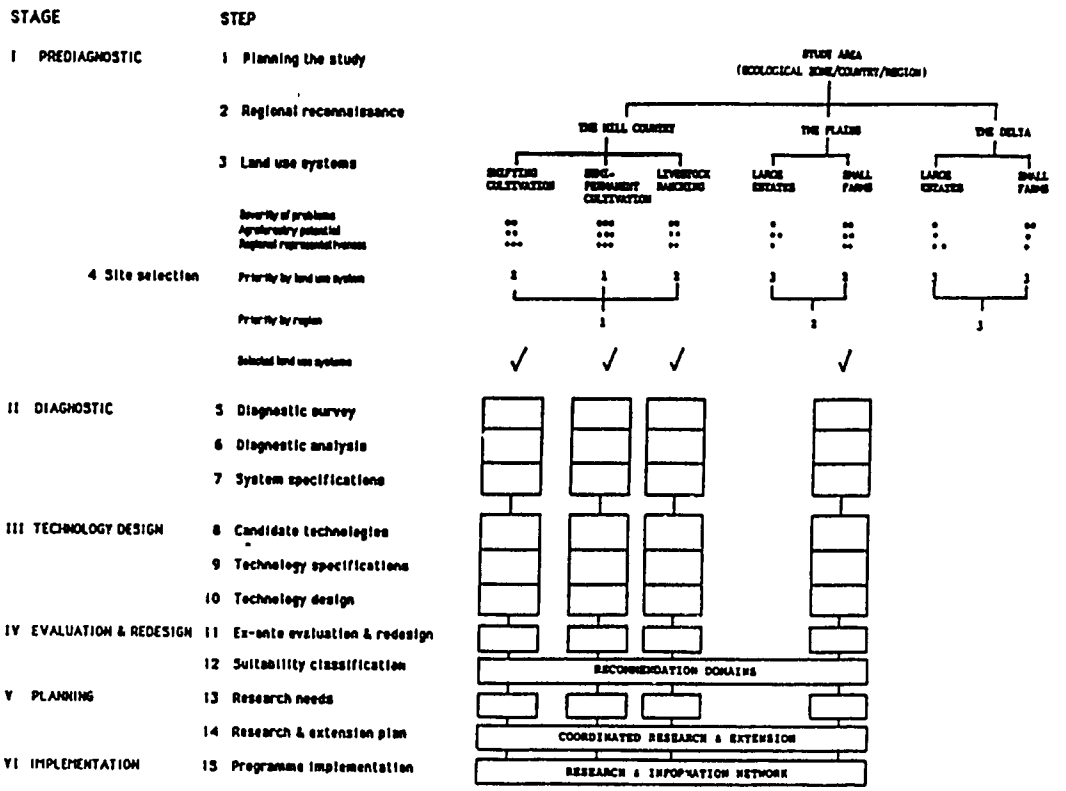

(Adapted from Young *in press*)

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I. PREDIAGNOSTIC STAGE

STEP 1. PLANNING THE STUDY

- Identify objectives
- Specify area to be covered
- Identify collaborating institutions and staff
- Select and adapt D&D methods to be used

STEP 2. REGIONAL RECONAISSANCE

- Identify, map and describe major land units and population distribution

STEP 3. IDENTIFICATION AND PRELIMINARY DESCRIPTION OF LAND USE SYSTEMS

- Differentiate and describe important land use systems
- Make a preliminary assessment of their constraints & problems
- Make a preliminary assessment of their agroforestry potential

STEP 4. SITE SELECTION

- Select land use systems for priority attention based on:
  - (i) severity of problems
  - (ii) agroforestry potential
  - (iii) regional representativeness
- Select sites representative of the chosen systems for in-depth D&D

II. DIAGNOSTIC STAGE

STEP 5. DIAGNOSTIC SURVEY

- Conduct field survey of representative managment units to identify common land use strategies and problems
- Troubleshoot the production systems to identify causal factors and contraints
- Investigate interactions between and within managment units and processes in the general landscape

STEP 6. DIAGNOSTIC ANALYSIS

- Analyze field data to identify key constraints and intervention points for development of system potential
- Assess sustainability problems

STEP 7. SPECIFICATIONS FOR APPROPRIATE INTERVENTIONS

- List system specifications:
  - (i) Functional specifications for interventions
  - (ii) Design constraints
  - (iii) Desirable attributes of new technology
  - (iv) Overall development strategy for the system

III. TECHNOLOGY DESIGN STAGE

STEP 8. IDENTIFICATION OF CANDIDATE TECHNOLOGIES

- List feasible technologies which meet the system specifications
- Select and prioritize the most promising technologies and combinations

STEP 9. DETAILED TECHNOLOGY SPECIFICATIONS

- Make a detailed list of desirable attributes of each of the selected technologies (component characteristics, mngt. considerations, etc.)
- Prioritize the attributes on this list in the light of the total knowledge of the diagnosed system

STEP 10. TECHNOLOGY DESIGN

- For each specific technology, give detailed answers to each of the following questions:
  - (i) What **functions** should each intervention address?
  - (ii) At what **location** within the farm or general landscape should these functions be performed?
  - (iii) What component or combination of **components** (plant/animal species & varieties) are the best choices for performing these functions?
  - (iv) **How many** of each component are required to meet production targets?
  - (v) What precise **arrangement** of components is envisaged? (give details of spatial and temporal associations of components at a given location)
  - (vi) What **management** practices are required to achieve the desired performance characteristics?
- Take note of all design questions to which the D&D team is presently unable to give satisfactory answers (these are topics for further consultation or research)
- Synthesize all of the above into an integrated design for an agroforestry system which best answers the needs and potentials of the existing land use system (consider stepwise introduction of component technologies if the full system is likely to be too much for local farmers to adopt all at once)

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IV. EVALUATION AND REDESIGN STAGE

STEP 11. EX-ANTE EVALUATION & REDESIGN

- Check land users' response to the design proposal (optional D&D verification survey)
- Conduct a preliminary evaluation of the agroforestry design, compare with present land use and non-agroforestry alternatives in terms of:
  - (i) **productivity** (biological potential, economic efficiency & diversity of production)
  - (ii) **sustainability** (environ. impact, resource conservation)
  - (iii) **adoptability** (fulfilment of felt needs, cultural compatability, social distribution of benefits)
- Return to design stage activies to make modifications suggested by the preliminary evaluation

STEP 12. SUITABILITY CLASSIFICATION

- Summarize system evaluations for each of the designed agroforestry systems and develop classification of suitability for wider application
- Combine these classifications into suitability maps and tables for the study area/region as a whole (define preliminary "recomendation domain")

☞ **Note: Results of ex-ante evaluation and preliminary suitability classification should be considered provisional until validated by field experience at the implementation stage. Strictly speaking, favorable evaluation at this stage merely indicates that a particular technology is worth developing and testing.**

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V. PLANNING STAGE

STEP 13. STATE OF KNOWLEDGE REVIEW AND ASSESSMENT OF RESEARCH NEEDS

- Assess readiness of each of the designed technologies for direct extension and/or need for further research
- Compile integrated list of research needs, including:
  - (i) Need for further D&D (pre-project follow-up and/or monitoring of field trials during project implementation)
  - (ii) On-farm trials of candidate technologies
    - farmer managed trials to assess adoptability and elicit farmer's own design ideas
    - researcher managed trials to evaluate experimental variables under
  - (iii) On-station investigations under controlled conditions to obtain detailed information on component interactions, response to management, germplasm screening, etc.

STEP 14. RESEARCH AND EXTENSION PLAN

- Develop overall plan of action, detailing:
  - (i) Individual research investigations
  - (ii) Extension activities
  - (iii) Integration of research and extension goals and activities
  - (iv) Collaboration in research & extension networks

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VI. IMPLEMENTATION STAGE

STEP 15. IMPLEMENTATION OF R&D AND EXTENSION ACTIVITIES

- Continue to apply the iterative D&D process to refine prototype agro-forestry systems on the basis of feedback from research and extension experience (rediagnosis and redesign)
- Institutionalize communication channels between different programme components (hold periodic meetings to pool experience, assess new developments and modify the plan of action in the light of new experience)

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The view from the village

THE TWO CENTERS OF AGROFORESTRY INNOVATION

Not every village will be reached by a formal agroforestry research project on the model of the preceeding section. Indeed, for the the benefits of national research programmes to reach most villages informal processes of technology diffusion must be activated on a massive scale. Moreover, the villages themselves are important centers of indigenous agroforestry innovation. Informal sector community development workers have an significant role to play in complementing the efforts of formal sector programmes.

Although much of what is presented in this section is applicable to on-farm researchers and extension agents in formal programmes, it is primarily intended for agroforestry catalysts who work directly with local communities but who are not necessarily part of a formal research and development programme. Ways are suggested for improving the linkages between these two complementary centers of agroforestry innovation.

ARE YOU A COMMUNITY-BASED FIELDWORKER?

If you are a village extension agent or community development fieldworker already working in a particular village or regional community, much of what has been presented in the preceeding section will seem superfluous or overly formalized for the kind of work you are doing. As necessary and appropriate as the steps in the more elaborated methodology might be for large-scale, multi-institutional programmes, many of them will be irrelevant to your own needs and circumstances. You should feel free to select and adapt those aspects of the D&D methodology which would be of real use to you in your own situation. The **Basic Procedures** (pages 6-7) will probably be of most direct use to you as a guide for your D&D activites.

ADAPTING D&D TO YOUR OWN NEEDS

Since you are already working at a particular site, you will have little use for the Prediagnostic steps concerned with institutional arrangements, regional reconaissance and site selection. You may still find it useful, however, to make a systematic inventory of the

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land use systems and farm types in your area, and for some of these you may wish plan a more in-depth diagnosis of problems and agroforestry potentials.

The same applies to the formal exercises of the Planning Stage. Your own planning procedures are likely to be more fluid and participatory, particularly if you are working within an informal non-government, private voluntary or community-based organization. Still, any systematic thought you can give to the planning of your own informal research and extension activities is likely to pay off in greater effectiveness of your agroforestry efforts.

The heart of the D&D methodology--the iterative process of diagnosis, design and evaluation--is potentially very relevant to the effectiveness of your agroforestry work, though perhaps not in the style suggested by the more formal procedures.

IN-DEPTH DIAGNOSIS

In general, there will be much less pressure to conform to the time constraints of an initial "rapid appraisal" D&D. By living and working in close and continuous contact with your community you may already possess a deeper diagnostic understanding of the land use problems of your area, and your communication with the inhabitants is probably far better, than what could be achieved within the time frame of a short term exercise by even the most experienced and sensitive D&D team from outside the community.

Still, your perceptions might be sharpened by a more systematic application of the diagnostic logic and selective use of some of the diagnostic tools. Also, if you are working without the benefit of a multidisciplinary team, you may find it helpful to consult with outside experts on certain aspects of your diagnosis or design. If there is a formal agroforestry project dealing with a similar land use system, it may be particularly relevant to compare their results with your own.

LOCAL PARTICIPATION

Although close interaction with the intended users of technology is an integral part of all D&D-based projects, as a community-based fieldworker you may find yourself in a position to implement this principle with more thoroughness than many externally-based researchers. You may lack the sophisticated techniques and resources of formal research institutions, but your ability to maximize local participation in the development and testing of agroforestry innovations may give you the advantage with respect to the "adoptability" of the new technologies. And ultimately, given the overriding importance of adoption, you may have greater impact on the local agroforestry scene.

INTERACTIVE DIAGNOSIS & DESIGN

The way to take advantage of your opportunities in this respect is to take a thoroughly interactive approach to diagnosis and design. The principle that "diagnosis should precede treatment" still holds as a requirement for accountability in technology generation, but once you begin the iterative cycle of diagnosis and design the process becomes circular. "Diagnosis by treatment" is a practical expedient employed by medical doctors whenever they cannot immediately confirm their diagnostic suspicions prior to treatment. If the treatment works the diagnosis was correct.

PERTURBATION EXPERIMENTS

This practice has a parallel in agroforestry in the form of small interventions undertaken to see how the system responds. If the farmers show interest in adopting a particular problem-solving technology, then this is evidence that the problem is real and important in the minds of the local people--providing, of course, that they are not adopting it for some other reason. In any case, such "perturbation experiments" are significant insofar as they may uncover previously unsuspected problems or local development priorities.

Close monitoring of farmer-originated innovations, modifications of prototype technologies, and the reasons behind farmer adoption behaviour not only provides important diagnostic clues but may also be a rich source of ideas for design improvements.

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FARMERS AS EXPERIMENTERS

Although it is rarely given full recognition by university educated researchers in developing countries, it is an undeniable fact that farmers themselves are active experimenters. Informal experimental research has been a continuous feature of the farming scene since the dawn of agriculture. Without it we would have none of our contemporary crops and, indeed, very little agricultural technology at all!

Even when farmers adopt a technology developed by a research station, they tend to do it *experimentally*--step by cautious step on a little corner of their land. In the process it is usually *adapted* to fit the farmer's circumstances. Ultimately, it is *their thinking*, not only that of research scientists, which must be developed before change in land use practice can come about. This is not an "alternative" to what formal researchers do, but a necessary and complementary step in the sequence of rural development processes. If this step is not completed, then the technology simply sits on the shelf and nothing practical is accomplished.

TWO-WAY INFORMATION FLOW

Increasingly, researchers in developing countries are trying to reach out to farmers through on-farm experimentation, but the number of sites in which they can work is severely limited and the "partnership" is still somewhat one-sided. Even in the best-intentioned programmes the language in which this activity is couched reveals a lingering "center bias." Scientists "go out" to the farmers and "bring back" information to help them decide how best to make their technologies more relevent to their clients needs, but farmers still have relatively little scope for direct expression of their own research and development priorities. What is needed to make the partnership successful is a communication channel in which information about technology and research needs and priorities flows with equal ease in both directions.

THE COMMUNITY-BASED FIELD WORKER AS INFORMATION BROKER

As national agroforestry research programmes get underway there will be an expanding stock of research results, germplasm and new prototype technology to draw upon in applying agroforestry to

community development problems. Extension services will undoubtedly be called upon to play a greater role in getting the new technology out to potential users, but it is unlikely that they alone will be able to handle the potential volume of information and they tend still to be limited by a one-way approach to the flow of information. Informal sector fieldworkers have a useful role to play in obtaining relevant information and technologies for their communities and, on the other side, in providing formal agencies with better access to information on local research and development priorities and technical innovations originating within their communities. D&D concepts may provide a kind of "lingua franca" for this work.

COMMUNITY-BASED R&D

The challenge to all concerned parties, if agroforestry is to have a significant impact on the rural landscape, is to get the two complementary centers of experimentation and technical innovation working together in a mutually reinforcing relationship. This is most likely to be successful if *both* centers of research and development activity are strengthened. For the formal sector research center it should not become a question of who takes the initiative. In technology generation the initiative is where you find it (a surprising number of the technologies 'released' by international research centers have their origin on farmer's fields). The question, rather, is whether the effectiveness of the total--formal and informal--agroforestry R&D effort can be enhanced through awareness and support of farmers in their own informal research and development activities.

This is where community-based fieldworkers--in the role of development catalysts, information brokers translating between different knowledge systems and, in some cases, leaders of informal R&D teams--can make a signficant contribution to the realization of agroforestry's potential in rural development. In the hands of a skilled change agent, the D&D methodology may prove to be a useful tool for the job, particularly if coupled with an effective information network.

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PREDIAGNOSTIC STAGE

OVERVIEW

PURPOSE: The purpose of the Prediagnostic Stage is to lay the groundwork for the Diagnostic and Design Stages which follow by describing the diagnostically relevant characteristics of the chosen land use system and its environment.

PERSONNEL: It is suggested that a Prediagnostic Working Group be formed to carry out this task. It is highly desirable, but not absolutely necessary, that the Working Group contain at least one senior scientist who will continue on as part of the D&D Field Team at the Diagnostic Stage.

SOURCES OF INFORMATION: The two main sources of prediagnostic information are:

1) *Existing documentation* on the study area, including published and unpublished research reports, soil surveys, meteorological records, census reports, maps, air photographs, etc., supplemented by consultations with experts familiar with the study area; and 2) *Reconnaissance visits* to the study area, partly to familiarize the Working Group with the area and to aid in the interpretation of existing documentation, but also to collect supplementary information through direct observation of environmental features and land use patterns and through interviews with qualified informants (local officials, extension agents, articulate farmers, researchers familiar with the area, etc.). See Appendix A-1 for further suggestions on sources of prediagnostic information.

SUGGESTED PROCEDURES:

Step 1. Environmental Description of the Study Area

Step 2. Differentiation of Land Use Systems Within the Area

Step 3. Preliminary Description of Selected Land Use System(s)

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GENERAL GUIDELINES

The aim is not description per se, but description for the purpose of diagnosis and design. The amount of documentation produced at this stage will vary from application to application. Good documentation is necessary if different personnel are to carry out the next stage or if a formal report or project proposal is planned. On the other hand, brief notes will suffice if it is judged that there is no particular value in extensive documentation.

SPECIFIC PROCEDURAL SUGGESTIONS

STEP 1. ENVIRONMENTAL DESCRIPTION OF THE STUDY AREA

The purpose of the information gathered at this step is to characterise the environment of the land use system or systems which will be selected for more detailed attention in succeeding steps and thus to provide a context for the interpretation of information about the focal system(s). For completeness and clarity it is convenient to divide the environmental description into three substeps: 1) description of the *biophysical environment*, 2) description of the *socioeconomic environment* and, if sufficient information is available, 3) description of the organization (structure and function) of the *human ecosystem* in which all dimensions of the relevant environment are integrated.

1.1 Biophysical Environment

1.1.1 Worksheet

Worksheet 1.1 has been provided to assist in the selection and recording of relevant environmental information in accordance with the guidelines given in Appendix A-2. The suggested information system is based on ICRAF's Environmental Data Base for Agroforestry and is designed to provide a standard set of descriptors for aspects of the biophysical environment which are relevant to land use systems in general and agroforestry systems in particular.

Minimally, the information categories described in Appendix A-2 are meant to be suggestive of what may be relevant to know about the environment of the study area and as such it is not absolutely necessary to use the suggested recording system to satisfy the purpose of this step. However, the use of this information system is highly recommended if you wish to maximise the international accessability and comparability of your case data and particularly if you intend to contribute to ICRAF's global data bank on agroforestry or to the publication series on Case Studies in Agroforestry Diagnosis and Design.

See Appendix A-2 for detailed guidelines on the use of Worksheet 1.1

1.1.2 Additional Climatic Information

In some cases additional climatic information may be required to assess land use constraints and agroforestry potentials. Where water is a limiting factor for agriculture, it may be particularly useful to undertake a more detailed assessment of water availability throughout the year. Part 1 of Appendix A-3 contains detailed guidelines for

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computation of water budgets. Part 2 contains a more general discussion of temperature effects on plant development. The Working Group should evaluate the need for additional climatic information and compile the necessary data from existing sources.

1.2 Socioeconomic Environment

Relevant information on the socioeconomic dimensions of the environment may be more difficult to identify and collect, but is no less important than biophysical information as a determinant of land use decisions. The categories of socioeconomic information suggested in Worksheet 1.2 are designed to provide a reasonably complete, and yet efficient, coverage of potentially useful background information. The level of detail in the completed Worksheet will obviously depend on the availability of existing information. Following a reasonable effort to gather the information to complete Worksheet 1.2, the Working Group should restrict further expenditure of time and energy to those categories which it knows, or strongly suspects, will be relevant to the deliberations of the D&D Team. Unexpectedly important information gaps can be filled by the D&D Team or a subsequent working group once the relevance of the missing information has been established. (This comment applies to all categories of information at any stage in the D&D process).

See Appendix A-4 for detailed guidelines on completion of Worksheet 1.2.

1.3 Structure and Function of the Human Ecosystem

The human ecosystem (i.e. an ecosystem whose organization reflects the dominant influence of human activity) is a distinctive level of integration comprising both biophysical and socioeconomic dimensions of the environment characterized in 1.1 and 1.2. It is the effective environment of long term relevance to the land use systems and management units to be identified and described in Steps 2 and 3.

A descriptive understanding of the main structural and functional attributes of the larger human ecosystem can assist in identifying the most important land use systems within the study area for D&D attention. It can also aid in the understanding of those systems and, perhaps more importantly, in the diagnosis of problems and potentials which exist beyond the boundaries of the unit systems. These notes and the detailed procedures described in Appendix A-5 are designed to assist the user in arriving at a meaningful prediagnostic overview of the human ecosystem. The suggested procedures may, of course, be adapted to fit the needs and resources of the user.

The first step in most cases will be to define the boundaries of the human ecosystem in order to set limits on what is to be described. If the analysis applies to a watershed management project, then the watershed may be conveniently taken as the ecosystem unit, providing there are no overriding socioeconomic considerations (e.g. a different scale for the effective community or market organization of the area). Whatever weighting is ultimately given to the various factors, the definition of system boundaries for D&D purposes should reflect both socioeconomic and biophysical considerations.

Once defined, the system may be treated as a homogeneous unit or it may be stratified by geographical or social criteria. If it is treated as a homogeneous unit, the components, the status of the ecosystem and its relationship to the outside may then be inventoried (using checklist 1 in Appendix A-5 part 1) The various different components are defined by their role within the ecosystem: energy sources, physical resource base (land, water, soil), primary producers (vegetation), secondary producers (also consumers - animals for milk, meat, labour), consumers (people, one or more groups including migrant/seasonal labourers), and savings/investment stores (cash, buildings, other infrastructure, capital items). These components, their condition, the exchanges between them, external inputs and system outputs constitute a structural/functional outline of the human ecosystem and its links with the larger environment.

If the human ecosystem is to be stratified by geographical area and/or by population subgroup, the analysis emphasizes exchanges between subareas and groups within the ecosystem. This approach is useful where there is a pronounced difference in land management technology or internal division of labour by group or area. For example if there is a strong association of two socioeconomic groups with two respective land units and types of production, then the modified input-output analysis in Appendix A-5 (Checklist 2 and related text) may help to clarify the roles of the two groups relative to each other, the immediate biophysical environment, and the larger ecosystem.

This second type of analysis (check list 2) is intended as a prelude to the identification of problems and potentials at the ecosystem scale. It includes a modified input-output matrix defined by ecosystem subdivisions (or groups) and basic needs of the inhabitants. Surplus and deficits may be reported in addition to inputs, outputs and static condition.

See Appendix A-5 for detailed guidelines and Appendix B-8 for optional diagramming tools.

STEP 2. <u>DIFFERENTIATION OF LAND USE SYSTEMS WITHIN THE STUDY AREA</u>

For diagnostic and design purposes it is important to distinguish clearly between the different land use systems found in the study area. Each distinct land use system can be expected to have its own unique set of constraints and potentials, different from those of other land use systems in the area. Diagnosis and design are system-specific activities, so it is crucial, right from the start, to have a clear definition of the system(s) being addressed. All subsequent information will relate to the systems so defined or to their environments.

As conceived from D&D purposes, a *land use system* has both biophysical and socioeconomic dimensions. To define a land use system thus involves specifying the particular *combination* of biophysical and socioeconomic characteristics which distinguish it from other land use systems in the area. It could be that a difference of even only one salient characteristics, e.g. soil type (a biophysical characteristics) or land tenure (a socioeconomic characteristic), may justify the classification

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of two otherwise similar farms in different land use system categories. On the other hand, it is also possible that several minor differences do not, in the judgement of the Working Group, add up to a significant difference, requiring a separate land use system classification.

There are no hard and fast rules for assigning farms (or other land use units) to one category or another, but basically the deciding criterion is a pragmatic one: Whether or not a difference of one or more characteristics is likely to result in a *significantly different set of land management constraints and potentials*, requiring separate diagnostic and design treatment. Based on this criterion the Prediagnostic Working Group must come to its own decision. Keep in mind, however, that this is only a preliminary classification. The D&D Team may, on the basis of its survey findings, decide to modify the initial classification to bring it more into line with identified technological options.

To simply the task of the Working Group in arriving at a preliminary classification of land use systems within the study area, Step 2 is broken down into three substeps:

2.1 Identification of land units with a relatively homogeneous set of biophysical characteristics.

2.2 Identification of management units and their characteristics.

(Alternatively, the order of the preceeding steps could be reversed).

2.3 Identification of those combinations of land units and management units which represent distinctive land use system.

2.4 Selection of priority land use system(s) for D&D attention.

Worksheet 2 is provided to record the results of this stepwise process. Specific guidelines follow below.

2.1 Identification of land units

A *land unit* is an area or type of land which possesses relatively homogeneous biophysical characteristics. All land within a land unit has similar resource potential and hazards, and compared with other parts of the study area. It is the basic unit for diagnosis of biophysical resource constraints and potentials.

It should be noted that the term "land unit" is not restricted to a particular scale or degree of homogeneity. In reconnaissance studies covering large areas, the land units may cover areas of hundreds of square kilometres and possess substantial internal variations of land characteristics. In more detailed studies, the appropriate land units will be smaller and more uniform. Whatever areas of land are perceived as the appropriate physical basis for the diagnostic survey are taken as the "land units" for the survey.

Possible mapping units which can serve as land units include *land systems* or *land facets*, terms taken from the land systems approach; *land capability subclasses* or *land capability units*, taken from the method of land capability classification; and *soil associations* or *soil series*

as distinguished in soil survey. For definitions of these mapping units, and accounts of the methods of survey, see Dent and Young (1981). Land systems or soil associations are appropriate at reconnaissance scales or survey, while land facets, land capability units or soil series are appropriate in detailed surveys. For most diagnostic survey work, land facets will form the appropriate land units. However, where a reliable map of any one of the above kinds, at a suitable scale, already exists, it will be time-saving to accept the units which it shows as the land units for survey purposes.

If no such map exists, the land systems approach (also known as the method of integrated survey) is recommended. It is a rapid method of survey in which all factors of the physical environment are taken into account simultaneously. The method is first to identify the *land systems* which occur in the study area, and then the *land facets* which occur in each. The land systems are first delineated (i.e. their boundaries are drawn) on air photographs for the whole of the study area, these boundaries being subsequently transferred to a map. Land facets will then be identified, but need only be delineated for sample parts of each land system. If air photographs are not available, the Working Group should follow basically the same procedure using whatever topographic maps and survey information are available.

Worksheet 2 has been prepared for the land systems approach. If other mapping units are being used, then the headings for columns 1 and 2 must be changed accordingly.

Column 1. *Land Systems*. A land system is defined as an area with a recurring pattern of land facets. Most land systems are initially identified and defined in terms of their landforms; they are then described in terms of the full range of environmental factors (as in Worksheet 1.1). Examples of land systems are an undulating plain, a range of hills, and a coastal or alluvial plain. Some land systems are given local names, e.g. the Masambara Hills Land System.

To complete column 1, simply decide what land systems are present in the study area and enter their names or brief descriptive phrases. Be sure to leave enough vertical space between entries to allow for recording of subsequent information in columns 2-12.

Column 2. *Land Facets*. A land facet is an area within which, for most practical purposes, biophysical conditions are uniform. All land within a land facet can be expected to respond similarly to management. Land facets frequently occur in regular sequences, within a land system, from hill crest to valley floor; they often correspond to elements in a soil catena. For example, a land system characterized by moderately undulating relief might include the following land facets: steeply sloping land with shallow soils; gentle to moderate slopes with deep, freely drained soils, and poorly-drained valley floor. A convenient method for identifying land facets is to draw a representative cross-section of the land system and mark off the land facets, showing their relative positions and getting an approximate idea of their relative extent.

Once identified, the major land units may be entered into column 2, leaving space for the information which is to follow.

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2.2 Identification and Characterization of Management Units within Each of the Identified Land Units

Once the major biophysical divisions of the study area have been identified, the next step is to differentiate the types of management units found within each of the major land units. *(Alternatively, one could begin with the management units and then differentiate them according to their location in different land units).* It may be that there is no simple relationship between land units and management units. Thus, there may be more than one type of management unit per land unit, or a single management unit type may span several different land units (e.g. several different farms of the same type spread over several land units, or even a single farm with parts in different land units). Flexible use should be made of Worksheet 2 to indicate the relationships between management units and the associated land units.

Each set of entries in columns 3 and 4 refer to a *single* management unit type characterized in terms of the scale (column 3) and the social identify (column 4) of the typical management unit. Columns 5-10 are for notes on the main characteristics of each unit which are likely to be important for purposes of diagnostic classification. Needless to say, if the Working Group identifies other characteristics, not on the Worksheet, which are considered important for the purposes of this step, then they should also be noted. Specific guidelines for completing columns 3-10 follow directly.

Column 3. Scale of the Management Unit. Enter one of the following terms which best describes the scale of the management or production unit: *small, medium* or *large*. Since the scale of production is a relative dimension which varies from area to area, indicate the range (in hectares) of the scale terms you are using for the study area in the space provided on the Worksheet.

Column 4. Social Identity of the Management Unit. The social identity of the management unit may be a bit harder to define and will require some judgement. The most important criterion is to choose a term which best describes the social unit which acts collectively in making and implementing land management or production decisions. For example, the most common units might be: the family farm (in some cases it may be useful to distinguish between different types of family units, e.g. nuclear or extended); the corporation (private or parastatal); the cooperative farm; various communal farm units (organized along traditional rather than modern cooperative lines); etc. The Working Group should feed free to use other categories as necessary to adequately characterize the relevant units. (Obviously a different set of terms might be needed to characterize forestry management units operating within the study area).

Column 5. Labour Sources. What are the main sources of labour for the management unit? Possibilities include: family labour, hired labour, communal labour, reciprocal exchange labour, etc. Add other categories to adequately characterize labour resources. If more than one type of labour is used, list in order of importance.

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Column 6. Land tenure. Common forms of agricultural land tenure include: Freehold ownership, lease, rent, tenancy (usually implies share-cropping and a more inclusive set of social rights and obligations vis-a-vis the landlord), communal tenure (distinguish between collective and individual use rights), etc. Tenure rights in forestry production systems usually reside with government, parastatal or private owners, but an additional descriptive phrase may be necessary to characterise use rights of the labour force (e.g. as in taungya systems or where workers are permitted to gather firewood, make charcoal, etc.). Tenure rights and restrictions exert a strong influence on land management decisions, so feel free to use other terms or descriptive phrases to adequately characterize this feature of the land use systems.

Column 7. Land preparation tools. One of the most distinguishing features of agricultural land use systems is the type of tool used for land preparation. Indicate the predominant tools used by the management unit for clearance (if relevant) and cultivation, e.g.: axe, machette, fire, etc. for land clearance; tractor, animal-drawn plough, dibble stick, etc. for cultivation. Add other terms as necessary.

Column 8. Inputs. List major agricultural inputs such as fertilizer, manure, pesticides, herbicides, etc. used by the management unit.

Column 9. Economy. Indicate the main production emphasis of the management unit, i.e. subsistence, commercial, or mixed. Some judgement must be exercised here. There are very few, if any "pure" subsistence economies left in the world today. Almost every household land management system has a cash production component, however limited. We arbitrary propose the following definitions: A *subsistence* system will be defined as one in which the major production goal is to satisfy the basic needs of the land management unit, even if this involves a supplementary cash production component. A *mixed* system, by contrast, is one in which the basic needs and cash production objectives are nearly equal. A *commercial* system is one in which cash cropping or home processing activities constitute the mainstay of the economy of the management unit, even if there is a supplementary subsistence-oriented production component (e.g. a large home garden, a fruit orchard for domestic use, or perhaps a domestic fuelwood lot). Minor variations on the main production emphasis may be indicated in the space provided in the Worksheet by a brief descriptive phrase.

Column 10. Major products. Indicate the two or three most important products of the land management unit. These should describe the main outputs of the system (whether for domestic use or sale) in terms of the production emphasis indicated in column 6; e.g. for subsistence system: "maize, beans and squash;" for mixed systems: "maize, beans and squash for subsistence, coffee for cash;" for commercial systems:"milk and cheese".

2.3 Differentiation of Land Use Systems. Having separately characterized the physical and management aspects of land use, the next task is to combine the two sets of characteristics and distinguish those combinations which define distinctively different land use systems within the study area.

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Column 11. Reference Number. Review the information previously entered in columns 1-10, evaluate whether the combination of characteristics associated with the different management units (Step 2.2) within each of the land units (Step 2.1) are *sufficiently different* to justify distinguishing different land use systems, and assign a reference number to each of the systems so distinguished. This step involved analysis and grouping of similarities and differences between rows of data displayed in the Worksheet. It undoubtedly requires a lot of judgement and may occassion extended discussion among members of the Prediagnostic Working Group.

Criteria for distinguishing different land use systems are entirely relative. It may be that in the judgement of the Working Group only one significant difference is sufficient to warrant different land use systems classifications. Or it may be that several minor differences do not, in the judgement of the group, add up to a major difference in land use system type for purposes of the D&D exercise. It is up to the Working Group to decide. No foolproof guidelines can be given for the completion of this step.

The aim should be to produce an heuristic classification of land use systems which are sufficiently different from each other (on salient biophysical and/or socioeconomic dimensions) to require separate diagnoses and potentially different approaches to design.

Column 12. Naming of Land Use Systems. This is simply a naming step. The purpose of giving a name to each of the land use systems distinguished by a separate number in column 11 is to facilitate communication about them. Usually a short descriptive phrase (e.g. smallholder subsistence farming) will suffice as a name for a system.

2.4 Selection of Priority Land Use System(s) for D&D Attention

Having differentiated the major land use systems within the study area, the next step is to decide which of them will receive priority attention in the Diagnostic and Design exercise. Prioritization is necessary since, in most cases it will not be possible to survey each and every land use system in the study area in a single field exercise, particularly if there are many.

It is difficult to predict the capacity of the D&D field team, i.e. how many systems the team will be able to survey in a single exercise, since this will depend on weather, logistical factors, the complexity of the systems, the degree of difference between the systems, etc. As a general rule, however, it will be difficult to survey more than one distinctly different system per week of field time. Thus, if the exercise is planned to be of two weeks duration (the usual upper limit for sustained field survey activity by a highly qualified multidisciplinary team), then only two systems can be surveyed. This, of course, does not preclude the possibility of subsequent survey exercises to deal with any remaining systems in the study area.

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Priortization of the systems at the Prediagnostic Stage will aid the D&D Team to focus its efforts on the most important systems first and then proceed to the others in turn. The number of systems to be dealt with will depend, not only on the number of distinct land use systems in the study area, but also on the objectives of the exercise. If some of the existing systems fall outside the scope of the exercise (e.g. large commercial farms in an exercise which is mandated only to focus on smallholders), then the task is correspondingly simplified.

What criteria should be used in selecting priority systems? Obviously, the selection will be based on the judgement of the Prediagnostic Working Group, but it may be helpful to think in terms of the following suggested criteria:

1) The selected system(s) should be *representative* of important land use systems within the country, so that the results of the D&D exercise and any resulting research and development activity may find wider relevance beyond the study area. Importance, in this sense, may be judged either on the basis of the size of the potential recommendation domain for the agroforestry technologies which may result, or by some measure of the importance of the problems which the identified technologies may solve (even if the recommendation domain is not large). For example, a land use system which is at present of limited spatial extent, could become the target of an agroforestry R&D effort if it is judged to be one that will figure prominently in the *future* of the study area or some significant portion of the country as a whole.

2) The selected system(s) should be in *need of technical assistance* to solve pressing land use problems, either of a production of conservation nature, or both. Otherwise, perhaps research and development resources should be committed elsewhere, where problems in need of a solution do exist.

3) There should be at least a prima facie *potential for an agroforestry approach* to the improvement of the selected land use system(s). Although the D&D team is not automatically obliged to return an agroforestry-oriented recommendation if in its judgement no significant agroforestry potentials exist, it will be helpful in making best use of the human and other resources committed to the exercise to pre-screen the target systems for relevance to an agroforestry approach. (See Appendices C-5 and C-6 for an indication of the scope of the agroforestry approach)

STEP 3. <u>DESCRIPTION OF THE SELECTED LAND USE SYSTEM(S)</u>

The information provided at this Step will be crucial to the D&D Survey Team in making a rapid entry into the diagnosis of the system. The Prediagnostic Working Group should be aware, however, that the D&D Survey Team may, on the basis of more in-depth survey work, find it necessary to modify the preliminary description by the Working Group. An effort should be made to make the preliminary description as complete and accurate as possible within reason, keeping in mind that the main purpose is to provide a good starting point for the diagnostic survey and that, in any case, it will not be possible to anticipate all information needs.

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The main source of information for this Step will be interviews with qualified informants, supplemented by any available documentation on the focal system(s). Basic instructions for each substep are given below, with more detailed suggestions for specific or alternative procedures in Appendices A-6 through A-10.

3.1 Preliminary Description of Household Production Subsystems

The main purpose of this step is to characterize the production objectives and the location of the related production activities on the land management unit. Worksheet 3.1 provided for this step is oriented toward the description of household management units, although it could be used with minor adaptations for multipurpose management units which have some other basis of social organization. Likewise, although the "basic needs" approach which underlies the Worksheet (See Appendix A-6) is most fully and usefully employed in dealing with systems which attempt to produce a wide range of outputs to satisfy a variety of production objectives, the Worksheet can also be used for other land use systems with more narrowly defined objectives, providing that those objectives can be classified under one or more of the production objectives listed in column 1 of the Worksheet. Thus a specialized commercial land management unit would have most of the entries under the cash subsystem. The same crop or animal component may be listed under several production subsystem headings (e.g. a particular food crop could be listed under food, cash, and social expenditure headings; firewood could come under fuel, cash and raw materials for cottage industry headings; livestock could have multiple purposes food, cash, and savings/investment enterprises. By the same token, there could be several locations on the management unit where specific production/objectives are fulfilled.

To complete Worksheet 3.1 simply list the specific crop, tree or animal component in the space provided under the headings in column 1 *and* in each box of the location matrix where the component is produced. Modify or add other production objectives or locations as needed to adequately characterize the system.

In cases where Worksheet 3.1. does not, even with modifications, provide an adequate basis for description of management objectives and the location of associated land use activities, a different matrix format should be devised by the Working Group. For example, in the case that the client for the D&D exercise is a forestry or watershed management project, the management objectives and locations would be quite different from those in Worksheet 3.1 (appropriate to farm households). Alternative guidelines are given in the Appendix for forestry (A-7) and watershed (A-8) applications.

The use of alternative Worksheets to describe different management units does not, of course, preclude the *complementary use* of Worksheet 3.1 to describe any household (or other multipurpose management unit) which may also exist within the project area. Thus, in a complex situation involving forestry and watershed management units together with farmers, at least 3 different Worksheets could be completed, one for each set of management objectives.

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WORKSHEET 1.1

BIOPHYSICAL ENVIRONMENT: BASIC CHECKLIST

REF. NO. _____ AREA NAME _____

		RELIABILITY
LOCATION	_____	____
	_____	
Latitude	_____	____
Longitude	_____	____
Altitude(m)	_____	____
GEOLOGY	_____	____
LANDFORMS	_____	____
CLIMATE		
Generalized type	_____	____
Köppen classif.	_____	____
HYDROLOGY		
Waterlogging	_____	____
River Regime	_____	____
Degradation	_____	____
SOILS		
Generalized type	_____	____
Local Classif.	_____	____
Degradation	_____	____
VEGETATION		
Area in general	_____	____
Specific Localities	_____	____
Degradation	_____	____
LAND USE (by Land Unit)*		
_____	_____	____
_____	_____	____
_____	_____	____
_____ (Unit)	_____ (Uses)	____

1 Reliable
2 Probable
3 Guess

NOTES:

*See guidelines Step 2.1. for definition of Land Unit.

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WORKSHEET 1.2

SOCIOECONOMIC ENVIRONMENT

Reliability codes: 1. Reliable, 2. Probable, 3. Guess.

HUMAN FACTORS			Reliability rating
Population density	_____		_____
Population growth rate	_____		_____
Sex ratio	_____		_____
Ethnic composition of population			_____
Other relevant social differentiations of population			_____
Migration trends			_____
Settlement history			_____
Current settlement pattern			_____
Size of holding	_____ Average	_____ Range	_____
Labour utilization pattern			_____
Land tenure			_____
Land use traditions			_____

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SOCIOECONOMIC DATA SHEET CONT'D

INFRASTRUCTURE	Reliability rating
Roads and transport	____
Agricultural input supply	____
Processing facilities	____
Storage facilities	____
Water supply	____
Extension services	____
ECONOMY	
Area exports	____
Area imports	____
Marketing structures	____
Agricultural commodity price (indicate subsidies if any)	____
Use of agricultural inputs	____
Agricultural input prices (indicate subsidies if any)	____

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SOCIOECONOMIC DATA SHEET CONT'D

	Reliability rating
Degree of mechanization	____
Degree of commercialization	____
Availability of credit	____
Opportunities for non-farm employment	____
Important cottage industries	____

ADDITIONAL NOTES

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WORKSHEET 2

DIFFERENTIATION OF LAND USE SYSTEMS WITHIN THE STUDY AREA

Step 3.1		Step 3.2								Step 3.3	
1	2	3	4	5	6	7	8	9	10	11	12
Land Unit		Management Unit									
Land System	Land Facet	Scale*	Soc.Ident.	Labour Source	Land Tenure	Land Prep. Tools	Inputs	Economy	Major Products	Ref. No.	Land Use System

*Scale Definition: Small = _____ha, Medium = _____ha, Large = _____ha
(indicate range)

9. Form 1: Description and Problems of Your Area

1. Identification of Your Sub-Catchment

Your Name: Date:

Peasant Association(s):

Wereda: Awraja: Region:

Name of Catchment:

Agroclimatic Zone(s):

2. Size of Sub-Catchment where You are Located:

Measure total length and total width of the area (in metres), and calculate the approximate area assuming an elliptic shape:

$$\text{Area} = \frac{\text{Length (m)} \times \text{Width (m)} \times 3.14}{40'000} = \ldots\ldots \text{ ha}$$

Remember: 1 ha = 1 hectare = 100 m × 100 m = 10'000 m^2
Preferably, one sub-catchment should be 50–200 hectares.

3. Landuse and Topography of Your Sub-Catchment:

Estimate the proportions of each landuse type in percentage of the total catchment and write the figures in the table below. On the next page it is shown how to estimate percentages and how to calculate corresponding areas in hectares.

Landuse type in catchment	Proportion in % of total	Proportion in hectares (ha)	Average slope gradient (%)
I Cultivated Land:			
II Grassland:			
III Forest Land - Existing:			
- Planned:			
Total	100%		

Table: Main landuse types, sizes and average slope gradients of your sub-catchment.

You can see some percentages of land cover in the following drawings and compare them with your sub-catchment for estimating the percentages of each landuse type of your area:

10% cover 30% cover 50% cover 70% cover

With the estimated percentages, calculate the hectares of each landuse type by multiplying the total catchment area (ha) with the percentage and dividing it by 100. Enter your estimations in the table on the previous page. Also measure the average slope gradient (in %) for each landuse type (see page 86) and write it into the same table.

Describe in words the following points: Main crops grown in the area:

Cropping season(s): Give months between seeding and harvesting of each season:

Trees and grass in the area:

Describe *traditional ways of soil conservation/water conservation/water drainage* for the different landuse types, with focus on cultivated land:

4. Soil

Mark with cross the nearest soil colour observed on the different slope types. Give the texture (see page 83) and the average soil depth for each slope and landuse type in the table below:

	Soil colour: black	red	brown	yellow	Soil texture	Soil depth
I Cultivated Land - Steep slopes:						cm
- Gentle slopes:						
- Flat land:						
II Grassland - Steep slope:						
- Flat land:						
III Forest Land - Existing:						
- Planned:						

Table: Inventory of soils for different slopes and landuse types in your sub-catchment

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5. Erosion Problems in Your Sub-Catchment

First describe sheet and rill erosion problems for each landuse type. Observe signs of sheet erosion which you can see as shallow soil depths. Ask farmers whether rills are developing during the rainy season and if yes, on which slopes. Write down your observations and describe where they are located and why erosion is occuring there.

I Cultivated Land: _____

_____

_____

II Grassland: _____

_____

III Forest Land

- Existing: _____
- Planned: _____

Also, measure length, width and depth of all *gullies* (in metres), and indicate in the table below together with the location within the catchment:

Location	Length (m)	Width (m)	Depth (m)	Landuse above gully

Table: Dimensions of major gullies in your sub-catchment.

6. Other Major Problems of Your Sub-Catchment

List other (non-conservation) problems as identified by the farmers: _____

_____

_____

7. Conservation Already Carried out by the Government

Give a description of measures carried out in your area in the previous years indicating what size of area has been treated with which type of measures for each landuse type.

I Cultivated Land: _____

_____

II Grassland: _____

III Forest Land (Afforestation): _____

_____

SOURCES OF PREDIAGNOSTIC INFORMATION*

1. MAPS, AIR PHOTOS AND SATELLITE IMAGERY

Topographic Maps

Existence: Do topographic maps of the area exist? If so, at what scales? Date of survey or revision? Are they contoured?

Availability: Are the maps in print? Are they security-restricted? What is the procedure for security clearance and/or purchase? Address of the national survey organization and/or outlet for purchase?

This enquiry should be started at an early stage, since it is basic but can be time-consuming. Contour maps at 1:50,000 scale are desirable, but may often not be available.

Geological Maps

A geological map may be of indirect utility. Most countries have a national geological map, obtainable for the Geological Survey organization. Request also a list, or cartographic key, to such more detailed maps as may exist.

Vegetation and Land Use Maps

Maps showing vegetation and/or land use are not a regular product of most survey organizations, and no standard forms exist. A good ecologically-based map survey can, however, be highly indicative of the nature of environmental interactions and possibly land use problems, and thus enquiry into the existence and availability of such maps is worth while.

Air Photographs

Existence: Is there air photo cover of the area? Date? Scale? Quality?

Availability: Air photos will usually be security-restricted. What is the procedure for obtaining clearance? Address for purchase (national organization, or outside consultant companies?).

High quality photos, less than 5 years old, at 1:25,000 to 1:20,000 scale are the most desirable. Air photos serve two kinds of function:

1) Location: Photographs can often be a more reliable means than maps of finding routes and identifying locations in the field.

2) Interpretation: A rapid stereoscopic examination of air photographs is the best means of pre-field familiarization with an area, particularly with respect to landforms, vegetation and land use. They may subsequently be needed for more through interpretation.

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*Contributions from A. Young, T. Darnhofer, and J.B. Raintree for sections 1, 2 and 3, respectively.

Satellite Imagery

Landsat imagery provides a rapid overview of the area, enabling broad regional differences to be seen at a glance. Whilst considerably less useful than air photographs, owing to their very small scale and low resolution, Landsat images are usually much easier to obtain. There is no security clearance needed. To request a Geographic Computer Search Inquiry Form, write to:

EROS Data Center
Sioux Falls
South Dakota 57198
U.S.A.

Fill in the form for the study area. You will receive a computer print-out listing the best quality imagery available, plus an order form. A false colour composite enlarged to either 1:500,000 or 1:250,000 is the best product. Computer-enhanced imagery is also available from commercial sources, but the cost may not be justifiable.

2. CLIMATIC INFORMATION

Macroscale surveys for D&D exercises will be mainly useful for delimiting the agroclimatic range for mesoscale surveys. Such information can in most cases be obtained from:

- agroclimatic surveys published by WHO, UNESCO, FAO or UNEP
- climatological handbooks and atlases
- climatological data compilations

Mesoscale surveys containing more relevant meteorological data are generally compiled and published by national meteorological services. These should be considered the main sources for meteorological information.

To facilitate data collection for research purposes worldwide, the World Meteorological Organization (WMO) has issued a catalogue of meteorological data, listing all relevant references and sources. In many countries meteorological data is also collected by organizations and authorities other than the national meteorological services (e.g. agricultural and forestry departments, private companies, non-government volunteer organizations, international agencies, etc.). A local inventory of these sources can very often turn up useful climatological data.

It should be mentioned, however, that in many countries relevant climatological data, even if it exists, can be difficult to obtain (original documents not accessible, publications out of print, recent data not yet processed, old records badly documented or lost; even data stored on modern supports such as microfilm, punch cards or magnetic tapes may not be available due to reproduction problems). To retrieve such data may require considerable material and personnel resources.

Therefore, the following bibliographic list of sources of general climatological and specific meteorological information is given (not all of which may be specifically relevant for prediagnostic purposes).

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General

WMO "*Guide to Agricultural Meteorological Practices*" WMO No. 134, 2nd edition 1981. An overall view of the scope of agricultural meteorology is given in 8 chapters under headings like: Agricultural Meteorological elements and their observation, Agromet, eorological forecasting, Application of Meteorology to Forestry etc.

Appendix I - Bibliography of literature on agricultural meteorology

Appendix II - List of periodicals of interest to agricultural meteorology

Appendix III - List of international organization of interest to agricultural meteorologists.

GEIGER R. "*The Climate near the ground*" (611 p) 1965 English translation, Harvard University Press. Textbook on basic microclimatology. It gives an exhaustive analysis of physical laws and their consequences on various meteorological elements including descriptions of the influences of topography vegetation and artificial devices on weather.

MOTHEITH J.L. "*Vegetation and the atmosphere*" 1976 N.Y. Academy Press. Summary of actual micrometeorological and ecological knowledge. Vol. 1. Summary of physical biological elements. Vol. 2. Case studies in agricultural, forestry and ecological fields.

J. HU. CHIANG "*Climate and Agriculture - an Ecological Survey*" Aldime Publishing Company 1968. 304 pp. Textbook on the general principles of agricultural climatology.

Y. SEEMANN Y. CHIRKOV, J. LOMAS, B. PRIMAULT "*Agrometeorology*" (324 pp) 1979. Springer Berlin. Introduction to the present day problems of agrometeorology, a series of accounts, each complete in itself, of agrometeorology problems.

G.W. ROBERTSON, "*The Role of Agrometeorology in Agricultural Development and Investment Projects*" WMO No. 536, 1980, 85p.

Climatology

LANDSBERG H.E. and other "*World Survey of Climatology*" Elsevier Publishing Company; Vol. 9: Climates of South and Western Asia 248 p. Vol. 10 Climates of Africa 604 p. Vol. 12. Climates of Central and South America. Summaries of the existing climatological knowledge for the area concerned with references for more detailed literature.

BLUETHGEN "*Allgemeine Klimageographie*" 2nd edition (German) 1966 720 p. WALTER DE GRUYTER and COM.BERLIN. Basic textbook on geographical climatology, covering the fields of analytical climatology, synoptical climate geography, general circulation, general types of climates, climate classification, changes in climate, climate modification by man.

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L.H. BROWN, J. COCHEME "*A study of the agroclimatology of the highlands of East Africa.* WMO No. 339, 1973 197 p. Report on the FAO/UNESCO/WMO Project on the Agroclimatology covering the countries Ethiopia, Kenya, Tanzania and Uganda.

"*Agroclimatology of the highlands of Eastern Africa*". Proceedings of the Technical Conference Nairobi 1973. WMO No. 389 242 pages. Follow up of the agroclimatic survey carried out by FAO/UNESCO/WMO.

J. COCHEME, P. FRAUQUIN " *Agrometeorological survey of a semi-arid area in Africa South of the Sahara*" WMO No. 210, 1967 136 p. The subject covered include rainfall, crop transpiration, availability of water during different periods of the year, heat and light and the correlation between crops and climate.

"*Agroclimatology in the Semi-arid areas South of the Sahara*" Proceedings of the technical regional conference Dakar 1971 WMO No. 340, 1973, 253 p FAO/UNESCO/WMO interagency project. Follow up of the survey mentioned under reference 15.

E.G. DAVY, F. MATTEI, S.I. SOLOMON "*An Evaluation of Climate and Water Resources for Development of Agriculture in the Sudano-Sahelian Zone of West Africa*" WMO No. 459 1976. 289 p. General background information on agrometeorology and surface water resources in a large part of West Africa.

M. FRERE, J.Q. RIJKS, J. REA "*Estudio agroclimatologico de la Zona andina*" WMO No. 506, 1978 297 p. (Spanish). Outcome of an agriclimatology project carried out jointly by FAO/WMO and UNESCO. The first part of the note analyses the agrometeorological factors; the second part studies the main crops in the area and their reaction to agroclimatic factors.

AMARE-GETAHUN "*Agro-climates and agricultural systems in Ethiopia*" 1980. Agricultural systems, Vol. 5: 39-59.

I.J. JACKSON "*Climate, water and agriculture in the tropics*" 1977 Longman Corp. 248 p. This book examines characteristics of tropical rainfall and evaporation together with their implications especially related to agriculture landuse, and aspects such as soil erosion and irrigation.

Agrometeorology of Crops

"*Agrometeorology of the wheat crop*" Proceedings of the WMO Symposium in Brunswick 1973, WMO No. 396, 1974. 242 p.

"*Agrometeorology of the Maize Crop*" WMO No. 48, 1977 454 p. Proceedings of the Symposium on the Agrometeorology of the maize crop. WMO - Iowa State University, Iowa 1976.

F.S. DA MOTA "*Soya Bean and Weather*" WMO No. 498 1978 64 p.

G.W. ROBERTSON *"Rice and Weather"* WMO 423, 1975 40 p.

"Agrometeorology of the Rice Crop". Proceedings of the WMO/IRRI Symposium WMO No. 541 1980

Agro-Ecology

"Report on the Agro-ecological zones project" Vol. 1: Methodology and Results for Africa 1978. Vol. 2: Results for Southwest Asia 1978. Vol. 3: Results for Southeast Asia 1980. FAO World Soils Resources Report No. 48.

L.R. HOLDRIGE and others *"Forest Environments in Tropical Life Zones"* A pilot study., 1971, Pergamon press 747 p. Particular reference is made to chapter two on the Holdridge "life zone system" as proposed 1947

Miscellaneous

"Crop Water Requirements" FAO Irrigation and Drainage papers No. 24 1974 198 p.

M. FRERE, F. POPOV *"Agrometeorological Crop monitoring and forecasting"* FAO Plant Production and Protection Paper No. 17 1979 64 p.

"Windbreaks and Shelterbelts" WMO No. 59 1964 188 p. Established by a working group of the Commission of Agricultural meteorology this publication summarised the results of research on this subject. The bibliography lists about 550 references. (another approximately 300 references on shelterbelts for the period 1970-1980 are available through the National Agricultural Library, U.S. Department of Agriculture).

"Drought and Agriculture" WMO No. 392 1975 127 p. This publication gives consideration to many meteorological factors of drought including its definition and early recognition, its effect on plants animals and diseases as well as methods for alleviating its effects.

J.W. DAVIES *"Mulching Effects on Plant Climate and Yield"* WMO No. 388 1975 92 p. This publication deals with effect of mulching on the climate of the soil and microclimate near the ground. The effect of mulching on temperature and moisture regimes of the soil, soil erosion, soil physics, pest, diseases and the growth of weeds are given with the published experimental evidence.

W. BAIER, *"Crop Weather Models and their use in Yield Assessments"* WMO No. 458 1977, 48 p. A review of the techniques currently available for simulating and analysing crop responses to weather, with special emphasis on the operational use of empirical statistical yield models for periodic assessment of regional production.

"The effect of Meteorological Factors on Crop Yields and Methods of forecasting the yield" WMO No. 566 1982 54 p..

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C. DANCETTE, J.F. POULAIN "*Influence de l'acacia albida sur les facteurs pedoclimatiques et les rendements de cultures*" 1969 Sols Africains XIII No. 3 (197-238).

H. SMITH, "*Light Quality, Photoperception and Plant Strategy*" Ann. Rev. Plant Physiology 1982, 33: 481-518

"*Symposium on Forestry Meteorology*" Proceedings of the Symposium on Forest Meteorology 1978 in Ottawa. WMO No. 527 1978: 233 p.

Bibliography

"*Agrarmeteorologische Bibliographie des Deutschen Wetter dienstes*" 1978, 1979, 1980. Annual bibiiography on agricultural meteorological publications which have become known to the Central Office of the "Deutscher Wetterdienst" in the course of the year. (1980: 2263 references including short abstracts).

3. SOCIOECONOMIC INFORMATION

Sources of relevant socioeconomic information may be harder to identify than for biophysical information. Nevertheless, the following potential sources should be checked for information on the study area:

- the national census authority
- national and regional planning authorities
- ministries or departments of agriculture, economic development, rural welfare, rural health, etc.
- university departments (researchers in departments of economics, sociology/anthropology, planning, rural health, etc. may have published research reports on the area or have relevant information in manuscript form)
- university libraries
- libraries of international agencies
- non-government organizations working in the study area

4. INTERVIEWS WITH QUALIFIED INFORMANTS

Qualitative information on all of the above areas of concern may also be gleaned from interviews with local officials, teachers, extension agents, rural health workers, community workers, articulate farmers, etc., as well as from researchers familiar with the study area. For some aspects of prediagnostic information, these may be the main sources.

3.2 Additional Land Use Information

Completion of the foregoing section will not, in most cases, complete the description of the system. Depending on the type of production technologies or management objectives, the following additional information might also be needed:

Agricultural Production

a) Intensity of agricultural land use (see Appendix A-10 for suggested indices)

b) Most common crop rotations

c) Most common intercrop combinations

d) Cropping calendar

Forestry Production

a) Establishment practices

b) Maintenance operations

c) Management system

d) Harvest practices

e) Rotation schedule

(See Appendix A-7).

Livestock Production

a) Type of livestock and herd structure

b) Role of livestock in the system (consumption, sale, savings, draught power, etc.).

c) Seasonal feed sources

d) Management practices

(See Appendix A-9).

Agroforestry Practices

a) Component combinations (trees with herbaceous crops and/or livestock)

b) Role of the tree in the system (production/service roles)

c) Interaction of trees with other components (in space and/or time)

d) Spatial arrangement of components (zonal/mixed)

e) Management practices (pruning, lopping, mulching, etc.)

(See Appendix C-5)

Watershed Management

a) Sources of water (type/location)

b) Type and distribution of water harvesting or drainage infrastructure

c) Condition of land surface in watershed

d) Distribution of land cover types (sketch map)

e) Condition of river and stream channels

f) Community groups potentially concerned with watershed management

(See Appendix A-8 for detailed guidelines)

3.3 Structural-Functional Description of the System

Worksheet 3.3. is designed to enable the analyst to determine the flow of inputs and outputs within the selected land use system. Both economic and ecological aspects of the system are included.

The main purpose of this description is not to identify problems but to assist in the understanding of some of the problems which will be identified later at the Diagnostic Stage. The Worksheet, in effect, describes the system's operating context and, hence, the context of the problems. This information will assist the D&D team to simulate the system's response to potential interventions. One use of the completed Worksheet which might be made is to produce a functional diagram of the system. See Appendix B-8 for guidelines on the construction of functional diagrams. It may be helpful but it is not necessary for the Prediagnostic working group to produce such a diagram in order to complete this step.

The Worksheet is comprised of 2 sections. The first section deals with the sources and uses of major inputs. The second section deals with sources and uses of outputs and includes by-product outputs such as soil erosion and surface water runoff.

Specific Guidelines for Completion of Worksheet 3.3

3.3.1 Inputs

Inputs have been subdivided into 3 main categories i.e. labour, land and other.

Labour is defined in terms of its availability for farming, off-farm and household activities. It is subdivided into family, hired and other e.g. community labour.

Land is here defined in terms of acreage and existing vegetation and/or infrastructure improvements, e.g. terraces, irrigation canals, fences etc. It is subdivided on the basis of whether it is owned, rented or has other use rights, e.g. communal land, forest land temporarily used for intercropping, etc.

Other is divided into capital and operational inputs. Capital items, other than the previously mentioned land-based infrastructural improvements, are draft animals, productive animals (dairy and/or beef cattle, pigs, sheep, goats, chicken), equipment (tractor, plough, irrigation pumps and pipes).

Most common operational inputs are planting material, fertilizers (organic and inorganic), chemicals (insecticides, pesticides, herbicides, drugs) raw material for cottage industries, water, fodder, fuel.

The main *activities* of the farm family (the uses of the inputs) are summarised below.

Primary activities

Cropping of annuals is here defined as producing, harvesting and selling of crops as well as development and maintenance of land infrastructure.

Cropping of perennials is here defined as producing, harvesting and selling of tree (products) as well as development and maintenance of land infrastructure.

Livestock keeping is here defined as rearing, grazing, watering and selling livestock (products).

Gathering is here defined as collecting products other than from cropping and livestock keeping for home consumption or cottage industries or livestock keeping.

Off-farm employment is here defined as family labour engaged in paid income generating activities off-farm.

Secondary activities

Cottage industries are here defined as the on-farm processing of purchased or farm produced raw materials into products for sale or home consumption.

Household maintenance is here defined as all regular household chores other than gathering including maintenance of household structures.

Livestock keeping is here defined as rearing, feeding, watering and selling livestock (products).

Note that livestock keeping can either be a primary or secondary activity depending on whether the animals are grazed or fed with products from primary activities.

3.3.2 Outputs

Products resulting from primary activities are crops, fruits, animals, livestock products (milk, eggs), fodder, fuel, (fuelwood crop residues, manure), water, timber and poles, organic fertilizers, manure, planting material, raw material for cottage industries and draft power. Water is considered a primary product when it is an output of a specific activity or a new infrastructural investment for the purpose of water storage or harvesting. Otherwise it is considered a by-product.

Products from secondary activities are processed food, shelter and cottage industry products.

The final uses of the products are subdivided into household consumption, sold for cash or recycled as inputs into the production system.

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By-products of both primary and secondary activities may also constitute outputs, as in the case of soil erosion, surface runoff or deep percolation of water resulting from particular cropping systems, livestock raising activities or farm infrastructure. The effects (rather than uses) on the farm and off the farm are shown as land degradation (from soil erosion), as effects on specific activities (cropping for example), or as farm exports to the larger ecosystem. These may serve as positive or negative inputs to other farming units in the area.

3.4 Preliminary Identification of Major Land Use Problems and Potentials(Optional)

On the basis of the groundwork undertaken to complete the preceding Prediagnostic Steps, the Working Group will have developed a preliminary appreciation of the outstanding land use problems and potentials of the selected systems. Although, this area will be covered again in greater depth by the D&D Field Team, it would be a pity not to benefit from the thinking already done in the Prediagnostic stage. Therefore, a brief characterization of the major land use problems and potentials identified by the Working Group would be desirable.

The information should refer to problems and potentials at two levels: that of the local ecosystem and that of the management unit. Information on the latter would tend to be system specific, so a separate entry should be made in Worksheet for each land use system. At the ecosystem level, the problems and potentials might be more general, but any system specific (or land unit specific) influences should be noted. It is not expected that the Working Group will go into great detail, but reference might be made to the detailed guidelines given in the Appendices.

3.4.1 Problems and Potentials at the Ecosystem Level

In the spaces provided in Worksheet 3.4 list:

Major Resource Limitations and Potentials

Some analysis of previously collected information and perhaps more supplementary information will be needed to complete this section. See Appendix B-9 for guidelines.

Major Conservation Problems and Potentials

This should be based mainly on the understanding development by the working group on the basis of its previous information gathering activities, supplemented by brief additional consultations with qualified informants. See Appendices A-5, A-8 and B-6 for guidelines.

3.4.2 Problems and Potentials at the Management Unit Level

Based mainly on interviews with qualified informants and existing surveys or research reports, complete the following sections of Worksheet 3.4. A separate Worksheet should be completed for each management unit type of relevance to the D&D exercise.

Failure to Meet Management Objectives

The aim here is to identify the major problems arising from the failure of the management unit (whatever if may be) to meet its management objectives (whatever they might be). In the case of household production systems, the basic needs supply subsystems identified in Step 3.1 provide a checklist for a quick preliminary assessment of household supply problems which will suffice for completion of this section. In the case of other types of management units with different management objectives, substitution or addition of other objectives will be necessary (e.g. non-household production units, forestry production or watershed management units as discussed in the instructions for Step 3.1).

Production Constraints

Specify, if known, what major management constraints (e.g. low soil fertility, lack of labour, poor erosion control, etc.) are responsible for the problems identified in the previous step (See Appendix B-6).

Outstanding Potentials for Overcoming the Identified Problems and Constraints

It is not necessary to spend a great deal of time on this section since this will be the main subject of the D&D field exercise. The aim here is simply to record existing thought on the most outstanding potentials for improvement of the system.

3.5 Final Preparations for the Diagnostic Survey

Before the Prediagnostic Working Group concludes its work in preparation for the activities of the multidisciplinary D&D Field Team, the following two items should be addressed.

3.5.1 Selection of Representative Management Units

Some effort should be made to identify a selected sample of management units which are broadly representative of the system(s) to be surveyed by the multidisciplinary field team at the Diagnostic Stage. A formal statistical sample is not required, but a list of about 20 representative farms, or other relevant management units, would aid the D&D team to gain a rapid entry into the diagnosis. A separate list should be prepared for each distinct land use system selected for D&D attention in Step 2.4.

'Representativeness' should be interpreted broadly to include examples of 'typical' management units as well as other management units which illustrate the range of significant variation within the selected system (e.g. smaller, average and larger farms within the range of size variation for the system). The list is intended as an aid to the D&D team in planning and giving an initial focus to its survey activities, although the Team may elect to go beyond the working list to clarify any diagnostic questions which may emerge in the course of the survey.

Worksheet 3.5.1 may be used to record the list of representative management units. This list should be developed on the basis of prior consultation with unit managers to check on the representativeness of the unit, as well

WORKSHEET 3.3

STRUCTURAL-FUNCTIONAL DESCRIPTION OF THE LAND USE SYSTEM

1. INPUTS

USES OF INPUTS	SOURCES OF INPUTS: LAND			LABOUR		
PRIMARY PRODUCTION	Owned	Rented	Other	Family	Hired	Other
___ Annual cropping	___	___	___	___	___	___
___ Perennial cropping	___	___	___	___	___	___
___ Livestock keeping	___	___	___	___	___	___
___ Gathering	___	___	___	___	___	___
___ Off-farm employment	___	___	___	___	___	___
___	___	___	___	___	___	___
___	___	___	___	___	___	___
SECONDARY PRODUCTION						
___ Livestock keeping	___	___	___	___	___	___
___ Household maintenance	___	___	___	___	___	___
___ Cottage industries	___	___	___	___	___	___
___	___	___	___	___	___	___
___	___	___	___	___	___	___

OTHER INPUTS	Farm Produced	Purchased	Rented	Other (Specify)	Uses
___ Draft power	___	___	___	___	___
___ Productive animals	___	___	___	___	___
___ Machinery	___	___	___	___	___
___ Hand tools	___	___	___	___	___
___ Planting materials	___	___	___	___	___
___ Water	___	___	___	___	___
___ Manure	___	___	___	___	___
___ Fertilizers	___	___	___	___	___
___ Pesticides	___	___	___	___	___
___ Herbicides	___	___	___	___	___
___ Feed	___	___	___	___	___
___ Timber/poles	___	___	___	___	___
___ Fuel	___	___	___	___	___
___	___	___	___	___	___
___	___	___	___	___	___
___	___	___	___	___	___

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WORKSHEET 3.3 Cont'd

2. OUTPUTS

SOURCE ACTIVITIES (Specify)	PRIMARY PRODUCTS	PRODUCTION	HOUSEHOLD CONSUMPTION	SALE
_____	Field crops	___	___	___
_____	Fruits	___	___	___
_____	Animals (live)	___	___	___
_____	Animal products	___	___	___
_____	Draft animals	___	___	___
_____	Feed	___	___	___
_____	Organic fertilizer	___	___	___
_____	Planting material	___	___	___
_____	Timber/poles	___	___	___
_____	Fuel	___	___	___
_____	Raw material	___	___	___
_____	Water	___	___	___
_____	_____	___	___	___
_____	_____	___	___	___
_____	_____	___	___	___
	SECONDARY PRODUCTS			
_____	Processed food	___	___	___
_____	Cottage ind.prods.	___	___	___
_____	Shelter	___	___	___
_____	_____	___	___	___
_____	_____	___	___	___
_____	_____	___	___	___

	BY-PRODUCTS	EFFECTS On-farm	EFFECTS Off-farm
_____	Water (runoff and groundwater)	_____	_____
_____	Soil (erosion and sedimentation)	_____	_____

WORKSHEET 3.4

PRELIMINARY IDENTIFICATION OF MAJOR LAND USE PROBLEMS AND POTENTIALS

3.4.1 Problems and Potentials at the Ecosystem Level

Major Resource Limitations and Potentials

Major Conservation Problems and Potentials

WORKSHEET 3.4 cont'd

3.4.2 Problems and Potentials at the Management Unit Level

Failure to Meet Management Objectives

Production Constraints

Outstanding Potentials for Overcoming the Identified Problems and Constraints

APPENDIX A-6

NOTE ON THE ICRAF BASIC NEEDS APPROACH*

As the concept of "basic needs" has been developed and applied in different ways in other contexts, it is important to specify clearly what is meant by this approach as developed for agroforestry purposes by ICRAF. The basic points are as follows:

1. In analyzing land management systems, we have identified the household management unit as a prime focus of D&D attention because this is where most of the land management decisions are made.

2. In our approach to the modeling of household land management systems, we define the subsystems in terms of *outputs*. In other words, the *output subsystem* is defined as the set of all activities, resources and other landuse factors which are involved in generating an output which satisfies one of the major production or land management objectives of the household.

3. In deciding specifically what output categories to consider in defining the major subsystems, it is important to satisfy two requirements:

a) general applicability, and

b) adequate representation of the characteristics of local land use systems

4. To satisfy both requirements and also to facilitate subsequent linkage with categories of agroforestry potentials, a basic needs approach is indicated. The production outputs which may be considered basic to the economic wellbeing of people everywhere are:

- food
- water
- energy
- shelter
- raw materials for local industries
- cash
- savings/investment
- social production

*Contributed by J.B. Raintree

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5. The assumptions which underlie this approach are

a) that the needs in the above list are basic and univeral, and

b) that local and regional land use systems are in large part organized so as to satisfy these basic needs.

6. It is important to emphasize that, in espousing this approach, the aim is to insure satisfaction of basic needs but *not* to restrict development efforts to only minimal satisfaction of these needs. Rural development needs *floors*, not ceilings. One implication of this approach is that, once subsistence needs are adequately satisfied, the emphasis shifts to improvements in the cash or savings/investment subsystems.

7. To further clarify this point, in referring to 'basic' needs we mean basic *types* of needs, rather than basic *levels* of need satisfaction. For example, a particular household may be well above the subsistence level in its production of cash but, because of drought or deforestation may have serious problems in meeting its food and fuel requirements. Cash income, which is normally taken as the prime indicator of economic wellbeing, is not always readily convertable into a form which satisfies the other basic needs (e.g. one definition of 'famine' is that there is no food to buy, even if you have the money). For this simple reason, it is necessary to consider the performance of each basic output subsystem separately.

8. Having identified the subsystems in which the problems exist, and having traced the symptoms and antecedent causal factors, analytical aids are then used to model problem etiology and identify agroforestry potentials (see Appendix B-7). For each subsystem the general question is: *Is there anything that trees can do to improve the performance of this subsystem?*

A partial list of the general types of answers which are possible is given below.

POTENTIAL CONTRIBUTION OF TREES TO BASIC NEEDS SUBSYSTEMS

Food Subsystem

a) *Human food* from trees (fruits, nuts, cereal substitutes) at low input levels on marginal land

b) *Livestock feed* from trees (one step down the trophic chain)

c) *Fertilizer* from trees from improving the nutritional status of food and feed crops (through the *addition* of atmospheric nitrogen

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to the soil system by leguminous trees, through *improvement of access* to a greater volume of subsoil nutrients by the nutrient recycling action of appropriate trees and also by the *improved availability* of soil nutrients which often accompanies the higher CEC levels associated with the higher organic matter levels and improved physical structure of tropical soils under the influence of appropriate tree canopies)

d) *Soil Conservation* effected by trees in agroforestry intercropping systems has a direct and measurable long term benefit on the production of food crops from the protected fields

e) *Micro-climate amelioration* associated with properly spaced trees (e.g. the "shelterbelt effect") can also have a direct impact on food crop production (e.g. 30% increase in Russian wheat yields attributable to shelterbelts)

Water Sybsystem

a) *Regulation of water delivery* for human consumption, household use, watering of livestock, etc., through reduction of runoff and improvement of interception and storage in infiltration galleries (various watershed management practices involving trees)

b) *Improvement of soil moisture retention* by rainfed cropping systems and pastures (soil structure and microclimatic effects of trees)

c) *Protection of irrigation works* by hedgerows of trees

d) *Prevention/reduction of downstream flood damage* by various watershed management uses of trees

e) *Improved drainage* from waterlogged or saline soils by phreatophytic trees

f) *Increased biomass storage* of water for animal consumption in forage and fodder trees (higher water content of feeds in dry season)

Energy Subsystem

a) *Woodfuels*

   i) firewood
   ii) charcoal

b) *Methanol* (wood alcohol)

c) *Ethanol* (from fermentation of high carbohydrate fruits, e.g. *Prosopis* pods)

d) *Producer gas* from charcoal

e) *Latex* and other combustible saps and resins

f) Other fuels and energy technologies under the general heading of *biomass*

g) Augmentation of *windpower* by jet stream effects of appropriate tree arrangements

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Shelter Subsystem

a) *Building materials* for housing

b) *Shade trees* for humans and livestock (and even some heliophobic crops)

c) *Windbreaks* around settlements, fields and pastures

d) *Living fences*

Raw Materials Subsystem

a) *Wood* for a variety of craft uses

b) *Fiber* for weaving industries

c) Ingredients for *medicinal preparations*

d) Etc.

Cash Subsystem

a) *Direct cash* benefits from sale of the above listed products

b) *Indirect cash* benefits of non-tree crop productivity improvements effected by trees (e.g. higher profits from savings in fertilizer costs)

Savings/Investment Subsystem

a) *Addition of a savings/investment enterprise* on farms now lacking one (e.g. growing of high value timber trees for future educational expenses, etc.)

b) *Improvement of existing savings/investment enterprises* by a variety of tree roles (e.g. fodder trees in systems where livestock play the role of "savings on the hoof")

Social Production Subsystem

a) *Production of goods in kind* for social exchange purposes (e.g. fruits, more livestock for ceremonial occassions or marriage needs, etc.)

b) *Increased cash* for social purposes (e.g. political contributions, taxes, gifts, etc.) by means of various productive or service roles of trees.

Coding Survey Data - Farming System Problem Identification Survey

Coding data means putting it into a form which can be easily stored and used for analysis. A code is an abbreviation. By abbreviating or coding information obtained from surveys we put answers to our questions into the form of 1, 2 or perhaps 3 digit numbers. Each number stands for a different response to the question.

The first step in coding data is to make up classes or groups of possible answers to your question. You want to have enough groups to reflect the range of responses which could make a difference to your analysis or your plan of action. You do not want so many categories however, that it becomes difficult to define any important differences among them.

For example, let's examine the Farming System Problem Identification Survey in Sourcebook Support Materials 5-8. In Section 1 of the survey, Land Use History, the first question, 1.1. is:

For how long have you lived in this area?

You want to create categories of responses to this question which will cover all of the possible answers, and which will make a difference to your understanding of the situation you are surveying.

Essentially you want to know if your respondent is relatively new to the area, or if s/he has lived in the area long enough to have observed important changes or trends over time, and long enough to have developed strong opinions about what is happening or should be happening there. Answers to this question, when you examine all the respondents together, can also give information about how stable the population is, depending on whether there appears to be a relatively high proportion of newcomers.

For such a question five categories of response might be appropriate, allowing for up to two answers from each respondent. Each category would be assigned a one-digit number, or code. For example:

1. less than two years
2. two to five years
3. five to ten years
4. 10 to 20 years
5. 20 to 40 years
6. All my life.

For each respondent you would fill in code number one through five. If applicable you may also fill in code number six.

Before implementing a survey it is necessary to prepare a "coding manual" to go with your questionnaire. Your coding manual will list the possible groups of responses to each question and assign a digit to each.

You should form your categories of responses by "pre-testing" your questionnaire. This means conducting the survey with a few households which represent the range, or diversity of characteristics you expect to find when you conduct the survey 'for real'. From these trial questionnaires examine the different responses you receive to each question and create categories for your coding manual which accommodate all of them. Consider also answers you feel quite sure you will receive, but for some reason did not obtain during the pre-test. If you turn out later to be wrong and such answers are not provided, you can simply drop or ignore codes for which there are no data, and adapt your coding manual accordingly.

To code survey data it is often most efficient to mark the code directly on the questionnaire. This involves 'pre-coding' the questionnaire, or marking space on it where the correct code is placed when the answer is given. Pre-coding involves either learning your coding manual very well before conducting the survey, or marking the coded answers on the questionnaire. Referring to your coding manual while conducting the questionnaire is not an efficient practice. If it is necessary to refer to your manual it is probably more efficient to code the data later, after you return to your office.

Following are examples of the types of codes you might develop for questions in Section 2 (Land Ownership) of the Problem Identification Survey Questionnaire. Remember, it is important to develop a coding manual which fits the characteristics of your own project area. This means learning enough about the area to effectively code your data, before conducting the survey!

2.1. Approximate size of plot

Code	Response
1.	less than 1 ha.
2.	1-2 has.
3.	3-5 has.
4.	5-10 has.
5.	more than five has.

2.2. No. additional plots

1. none
2. one
3. two
4. three
5. more than three

2.3. Title deed

1. yes
2. no

2.4. Reason no title

1. land not adjudicated
2. another family member owns
3. can't afford

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FARMING SYSTEM PROBLEM IDENTIFICATION SURVEY

Interviewer_____

Date_____

Project Area_____ ( ) ( )
Farmer's Name_____ ( ) ( )

1. LAND USE HISTORY

1.1. For how long have you lived in this area? ( )( )

1.2. For how long have you farmed this plot of land? ( )( )

1.3. Since you began farming here have you introduced any major changes in your cropping patterns or livestock practices? ( )( )

1.4. If yes, what changes have you made? ( )( )

1.5. Since you began farming here has there occured any significant land degredation? Describe. ( )( )

1.6. If so, what have you done about it? ( )( )

2.0. LAND OWNERSHIP

2.1. What is the approximate size of this plot? ( )( )

_____acres

2.2. How many additional plots do you own? ( )

_____plots

2.3. Do you or your family have the title deed to this plot? ( )

2.4. If not, what is the reason? ( )

* Adapted from ICRAF by Mazingira Institute and CARE-Kenya.

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3.0. LAND USE TYPE

3.1. Approximately what proportion of the total acreage of this plot is devoted to each of the following land uses?

Land Use	Percentage of Total						
	0	5-15	15-30	30-50	50-75	75- 90	
Homestead							( )
Non-irrigated crop							( )
Irrigated crop							( )
Natural grazing							( )
Improved pasture							( )
Orchard							( )
Woodlot/windbreak							( )
Fallow							( )

4.0. LABOUR

Source		Number	Notes	
4.1. Family -	Adult Male	_____		( )( )
	Adult females	_____		( )( )
	Children (part-time)	_____		( )( )
	(full-time)	_____		( )( )
Hired -	Full-time Male	_____		( )( )
	Full-time female	_____		( )( )
Casual -	Year-round	_____		( )( )
	Sowing season	_____		( )( )
	Weeding Season	_____		( )( )
	Harvesting season	_____		( )( )

5.0. FOOD PRODUCTION

5.1. Crops

Crop	Objective (cons./sale) Primary	Secondary	Monthly Calendar 1st Sowing	2nd Sowing	Weeding	Harvests	
1. Maize							( )( )
2. Beans							( )( )
3. Sorghum							( )( )
4. Bananas							( )( )
5. Potatoes							( )( )
6. Vegetables							( )( )
7. Coffee							( )( )
8. _____							( )( )
9. _____							( )( )
10. _____							( )( )

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5.2. Livestock

Type	Prim. Obj.	Second. Obj.	Tertiary Obj.	
1. Cows				( )
2. Bulls				( )
3. Oxen				( )
4. Goats				( )
5. Sheep				( )
6. Pigs				( )
7. Donkeys				( )
8. Chickens				( )

5.3. Livestock Feeding

(Rank in importance)

1. On-farm grazing ( )
2. Off-farm grazing ( )
3. On-farm cut & carry ( )
4. Off-farm cut & carry ( )
5. Commercial feed ( )
6. Do you have enough feed to satisfy your needs year round? _____ ( )
7. If not, what are the specific problems you face in obtaining adequate feed? ( )( )

5.4. Food Sufficiency

1. Do you produce enough food to satisfy all of your needs, year round? _____ ( )
2. Do any of the following affect your ability to produce and store enough food?
   1. Access to tools and implements ( )
   2. Access to fertilizer/manure ( )
   3. Access to pesticides/fungicides ( )
   4. Availability of labour ( )
   5. Availability of land ( )
3. What do you do to satisfy your food needs in bad years?

Rank Order

1. Purchase ( )
2. Borrow ( )
3. Exchange ( )

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4. How often do you experience bad years? ( )

6.0. WATER SUPPLY

6.1. Rank order the water sources depended upon for each use specified, for dry and wet seasons.

Source	Domestic		Livestock		Shamba	
	dry	wet	dry	wet	dry	wet
1. Unharnessed rainfall						
2. Springs						
3. Streams						
4. River						
5. Wells						
6. Rainfall Storage tanks						
7. Surface pools						

6.2. How far away is your primary wet season water source? _____kms. ( )

6.3. How far away is your primary dry season water source _____kms. ( )

6.4. Do you consider water quality to be a problem for your family? _____ ( )

7.0. ENERGY

7.1. Rank the following energy types in terms of their frequency of use for household cooking:

Source	Rank
1. Firewood	( )
2. Charcoal	( )
3. Paraffin	( )
4. Dung	( )
5. Crop residue	( )
6. Electricity	( )

7.2. Besides cooking, for what other purposes do your household use woodfuels (charcoal or firewood)? ( )

7.3. How do you obtain your firewood? (If collected, estimate how often and how far walked, and who in household usually collects.) ( ) ( )

7.4. Do you consider getting enough firewood for your household's cooking needs to be a problem at the present time? ( )

7.5. Do you consider getting enough firewood for your household's industrial needs to be a problem? ( )

7.6. Do you think that obtaining enough firewood will be a problem in the foreseeable future? ( )

7.7. Why or why not? ( )

8.0. SHELTER

Function	Materials	Strategies C.B.P.	Strategies F.M.	Supply or Maintenance Prob.	
8.1. Fencing					( )( )
8.2. Shade					( )( )
8.3. Building					( )( )
8.4. Mats					( )( )
8.5. Windbreak					( )( )
8.6. Others					( )( )

C,B,P = Collect, buy, produce

F, M = female/male responsibility

9.0. RAW MATERIALS (Home Industry)

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9.1. Which of the following home industries are you involved in and what are the sources of your raw materials?

Industry	Raw Material	Source (collect/ purchase)	Problems	
1. Charcoal burning				( )
2. Brick-Making				( )
3. Pottery				( )
4. Tobacco curing				( )
5. Bakery				( )
6. Crafts				( )
7. Others				( )

10.0. CASH

10.1. Rank order the following in terms of contribution made by each to total household income.

1. Off-farm family business _____ ( )
2. Off-farm employment (husband) _____ ( )
3. Off-farm employment (wife) _____ ( )
4. Off-farm employment (children) _____ ( )
5. Cash crop sales _____ ( )
6. Surplus food crop sales _____ ( )
7. Livestock Sales _____ ( )
8. Home Industry _____ ( )

10.2. Rank order five of the following in terms of household expenditure:

1. Food ( )
2. Energy ( )
3. Livestock feed ( )
4. Other farm inputs ( )
5. Household utensils and furniture ( )
6. Clothing and personal items ( )
7. School fees ( )
8. Harambee ( )
9. Savings and investment ( )

11.0. COMMUNITY

11.1. Which schools are attended by your children? ( )( )

11.2. Which church does your family attend? ( )

11.3. What community groups or organizations do you or your husband/wife belong to? (women's groups, labour groups, development committees, sport clubs, etc.) ( )( )

12.0. TREES

12.1. Have you planted and raised trees on your shamba? ( ) ( )
_____

12.2. If yes, how long ago did you first begin planting trees? _____ ( )( )

12.3. If yes, which species have you planted? ( )( )

12.4. Where did you get the seed or seedlings of each? ( )( )

12.5. Have you left indigenous trees on your shamba?_____ ( )( )

12.6. If yes, why? ( )( )

12.7. For what purposes would you like to plant more trees ( )( )

12.8. What species would you most like to plant? ( )( )

12.9. What has prevented you from planting more trees date? ( )( )

APPENDIX B-2

INTERVIEW GUIDELINES FOR AGROFORESTRY DIAGNOSIS AND DESIGN

Farming systems Research and Extension programs and farming systems rapid appraisal methodologies have been developed and tested under diverse conditions within recent years. The widespread application of an integrated farming systems approach has fostered the testing and refinement of several rapid appraisal techniques (Chambers, 1981) including the "sondeo" of Hildeband for FSR/E programs (Hildebrand, 1981), the cropping systems approach developed at IRRI(Zanstra *et al.*, 1981) and the step-wise series of interviews and surveys used by Collinson (1981) in East Africa. Summaries of these methodologies and the related interview techniques are also reviewed in a compendium on Farming Systems Research by Shaner *et al.* (1982). A useful discussion of the art of the informal diagnostic survey is contained in Rhoades (1982). As such, general farming systems applications of diagnostic methods have been discussed and described in the literature and need not be treated here.

To the extent that agroforestry systems D&D differs from the usual farming systems approach it requires some additional guidelines, both on content and methods of interview. The major objectives of agroforestry technology development are:

1. to meet basic needs of client populations
2. to improve the sustainability of production systems
3. to further improve quality or quantity of production where possible, once the first two conditions are satisfied.

The first objective usually refers to the basic needs of the farm household: food, water, fuel, shelter, cash and raw materials for cottage industry (See Appendix A-5). This emphasis introduces a sliding spatial scale to the analysis (and the interviews) ranging from the intra-household level (distribution of labour, responsibilities, and benefits relative to each need) to the ecosystem level (distribution, use, and management of off-farm water, fuel, related land resources, labour and socio-economic and physical infrastructure).

The second objective, by definition, extends the time scale of the diagnosis. To judge system sustainability under existing technologies and proposed alternatives we require some knowledge of past conditions, as well as trends in production rates and the state of the resource base. On this basis we can determine likely trends for the future. The fact that agroforestry deals with combinations of long-lived trees and shrubs, together with annual crops and animal production, also reinforces the need for a longer time frame than that normally applied to farming systems analyses.

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*Contributed by D. Rocheleau

Historical accounts of land use, production, household conditions and ecosystem conditica become important tools both for diagnosis of sustainability and production constraints and for feasibility evaluation of proposed solutions. Imagining the futures - possible, with the farmers' help, becomes important for judging technologies that require present investments for relatively long term returns. Sustainability considerations may also require topical emphases on soil, water, and/or labour depending on which resource is, or is likely to become, limiting. In many cases agroforestry technologies are intended as methods for maintenance or rehabilitation of soil and water resources in fragile and/or degraded ecosystems.

The third objective, improved production, does not differ substantially from the usual focus of farming systems analyses and surveys. As such it requires no special guidelines beyond those already referred to in the literature.

Interview guidelines are presented for determining intra-household perceptions of problems and potentials with respect to basic needs, for determining historical trends and exploring futures possible at the farm and ecosystem scales, for describing the interaction between the farming system and the larger ecosystem (including the community), and for diagnostic interviews in soil and water conservation or watershed management projects.

1. GENERAL INTERVIEW GUIDELINES

Intra-household distribution of labour and interests re: basic needs

Problem diagnosis can easily be biased by speaking exclusively to adult males and/or heads of household. For example, in many areas, although men are recognized as farm managers and heads of household, they specialize mainly in cash and food production. It is also necessary to consider the role of women as managers of water, fuel, milk, food supplies, cottage industries and small animal production. Children are often employed in such tasks as well, usually under maternal supervision.

Early on in the interview (perhaps just after a brief overview of the farm's layout and the land use history) the team should determine who is responsible for collecting, producing, purchasing and/or managing each of the end-products identified as basic household needs. Based on the answer, part or all of the team may wish to question the farmer's wife or husband, some of the children, a parent, or other members of the farm household. It is often helpful to let one or two team members split off and converse with other persons while the group stays with the main farm (or unit) manager.

These parallel interviews contribute two types of information: First, the concerns and opinions of each sub-manager or participant about the activities and needs of greatest import to them; and secondly, verification of data obtained from other informants. Differences between responses to certain common questions asked of all informants

(land use history, trends in yields, trends in environmental conditions and utilization of labour on and off-farm, etc.) can be verified in this fashion, as well as by comparing responses between similar farm households. The first type of information is more uniquely the province of intra-household stratified interviews and should take priority in terms of time and emphasis given in the interviews.

For these supplementary interviews the actual questions to be asked may vary little from the checklist and questions suggested for each basic needs in Appendix B-3. The major differences will be in the range of basic needs discussed and in the format for discussion itself. For example one might walk to the well, river or waterhole (if nearby) with the farmer's wife to discuss a problem of water supply (quality, quantity, transport) or the interview might take place inside the cooking area while food is being prepared, or in a milking area near the house. Conversation about other related concerns of the women such as child-rearing may lead to identification of nutritional or health problems, fuel shortage or household labour shortages. These informants may be invited or requested to tour other parts of the farm premises with the team member(s) if it will help to clarify activities managed by that person in another part of the farm holdings or environs. In the case of cottage industry one or more team members may enter the work area or shop if, for example, there is a separate building for woodworking, weaving or similar activities. Artisans may be interviewed while working. Gathering or collecting sites for raw materials may also be visited, if pertinent.

It should be kept in mind that to the extent the team splits up for part of the interview time, more post-interview discussion will be required for the team to synthesize the results and complete the diagnosis. If only one person can be interviewed, due to logistic, cultural or other constraints, then more attention should be directed toward questions about the concerns and work of other people within the farm household. To the extent possible, interviewers should pose questions that might indicate indirectly whether other household members face problems with respect to each of the basic needs categories. For example time-and-distance questions with respect to fuel and water collection can indicate potential problems in labour utilization within the household. Where such indicators prove positive one can probe further to elicit the second-hand impressions of the farm manager with respect to such activities and related problems. It is, however, always preferable to speak to two or three members of the household where responsibilities and labour are divided.

2. INTERVIEW GUIDELINES FOR EXPANDING THE TIME FRAME OF THE DIAGNOSIS

The rapid appraisal time constraints for the diagnostic process itself do not necessarily limit the time span considered in diagnostic and design interviews. The agroforestry D&D methodology includes a dynamic analysis conducted within a rapid appraisal context.

The back drop for such an analysis fits well into the needs of the interview team. After the introduction at the outset of the farm tour the team can ask the land manager about his/her length of residence in the vicinity and on the present holding. This can be followed by an open question about the history of land use and management on the farm and its immediate surroundings. Further prompting should be directed

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toward: land use/farm management changes and the reasons for them; trends in yields and prices of farm products, trends in amount and prices of purchased production inputs and purchased household goods; past problems experienced by the farm household, the responses to them and the eventual outcome; differential impact of past economic or natural stresses on various land use types and on fulfilment of the various basic needs at the household level. Other specific questions may arise based on the responses of the interviewee. Discussion of the current situation may be guided somewhat by this knowledge of the land use history, but the general approach would follow the guidelines normally used for farming systems interviews about present conditions.

Projecting the present conditions and alternative technologies or systems into the future should be presented casually as an exercise in imagination. The potential for this technique will vary with personal and cultural attitudes about the future and planning in general. However, in many cases the farmer may anticipate future problems not yet apparent (and seek solutions to them). Informants may also veto some suggested alternatives based on latent constraints previously unknown to the team. The alternatives should be raised in very general terms leaving the field open for elaboration or other suggestions by the informant. The changing conditions on the farm must be imagined into these technology previews, including the demographic characteristics of the farm household, the condition of the natural resource base on the farm, price changes in farm products and purchases, and changes of all 3 three types in the wider environment of the farm. The informant may anticipate these, but if not some prompting should be provided to explore the impact of such changes on adoptability and performance of suggested technologies.

This same type of exercise could apply if the informant names a constraint that the team judges to be ephemeral or realistically subject to removal. Then the question "what if that were changed?" could be used to postulate an alternative future condition for technology adoptability/performance.

3. INTERVIEW GUIDELINES FOR CHARACTERIZING FARM-ECOSYSTEM INTERACTIONS

The relationship of the farm to the larger ecosystem is important to agroforestry D&D for three reasons:

1. The need to better understand and cope with farming systems opportunities and limits that reside (or originate) in the next larger system of which the farm is a part.

2. The need in many projects (which currently apply a farming systems approach) to serve a broader client group than a particular type of farm household.

3. The need to analyse the combined use of private and public (or otherwise shared) resources in rural agricultural and forest production.

Two major topics of interest can provide focal points for discussion with land managers (unit managers) about the relationship of the land use unit to its surroundings. First, discuss dependence on local off-farm resources for satisfaction of basic needs, especially fuel and water, which

are often collected off-farm but nearby. Cash may also be earned from nearby off-farm work or sales to local consumers. The degree of direct dependence on local off-farm resources can be established by asking about the relative amounts and the importance of the goods secured off-farm. Ask about who owns and uses these resources and about the terms of use, trade, purchase or collection. If possible try to get the farmer's impression as to the future reliability of the quality, quantity and accessibility of these resources.

The second related point is the reliance on local market services for transactions with external sources. Questions about where the household sells its goods, where it makes its purchases and what kind of items are traded, should be directed toward establishing the degree of interdependence between local farms and other land use systems and the degree of interaction with (or dependence on) outside sources of basic household needs.

As a complement to the farm interviews it is advisable to go to public plazas or similar gathering places with one who knows the settlement or town. Visit homes, if necessary, to conduct interviews and visit some businesses or market place locations if possible. Rely on local team members or guides to identify potential informants and request their participation in a discussion. The feasibility of doing this in a park, marketplace or business will vary with the cultural predisposition to talk to strangers under these circumstances and will also vary with the timing of the interview (re: crowding, noise level, presence of potential interviewees, etc.).

Once an introduction has been made, begin by discussing current conditions that relate to local production and livelihood of the inhabitants: the weather, this season's harvest, current prices in the market. Determine the length of time the informant has lived in the area, his/her place of residence, size and type of holdings, if any, and occupation. This should be accomplished if possible with general open-ended questions to avoid placing the informant in a defensive position. Ask more specific (but still open-ended) questions about the availability of food, water, fuel shelter, employment, raw materials, labour, desired "imported" goods, and markets for local products. With respect to these topics, informants may be asked for their opinions on the general case for the community at large, their own case, and how the situation varies by group or location.

If interviews are being conducted in a public place try to stay out of earshot of other groups. Be particularly careful of mixing people of different socio-economic groups if small-group interviews are conducted, especially when treating issues such as employment, markets, and labour. Even among peers it is possible that responses to some questions may be biased by the informant's efforts to maintain his/her image.

A significant part of the information on farm-ecosystem interactions may also come from discussions with other qualified informants such as civil servants, extension agents, health and/or social workers. Reliance on any single agency (such as agricultural extension) should be avoided since this would bias both the content and the conclusions of information on

community needs and problems within the ecosystem. For example, the obstacles to adoption of new technology should also be discussed with public servants concerned with other evaluation criteria.

Some landless people and some who have very small farms and depend primarily on off-farm income should be interviewed, especially if their numbers are large and more so if the ecosystem analysis is being conducted within the context of a rural development project. To determine the condition as well as the current role of these people within the ecosystem, questions should address a wide range of topics: sources of cash and/or materials for fulfillment of basic needs; the degree to which these needs are met; problems or potentials for improvement perceived by the informants; and the degree and type of interaction with local land use systems and the larger system. Note types of activity, location, timing (if seasonal) and exchanges of goods/services/cash.

Ask about time of residence in the area and in their current home. Probe for predisposition to remain in the area and to engage in employment (on or off-farm) related to potential agroforestry technologies or land use changes. Present these alternatives as part of an array of future possibilities so as not to bias reponses. Encourage informants to suggest future alternatives or solutions to current problems, since this gives the team an idea of what people most need, want and are willing to do.

4. INTERVIEW GUIDELINES FOR AF APPLICATIONS TO SOIL AND WATER CONSERVATION OR WATERSHED MANAGEMENT

The rapid appraisal or diagnostic survey offers a vehicle for gathering pertinent qualitative information about the soil, water, vegetation animals and water resources of the region and the local ecosystem(s). Farm families and other residents often have considerable knowledge of the characteristics and behaviour of their environment.

It is advisable that these interviews be conducted by the whole team or at least by two members in order to utilize both social science skills and ecological knowledge.

It is particularly important, for design purposes later on, to diagnose the local perception of the soil and water management problems, as well as the characteristics, magnitude and trends of the problems. Moreover, the will and ability to apply specific conservation practices or technological solutions must be gaged, if possible, particularly with regard to agroforestry substitutes or supplements to standard practices.

Trends in the degradation of water and vegetation can also be identified and described, particularly by elderly residents. This type of information can indicate whether such trends are perceived as "problems," and whether there is a marked relationship to land use and management. This in turn indicates whether agroforestry technologies might be used for rehabilitation or stabilization purposes at the ecosystem scale.

For example, flood frequency and intensity, and its variation with land use over time, may be estimated for ungaged streams for information gained in interviews with reliable informants. This is best accomplished by independent questioning of several people, including 2 or 3 elderly residents who live near regularly observed streams or rivers of interest. Their description of flood crests should be related to recognizable features on or near the stream banks so as to allow location on topographic maps or aerial photographs later on. Other questions about flood frequency and characteristics can also be answered in qualitative terms. It is important to avoid leading questions about the trends involved or the potential relationship to land use.

It is best to broach the subject of the river, it's behaviour and it's history and then to let the informants relate their experiences, observations, impressions in a more or less uninterrupted fashion (if time permits and if informantion is relevant). If the information is not volunteered, some specific questions should be posed regarding the situation during the informant's childhood and young adult years. The answers can be compared later with statements about the current condition and behaviour of the stream. It is usually possible to determine: the highest flood on record or in memory , the relative frequency of lesser flood magnitudes, including before and after specific land use changes of interest, the approximate extent of the mean annual, 5 year and 10 year floodplains, the intensity of channel erosion and changes over time, the relative amounts of sediment transported and deposited in stream or river channels during floods, the existence of seasonal water shortage problems, whether there are apparent effects from upstream land use, and whether residents relate watershed management or land use to stream behaviour, stream water quality, dependability of water sypply or damage to floodplain fields.

The historical development, probable causes and effects of prominent erosion features, such as gullies and landslips, or outcrops exposed by erosion, can also be ascertained in like manner. This is often an easier topic than river regime and watersheds, since farmers are usually more aware of such features and the time frame required for their analysis is relatively short by comparison. After establishing how long the person has lived on the farm it can be determined whether the current features on or near the farm (a large gully for example) pre-date his/her arrival.

The time of appearance and the conditions (land use, management, weather) under which a particular feature occurred may offer clues as to the cause. If he/she does not recognize such a feature as a "problem" per se it may be useful to probe for the reason.

If soil or water conservation programs have been promoted or introduced in the past it is particularly important not to refer directly to erosion control or conservation practices until the farmer has had a chance to indicate his/her attitude towards land condition or specific features. Otherwise results are likely to be biased by "official line" responses known to be the "correct" answers. If the answers seem to be of this type interviewers can probe by asking about the labour and capital requirements for such practices, or by asking about where they have been applied and what have been the results. Also, one may ask if other farmers are implementing the recommended practices, and why (or why not).

The informant or the team may observe that significant effects exist but are felt primarily off-farm. In such a case the persons or groups most directly affected may be identified and interviewed, depending on the importance of soil erosion/land degradation within the context of the project. Such special interviews (on land degradation effects) can determine whether the effects are perceived, how serious they are (and are perceived to be), if those affected relate the problem to land use or to natural causes, if there are discernible historical trends in the occurance and/or magnitude of the effects, and what measures have been taken to combat/correct the problems (by whom, how, at what cost?).

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12.4 Taking Women's Needs into Account

There is a particular need to ensure that the role of women is considered at the project design stage. It has been found that in some cases development efforts have not just by-passed women, but have actually made their position worse. It has also been noted that failing to consider the role women play in rural society, or excluding them from project planning, has at times resulted in the failure of projects (Edgren, 1982).

In most developing countries it is the women who are primarily responsible for collecting fuelwood. Men are, therefore, frequently isolated from the problems which arise if supplies become scarce. This has been suggested as an important reason why men are often unconcerned about fuel scarcity problems and indifferent to suggestions that they should plant more trees.

Another very practical reason for taking women's views fully into account is that to an increasing extent they are becoming the effective family decision makers in many parts of the world. An increasing number of men are migrating away from small holdings with the consequence that there is a growing number of women-headed rural households. It has been estimated that a third of the world's total households have women as their heads, but this figure would be higher if it took account of the number of households in which men are present but provide little effective economic input (Hoskins, 1982).

If programmes are to help women, it is absolutely essential that accurate information on their actual work and role in the community is available. In the case of fuelwood, the statistical approach of recording the distances travelled to collect firewood, the time taken, and the loads carried, provides useful information on the actual physical tasks carried out by women. But it does not provide any information on how women themselves regard their problems, and what they see as realistic possibilities for taking action to ease them.

Particular care must be taken not to impose external values on what is happening at a local level. The collection of fuelwood is normally assumed to be a task which should be reduced or eliminated. But this is not necessarily always the case. In one part of Tanzania, for example, it was found that many of the women prefer wood collection to the work they would otherwise have to be doing. It is apparently seen as a relatively enjoyable task which they carry out in groups (Skutsch, 1983).

Similar instances in which women regarded firewood collection as a pleasant social activity have been noted in other countries (Brokensha and Riley, 1983). Measures for reducing the amount of time spent collecting wood in these cases would not necessarily be viewed by the women as an important improvement in their daily lives. The point is that there is no general rule about attitudes to firewood collection; women's own views must be established in each case. In many cases, such information cannot be obtained by men; women survey staff will often be needed.

The possibility of a conflict between men's and women's interests must also be borne in mind. One example of this comes from the Himalayan district of Chamoli. In discussions as to which trees should be planted in a number of village planting projects, the men's preference was for fruit trees from which they might gain income by selling fruit by the roadside. The women, on the other hand, wanted trees which produced fuel and fodder.

An account of this episode also states that:

> "It is also interesting to note that when the forest department was approached for saplings of fuel and fodder tree species, it had fruit trees (men's trees) or trees which yield good commercial timber. It had few women's trees" (Chowdhry, 1983a).

In Senegal, women often have an independent economic role within the rural family structure. In some areas, for example, the family works together in the cultivation of millet, but both men and women each have their separate areas in which they cultivate crops for their own personal income. Any increase in communal activity which imposes a proportionately greater burden on women, as could well be the case with some types of farm and community forestry programmes, would therefore diminish the opportunity they have for earning money for themselves. For this reason, such programmes are unlikely to be supported by women.

If women's needs are to be reflected in community programmes, it is highly desirable that they are given official representation within the village organisations involved. This can be done by ensuring that women are elected or nominated to whatever village or community committees are engaged in the negotiation and local planning of projects.

This, however, may not provide an adequate protection of their interests in all cases, since women representatives may be subjected to strong domestic and communal pressures to conform to the conventional norms of their societies. In many cases, women will not speak if men are present, and wil allow men to answer on their behalf even when they know that what men are saying is incorrect. For example, Senegalese men have said that women do not plant trees in spite of the fact that this is untrue, since the fruit trees around the houses are actually planted by women (Hoskins and Guigonis, 1979).

In order to provide a safeguard against such possible distortion or suppression of local women's views, it will often be necessary to ensure that women are adequately represented on the professional planning and executive side of projects. Identifying the specific concerns of women, and translating these into specific provisions in farm and community forestry programmes is a complex process (Hoskins, 1983). It requires a commitment and understanding which are frequently lacking in men. Preferably, it will be achieved by ensuring that women professional staff are appointed with explicit responsibilities for dealing with the impact of the project on women.

Table 1. Cont'd

E&C AFRICA

* FAIR
** GOOD
*** EXCELLENT

SPECIES	FUNCTIONS/USES: FOOD						FODDER				WOOD						SERVICES								OTHER									REMARKS	REFERENCES
	Fruits/Pods	Nuts/Seeds	Vegetable	Oils/Sap	Starch	Spices (S)/ Condiment (C)	Leaves	Fruit/Pods/Seeds	Shoots	See Forage	Fuel Wood	Charcoal	Building Material	Wood for Utensils & Tools	Farm Timber	Others	Windbreak	Live Fences	Soil Conservation	Dune Fixing	N Fixing	Organic Manure	Mulch	Other	Manna	Essential Oils	Tannins (T) Dyes (D)	Gums	Fibres	Medicinal/Drugs	Cultural, Ritual Social	Ornamental	Other		
Acacia albida							*	*	*	*	*		*	*			*		*	*	*	*					*					*			12,15,20,49,58,73,77
A. mellifera							*	*	*	**	*	**									*														23,
A. senegal							*	*	*	*	**	*	*	*					*	*	*						*	**						Gum arabic	12,15,29,62
A. seyal							*	*	*	*	*	*							*		*														12,23
A. tortilis							*	*	*	**	**	**	*	*					**	*	*						*			*		*			12,21,23,25,47,48
Adansonia digitata	*		*					*						*													*		*	*	**				12,62,58,76,80
Anacardium occidentale	*	*						*		*	*								*				*			*	*	*						Cash crop	12,53,71
Balanites aegyptiaca	*						*		*		*		*	*																*				Bilharzia control	12,23,80
Borassus aethiopum	*		*										*	*																					12,58,62,80
Butyrospermum parkii	*			*																														Bark for bee-hives	45,80
Cassia sieberiana											*		*	*			*		*																48,58,73
Casuarina equisetifolia											***	**	*	*			***		*	*			*				*								12,48.
Catha edulis							*				*		*	*																*	**			Cash crop	12,43
Cordeauxia edulis		*					*												*															Drought feed	49
Euphorbia tirucalli											*						*	*																	12,23,81
Magnifera indica	*					* (C)		*			*																			*		*		Cash crop	15,
Mangroves	*										**	**	*	*																				Aquaculture	12,27
Prosopis chilensis	*						*	*	*		*		*	*			*		*	*	*						*	*		*					19,48,63,73
P. juliflora	*							*		*	*	**					*				*														19,48
Rhus tenuinervis	*						*		*		**		*																	*					12,23
Simmondsia chinensis																			*						***					*				Cash crop	29,41
Terminalia brownii							*		*				**	*																*					12,23,75

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Table 1. Cont'd

E&C AFRICA

FUNCTIONS/USES		Zizyphus mauritiana
FOOD	Fruits/Pods	•
	Nuts/Seeds	
	Vegetable	
	Oils/Fats	
	Starch	
	Spices (S)/ Condiment (C)	
FODDER	Leaves	•
	Fruits/Pods/Seeds	•
	Shoots	
	Bee Forage	
WOOD	Fuel Wood	•
	Charcoal	•
	Building Material	
	Wood for Utensils & Tools	•
	Farm Timber	
	Others	
SERVICES	Windbreak	
	Live Fence	•
	Soil Conservation	
	Dune Fixing	
	N Fixing	
	Organic Manure	
	Mulch	
	Other	
OTHER	Waxes	
	Essential Oils	
	Tannins (T), Dyes (D)	•
	Gums	
	Fibres	
	Medicinal/Drugs	
	Cultural, Ritual, Social	
	Ornamental	
	Other	
REMARKS		
REFERENCES		12,48

• FAIR
•• GOOD
••• EXCELLENT

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Annex

NFT SPECIES CHARACTERISTICS

Species Name	Origin	Minimum Rainfall (mm.)	Dry Season (Months)	Mean Annual Temperature (°C)	Elevation (m.)	Soil Reaction	Height at Maturity (m.)	DBH at Maturity (cm.)
Acacia albida Del.	Africa	300	extended	NA	NA	NA	20	150
Acacia auriculiformis A. Cunn. ex. Benth.	Australia Papua New Guinea	1300	4-6	20-30	0-600	strongly acid - highly alkaline	15-25	60
Acacia confusa Merr.	S.E. Asia	750	NA	NA	NA	acid soils	14	NA
Acacia farnesiana (L.) Willd.	C. America S. America	NA	NA	NA	NA	wide adaptability	10	NA
Acacia mangium Willd.	Australia	1000	NA	NA	NA	moderately acid	30	25
Acacia mearnsii Willd.	Australia	500	2-3	12-18	1500-2500	neutral to acid	25	NA
Acacia nilotica (L.) Willd. ex Del.	Africa	NA	extended	NA	NA	NA	20	NA
Acacia saligna (Labill.) H. Wendl.	Australia	300	NA	13-30	0-300	acid to alkaline	8	30
Acacia senegal (L.) Willd.	Africa	200	extended	14-43	100-1700	NA	13	NA
Acacia tortilis (Forsk.) Hayne	Africa	100	extended	NA	lowland	NA	15	NA

Species Name	Origin	Minimum Rainfall (mm.)	Dry Season (Months)	Mean Annual Temperature (°C)	Elevation (m.)	Soil Reaction	Height at Maturity (m.)	DBH at Maturity (cm.)
Albizia falcataria (L.) Fosberg	S.E. Asia	1000	0-2	20-34	0-1200	neutral to acid	45	200
Albizia lebbek (L.) Benth.	S. Asia	600	2-6	20-36	0-1600	neutral to acid	30	100
Alnus acuminata O. Kuntze	C. America S. America	1000	NA	4-27	1200-3200	NA	25	NA
Alnus glutinosa (L.) Gaertn.	Europe	500	NA	NA	NA	NA	40	NA
Alnus nepalensis D. Don	Asia	800	NA	NA	1000-3000	NA	30	40
Cajanus cajan (L.) Millsp.	Africa	400	NA	NA	NA	NA	3-5	NA
Calliandra calothyrsus Meissn.	C. America	1000	NA	NA	0-1500	NA	10	20
Casuarina cunninhamiana Miq.	Australia	500	NA	NA	NA	NA	35	NA
Casuarina equisetifolia L.	Australia	750	3-4	10-35	0-1400	alkaline to neutral	35	18
Casuarina glauca Sieb. ex Spreng.	Australia	NA	NA	NA	NA	NA	20	NA
Casuarina junghuhniana Miq.	Indonesia	NA	NA	NA	NA	NA	30	NA

Species Name	Origin	Minimum Rainfall (mm.)	Dry Season (Months)	Mean Annual Temperature (°C)	Elevation (m.)	Soil Reaction	Height at Maturity (m.)	DBH at Maturity (cm.)
Dalbergia sissoo Roxb.	Asia	500	3-4	NA	0-1000	NA	30	NA
Erythrina bertoeroana Urban	C. America S. America	NA	NA	NA	to 2000	NA	10	NA
Erythrina fusca Lour.	C. America S. America	NA	NA	NA	to 1500	NA	30	NA
Erythrina poeppigiana (Walpers) O.F. Cook	S. America	NA	NA	NA	NA	NA	40	NA
Gliricidia sepium (Jacq.) Steud.	S. America C. America	1000	4-6	22-30	0-1600	NA	10	30
Inga vera (L.) Britton	C. America	1000	NA	NA	lowlands	NA	20	100
Intsia bijuga (Colebr.) O. Kuntze	S.E. Asia	2000	NA	NA	NA	NA	40	150
Leucaena diversifolia (Schlecht.) Benth.	C. America	500	4-8	18-30	0-1500	moderately acid to alkaline	20	20
Leucaena leucocephala (Lam.) De Wit	C. America	600	4-8	20-30	0-1000	moderately acid - mod alkaline	20	50

Species Name	Origin	Minimum Rainfall (mm.)	Dry Season (Months)	Mean Annual Temperature (°C)	Elevation (m.)	Soil Reaction	Height at Maturity (m.)	DHB at Maturity (cm.)
Mimosa scabrella Benth.	S. America	NA	NA	NA	to 2400	NA	12	40
Parkia javaniva (Lam.) Merrill	S.E. Asia	NA	NA	NA	0- 700	NA	40	NA
Parkia speciosa Massk.	S.E. Asia	NA	NA	NA	to 1500	NA	15	NA
Parkinsonia aculeata L.	C. America S. America	200	6-9	NA	0-1300	NA	20	40
Prosopis alba/ chilensis "complex"	S. America	200	8-11	NA	to 2900	NA	15	NA
Prosopis cineraria (L.) Druce	S. Asia	100	8-11	NA	lowlands	neutral to highly alkaline	9	NA
Prosopis pallida/juliflora "complex"	C. America S. America	200	NA	NA	0-1500	NA	15	NA
Pterocarpus indicus Willd.	S.E. Asia	NA	NA	NA	NA	NA	40	200
Robinia pseudoacacia L.	N. America	1500	NA	0-10	1000	strongly acid - slightly alkaline	30	90
Sesbania grandiflora (L.) Poir.	S. Asia	1000	2-3	20-30	800	limits not reported	10	30

Remarks: NA means Not Available

Important fuelwood/Afforestation/Agroforestry Tree/Shrub species for dry zones of Kenya

Table 1

	SPECIES	Firewood Charcoal	Pole Posts	Timber	Animal Feed	Human Food	Honey	Gums Resin	Veg. Tanning	Water Soil & Cons	Nitrogen Fixing
1	*Acacia albida	X			X			X		X	X
2	*Acacia cyanophylla (A. saligna)	X			X		X	X		X	X
3	Acacia senegal	X			X		X	X			X
4	Acacia nilotica	X			X			X			
5	Anacardium occidentale										
6	Atriplex nummularia				X	X	X	X			
7	Anona squamusa	X	X		X					X	
8	Atriplex repanda	X	X	X		X				X	
9	&Azadirachta indica	X			X		X			X	
10	Balanites aegyptica	X	X		X	X	X			X	
11	Bauhenia spp										
12	*Casuarina equisetifolia	X	X								X
13	Casuarina cristata	X	X	X							X
14	*Cassia siamea	X	X				X			X	X
15	*Conocarpus lancifoleus	X	X	X			X			X	
16	Combretum spp	X					X		X		
17	Citrus spp					X	X				
18	*Dalbergia sissos	X	X	X			X			X	X
19	Dalbergia melanoxylon	X	X	X			X			X	X
20	Erythrina spp			X						X	
21	*Eucalyptus maculata	X	X	X		X					
22	*Eucalyptus camaldulensis	X	X	X		X					
23	Eucalyptus tereticornis	X	X	X		X					
24	Eucalyptus microtheca	X	X	X		X					
25	Eucalyptus paniculata	X	X	X		X	X				
26	Euphorbia tirucalli	X	X	X		X	X				
27	Ficus spp	X	X			X					
28	Grevillea robusta	X	X					X			
29	Gleditsia triacantha				X	X		X			
30	Leucaena leucocephalla	X	X	X			X			X	X
31	*Mangifera indica	X	X	X		X				X	X
32	Markhamia platycalyx	X	X		X	X	X			X	
33	Parkia clapertoniana	X				X	X				
34	*Psidium guajava	X	X	X			X				X
35	Parkinsonia aculeata	X			X		X			X	X
36	Pithcerlobium dulce						X			X	X
37	*Prosopis cineraria				X		X	X		X	X
38	Prosopis juliflora	X			X		X	X			X
39	Prosopis chilensis				X	X	X	X		X	X
40	Prosopis pallida				X		X	X	X	X	X
41	Schinus molle	X								X	
42	Simondisia chinensis									X	
43	Tamarindus indica										X
44	Tamarix spp									X	
45	Terminalia browhii										
46	Ziziphus spp				X	X	X			X	

NFT HIGHLIGHTS

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Acacia holosericea - A Successful Newcomer for the Dry Tropics

This shrubby acacia is little used in its native Australia, yet it promises to be an outstanding multipurpose tree for the dry tropics. Its excellent potential for fuel, charcoal, animal fodder, land rehabilitation and as an ornamental is now being realized in Africa and the Indian subcontinent.

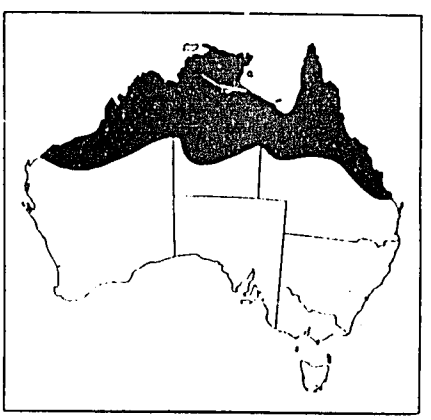
BOTANY: *A. holosericea* A. Cunn. ex G. Don is one of some 850 thornless species of the genus endemic to Australia. It bears large phyllodes, 10-25 cm long and 1.5 to 10 cm broad, usually covered densely with fine hairs, giving the tree attractive silvery foliage. Small bright yellow flowers are aggregated in prominent spikes 3-6 cm long. Narrow, hairless pods, 3-6 cm long, are coiled in dense clusters and contain shiny black seeds, each with a yellow aril at the base. Flowering is heavy and precocious, and abundant crops of mature seeds may be formed within two years of planting. It commonly forms a spreading shrub to 5 m in height with many ascending branches from just above ground level. Occasionally it grows as a small tree up to 8 m in height.

ECOLOGY: Natural populations occur in a wide range of tropical climates. In semi-arid areas mean annual rainfall can be as low as 300 mm, and in these conditions it is confined to seasonally dry stream banks. Throughout much of its natural distribution annual rainfall is 600-1200 mm with most rain concentrated in four months. It does occur, however, in areas where rainfall exceeds 1500 mm (Booth and Jovanovic 1988). Most of the distribution is frost-free, but up to ten frosts each year occur at some inland sites. It occurs on a variety of soil types, but mainly on shallow, acidic, stony sands and loams of low fertility (Turnbull, et al. 1986).

In Senegal, tests have shown that the species behaves satisfactorily with rainfall over 500 mm in areas under coastal influences and over 600 mm in continental Africa (Cossalter 1987). In extremely dry areas when annual rainfall is less than 250-300 mm seedlings can survive for 2 to 3 years but then die. In the island environment of Cape Verde, however, where low rainfall is counterbalanced by higher air moisture, cooler temperatures and lower evapotranspiration, *A. holosericea* has withstood an average annual rainfall of about 200 mm in a 5-year period. In Senegal, it reportedly tolerates saline and waterlogged soils (Cossalter 1987).

The wide variability in soils and climate suggest major provenance differences will occur in growth rates and drought and frost tolerance. Provenance trials have been started, but results are not yet available.

FUELWOOD AND CHARCOAL: The wood is hard and has a high density of about 870 kg/m^3. With calorific values for wood and charcoal of 4670 Kcal/kg and 7535 Kcal/kg, respectively, it is a good quality fuel (Cossalter 1987; CTFT 1983). The rapid early growth rate makes it a highly productive fuelwood source.



The shaded area is the natural range of Acacia holosericea (Turnbull, et al. 1986).

FODDER: The fodder potential is mainly due to the large phyllode biomass produced during the dry season, a period when most non-Australian acacias traditionally used for fodder shed their leaves. Fresh phyllodes are not palatable for cattle and sheep, but when the branches are lopped the dry foliage is eaten readily. Four-year-old trees in Senegal have produced about 3 tons of dry phyllodes per hectare, but estimates of crude protein and *in vivo* digestibility are low and suggest *A. holosericea* has a low feed value (Vercoe 1987).

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WINDBREAKS & LAND REHABILITATION
The large, dense crown of this shrubby acacia enables it to form a screen. In Africa it is used to form the lower part of a multistorey windbreak with the taller *Eucalyptus camaldulensis*, a species with which it is frequently found in its natural range (Hamel 1980).

Advantage can be taken of the fast growth, dense crown, nitrogen fixing ability and vigorous colonizing characteristic of this species to revegetate and restore degraded mining areas (Langkamp and Dalling 1983). It also shows promise for sand dune fixation in Senegal and Somalia (Hamel 1980).

ORNAMENTAL: The silvery foliage, early appearance of long yellow flower spikes, and prominent twisted pods make *A. holosericea* an attractive ornamental shrub or small tree.

ESTABLISHMENT: For good germination, seed (95,500 to 175,000/kg) should be scarified by mechanical abrasion or immersed for one minute in boiling (100 °C) water. Coppicing is generally regarded as poor, but contradictory reports suggest its resprouting ability may be influenced by tree age, season of cutting and height at which the cutting takes place.

GROWTH: Seedling growth is rapid. On favorable sites in Central Australia it has reached 4 m tall in 18 months. On drier sites 3 m growth in 3 years is average, and growth rate diminishes in succeeding years (Kube 1987). In Senegal a growth rate of 4.8 m in 40 months has been recorded in an area with 585 mm rainfall and a 7-month dry season (Cossalter 1987). At Bambey, Senegal, 4 year old *Acacia holosericea* produced 13 tons/ha of green wood and almost 3 tons/ha of dry phyllodes, demonstrating its considerably greater productivity than the local *Acacia senegal*.

SYMBIOSIS: *A. holosericea* forms nodules with rhizobium and develops endomycorrhizal associations. Greatly stimulated growth has been reported when seedlings were inoculated with a selected rhizobium and the endomycorrhizal fungus, *Glomus mosseae* (Cornet and Diem 1982).

PESTS: This acacia appears to be relatively free of pests and diseases in cultivation and resists termite attack.

PROBLEMS: The early and abundant seeding habit has the potential to make *A. holosericea* a weed species under certain conditions. Like many acacias, it is relatively short-lived, from as little as 4-5 years to not more than 10-12 years, and this may be a problem under some circumstances.

(Simmons 1981)

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Parkinsonia aculeata

Botanic Name *Parkinsonia aculeata* L.

Common Names Jerusalem-thorn, palo de rayo, Mexican or blue palo verde, horse bean tree, retama, sessaban (Arabic), Hanson sessabani (N. Nigeria), Barbados flower fence

Family Leguminosae (Caesalpinioideae)

Main Attributes This fast-growing tree is easy to plant and cultivate; it adapts to a variety of environments and soil types and is extremely drought resistant. Its dense, hard wood burns well.

Description The Jerusalem-thorn is a small, often crooked tree, growing to 10 m tall, with a green trunk up to 40 cm in diameter. It has thorny, gracefully drooping branches. Its foliage is "transparent" because the tiny leaflets are borne on long, flat leaves that look like blades of grass. Numerous bright yellow flowers occur in loose racemes.

Distribution The plant is native to a vast New World area extending from southwestern United States (Texas, New Mexico, and Arizona) to Argentina. It has become naturalized in Hawaii, South Africa, and most of India. It is cultivated as an ornamental in Florida, Cyprus, India (in dry Deccan areas and the Punjab), Jamaica, Israel, Uganda, and South Africa.

Use as Firewood The wood is used for firewood and charcoal in countries such as Mexico and Puerto Rico. It is close-grained, hard, heavy (specific gravity, 0.6), and brittle. The trees regrow vigorously even after drastic pruning.

Yield The tree is noted for fast growth. Young plants, fertilized, will grow up to 1 m annually.

Other Uses

- Beautification. Because of its unusual foliage and vivid flowers, it makes an attractive ornamental that withstands pruning and can even be trained as a hedge.
- Erosion control. Since it grows in arid climates and in sandy soils, the Jerusalem-thorn can be used to afforest eroding and sandy soils.
- Fodder. Its seeds have been used in the past in Mexico for food, and the seed pods are greedily eaten by animals. Young branches are lopped to feed goats and sheep.

Environmental Requirements

- Temperature. It grows in tropical and subtropical climates. It withstands high temperatures (for example, up to 36°C) and light frosts. (In the United States it survives the cold as far north as Georgia.) For best growth it requires full sun and will lean toward the sun; in shaded sites its growth is retarded.
- Altitude. It is generally found at altitudes below 1,300 m.
- Rainfall. The tree grows well where annual rainfall is as high as 1,000 mm, but its greatest potential is in dry areas receiving as little as 200 mm annually and having dry seasons as long as 9 months.
- Soil. Jerusalem-thorn occurs naturally in poor, gravelly, or sandy alluvial soil and in desert grasslands and canyons. It flourishes in oolitic limestone of southern Florida, even when given no care. It tolerates saline sites, but grows poorly in soils subject to waterlogging. Although this species is a legume, it is not now known whether it fixes nitrogen; young plants respond to fertilizer, however.

Establishment The plant produces seed prolifically and it grows easily from seed, root or shoot cuttings, or air-layers.

- Seed treatment. The seeds are either soaked in water for 3 or 4 days or scarified and then soaked in warm water for 1 day.
- Ability to compete with weeds. Unreported.

Pests and Diseases The tree is generally free of disease and insects but can be attacked by twig borers and by snow scale; new growth is subject to fungal die-back in winter months in humid climates. Young plants are damaged by termites.

Limitations The tree is thorny and reproduces so easily that it can escape from controlled cultivation and become a weed.

Related Species

- *Cercidium microphyllum*
- *Cercidium floridum*

Prosopis chilensis

Botanic Name *Prosopis chilensis* (Mol.) Stuntz

Common Names Algarroba, kiawe (Hawaii), algarrobo blanco, algarrobo de Chile, mesquite

Family Leguminosae (Mimosoideae)

Main Attributes *Prosopis chilensis* is a South American tree that is a useful shade and fodder plant for hot dry zones. It is very drought resistant, well adapted to light soils, and is probably nitrogen fixing. It has proved suitable for planting in subdesert regions of Africa. It is the most drought resistent and consistently high yielder of biomass of all the *Prosopis* species tested in North America.*

Description *Prosopis chilensis* grows 8 to 15 m high. It has a shallow, spreading root system and branches freely. Its flowers are greenish yellow and it has a slender seed pod.

Distribution *Prosopis chilensis* is native to the Pacific coast of Peru, central Chile, and eastern Argentina. It is naturalized in Hawaii and is common in thickets along the beaches.

Use as Firewood *Prosopis chilensis* wood is hard, heavy, and strong (specific gravity, 0.80–0.92).

Yield This tree is not normally considered fast growing like *Eucalyptus* or leucaena, but it dark brown, often with a purplish hue. It is rather coarse textured and irregularly grained, but is easy to work, finishing smoothly and taking a natural polish. The wood is very resistant to decay.

- Ornamental. Thornless varieties are becoming popular for landscaping in the southwestern United States.

Environmental Requirements

- Temperature. The tree withstands extremely high desert temperatures. It is poorly adapted to cold and requires temperatures of about 27°C for good growth. Seedlings may tolerate an odd mild freeze of -5°C but cannot withstand lower temperatures or even many (10 or more) mild frosts.
- Altitude. In southern Peru, the tree is found at elevations of up to 2,900 m. In India, it is recommended for planting as a fodder tree at altitudes ranging from 340 to 1,230 m.
- Rainfall. In Africa, it is recommended for unirrigated subdesert areas receiving 200–400 mm annual rainfall† and suffering 8-11 dry months a year.
- Soil. Unreported.

Establishment *Prosopis chilensis* is propagated by seed. For one establishment procedure, see *Prosopis alba*.

- Seed treatment. Seeds must be scarified

*Information supplied by P. Felker.

†Laurie, M. V. 1974. *Tree Planting in African Savannas*, Food and Agriculture Organization of the United Nations, Rome: p. 72.

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1.1 ACACIA ALBIDA

Narrative Description

Introduction, reintroduction or protection of Acacia albida seedlings in worn-out farm fields is very desirable. Acacia albida occurs naturally throughout arid and semi-arid portions of Africa. Although the precise nature of this tree's benefits are not completely understood, crops such as millet, sorghum, or peanuts do much better under and near Acacia albida than in open fields. The presence of Acacia albida can make a decided difference as to whether a field can be cropped continuously without degenerating, or whether soil fertility declines to a point where extended fallow periods are necessary to restore fertility.

Areas of Applicability

Acacia albida is most successfully grown in areas receiving below 800 mm of rainfall (In areas with more rainfall, tree crops usually apply. See 1.2 Tree Crops.).

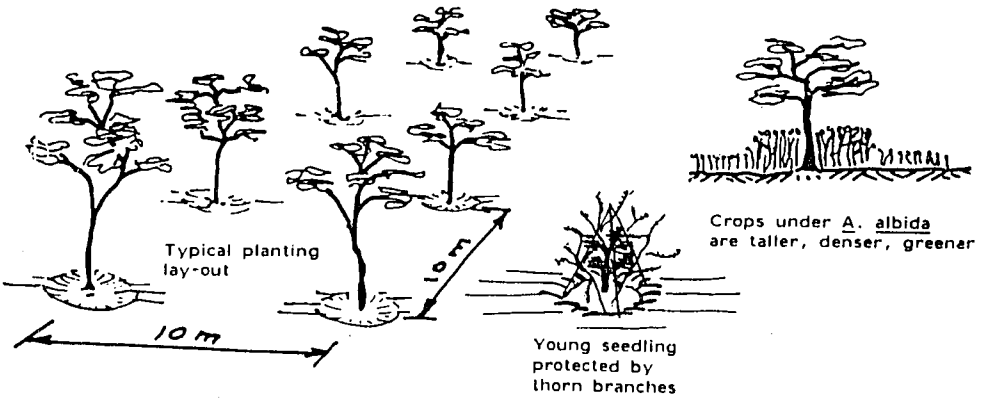
Mostly sandy, well-drained, typical "millet soils" are preferable. However, Acacia albida also have been successfully introduced in intermittently flooded river plains on clayey soils.

This species is especially valuable on overused, traditional dryland farm areas near villages or individual compounds.

Restricting Conditions

Do not plant Acacia albida where natural reproduction is found; protect existing young trees instead. Where mechanized soil preparation is used, trees must be in line. One constraint: Acacia albida attract birds which eat the cereal crops. Therefore, farmers may be reluctant in some areas to have additional trees in or near their fields.

Planting Acacia albida is not a reforestation effort. Use the species only in farm fields, especially where crop yields have been regressing. Species other than Acacia albida can also play a significant conservation role on agricultural land (see 1.2, Tree Crops).



Design Guidelines

Trees can be raised in nurseries during three to four months. Plant 10 m by 10 m; an ultimate density of 40 to 60/ha is recommended. Some direct seeding trials have yielded encouraging results. Always carefully select seeds from large, well-formed parent trees.

Notes on Local Participation

Land: Guaranteed long-term land-use right is essential in interesting residents in planting and protecting a tree which will not grow or change field conditions quickly.

Labor: Added labor may be needed the first year during the busy planting season, but this technique does not require long planting efforts. Surveillance, however, is needed year-round for 3 to 6 years to protect the trees from animals which traditionally browse in fields after harvest. Trees may be protected individually or access to the area may be limited, but either way labor investment is required.

Benefits: If animals access for browsing is changed, farmers may lose valued manure, fodder or other benefits from herders. If the farmers stay after harvest to protect trees they may lose off-season employment. Benefits to soil may take years to realize.

Extension: Farmers already value *Acacia albida*; thus, consciousness-raising may not be necessary. Planting stock, proper organization, timing of production, transport and distribution of seedlings are critical where planting is to be done.

Organization: This can be an individual or family voluntary activity. Outside support may be needed to back up local efforts to protect trees.

Combination With Other Conservation Activities

Especially where land pressure is extreme, combine with windbreaks and live fencing (3.1.1 and 3.1.2). Planting *Acacia albida* along berms (3.2.1.4) also is possible. On slight slopes of heavier soils, *Acacia albida* growth will benefit from "mini-catchments" (4.1).

Possible Production Benefits

Pods for supplemental livestock feed. Limited amount of branches for thorn fences. Above all: crop production under fully grown *Acacia albida* is significantly and consistently higher than in unprotected areas. Studies have shown yield increases in the range of 30% to 60%.

Inputs Required

Plants (seedlings) - where sufficient water is available, seedlings can be grown in family or village nurseries (Upper Volta). Proper planting techniques and timing are very important.

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Major, continuous protection is required for at least three years against free-grazing animals.

Location of Previous Experience

Earliest efforts (1930) undertaken in Senegal; several additional campaigns have occurred since then. The latest efforts were jointly carried out by Forest Service and SODEVA (Parastatal organization for agricultural extension).

Positive results were also recorded in Niger (excellent results in Maradi area; direct seeding success near Matameye, with seeds being distributed by sheep and goats).

Good results were also experienced in Chad, between N'Djamena and Bongor (CARE project).

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As applied in the D&D context, casual diagramming will be mainly used to analyze the causal background to household supply problems. Optionally, the tool could also be used to assist the team in its understanding of sustainability problems and problems at the ecosystem level, although the use of causal diagrams to analyze problems at the household (or other unit) management level may already depict the important causal aspectes of these other problems. The following conventions are expressed in terms of the analysis of household supply problems. Reference is made to the accompanying examples in Figure 1 to Figure 4.

1. First identify the *problems* to be explained. These are given in the listing of household supply problems in Worksheet 5.1.1

2. Then identify the *causal factors* involved in the generation of each problem. These are given in Worksheet 5.1.2

3. Next, decide on a word or descriptive phrase to describe the problem, and enter this on the *left-hand* side of the paper and draw an oval around it. The convention is to move from effects on the left to causes on the right. Observation of this convention greatly increases the clarity of the diagram and the ease of its interpretation. Since the problem to be explained is the ultimate effect, it is entered at the extreme left side of the paper.

4. Then, decide on words or descriprivé phrases for the various causal factors related to the problem and start entering then within ovals to the right of the problem. Do not worry too much about the positioning of the various causal factors at this point. Start with the most significant factors. Leave trivial factors out.

5. Next, examine the various factors and draw arrows between the respective ovals showing cause-effects relationships between different causal factors and between causal factors and problems. Not all causes are equal; some are more distantly related to the problem than others. In analyzing complex systems of causation we are always dealing with cause-effect chains. A "cause" at one position in the chain is an "effect"at the next. The arrows are used to depict the movement from cause to effect. When all of the arrows are drawn in the pattern revealed will contain *causal chains* and, perhaps, also causal *loops*.

6. At this stage what will have been produced is a rough and rather messy first approximation of the final causal diagram. The next step is to clean it up and make any necessary additions and modifications to improve its contistency and clarity. This is done by renaming the causal factors so that the terminology within each oval is consistent with the relationships shown by the arrows coming in and out. Also, the position of the ovals is rearranged so as to display an orderly cause-effect progression from right to left. In other words, the arrows should mainly point in a general leftward direction. Exceptions must be made, of course, in the case of causal loops depicting feedback relationships.

7. At any point from step 4 onwards, it may become apparent that there is a missing term in the cause-effect sequence. This may indicate a causal factor that has been overlooked by the team, or it may merely signify the need to reconceptualize the terminology used to describe the causal factors enclosed within certain ovals. In either case, it may be necessary to add an additional "intermediate" factor between two or more ovals.

Forexample, in Figure 1, "low available moisture" was not in the initial diagram for this problem complex. It was added in the second round of the diagramming process to receive and summarize the effects of several contributing factors (insufficient rainfall, poorly distributed rainfall, low infiltration and high runoff losses, and weed competition). "Poor soil fertility" was included in the first diagramming attempt, along with the contributing causes (low organic matter and low nutrient levels), but "low available nutrients" was added in the second round to integrate the effects of these factors together with nutrient competion from weeds. The double effect of weed competion on both water and nutrients available for crops was not clearly displayed in the first, rather messy diagramming attempt, but became clear after reconceptualization and rearrangement of the diagram.

After this diagrammatic optimization process, the final diagram (Fig. 1) displays a clear progression from the main problem to be explained (poor and unrealiable crops) to the main summary causes (low available moisture, low available nutrients and insect damage) to the various contributing causes. Or, reading from right to left, from contributing causes to proximate causes to the problem. Thus, the diagnostic knowledge of causal factors involved in the generation of the problem has been *organized* into a coherent picture of the problem (i.e. how it arises within the system).

Figure 1 is a partial causal model dealing with only one of the diagnosed problems in a system in the semi-arid zone of Kenya. It depicts causal chains but no causal loops. Figure 2 shows a generalized causal model of an entire national land use problem complex derived from secondary information on Rwanda (ISNAR, 1982). The four main problems to be explained are shown on the left-hand side of the diagram. The causal analysis displayed to the right of the problems reveals both causal chains and loops, depicting the combination of social and biophysical causes and effects underlying the general degradation syndrome affecting land use systems in the country. To give an idea of what a causal diagram adds to an understanding of causal relationships, it may be useful to cite a prose description of the Rwandan problematique:

> Rwandan agriculture is now caught in a process of continuous degradation: overpopulation goes hand in hand with overcropping of fertile lands, the use of more fragile areas around arable lands, shrinking of pastureland, overgrazing, uncontrolled deforestation, etc. Labour productivity is decreasing. Ill-nourished crops grown on improverished soils, moreover, become disease-susceptible. In sum, the country is suffering from deterioration of its plant canopy which includes decreasing biological and genetic diversity, decreasing soil fertility, and soil losses due to erosion (ISNAR, 1982).

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This statement, together with addtional descriptive information on the Rwandan problematique, has been transformed into a clear diagrammatic representation (Fig. 2) of *how* the problem is generated.

Using Causal Diagrams to Discover Potential Intervention Points Within the System

At Step 14.2 the D&D team is asked to identify points within the diagnosed system where functional interventions may play a role in removing or reducing constraints on system performance. Figure 1 and Figure 3 illustrate the use of causal diagrams for this purpose. The team simply studies the causal diagram of the problem and for each causal factor or constraint asks itself the question: "Is there anything than can be done at this point in the system to remove or reduce the constraint or otherwise improve system performance?" Ideas for functional interventions will generally be forthcoming if this procedure is followed. The team may then go on to assess how effective the various suggested interventions might be in reducing constraints, alleviating problem-causing syndromes, and ultimately solving the identified problems.

Combining Causal Diagramming with Functional Diagramming

Functional diagramming techniques and uses are discussed at some length in Appendix B-8. Such diagrams may be used independently or as an adjunct to causal diagramming. An example of the latter usage came up in the course of a D&D exercise in the Philippines. In the midst of the diagnostic analysis it became clear that the main problem was a cash flow problem, and that to adequately conceptualize this problem it would be necessary to diagram the in-flow and out-flow of cash within the household system, in addition to the diagramming of causal factors affecting cash flow. Hence, Figure 4, which depicts causal influences by arrows with broken lines and the flow of cash and relevant inputs and outputs by arrows with solid lines.

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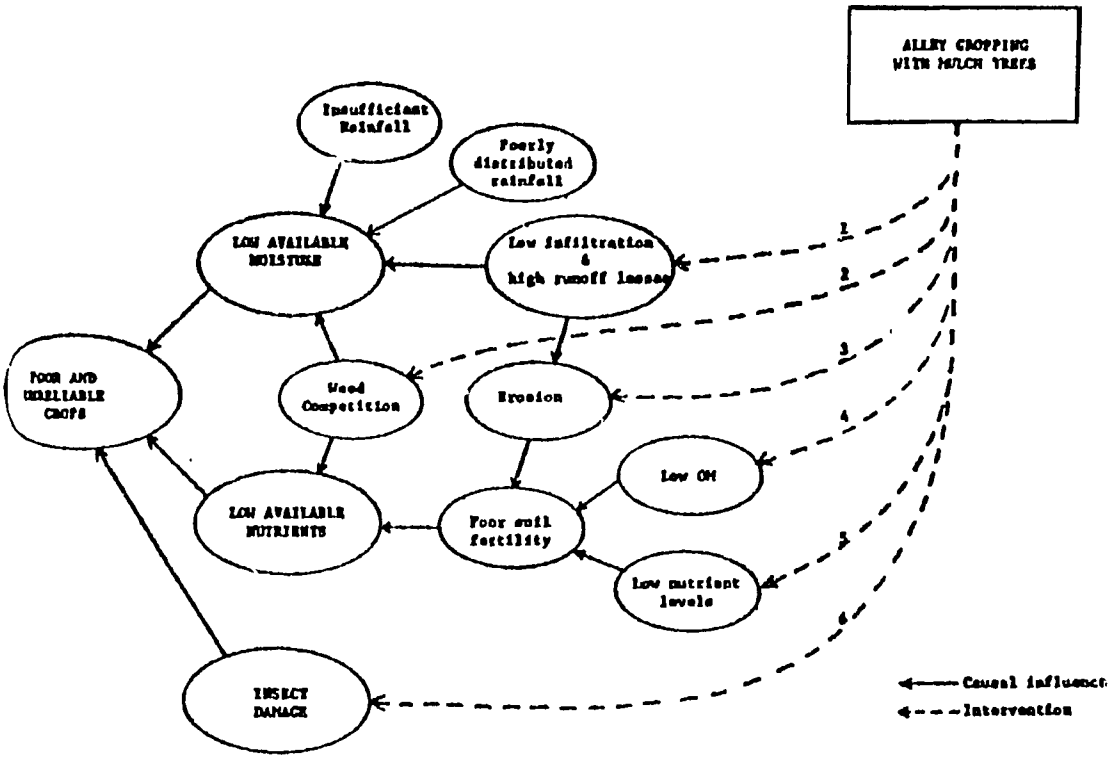

Potential Mulch Trees

N-fixing	Insect-repellent
Albizia lebbeckophala	*Adhatoda vasica*
Acacia scabrella	*Azadirachta indica*
Albizia blepinosa	*Derris indica*

Potential Interventions

1. Improved infiltration, reduced runoff
2. Weed control with reduced labour
3. Reduced splash and runoff erosion
4. Increased organic matter
5. N-fixation and nutrient pump action of deep penetrating roots
6. Use of insect-repellent mulch species.

Figure 1. Partial causal diagram depicting causes of food problems in a semi-arid zone mixed farming system in Kenya, with suggested technological interventions. (Source: Raintree, 1982)

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SOURCEBOOK SUPPORT MATERIALS - MODULE 6

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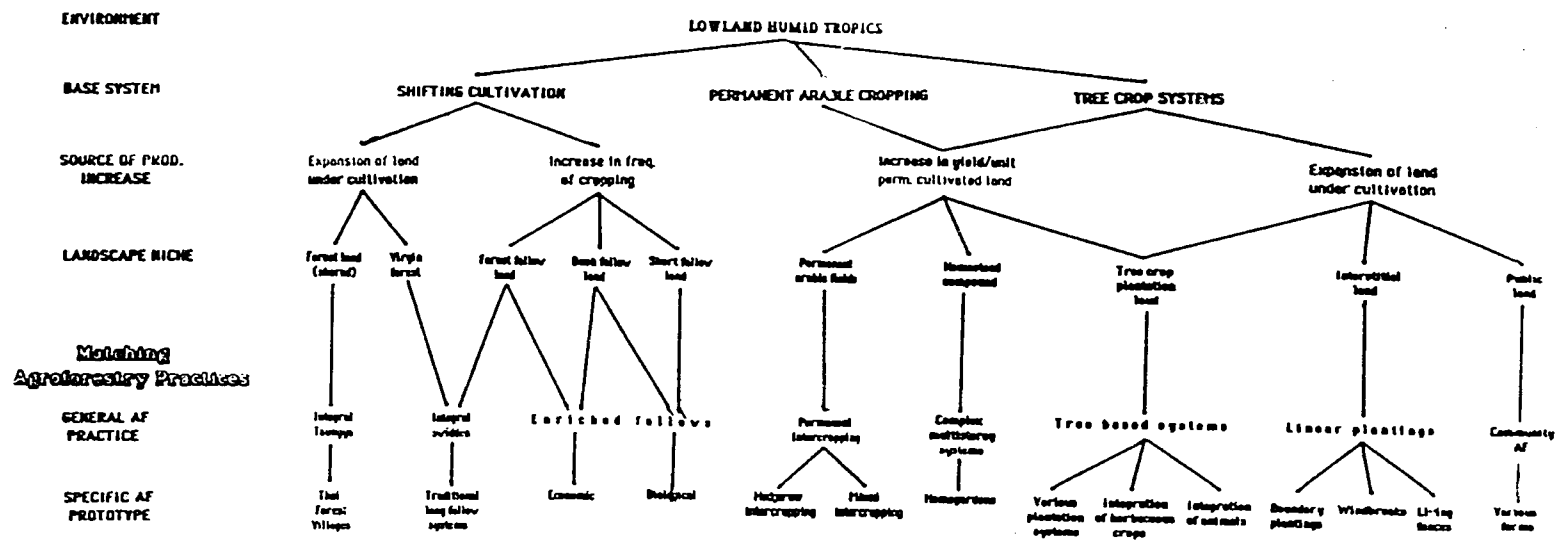
6.8 ON-FARM DEMONSTRATIONS

6.8.1 "On-Farm Demonstrations"

Provisional Indicative Draft

Agroforestry Decision Tree

(for initial, exploratory assessment of major agroforestry potentials)*



See site-specific design algorithm on accompanying sheet. This can be used with or without a preselected prototype technology in mind.

* Note: This decision tree may be useful as an aid to making an initial assessment of agroforestry potentials on the basis of limited data. The assumption behind this scheme is that one needn't have a great deal of detailed information about a land use system in order to make a provisional identification of potential agroforestry practices--providing the right information is known. If the reasoning behind this decision tree is correct, one only needs to know the general nature of the environment, the base system into which the agroforestry practice is to be introduced, the main sources of production increase within the system, and the available landscape niches. All of these are relatively easy to assess with good secondary data and a brief reconnaissance visit to the area. To properly diagnose the system, identify a sound development strategy and arrive at an appropriate site-specific design, much more detailed information will be needed on the characteristics and problems of the system (environmental, technical and socioeconomic--see the accompanying information sheet on information needs for agroforestry diagnosis and design). Such information is normally gathered in a D&D field exercise, supplemented by more detailed secondary data and regional analysis. While remaining open to "surprises" and to creative design ideas emerging in the field, the data collection process can be made more efficient by preparing the D&D team with an informed prediagnostic indication of what the major agroforestry interventions are most likely to be.

ALLEY CROPPING

Definition:

Alley cropping is an agroforestry system in which food crops are grown in alleys between rows of hedges. The hedges follow the contour and consist of trees and shrubs such as Leucaena or Pigeon peas. Leguminous perennials are more suitable as they fix nitrogen. Hedges can also be placed on conservation structures.

Area of Applicability:

1. Agroclimatic Zones:

All Dega
Moist and Wet Weyna Dega
Moist Kolla

2. Local Situation:
a) Slope Range:
All

b) Soil Range:
All, including shallow and degraded soils

Specifications:

- The following tree species are commonly used in agroforestry in Ethiopia:

Acacia albida: This tree occurs in the moist Kolla and moist Weyna Dega, and is used on cultivated land to improve soil fertility and as fodder. Branches are cut short to minimize shadow when planted with tef.

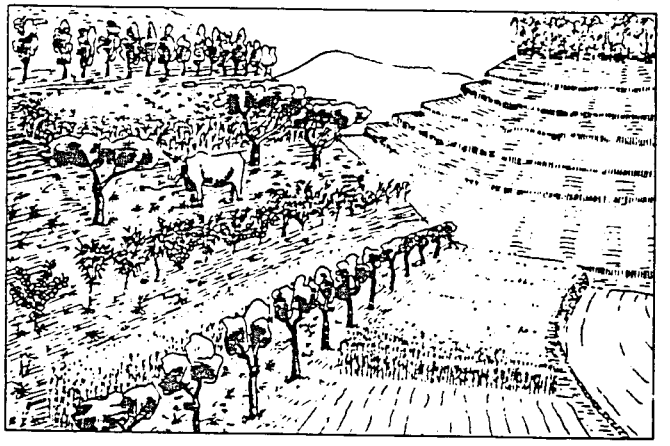
Sesbania and Leucaena: These have been introduced and are used like Acacia albida on cultivated land. They may be cut short at the end of the dry season to keep shadow to a minimum especially with tef. With sorghum and maize, problems of light competition are less.

Bamboo, «true man's tree», and many *local species* known to farmers can be used for alley cropping at the altitudes of their natural occurrence.

- See also the list of trees and legumes on page 90.
- Spacing between rows of hedges should not be more than 5 m. On hedgerows, trees and shrubs can be spaced 25-100 cm apart.
- When cutting down, take care that shrub is cut above lowest split of branches, and not below, to support fast regrowth.
- Alley cropping is applied by individual land holders on their land, and the products are at their own use.
- Trees are planted in rows of pits along the contour spaced with up to a 5 metre vertical interval on steep slopes.

Effects:

Trees and shrubs provide green manure or mulch for recycling nutrients to the soil. Prunings, applied during fallow, suppress weeds and create favourable conditions for soil organisms. Soil erosion is reduced. Bunds on steeper slopes are stabilized. Nitrogen is fixed and made available to companion plants.



Alley cropping is shown here on a steep slope. Rows of trees and hedges alternate with strips of grassland or cultivated land. Controlled grazing with cattle is possible between the rows. Crops can be grown for sometime until the soil is left fallow to improve fertility, supported by organic material from tree leaves and fixation of nitrogen through some trees.

Combinations:

Alley cropping can be used with physical measures applied on steep degraded slopes, even in the Dega belt for certain leguminous trees growing at that altitude (see page 90). Below steep slopes, CUTOFF DRAIN is used to protect cultivated land. CUT AND CARRY, TREE PLANTING and REVEGETATION are used with alley cropping.

Materials:

Besides the trees mentioned, bushes and shrubs, which are traditionally known as fodder perennials, can also be used for alley cropping. Additional materials are line level and digging instruments.

Management and Maintenance:

Planting must be narrow in the hedge (every 1 m). Weeding and pruning is needed. Grazing between rows of trees only with tied cattle, better even CUT AND CARRY. Crop production is shifting between trees, leaving a strip fallow after cultivation for about five years. Use traditional knowledge about soil fertility improvement and tree management. Up-bringing of trees needs careful supervision by the farmer who applies alley cropping on his land. Grazing should not degrade the grass cover. Crops are allowed only if soil fertility has improved. Crop rotation. Regular cutting of tree branches for mulch and fodder.

GRASS STRIP

Definition:

A grass strip is a ribbon-like band of grass laid out on cultivated land along the contour. Usually, grass strips are about 1 metre wide and spaced at 1 m vertical interval. They are mainly used to replace physical structures on soil with good infiltration (sandy, silty) on gentle slopes. Cattle must be excluded from this measure all year long to provide for sufficient length of the grasses to slow runoff and retain soil sediment.

Area of Applicability:

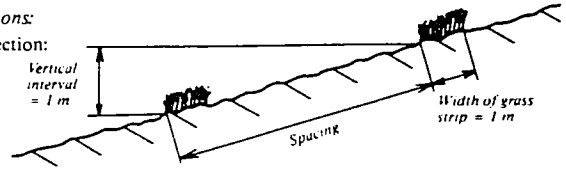
1. Agroclimatic Zones:

Moist and Wet Wurch
Moist and Wet Dega
Moist and Wet Weyna Dega
Moist Kolla

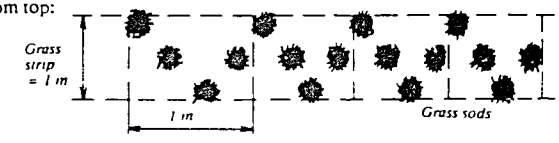
2. Local Situation:
   a) Slope Range:
      Slopes of less than 15% gradients
   b) Soil Range:
      All

Specifications:

- Cross-section:



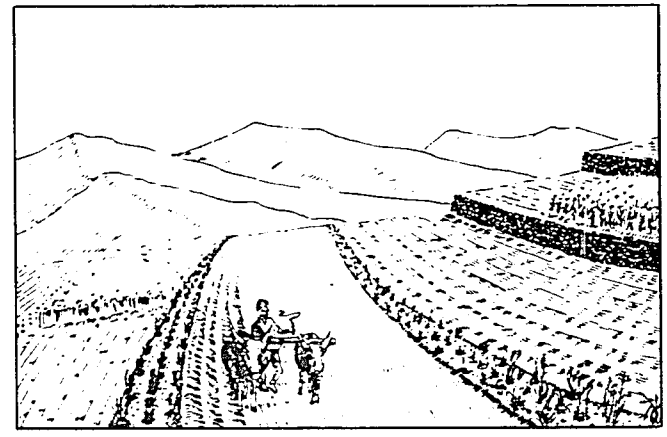
- View from top:



- Grass strips are planted along the contour or along CUTOFF DRAIN.
- Spacing with 1 metre vertical interval means that on a 3% slope, grass strips will be 33 m apart, and on a 15% slope, only 7 m apart, still sufficient for ploughing between the strips.

Effects:

Grass strips help to reduce runoff and to filter out sediments carried by runoff. They are especially suitable on soil with good infiltration and where the climate is not too dry for dense grass development. If grazing is totally prevented, the grass strips will effectively build up into terraces and provide good fodder for cattle which can be used with CUT AND CARRY.



Grass strips are used on the gentle cultivated land to the left. On the steeper slopes to the right, terrace development is needed. The farmer automatically ploughs parallel to the strips, a measure which reduces erosion further. The individual sods of grass planted into the strip can still be seen. To the right, the grass strip has already developed into a small terrace.

Combinations:

Use CUT AND CARRY for grass management. Sometimes, CUTOFF DRAIN between grass strips is useful for safety reasons if heavy storms occur. REVEGETATION as for bunds can be applied to improve grass strips.

Materials:

Local grass sods from well developed grassland for planting. Digging instruments, line level, stakes for marking strips. Grass seeds if available or collected nearby.

Management and Maintenance:

Select grass carefully and consult farmers. Runner grass is not suitable because it will disturb the crops. Introduced grass may be used, but generally the local species known to the farmers will do. Grass strips can be improved to ALLEY CROPPING. Every farmer maintains the grass strips on his own land and he is allowed to CUT AND CARRY. Care must be taken that the strips are not narrowed with every ploughing. Width of one metre is the absolute minimum required for effectiveness.

CONTROLLED GRAZING

Definition:

Controlled grazing is defined as direct grassland utilisation with livestock in a way that no degradation of vegetation and soils occurs. Controlled grazing can be continuous or in rotation.

Area of Applicability:

1. Agroclimatic Zones:

All Wurch
All Dega
All Weyna Dega
All Kolla

2. Local Situation:
a) Slope Range:
On gentler, well covering grassland

b) Soil Range:
All except heavily degraded soil

Specifications:

- Continuous grazing needs careful decision on the number and type of livestock to be allowed to graze on a certain area. The maximum number allowed varies during the year, being highest after the rainy season when the soil is dry but low during the rainy season and especially at the end of the dry season. Therefore, additional fodder has to be produced in AREA CLOSURE, REVEGETATION and with GRASSLAND IMPROVEMENT to overcome shortages in periods of limited access to grassland.
- Rotational grazing is a second useful means of providing for periodic recovery of the grassland (see drawing). Again, there exists shortage of grazing land in the second half of the dry season for which additional fodder must be produced in AREA CLOSURE.

Effects:

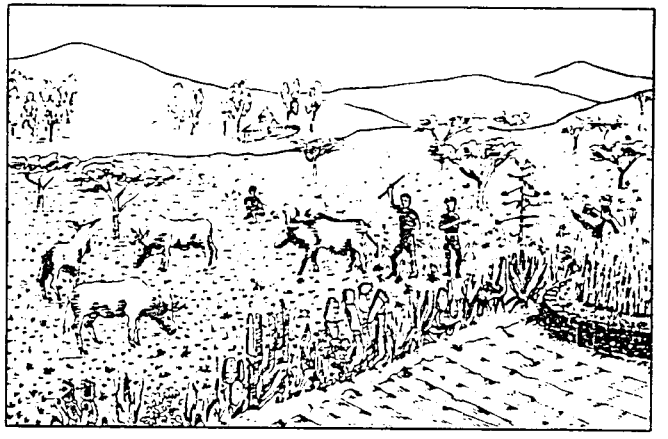
All forms of controlled grazing help to prevent degradation of grassland, to conserve soil, water and vegetation and to provide for better animal feed in amount as well as in quality.

Combinations:

AREA CLOSURE is indispensable for the production of fodder for periods of shortage in grazing land. About 30% of a Peasant Association needs to be reserved for this purpose in order to produce sufficient fodder. REVEGETATION is needed for degraded parts of the grassland and GRASSLAND IMPROVEMENT for increasing production. CUTOFF DRAIN protects cultivated land below from excessive runoff from the grassland.

Materials:

Plants to make live fence (Cactus, Euphorbia, Aloe, Sisal, Acacia, other trees like Juniperus).



Controlled grazing is applied here by herders who prevent livestock from entering the portion of grassland to the right. They do it by mere guarding, while the animals are allowed to move freely in the area to the left. When all grass is eaten up, the herd shifts to the right part of the grassland so that the left part can regenerate.

Management and Maintenance:

Controlled grazing has to be organized by the Peasant Association. Close supervision and training of herders is needed to keep the rules of rotational (or other forms of) grazing. The responsibility for controlled grazing is with the Peasant Association, which manages controlled grazing, supervises when rotation is needed and trains and supervises herders. Live-fences are the responsibility of land holders who have to protect the cultivated land from grazing.

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CUT AND CARRY

Definition:

Cut and carry is a system of utilising forage for stall feeding. It can be applied in AREA CLOSURE, in forests, on conservation structures and in all areas where livestock is excluded from grazing.

Area of Applicability:

1. Agroclimatic Zones:

All Wurch
All Dega
All Weyna Dega
All Kolla

2. Local Situation:
a) Slope Range:
After grass establishment, all slopes

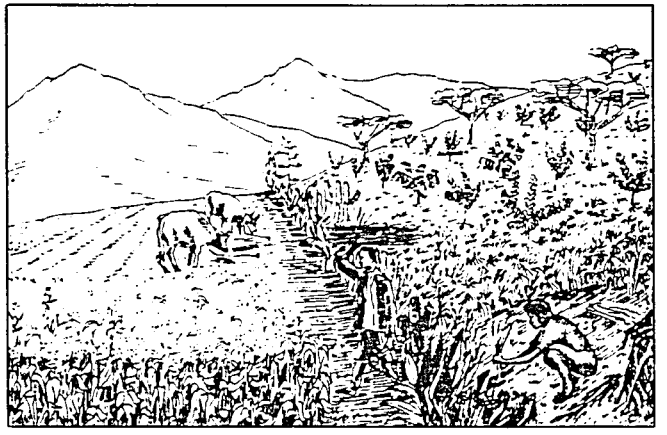
b) Soil Range:
All except very degraded parts

Specifications:

- Cut and carry is a conservation-based management technique to preserve soil and vegetation. It also provides fodder for livestock, and firewood and small fuelwood from area closures.
- Cut and carry is applied only after the grass has recovered or if certain types of grass, legumes or bushes have to be removed. Fire incidence should not develop. Therefore, it is advisable to cut grass once during the rainy season for immediate feeding of livestock and immediately after the rainy season before the grass is completely dry.
- Forage should be cut at about 10 cm above the ground before or at the flowering stage, but only if sufficient soil coverage is assured. Forage can be conserved as hay or silage for dry season feeding.
- Forage trees should not be lopped in the first year until they are established well. At later stages, they should be lopped for forage or fuel once a year or every two years. About 10 to 15 percent of top growth should be left on the plants.
- The Peasant Association decides who shall be allowed to cut and carry from a given area.

Effects:

Cut and carry allows an excellent recovery of vegetation and a maximum soil protection. Livestock trampling and extreme grazing down to the roots is excluded and a higher productivity will result. Water is retained better during storms and runoff is reduced. Natural vegetation grows with better competition between plants because there is no more selective eating by livestock. However, animal dropping is reduced with negative effects on soil fertility due to this absence.



The farmer to the right cuts the grass at flowering stage in a closed area. Cows and oxen are tied at a place nearby and fed directly. Like this, they do not disturb the grassland. Therefore, more fodder is produced. Leguminous trees are planted in rows in the closed area, and they can be lopped when they are well established. Branches of grown-up Acacia trees on the slope can be cut and fed to goats and donkeys.

Combinations:

Cut and carry is usually made in AREA CLOSURE as well as between HILLSIDE TERRACE and TREE PLANTING. GRASSLAND IMPROVEMENT increases productivity. For fodder trees, MICROBASIN may be useful. Cut and carry may be replaced by CONTROLLED GRAZING at a later stage.

Materials:

Sickle for grass cutting and ropes for cattle.

Management and Maintenance:

Cut and carry must be organised by the Peasant Association for communal land. The Peasant Association provides for management of cut and carry. Frequency of harvesting depends on the weather conditions, mainly on rainfall. Live-fences have to be developed by the land holders of the cultivated land which has to be protected from grazing.

THE DESIGN OF AGROFORESTRY SYSTEMS

The tree propagation explained in chapter 4 is an important part of agroforestry, but the next step is: where to plant the trees and how to manage trees in the most beneficial way for the farmers? Chapter 5 gives you some ideas. You will have to adapt those ideas according to the situation in your area.

5.1. ALLEY CROPPING

Alley cropping, also known as hedgerow intercropping, consists of managing rows of woody plants with annual crops planted in the space between. It is a form of intercropping. The woody plants are cut regularly and leaves and twigs are used as mulch on the cropped strips, in order to reduce evaporation and erosion from the soil surface, suppress weeds, and/or add nutrients and organic matter to the topsoil. A major purpose of alley cropping is to increase or maintain crop yields through improving the soil and micro-climate of the crops and to control weeds. Where Nitrogen is a limiting factor in agricultural production, Nitrogen-fixing trees and shrubs can be the main components of the hedgerows. The leaves and twigs can also be used for fodder. In addition to these services, alley cropping may produce fuelwood, poles, food, and medicine.

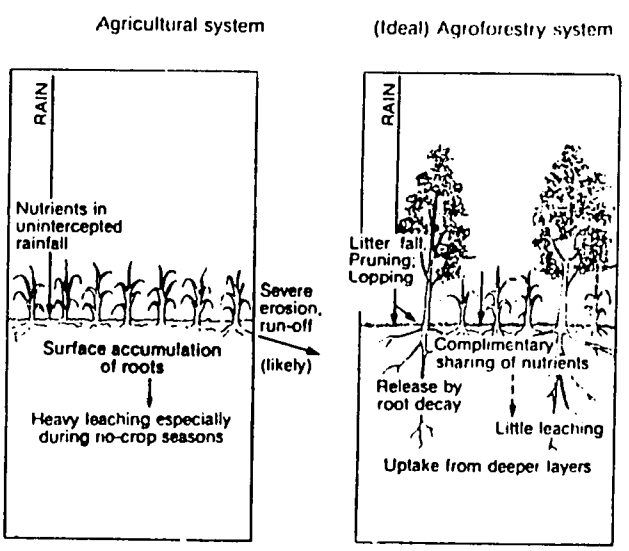


Fig. 13. The benefits of intercropping the right trees with maize. (Source: (8))

The practice of intercropping in lines is relatively new to most of Africa, and alley cropping experiments have been most promising in humid and subhumid climates. Planting closely spaced lines of trees in cropland is not traditional in rural areas. However, important conservation and production benefits have been reported at sites where such practices have been introduced on a trial basis.

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DESIGN

Woody plants are introduced as hedgerows in farm fields to maximize the positive effects and minimize the negative effects that trees may have on crop management and yields when they are scatterd more randomly throughout the landscape. without a doubt, trees compete with farm crops for soil nutrients, soil-moisture and light.. However the right kind of trees, at the right spacing, and with proper management, can result in a net increase in yields from cropland. This is especialy true if the production benefits of the trees (wood, forage, food, etc.) are included in the overall assessment of benefits. In some cases the improved crop yieds alone will make the practice worthwhile. In perhaps the majority of the cases it is the combined production benefits of agicultural crops and tree crops that justify the adoption of alley cropping.

The following questions can be asked when introducing alley cropping:

1) What spacing?
2) Which species?
3) How are the trees to be managed (and harvested)?

Spacing:

Exact spacing will depend in part of the species of hedgerow and crop plants, on climate, slope and soil conditions, and on the space required for easy movement of people and tillage equipmment. The spacing used in field triald usually ranges from 4-8 metres between rows and from 25 cm to 2 metres between trees within rows. The closer spacing is generally reserved for humid regions, and wider spacing is usually appropriate for subhumid or semi-arid conditions.

Farmers in drier areas are usually hesitant to plant trees very densely in their shamba for fear of heavy competition. Farmers in South Nyanza, for instance, were prepared to plant in the following density:

- 1 tree per 4 sq.m. near Awendo (av.ann.rainfall 1,400mm.)
- 1 tree per 5.5 sq.m. near Homa Bay (1,000mm.)
- 1 tree per 24 sq.m. near Muhuru Bay (700mm.)

At the FTC in Mtwapa, between Kilifi and Mombasa, research has been carried out to study the effect of Leucaena intercropping on the maize yield. The trees were planted at a number of different spacings, and after 2 years the maize yields were weighed to study the effect of the Leucaena. The highest tree density used was 2m. by 0.5m., while the lowest density was 3m. by 8m. It was found that the maize yield of the lowest intercropping density (3 by 8m.) had very little effect on the maize yield, while the highest density lead to a 60% increase in maize. Most other

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densities showed mixed results.

However, the results of the experiments in Mtwapa can not be used in Taita/Taveta because the conditions are very different here.

Spacing may also be affected by slope and the placement and design of soil and water conservation structures where these are combined with alley cropping. When on a slope, the rows should always be placed on the contour, even is this means that they will not have the desirable east-west orientation. Additional trimming may be needed to prevent excessive shading. In this way the tree rows may assist in soil and water conservation. Crop residues (such as maize stovers) can be laid along the hedgerow line and are held by the tree stems. However, care should be taken in case of young seedlings: crop residues may attract termites which can easily kill the trees if they are still young.

Once established, the trees and shrubs are usually left to grow for 6 to 24 months before the first cutting. At Mtwapa, it is recommended that Leucaena is allowed to grow for 24 months or a height of 4 m. before the first cutting. After that it can be cut frequently. Calliandra can probably be cut even more frequently than Leucaena before it is exhausted. In Mtwapa. Leucaena is cut at a height of 0.5 m. but cutting height will depend on the agricultural crops grown in between. If small agricultural crops such as cow peas and beans are grown, the trees may have to be cut at a lower height. If there is no serious competition for light, a cutting height can be chosen which is convenient for the farmer; for instance shoulder height.

The clippings may either be left on the soil, or they may be worked into the soil. It is known of Leucaena leaves that they decompose fairly quickly (about 2 weeks) and that more Nitrogen is released to the maize roots if the leaves are worked into the soil. On the other hand, if the leaves are left on top of the soil, they will help to reduce weed growth and thus reduce weeding.

Intercropping experiments in Nigeria as wel as the Mtwapa experiments suggest that during the dry season, the trees should be allowed to grow freely so as to cover the canopy and reduce weed growth, enhance minimum tillage and be able to fix more nutrients. But different farmers normally have different motives. One farmer, for example, may decide to prune some of the trees to encourage rapid growth of tall trunks with small high canopies. Another farmer might choose to allow tethered goats to browse on regrowth. Farmers may also vary the timing of management tasks to use labour in the low season or to fit hedgerow cutting into fixed ploughing or weeding schedules. Alley intercropping trials have been established in high- and lowlands of Taita/Taveta, but their management has barely begun.

In the examples of Leucaena/maize alley cropping in Nigeria and Mtwapa a particular management system has been used. This system is illustrated in fig. 14.

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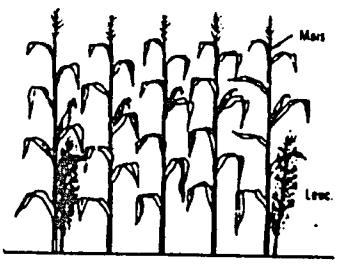
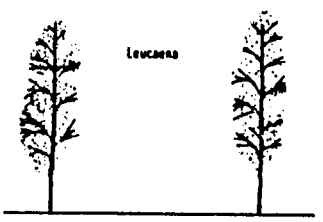
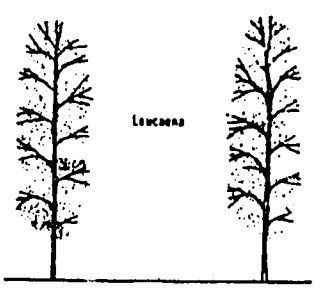
Fig. 14. Management of Leucaena intercropped with maize in the example of Mtwapa. (Sources: 9 & 13)



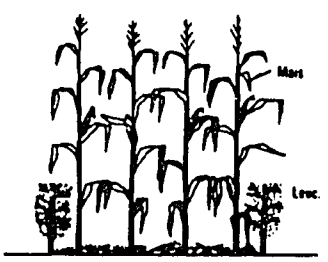
A. Leucaena is established together with the maize.



B. After the maize is harvested, the trees remain.



C. In the dry season, Leucaena keeps on growing if there is some rainfall.



D. The next year, Leucaena is cut to reduce competition to the maize. The leaves of the trees help to improve the soil.

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Intercropping of highly productive Nitrogen fixing trees has sometimes helped to reduce serious weed problems. In various parts of the world it has helped to eradicate Imperata cylindrica grass. In Western Kenya farmers try to reduce Striga weeds through alley cropping. In the Taita Hills bracken is known to be a serious weed; also here intercropping with Nitrogen fixing trees may be of assistance.

Photo's 7 and 8 Alleycropping of Leucaena leucocephala in maize, an example from Nigeria. (Source (14)) The first photo: Leucaena growing in the dry season. The second photo: The trees are cut and the maize is growing.

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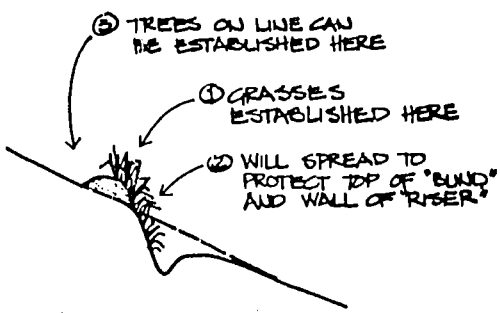
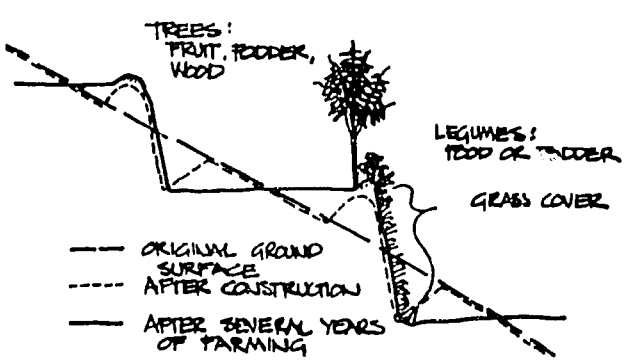
ALLEY CROPPING IN COMBINATION WITH SOIL CONSERVATION

Alley cropping can complement erosion control strips and structural measures for physical soil and water conservation. In such cases the spacing would follow first the placement of the structures or contour strips, and secondly the guidelines for alley cropping. Mulch production would complement the erosion control function and the hedgerow plants could strengthen structures while improving the soil fertility of the terraced.

Fig. 15 illustrates the incorporation of trees in fanya juu's. (Source: (7)).



TERRACES



GRADUALLY DEVELOPING BENCH TERRACES

Erosion control structures exist throughout the district. In Mbololo, for instance, leguminous trees could be planted on trash lines, fanya juu's and retention ditches by the farmers themselves due to the proximity of the seedling distribution centres. In most parts of the location this would help to solve the problems of low soil fertility and lack of dry season fodder. It may also assist in fuelwood production, now some of the hills are not accessible anymore for collection of fuelwood. However, care must be taken to make sure that the tree lines are well placed on the contour, otherwise they may increase erosion.

5.2 IMPROVED FALLOW

The practice of letting cropped fields lie fallow in order to allow the soil to recover some of its fertility is well known and widely used throughout Africa. In recent times, fallow rotations have become shorter and shorter. The shorter rotations, which have become necessary because of land scarcity, generally fail to enrich the soil as effectively as the traditional longer fallow periods. As a matter of fact, many farmers in Taita/Taveta have very little time left to leave their shamba's fallow.

Some of the important functions of fallow are:
1) protect the soil from erosion,
2) eliminate weeds, pests and diseases specific to the cropping system,
3) increase the organic matter content of the soil, cycle and trap nutrients from the subsoil, and improve the soil's structure

DESIGN

Improved fallows can be established by cheap means if trees were already growing in the cropland, whether dispersed or intercropped as alleys. Such trees are encouraged to take over and close the canopy, thereby improving the micro-climate. If no sufficient trees were growing on the cropland, they may be established through cheap means such as direct seeding and planting of wildlings.

In W.Kenya this is popularly done with Sesbania sesban. This tree seeds prolific and while weeding, the farmers leave some of the trees growing in their shambas. After the maize has been harvested, the Sesbania is left to grow freely and a temporary woodlot is established. This is a form of improved fallow, whereby the farmers harvest the wood for fuel and profit from the fast soil enhancement by the tree. Farmers report that also Striga weed is better controlled in this way.
According to research, Nitrogen addition of Sesbania to the soil is not so much through the leaves, but rather through the rootsystem directly.

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Other species suggested for improved fallow are Acacia mearnsii (black wattle), Leucaena, Calliandra, and Gliricidia species, and Cajanus cajan. Some people claim that Acacia mearnsii (black wattle) has a reputation of restoring soils to high fertility levels if cleared again for farming. However, black wattle is not suitable for intercropping because of serious competition with food crops.

5.3 MICROCATCHMENTS FOR TREES AND SHRUBS

Tree planting started in Africa in the areas of high agricultural potential and high population density. Kisii, Kakamega and Muranga can be mentioned as examples of districts where tree planting became popular a long time ago. In Taita/Taveta tree planting started also up in the highlands. In dry semi-arid and arid areas tree planting is more difficult and carries a much higher risk of failure. Yet population densities have also increased in dry areas and people have been forced to plant trees in dry places as well. In order to improve survival, additional water is often necessary and this may be either done through watering or through construction of water catchments. This is already done in Mbololo and other dry locations of the district, and it is useful to look at experiences from districts elsewhere in the country.

Micro-catchments can be used to improve the use of rainfall and reduce the need for hand watering, as described in this section. However, if micro-catchments cannot be used, or are not adequate, then hand watering will be necessary. To be effective, water must be applied in a way that encourages the trees to develop deep root systems that can reach the water table or moist soil deep below the soil surface. The Forest Department of Turkana District has gathered much experience about water harvesting.

In very dry areas (like Turkana or Voi) seedlings can be planted in a large pit (with a diameter about the lenth of an arm) so that the water will be kept near the plant. The pit should be well soaked - with at least 20 litres of water. The seedling should then be watered every two days with 5 to 10 litres os water for the first one or two weeks. Since the roots will not yet be well developed, watering should be continued every fourth day after that with about 10 litres of water. Once the trees have started to grow again, after about two months, the watering can be done just once a month, but with a larger quantity of water -between 20 and 40 litres.

The reasons for this method, developed from experience, is that too little water, frequently applied, will result in a larger loss to evaporation and, more importantly, a poorly formed root

system. the roots will tend to grow towards the water source - at the soil surface - rather than reach down to the water table or moist layers of soil at depth.

Micro-catchments are small soil structures in which water is collected. The collected water penetrates in the soil is benefits the trees planted there. One type of micro-catchment is made of small V-shaped hand-built bunds which direct the rainfall and runoff from a catchment area downslope into a small basin at the lowest point in the structure. Quite a lot of farmers in Taita/Taveta have already made microcatchments, especially on their compounds. Trees, grasses and crops can be grown in the lower portion of the catchment where the water from the area uphill soaks into the soil, supplying adequate moisture for plant growth.

In Taita/Taveta, where climatic conditions are less arid than in Turkana, smaller micro-catchments can be constructed. Such constructions still cost some labour, and it is most likely that they will be established for highly valued trees such as fruittrees and for shade trees on the compound. Erosion control measures are widespread in the district and most of them serve as a water catchment. An extra supply of water is available near trashbunds, fanya juus, etc., and it is sensible to plant drought sensitive trees close to such constructions.

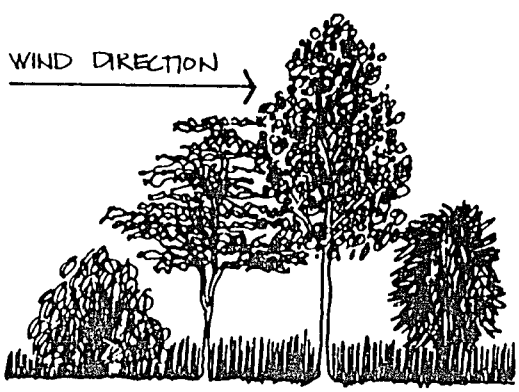
5.4 WINDBREAKS

Windbreaks are strips of trees and/or shrubs planted to protect fields, homes, canals, and other areas from the wind and blowing soil or sand. Wider strips or blocks of trees are often called shelterbelts. Windbreaks are planted for man reasons: to reduce soil erosion, improve the micro-climate for growing crops and to shelter people and livestock. Thus they can have many forms and can also serve other functions, such as fencing and boundary demarcation. Where wind is a major cause of soil erosion and moisture loss, windbreaks can make sustainable production possible and have been shown to increase the productivity of the crops which they protect.

A windbreak is like putting a lid on a souffria with boiling water: The escaping steam is lessened. In the case of a crop, less water is lost by wind, and more water is available for the crop.

Fig. 16. Light windbreaks are better than very solid, dense windbreaks. (Source: (7)).

Big gaps in windbreaks should be avoided, because such gaps act as a tunnel where very strong winds pass through.



One common design mistake can actually make matters worse. Be careful not to leave the lower level completely open while making the upper level too dense. If this does happen it can do serious damage to crops close to the downwind side. The woody profile understorey and herb layer should be well established and maintained both to prevent uncontrolled traffick through the trees and to protect soil cover against the wind.

Fig. 17: The profile of a windbreak:

In Taita/Taveta planting of windbreaks and shelterbelts is feasible wherever there are strong or dessicating winds. This may be found on top of some of the exposed hills and parts of the lowlands. The Taveta irrigation scheme also deserves consideration. The trees do not necessarily have to be planted in lines: also dispersed trees reduce windspeed.

5.5. TREES IN HOMEGARDENS

Homegardens are small, intensively cultivated plots near the homesteads, which can be found in areas of high population density and good rainfall. They are increasingly found in districts like Kakamega. Homegardens are characterised by a wide variety of agricultural and tree crops which are grown closely together. Often, though not exclusively, homegardens are tended by women. The wide species variety is a form of risk

minimization. In Taita/Taveta homegardens are not found with the same intensity as in some other places, but it is likely that they will be increasingly cultivated.

As a nearby example of homegardens, a description is given here of the Chagga homegardens.

The homegardens of the Chagga people on the slopes of Mt. Kilimanjaro (1000-1700 mm annual rainfall), with an average size of 0.68 hecates produce about 125 kg. of beans (184 kg/ha,) 280 kg or parchment - unhusked - coffee 412 kg/ha) and 275 bunches of bananas (404 bunches/ha). Fruits, vegetables and herbs, mainly for home consumption, have not been quantified. Each farmer keeps 3-5 traditional bee hives, each producing at least 5 kg. of honey annually. The Chagga farmers are also almost self-sufficient in fodder which they use to stall-feed their livestock. The fodder is primarily from the trees, shrubs, banana plants and grasses grown in the garden, and supports an average of 3 cows, 2 goats and 6 chickens. It is estimated that each homegarden supplies one quarter to one third of the household's fuelwood needs. Fuelwood production in the homegardens is estimated to be between 1-2 cubic meter per year (1.5-3.0 cubic metres per hectare).

Although local sources indicate that coffee and /or maize or bean crops fail once every 3-4 years. there has never been a failure involving all of the products of Chagga homegarden system. This illustrates how cultivating a diversity of products reduces the risk of all the crops failing in any one year.

5.6. WOODLOTS

A woodlot is a piece of land which is set aside for the sole purpose of growing trees. In general, steep land (slope between 25 and 55 percent, 14-29 degrees), river banks and rocky, stony, eroded or swampy soils are set aside for woodlots. The more extreme the site, however, the more specialised the tree species have to be. In addition, satisfactory tree growth cannot be expected on very infertile, shallow or unstable soils; shrubs might be the alternative on such soils.

It is clear that woodlots can also be established on good agricultural land. Indeed, from a technical viewpoint, the better the land the better the growth of trees. When good farmland is to

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be used for woodlots, farmers must take into account the labour and other expense required to clear the land should the land be needed again for agricultural production. Woodlots are normally restricted to areas of medium and high agricultural potential, and they are rarely found in (semi-)arid areas. Woodlots are often established if there is labour shortage, because the trees require much less labour than agricultural crops.

Kenyan farm woodlots range in size typically from 0.01 to about 1 ha. However, woodlots in the Taita Hills are often bigger than those found elsewhere in Kenya. Many farmers in the Taita Hills have woodlots which exceed 1 ha., often they are several ha. big. In Kenya, the most common woodlot species are Eucalypts (mainly E.saligna, E. citriodora, E. paniculata, E. camaldulensis, black wattle (Acacia mearnsii), cypress (Cupressus lusitanica), Grevillea robusta, Markhamia spp., pine (mainly Pinus patula) and Cassia siamea. In the Taita Hills Eucalyptus and black wattle are the most popular species, while pines and cypress are also widely planted.

In Western Kenya tobacco farmers are required to plant woodlots. Also most non-tobacco farmers plant woodlots. In Kakamega District, Eucalyptus poles usually reach about 10 m in 5 years, perhaps in 4 years if coppiced. Initial planting of these poles is dense (1 x 1 m), and trees are cut selectively every 4 or so years; most trees are harvested in the 10-15 m height range, with a few allowed to grow to sawntimber size. Rotations longer than 15-20 years are relatively rare in Kenya farms. However, the Taita woodlots are quite different. Not only are the woodlots here bigger than the average for Kenya, but also the management of the woodlots is different from elsewhere in the country. Establishment of the Taita woodlots is often through natural regeneration, and the rotation (the time between establishment and harvesting) is often longer, sometimes several decades.

A great gap in our knowledge of woodlots is their economics, particularly the net benefits under various conditions of climate, location with respect to markets, products, volumes and inputs. Observations within a 100-150-km radius of Nairobi reveal an active trade in poles (and, to some extent, firewood) from farm woodlots, but the details of this trade are virtually unknown. Poles 2-4 m long, 6-8 cm at the base, retail for about Ksh 15/- a piece in Nairobi, which suggests that gross farm gate revenues from a harvest of, say, 3,000 poles (one-third of a 10,00 stem/ha woodlot) could amount to about Ksh 22,500, assuming a 100 percent markup between the farm and retail outlet. This is a substantial sum, but from which must be substracted the costs.

Also our knowledge of the Taita woodlots is very limited, though efforts are undertaken to improve our understanding.

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NITROGEN FIXING TREES (NFT) IN AGROFORESTRY SYSTEMS FOR SUSTAINED FOOD AND FODDER PRODUCTION

Points made by Prof. J.L. Brewbaker in his presentation

I. Nitrogen-fixing trees (NFT) play many types of roles in relation to food and fodder production. The agroforestry systems using NFT are basically of two types. They are related to the production of either:

- o Animal feed, or
- o Human food

II. Animal feed, or fodder, systems include:

1. Traditional grazing in forest areas.
2. NFT-enhanced grazing
3. NFT hedges in grass pastures
4. Traditional lopped or pollarded fodder trees
5. Planted or protected fodder trees
6. NFT for ponds (fish production)
7. Cut and carry forage
8. Solid block plantings of NFT for grazing or harvest
9. Miscellaneous, e.g. honey production
10. Integrated Farm Forestry-forage for animals gives manure for food crops, etc

III. Human food agroforestry systems with NFT basically involve the green manure value of the tree foliage, together with added benefits (shade, wind protection, fuelwood), and include the following:

11. Traditional slash and burn
12. Short-rotation slash and burn with NFT protected
13. High input short rotation, with plowing down of young NFT
14. Taungya, with crops grown among young forest trees
15. Alley or avenue cropping
16. Cut and carry green manure
17. Traditional intercropping in forests with NFT
18. Hill culture
19. Nurse ("shade") trees in food crop plantations
20. Nurse trees in forest plantations
21. Others, including windbreaks and living fences of NFT that are also harvested for food or forage.

In all of these agroforestry systems, multiple uses exist and are often exploited for the NFT, notably including fuelwood and polewood. In most cases, however, adapted modern systems place emphasis on the tree as an aid to food cropping or animal feeding, and less on its value for wood per se. Clearly the impending fuelwood crises will change this emphasis. The following illustrations elucidate the points made above.

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* University of Hawaii at Manoa

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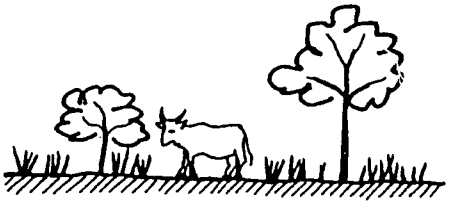
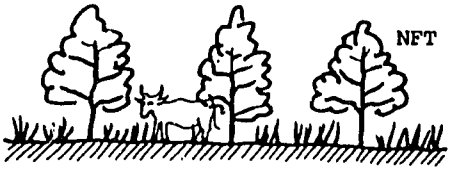
FODDER SYSTEMS

1. Traditional grazing



Many Genera

2. NFT-enhanced grazing



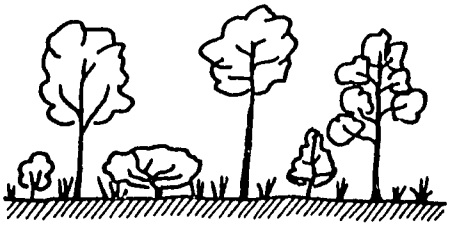
Erythrina spp.
Prosopis spp.
Acacia spp.

(NFT regularly spaced, often lopped)

3. NFT Hedges

Leucaena leucocephala
Cajanus spp.

4. Traditional Fodder Trees (lopped)



> 300 spp.
Some NFT

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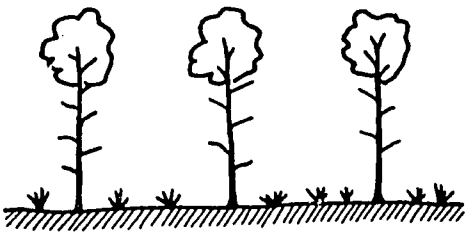
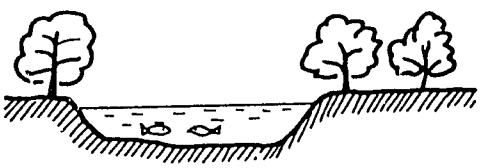
5. Planted, or protected Fodder Trees



Robinia
Alnus spp.
Acacia mearnsii
Gliricidia spp.

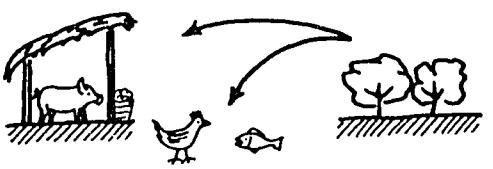
6. NFT for Ponds



Fish or algae

Sesbania spp.
Acacia spp.
Leucanea spp.

7. "Cut and carry"



pigs, poultry, rabbits, fish, etc.

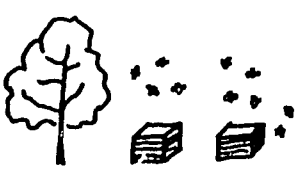
Leucaena
Erythrina
Calliandra
Acacia m
Prosopis (pods)

8. Solid blocks (or farrows)

(grazed or harvested)

Leucaena
Gliricidia

9. Miscellaneous



Bees

Prosopis
Calliandra?
Leucaena?

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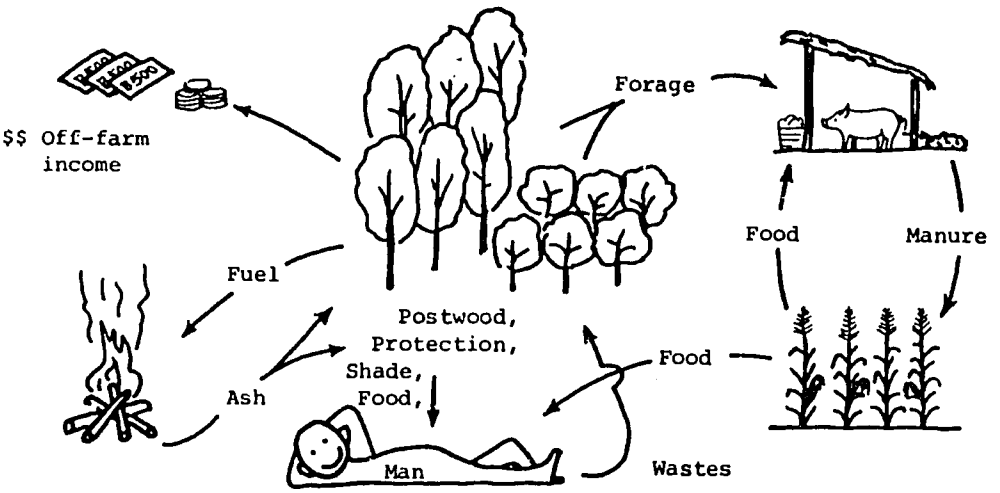
10. Integrated
Farm Forestry

(Essential Ingredient; Land tenure is long term



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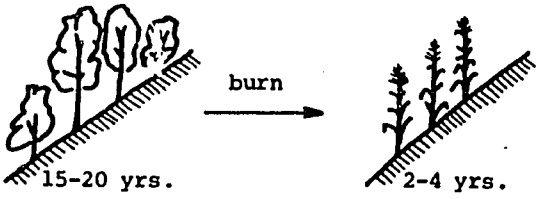
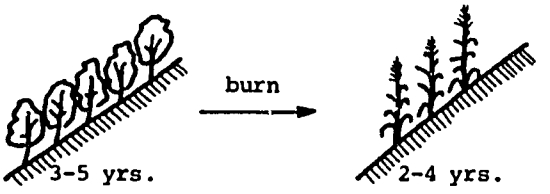
FOOD (= GREEN MANURE)

AGROFORESTRY SYSTEMS

11. Traditional slash and burn

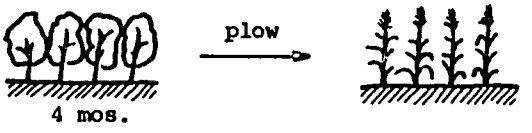


12. Short-rotation



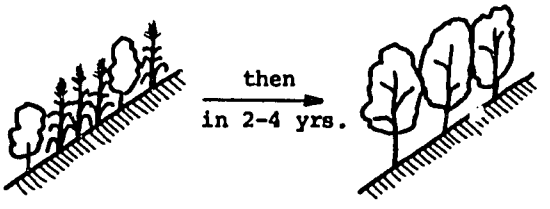
Leucaena
Gliricidia

13. High-input short-rotation



Sesbania aculeata
Cajanus cajan

14. Taungya



Albizia
Pterocarpus ?
Dalbergia ?
Leucaena +
many non-NFT

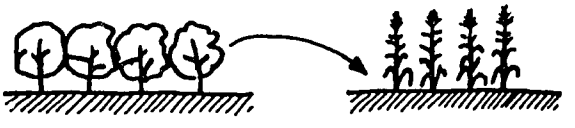
15. Alley (or "avenue") cropping

Cassava
Corn

Climbing
- yams
- beans
- passion fruit

Gliricidia
Leucaena
Cajanus

16. Cut and carry Green Manure



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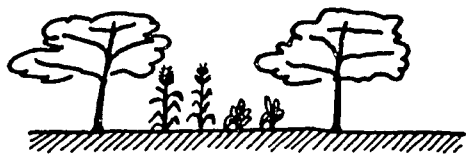
FOOD AND FOREST NFT AGROFORESTRY

17. Traditional Intercropping ("Nurse Trees")

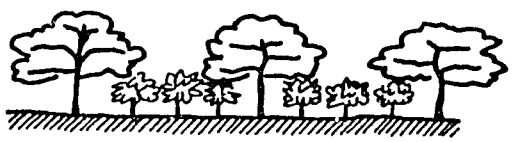


Acacia
Sesbania
Erythrina
Prosopis
Inga
Gliricidia

18. Hill Variation

Acacia
Afzelia
Xylia

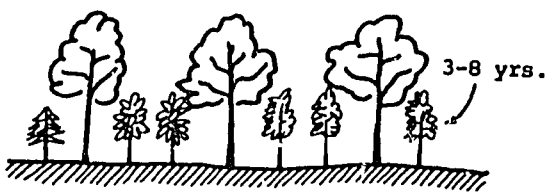
19. Nurse ("shade") trees



coffee, cacao, etc.

Gliricidia
Erythrina
Inga
Albizia
Leucaena
(often coppiced)

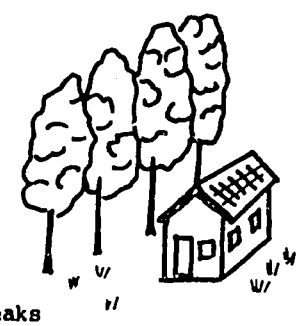
20. Nurse trees for forest trees



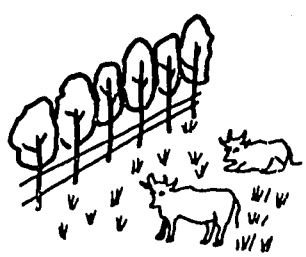
Pine, Teak, Gmelina, Eucalyptus (10-60 yrs)

Albizia
Acacia
Alnus
Leucaena

Others:



Windbreaks
+ food or forage



"Living Fences"
+ food or forage

	Learning Element	Code:	
	Title:	Date of issue:	Page: 1.
	Occupational Area:		

Objective:

When you finish this learning element you will know about: many ways to mix trees, shrubs, crops and animals on farm lands and you will be able to:

- choose combinations that interest you, based on what you want from trees (Learning Element 1) and what kind of planting places you have (Learning Element 2). You will be ready choose which trees and how many (Learning Element).

1. We will show ways to mix:

   1) Trees and crops

   2) Shrubs and crops

   3) Trees and shrubs and grasses on grazing land

   4) Trees and shrubs and grasses in gullies

   5) Trees and shrubs in fences and corrals,

   6) and how to mix all of these with soil and water conservation works.

Each idea has a picture, in the picture book, (Learning Element 3-8) that shows when and how these plants fit together.

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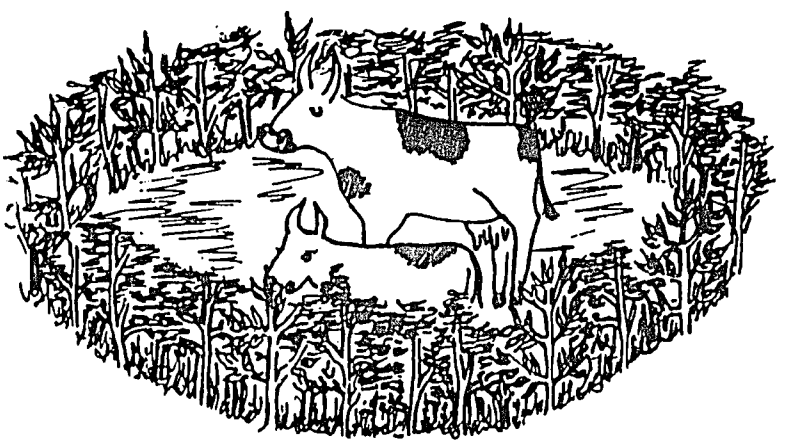
	Learning Element	Code:	
	Title:	Date of Issue:	Page:
	Occupational Area:		2.

2. Ideas for fencing:

2A. Live Boma (corral) fences for fuelwood and for "green manure" to add to boma soil (mixing done by animals; more manure for croplands)



2B. Live property (outside boundary) fences for fuelwood and for "green manure" to put in boma:

- thorn fence to protect new live fence just for first year
- sisal poles or other supports to help form and hold up live fences

2C. Live property fences for poles and fuelwood from same trees, different parts, or from two types of trees planted together

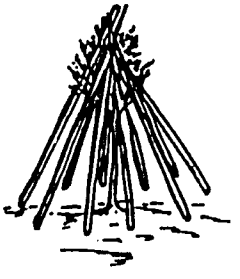
	Learning Element	Code:	
	Title:	Date of Issue:	Page: 3.
	Occupational Area:		

2D. Live fences in protected areas inside property:

- for fruit and fodder
- for stickwood

2E. Small live fences with sticks and small poles to protect

- single trees
- small plots of trees



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	Learning Element	Code:	
	Title:	Date of Issue:	Page: 4.
	Occupational Area:		

3. Ideas for the home compound

3A. Home gardens with fruit trees and animal feed and medicine - trees and shrubs planted closely with vegetables

3B. Trees planted alone, far apart
for shade,
fruit
animal feed
flowers for bees

3C. Trees and shrubs for shade, fuel, fruit: planted in lines along the entrance and paths inside the compound

3D. Fodder trees and grass planted inside small living fences (boma-size) for feeding animals in boma (corral) during busy times or dry months.

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	Learning Element	Code:	
	Title:	Date of Issue:	Page: 5.
	Occupational Area:		

4. Ideas for grazing land

4A. You can protech useful trees and shrubs and help them to grow faster:

- by trimming and putting-up and fencing trees kept low by browsing animals,

- by bringing more water to the tree and holding it in the soil (bunds or v-shaped hols to steer and hold water flowing over the soil after rains).

4B. Live fences to subdivide grazing land so animals can move in turns from one plot to the next, leaving the first to grow back before letting the animals back in. This is called rotational grazing.

4C. Planting of fast-growing or favorite fodder (fodder trees for pods or for cutting, not for browsing) and fuelwood trees (or pole trees) in deep holes, with small fences around the tree to protect it until the branches are beyond the reach of animals.

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	Learning Element	Code:	
	Title:	Date of issue:	Page: 6.
	Occupational Area:		

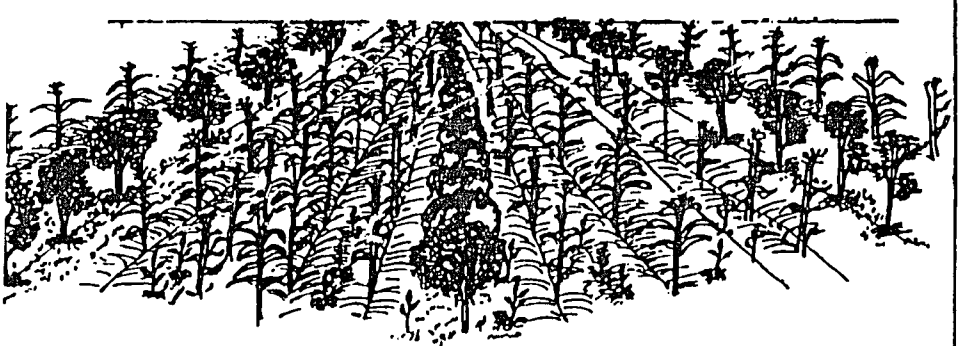
5. Ideas for croplands:

5A. Alley cropping (also called hedgerow cropping). The shrubs or trees are planted between rows of crops. They can be cut low two or more times per year and they can produce:

leaf manure to enrich soil for better crops;

fuelwood to save for the busy times

fodder to cut for animals



5B. Leafy trees planted in wide strips around crops, and inside cropland boundary. Trees or shrubs planted in this way can provide leaf manure to combine with animal dung and boma (corral) soil or leaf manure alone to put directly on soil in croplands

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	Learning Element	Code:	
	Title:		
	Occupational Area:	Date of Issue:	Page: 7.

5C. Fodder and fuelwood trees and shrubs on sloping croplands:

tall, with grasses in between or in hedges on bench (terrace) risers

tall, with grasses in between or in hedges in strips along the contour

tall, with grasses in between or in hedges in soil conservation ditches or along water catching bunds

5D. Fruit trees mixed closely with other food crops:

- in lines, or
  evenly spaced, or
  along ditches (drains), or
  along the low parts of bench terraces

5E. Large trees far apart in croplands for

fruit, animal feed (pods and leaves),

building poles and fuelwood

6. Ideas for wasted and worn-out lands

6A. On sloping lands with hard soil you can repair the land for grazing and fuelwood collection by using pits to hold water and soil. What to plant first depends on how bad or worn out the land is

1. For very bad places -
   Dig pits and leave them to fill part way with good soil and water and brush and natural plants. After 1 or 2 rainy seasons plant new trees in some pits and leave the natural plants in some.

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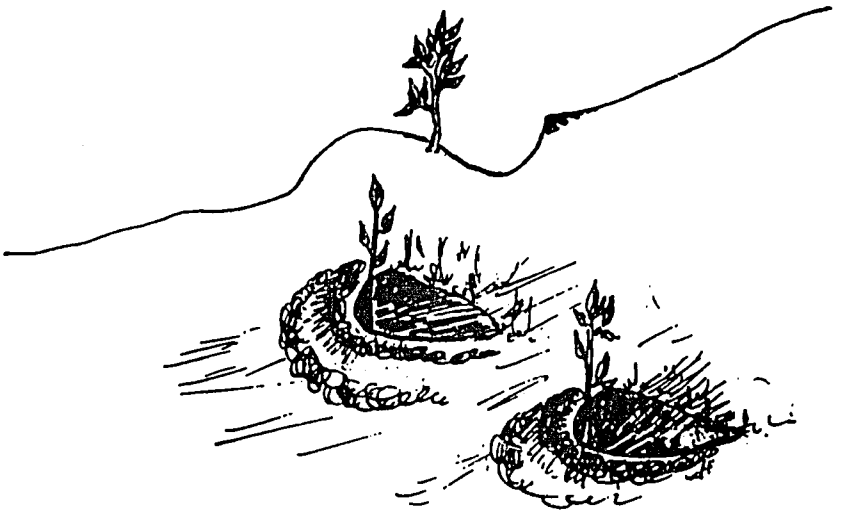
	Learning Element	Code:	
	Title:	Date of Issue:	Page:
	Occupational Area:		8.

2. For places where some grasses grow but soil is fairly hard or shallow -
   Dig pits and plant "grasses and creeping plants (from seed) to repair the soil and to fill the pits part-way. After 1 or 2 rainy seasons, leave some pits with these plants, fix other pits by burying the "green manure" plants, then plant trees and shrubs there.

3. For places where soil is only a little too hard or worn out -
   Plant grasses, shrubs and seed just after digging the pits. Put trees and shrubs in some pits, leave other pits for grasses only (natural or planted).

6B. On sloping lands with softer soil you can use small v-shaped bunds or holes micro-catchments in the pits. These may need to be held in places with stones if the soil is too loose. The planting ideas are the same as for pits.



	Learning Element	Code:
	Title:	Date of Issue: / Page: 9.
	Occupational Area:	

Another idea is to plant trees in rows as in "alley cropping" and plant seeds for grass or small creeper plants in between as "green manure". Then, after some time, when the soil is "rested" and lots of green manure has been aded, plough the low plants and leave rows of trees to keep making leaf manure for your crops. The branches and leaves can be chopped and laid on the soil before planting, just like manure.

6D. In gullies you can repair the land with trees and shrubs and grasses combined with check-dams made from wood and rock. Trees which take root from cuttings can be used to support the check-dams. When the dead wood rots they will hold the soil and rocks in place. Also

You can also produce fuelwood and poles and animal fodder. What you can do depends partly on how well protected the gully is:

In gullies that are protected from animals you can grow fodder (grasses shrubs and trees) as well as poles and fuelwood. These can be planted in the new soil when the check-dam starts to fill.

In gullies that are <u>not</u> protected from animals it is best to plant only pole trees and fuelwood trees and shrubs. Chose plants whose leaves are <u>not</u> liked by animals. Allow local grasses to come up but do not put special (tasty) grasses in, as this will only tempt animals to trample the gully.

It is best to also repair the places that send water to the gully so that the check-dams and plants are not washed away by floods. Pits or microcatchments can be planted or seeded with trees, shrubs or grasses inside a small fenced plot above the fully. This covers the soil and helps to hold water so that water does not run so fast into the gully from above, making it grow. This is a good place to put fuelwood or fruit trees with fodder trees and grasses to cut for animals.

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	Learning Element	Code:	
	Title:	Date of Issue:	Page: 10.
	Occupational Area:		

7. Ideas for Public and In-Between Places:

7A. - Pole trees along the road sides and paths:

in lines; wider-spaced: in water-holding pits

- Fuelwood trees along road sides and paths:

in lines; wide-spaced; in water-holding pits and bunds

7B. - Fuelwood, fodder and fruit trees in rows or widely spaced in

public or group

vegetable gardens (near permanent rivers or wells)

7C. - Fair spacing of trees along shared (double) boundaries:

living fuelwood fence with fodder trees alongside

living fuelwood fence with fruit trees alongside.

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4. Trees for integrated landuse development

4.1 Methodology for the selection and evaluation of trees for rural afforestation purposes

Trees may be grown as has been pointed out, on farmland according to two basically different spatial arrangements that shall now be dealt with separately for evaluation purposes.

One arrangement is the conventional or classical forest plantation, or if it is small, woodlot where the trees are established at fairly close and regular spacing for the purpose of the production of some type or types of forest produce.

The second spatial arrangement is applied where trees are established as an integral part of a farming system involving herbaceous crops and possibly animal husbandry as well as the production of such good and other benefits that may be obtained from trees.

In the case of the classical forest plantation, the selection of one or several suitable species does not pose any very complex problems.

We will be looking for a species that will show healthy and vigorous growth within a closed stand under the prevailing ecological conditions and produce wood or other produce of a desired quality.

Furthermore we will demand that the species is easy and cheap to establish and not seriously exposed to biological or physical hazards. In the case of fuelwood plantations we may also put emphasis in the selection of a good "coppicer". When it comes to evaluation, the main factors to consider will be cost of establishment, length of rotation, yield, and market value of produce.

In the case of the selection of trees for planting within an ecofarming system, we are faced with a much more complex situation, and the evaluation of the suitability will often be function of a whole range of variables.

All the plants, trees as well as herbaceous crops, within a farming ecosystem, interact with each other, directly or indirectly, and often according to a very intricate pattern. Partly the plants compete for available resources and partly, one may say they do just the opposite; they create mutually favourable conditions for each other. This last pattern of interaction is sometimes termed commensalism (for definitions of the various patterns of interaction, see section 3.6).

Assuming now that a tree species has been found that seems well adapted to thrive at the locality in question and within the particular ecological conditions characterizing farm and pastureland, and that furthermore can be expected to yield one or several of the benefits which a farmer will be wanting from a tree, how shall we now be able to evaluate the suitability and usefulness of such a tree, comparing it with other possible "candidates"? Obviously, it will not be enough, as it was more or less in the previous case to say "this is a fast growing tree producing excellent fuel and poles". The preparation of a more complex cost/benefit analysis will be required. As a kind of check list for such a calculation the following balance sheet has been prepared on which the more fundamental "credi and "debits" are outlined, that will have to be taken into consideration.

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Credit	Debit
Simplicity of establishment;	Cost of establishment
Ability to coppice	Time interval between investment of resources and returns;
Resistance to pests and diseases;	Susceptibility to pest and diseases;
Growth rate "premium"(highest mark for short-time span before yield of benefit commences;	Occupation of space - above ground - below ground
Quantity and value of goods produced: woods, fruits, fodder, mulch, fibres, nectar, medicine;	(spatial distribution of root system in relation to that of other crops);
Yield of other benefits -	Competition for light;
recycling of mineral nutrients	Competition for water;
fixation of nitrogen	Harbourer of consumers and other harmful agents;
regulation of wind velocity and atmospheric humidity	Exuding harmful inhibiting substances;
harbourer of useful predators	Indirect costs such as need of protection against livestock
Exuding useful inhibiting substances	
Total: Compound "benefits" to user of land	Compound "cost"

b a l a n c e

Much of the data listed on this balance sheet are difficult or even impossible to obtain, for most species at the present stage. However, as any economist will know, lack of data should not be an excuse for not preparing a balance sheet. The best possible estimates or even "guesstimates" must be used until such time as more solid data can be provided.*

* N.B. Until such time as sufficient data become available, it may serve a useful purpose to carry out a tentative evaluation or ranking of different tree species based on a grading (from one to ten) of credit and debit factors. An assessment of this type has been attempted for two tree species in appendix II

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Attention should also be drawn to the fact that the outcome of an evaluation may vary from place to place even assuming identical ecological conditions, as a result of different price relationships between the various goods produced by the user of the land. Near a town, a Eucalyptus sp. (for ex.) may show a "credit" to its account as the combined result of a good mark for "growth rate" short lapse of time between investment and return and high prices for fuel and poles, more than off-setting such serious debit headings as "occupatior of space below ground" and "competition for water". Farther away in the countryside, the same species may "fall seriously into the red" as a consequence of much lower prices, in relation to those of graincrops being paid for fuelwood and poles.

4.2 Choice of species

The question of suitable species for small plantations including woodlots, shall not be dealt with at length. A range of species have been selected by forestry research for this purpose which seems quite adequate, although the possibility cannot be excluded that other and better species and varieties may be found in the future, for certain environmental conditions or production purposes.

On the other hand, when it comes to choosing trees for intercropping with the wide range of herbaceous plants that farmers are growing for food production or as cash crops, then we are facing a pioneering problem. It would be wrong, however, to say that we will have to start from zero. Luckily, Malawian farmers have done some useful spade-work in this field already, and we are also able to draw on valuable experience in other countries which with some adaptation, may help to solve our problem.

As mentioned before, farmers often retain a number of trees when they clear land for cultivation. They are not doing this haphazardly. On the contrary, they can clearly be observed to favour trees that do not compete seriously with neighbouring crops, or even can be expected to enhance their growth. At the same time they are giving preference to such species that will yield produce the farmer is keen to obtain: wood for fuel or construction, fibres, medicine, etc. A survey throughout Malawi showed that farmers in particular like to retain legume trees. Some trees are also left because they belong to the category of "protected species". Fortunately, most of these, in particular Afzelia quanzensis, Pterocarpus angolensis and Terminalia sericea, show good neighbourly charateristics and their presence seem quite compatible with crop farming. Sometimes if a farmer can be observed to protect a tree that seems to affect the crops adversely, one can always be sure that it is because this particular species produces something of value to the user of the land that compensates for its "debit account" (refer section 4.1).

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NITROGEN FIXATION AND THE NITROGEN FIXING TREES

Prof. James Brewbaker*

Importance of Nitrogen as a Nutrient

The element nitrogen (N) is a very important plant nutrient which is often lacking in agricultural and forestry systems. It is a part of all proteins, and of many other vital plant substances. Nitrogen increases plant growth rates and the nutritional quality of plant tissues. Lack of soil N can severely limit growth, lower the quality of grain or fodder, and even result in crop failure.

Value and Use of Nitrogen in Agriculture and Forestry

Tree species generally require less N than cultivated crops. For example, corn absorb over 175 kg/ha per crop, while forest stands may use 20-60 kg/ha/yr, a large part of which is returned to the soil in leaf fall (Baker, 1950; Bormann et al., 1977). In natural forest systems nitrogen is continuously recycled, resulting in a balance between additions of N and losses. This balance is disturbed when man harvests forest resources. Some of the nitrogen in forest stands is removed with harvested trees or tree fruits, and some is lost through the soil (leached) when tree roots are no longer able to capture it. Nitrogen produced in biological systems can be used as green manure to fertilize other crops, and as a protein source in animal feed and food for human consumption.

Sources of Nitrogen

At least 70% world's annual input of N is through biological sources (Postgate, 1978). The atmosphere is made up of 80% nitrogen, but this N is not available to plants until it is fixed by biological means or is fixed by man in chemical fertilizers. These biological sources include N which is fixed in the soil by microorganisms, or washed out of the atmosphere by rainfall, or is released by the decomposition of organic matter in soil. This N is stored in both vegetation and in the soil. In the temperate zone nearly all nitrogen storage is in soil organic matter, while in the tropics a much higher percentage of nitrogen is stored in vegetation and the soil surface (Greenland and Kowel, 1960).

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* University of Hawaii at Manoa.

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Biological Nitrogen Fixation

A major source of biologically fixed nitrogen is in plants which fix atmospheric N through association with bacteria. These bacteria are free-living soil bacteria which infect root hairs, multiply and ultimately form root nudules, which are the site of N fixation. Several plant families are known to have this type of association with N fixing bacteria; the most important of these are of the family Leguminosae which includes some 18,000 species. Plants of this family are known as legumes and fix atmospheric N in root nodules containing bacteria of the genus Rhizobium. For example, an average of 45-225 kg/ha N per year can be added to the soil by agricultural legumes (Dalrymple, 1969). A large number of legumes are trees and shrubs, some of which are capable of fixing more than 500 kg N ha/year. Also, some tree species of other plant families fix nitrogen in association with bacteria of the genus Frankia (Bond, 1967).

Summary

NITROGEN IS:

Essential to all flowering plants (N_2 - NH_3 - NO_3)

Essential to all higher animals (amino acids, proteins)

Source = N_2 (gas), 80% of air (chemically inert)

charged to biologically-useful forms by

- lightning
- soil micro-organisms, including those
  - not associated with higher plants
  - nodule-forming bacteria
- man (largely as urea from natural gas)

Stored in:

	Tropics	Temperate
Vegetation	high	low
Soil organi	low	high

How rapidly lost?

- Rule of thumb: 3 "good" corn crops on most tropical soils

  (If yield averages 2 t/ha, this = 75 kg of N)

- One "excellent" crop of

- corn (BT grain)
- tapioca (cassava)

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The Nitrogen in Biomass

How much N is "stored" by biomass? Maximally,

- 540 kg N/yr leucaena, 3-month harvest (= 15 t dry)
- 720 kg N/yr corn, 3 crops/yr (= 42 t dry)

How much N is "needed" by biomass? Maximally,

- 720 kg N/yr corn (25 above) - 90% removed
- 550 kg N/yr sugarcane (2 yr) 70% removed
- 200 kg N/yr eucalyptus (4 yr) ? removed

How much N can be fixed by NFT?

- Est. range 50-500 kg N/ha/yr.

How much of this falls as "litter"?

- Leucaena - 80 kg N/ha/yr (from 8-12 t/yr litter)

How much of this recycles to plants?

- If incorporated in soil 32 % (ve. 50%
- If not incorporated 20% for urea)

What happens to the rest?

- It can return as N_2 gas to the air
- Be fixed in soil organic matter
- Be lost by leaching or erosion

Nitrogen Fixing Trees (NFT)

NFT species may be defined as all woody species known to fix nitrogen, are perennial, and over 3 m in height. There are 600 tree species known to be able to fix nitrogen (NFTA, 1983).

Taxonomy

Species of the legume family (leguminosae) include the vast majority species of the nitrogen fixing trees. Most of these species are of the

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sub-families Mimosoideae and Caesalpinoideae, and relatively few of the Papilionoideae. A high proportion of the tested mimosoide (92%) fix N, compared with the papilionoids (92%) and Caesalpinioids (34%) (Brewbaker et al., 1981). Nitrogen fixation has been measured in other plant families including the genera Alnus, Myrica, Hippophae, Coriaria, and Casuarina (Bond, 1967; NFTA, 1983).

General Characteristics

NFT species often have multiple uses ranging from fuelwood, timber and pulpwood to green manure, animal fodder and food for human consumption (Brewbaker et al. 1981). The foliage, flowers or seed pods of NFT are often usable as protein or nitrogen sources for other plants or animals, since they are often higher in nitrogen content than other non-nitrogen fixing plants in similar growing conditions. The generally higher foliar N content of many NFT species, as well as transfer of N from root nodules and rain-wash often results in improvement of soil nitrogen content. NFT are often aggressive, pioneer species which are able to grow more rapidly without N fertilizer inputs than non-nitrogen fixing species.

Important NFT Genera

Luxury timber: Dalbergia, Pterocarpus, Intsia, Perisopsia, Parkia, Samanea

Shade/Ornamental: Amherstia, Delonix, Acacia, Samanea, Erythrina, Sophera, Pterocarpus, Casuarina

Foods/Gums: Acacia, Inga, Parkia, Leucaena

Nurse/Shade: Gliricidia, Erythrina, Leucaena, Inga, Acacia, Albizia

Fence/Support: Ghrieidia, Erythriria, Leucaena

Fodder: Acacia, Albizia, Glirieidia, Leucaena, Prosopia, Sesbania, Calliandra

Posts/Props: Acacia, Albizia, Alnus, Casuarina, Glirieidia, Leucaena

Pulp/Paper: Acacia, Albizia, Alnus, Casuarina, Dalbergia, Enterolobium, Leucaena, Mimosa

Fuelwood: Acacia, Albizia, Calliandra, Casuarina, Dalbergia, Glirieidia, Leucaena, Mimosa, Prosopis, Samanea, Sesbania

Green Manure: Most spp., notably "fodder" species

Module 4

Soil and Climatic Requirements of NFT Species

Session 3: Summary of the Environmental Requirements of Important NFT Species

Objective

Readers and trainees will have a readily usable summary of the environmental requirements of a number of economically important NFT species.

Background

It is difficult at times to find a concise summary of the site requirements of tree species. This session provides a brief description of the known site requirements of NFT species which have major economic use. This information was extracted from the NFT Species Data Base maintained by the Nitrogen Fixing Tree Association.

The data provided here come from a wide variety of published sources. The current state of knowledge of the site requirements of many NFT species is highly variable, leaving much to learned about where the trees grow and how their performance is related to site qualities. The following summary most certainly contains errors of omission – when data are available somewhere but not included here. There are also many conflicting or incomplete reports in the literature which are not easily dealt with in a summary data base. Unless data were clearly inaccurate, conflicting reports are included as ranges of values, assuming that most of these reports describe a part of the range of adaptability for the species.

Also included in the summaries are brief descriptions of wood, fodder and other uses of the species. These are included for use with the exercise in Session 2. The uses are ranked as follows: 1 = excellent, 2 = good, 3 = fair, 4 = poor but usable. Blank values indicate a reported use, but no basis for ranking.

For further information or more complete descriptions from the NFT Species Data Base please contact NFTA, P.O. Box 680, Waimanalo, HI, 96795, USA.

Acacia albida Del.

Center of origin:	Africa: So. Egypt to So. Africa
Latitude range:	35 N – 25 S
Environment zone:	arid semi–arid
Minimum rainfall (mm):	250 mm
Annual rainfall:	250–1000 mm
Dry season tolerance:	6–9 months
Mean maximum temp.:	30–42 C
Mean minimum temp.:	6–18 C
Mean annual temp.:	18–30 C
Soil texture:	medium–light
Soil reaction:	neutral to acid
Soil drainage:	well drained, tolerates seasonal waterlogging
Other soil requirements:	tolerates slight salinity
Main wood uses:	fuel(2) timber(4)
Forage uses:	leaves(3) pods(3)
Other uses:	tannin( ): gum( ): shade(3) medicinal( ) food( )

Acacia auriculiformis A. Cunn. ex Benth.

Center of origin:	Queensland, Papua New Guinea
Latitude range:	20 S – 7 S
Environment zone:	humid tropics
Minimum rainfall (mm):	1300 mm
Annual rainfall:	1300 to 1700 mm
Dry season tolerance:	4–6 months
Mean maximum temp.:	28 to 34 C
Mean minimum temp.:	17 to 22 C
Mean annual temp.:	24 to 29 C
Soil texture:	light/medium/heavy
Soil reaction:	alkaline/neutral/acid
Soil drainage:	seasonally waterlogged

Other soil requirements:	adaptable to most soil conditions, even poor, sterile sandy soils
Main wood uses:	timber (4): pulp(2): fuel(2)
Forage uses:	none
Other uses:	tannin(2): ornamental(2) erosion control ( ) shade( )

Acacia albida Del.

Center of origin:	Africa: So. Egypt to So. Africa
Latitude range:	35 N – 25 S
Environment zone:	arid semi–arid
Minimum rainfall (mm):	250 mm
Annual rainfall:	250–1000 mm
Dry season tolerance:	6–9 months
Mean maximum temp.:	30–42 C
Mean minimum temp.:	6–18 C
Mean annual temp.:	18–30 C
Soil texture:	medium–light
Soil reaction:	neutral to acid
Soil drainage:	well drained, tolerates seasonal waterlogging
Other soil requirements:	tolerates slight salinity
Main wood uses:	fuel(2) timber(4)
Forage uses:	leaves(3) pods(3)
Other uses:	tannin( ): gum( ): shade(3) medicinal( ) food( )

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Soil reaction:	alkaline/neutral/acid
Soil drainage:	seasonally waterlogged
Other soil requirements:	adaptable to most soil conditions, even poor, sterile sandy soils
Main wood uses:	timber (4): pulp(2): fuel(2)
Forage uses:	none
Other uses:	tannin(2): ornamental(2) erosion control ( ) shade( )

Acacia farnesiana (L.) Willd.

Center of origin:	Tropical Americas from Texas to Chile. Naturalized in parts of E. Africa.
Latitude range:	30 N to 40 S
Environment zone:	semi–arid
Minimum rainfall (mm):	400 mm
Annual rainfall:	400 to 600 mm
Dry season tolerance:	4 to 6 months
Mean maximum temp.:	25 to 32 C
Mean minimum temp.:	2 to 10 C
Mean annual temp.:	15 to 28 C
Soil texture:	Light to (medium/heavy)
Soil reaction:	Neutral/acid/alkaline
Soil drainage:	Well drained
Other soil requirements:	Tolerates poor and saline soils
Main wood uses:	fuel( ):
Forage uses:	leaves(3): pods( ):
Other uses:	gum( ): dyes( ): tannin( ): perfume( ): low shelter shrub

Acacia mangium Willd.

Center of origin:	Australia, Papua New Guinea, Indonesia
Latitude range:	18 to 1 S
Environment zone:	humid and sub–humid tropics
Minimum rainfall (mm):	1000 mm
Annual rainfall:	1000 to 2100 mm
Dry season tolerance:	2 to 4 months
Mean maximum temp.:	30 to 32 C
Mean minimum temp.:	13 to 22 C
Mean annual temp.:	22 to 25 C
Soil texture:	medium
Soil reaction:	moderately acid, tolerates 4.2pH
Soil drainage:	moist; tolerates seasonal waterlogging

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Other soil requirements:	tolerates very poor sites and slight salinity; often grows on creek and swamp margins.
Main wood uses:	timber (2): fuel (2): pulp (1): veneer( ):
Forage uses:	browse (4)
Other uses:	Plantation of water catchments; fire-breaks; ornamental purposes

Acacia mearnsii De Wild.

Center of origin:	Australia; Tasmania, Victoria
Latitude range:	18 to 1 S
Environment zone:	tropical highlands
Minimum rainfall (mm):	500 mm
Annual rainfall:	1000 to 2100 mm
Dry season tolerance:	3 to 4 months
Mean maximum temp.:	30 to 32 C
Mean minimum temp.:	13 to 22 C
Mean annual temp.:	18 to 28 C
Soil texture:	Medium
Soil reaction:	Acid to neutral
Soil drainage:	Moist; tolerates seasonal waterlogging
Other soil requirements:	Tolerates very poor sites and slight salinity; often grows on creek and swamp.
Main wood uses:	fuel(2): timber(3)
Forage uses:	
Other uses:	green manure(2): tannin(1):

Acacia nilotica (L.) Willd. ex Del.

Center of origin:	Africa, S.E. Asia
Latitude range:	
Environment zone:	arid and semi-arid
Minimum rainfall (mm):	500 mm
Annual rainfall:	200 to 1270 mm
Dry season tolerance:	extended
Mean maximum temp.:	40 to 50 c
Mean minimum temp.:	−1 to −15c
Mean annual temp.:	› 22 C
Soil texture:	heavy clays to poor rocky site
Soil reaction:	alkaline
Soil drainage:	alluvial sandy loam subject to seasonal flooding
Other soil requirements:	frost susceptible
Main wood uses:	fuel (1): timber (1) pulp (3)
Forage uses:	leaves (2): pods (2):
Other uses:	tannin (1): gum (1) ink from pods, medicinal

Acacia saligna (Labill.) H. Wendl.

Center of origin:	coastal areas of W. Australia
Latitude range:	33 S to 29 S
Environment zone:	arid semi-arid
Minimum rainfall (mm):	300 mm
Annual rainfall:	300 to 1000 mm
Dry season tolerance:	4 to 8 months
Mean maximum temp.:	25 to 34 C
Mean minimum temp.:	4 to 10 C
Mean annual temp.:	16 to 26 C
Soil texture:	light to medium
Soil reaction:	alkaline to neutral
Soil drainage:	well drained
Other soil requirements:	tolerates moderately saline soils and highly alkaline soils
Main wood uses:	fuel(3):
Forage uses:	leaves(2) pods
Other uses:	gum(2): ornamental): erosion control( ) tannin( ): charcoal windbreaks

Acacia senegal (L.) Willd.

Center of origin:	Sahel zone of Africa from Mauritania to Sudan and Somalia
Latitude range:	11 to 18 N
Environment zone:	arid and semi-arid tropics
Minimum rainfall (mm):	200 mm
Annual rainfall:	200 to 500 mm
Dry season tolerance:	6 to 8 months
Mean maximum temp.:	30 to 40 C
Mean minimum temp.:	16 to 28 C
Mean annual temp.:	22 to 32 C
Soil texture:	Light/medium/heavy
Soil reaction:	Neutral to acid
Soil drainage:	Free draining
Other soil requirements:	Intolerant of water-logged sites.
Main wood uses:	fuel (1)
Forage uses:	leaves(2): pods(2):

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Other uses:	gum arabic(1): bee pasture():

Acacia tortilis (Forsk.) Hayne

Center of origin:	N.E. African deserts, Saudi Arabia
Latitude range:	15 to 30 N
Environment zone:	arid and semi-arid tropics
Minimum rainfall (mm):	100 mm
Annual rainfall:	100 to 800 mm
Dry season tolerance:	6 to 8 months
Mean maximum temp.:	32 to 45 C
Mean minimum temp.:	2 to 10 C
Mean annual temp.:	26 to 28 C
Soil texture:	Light
Soil reaction:	Alkaline
Soil drainage:	Free draining
Other soil requirements:	Thrives on poor shallow soils, often bordering deserts
Main wood uses:	fuel( ): posts (1): tools (2)
Forage uses:	pods(1): leaves(2):
Other uses:	fencing(): bee pasture(): sand dune stabilization(1): small implements: gum

Albizia falcataria (L.) Fosberg

Center of origin:	North Moluccas, Indonesia; naturalized in much of Far East
Latitude range:	10 S to 3 N
Environment zone:	humid tropics
Minimum rainfall (mm):	1000 mm
Annual rainfall:	2000 to 4000 m
Dry season tolerance:	0 to 2 months
Mean maximum temp.:	30 to 34 C
Mean minimum temp.:	20 to 24 C
Mean annual temp.:	22 to 29 C
Soil texture:	Light/medium/heavy
Soil reaction:	Neutral/acid
Soil drainage:	Free draining; moist
Other soil requirements:	Adaptable
Main wood uses:	pulp(3): veneer(3): timber(3): fuel(3):
Forage uses:	leaves(4)
Other uses:	tannin(): shade; cover for annual and perennial crops including coffee

Albizia lebbek (L.) Benth.

Center of origin:	Burma, India and Andaman Islands
Latitude range:	11 to 27 N
Environment zone:	semi-arid, sub-humid and humid tropics
Minimum rainfall (mm):	500 mm
Annual rainfall:	500 to 2500 mm
Dry season tolerance:	2 to 6 months
Mean maximum temp.:	26 to 36 C
Mean minimum temp.:	10 to 26 C
Mean annual temp.:	20 to 28 C
Soil texture:	Light/medium/heavy
Soil reaction:	Alkaline/neutral/acid
Soil drainage:	Free draining
Other soil requirements:	Adaptable
Main wood uses:	fuel(2): timber(2):
Forage uses:	leaves(2):
Other uses:	gum(): tannin(): ornamental(2): erosion control(2): shade tree

Alnus acuminata O. Kuntze

Center of origin:	Medium altitudes of mountain ranges in Central and South America from Mexico to Argentina
Latitude range:	18 N to 28 S
Environment zone:	tropical highlands
Minimum rainfall (mm):	
Annual rainfall:	1000 to 3000 m
Dry season tolerance:	0 to 3 months
Mean maximum temp.:	22 to 30 C
Mean minimum temp.:	4 to 14 C
Mean annual temp.:	12 to 20 C
Soil texture:	Light/medium/heavy
Soil reaction:	Acid
Soil drainage:	Free draining; moist
Other soil requirements:	On steep slopes; develops best on deep soils
Main wood uses:	timber(1): fuel(1): pulp(2)
Forage uses:	
Other uses:	anti-erosion. inner bark has served in tanning and dyeing pulp

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Alnus nepalensis D. Don

Center of origin:	Burma; N. India; W. China
Latitude range:	15 to 28 N
Environment zone:	tropical highlands, temperate
Minimum rainfall (mm):	
Annual rainfall:	500 to 2500 mm
Dry season tolerance:	4 to 8 months
Mean maximum temp.:	19 to 32 C
Mean minimum temp.:	2 to 8 C
Mean annual temp.:	13 to 26 C
Soil texture:	Medium
Soil reaction:	Neutral/acid
Soil drainage:	Free-draining; moist
Other soil requirements:	Better growth on deep soils; won't withstand continuous waterlogging
Main wood uses:	timber(3): fuel(2)
Forage uses:	Fodder (), soil
Other uses:	stabilization (1), tanning, dyeing

Cajanus cajan (L.) Millsp.

Center of origin:	India, Africa
Latitude range:	30 N to 30 S
Environment zone:	semi-arid to sub-humid
Minimum rainfall (mm):	
Annual rainfall:	600 to 1000 mm
Dry season tolerance:	extensive
Mean maximum temp.:	35 C
Mean minimum temp.:	18 C
Mean annual temp.:	
Soil texture:	
Soil reaction:	neutral
Soil drainage:	thrives in light sandy soils best in deep loams
Other soil requirements:	cannot withstand waterlogging
Main wood uses:	fuel
Forage uses:	leaves(3): browse(1): seeds (2): pods (2)
Other uses:	windbreak(2). medicinal( ): green manure(2): bee pasture( ): food(1):

Calliandra calothyrsus Meissn.

Center of origin:	Central America but well established in Indonesia
Latitude range:	10 to 18 N
Environment zone:	humid and sub-humid tropics
Minimum rainfall (mm):	
Annual rainfall:	1000 to 3000 mm
Dry season tolerance:	3 to 6 months
Mean maximum temp.:	24 to 30 C
Mean minimum temp.:	18 to 24 C
Mean annual temp.:	22 to 28 C
Soil texture:	Light/medium/heavy
Soil reaction:	Neutral/acid
Soil drainage:	Moist, moderately free draining
Other soil requirements:	Tolerates infertile and compacted soils. Does not tolerate poorly drained soils.
Main wood uses:	fuel(1): pulp (2)
Forage uses:	leaves(4), green manure (2)
Other uses:	Fodder (7 to 10 tonnes dry leaves/ha/an) (): honey flora ()ornamental (1)

Casuarina cunninghamiana Miq.

Center of origin:	Australia
Latitude range:	12 to 37 S
Environment zone:	tropical highlands, temperate
Minimum rainfall (mm):	500 mm
Annual rainfall:	500 to 5000 mm
Dry season tolerance:	
Mean maximum temp.:	25 to 40 C
Mean minimum temp.:	0 to 15 C
Mean annual temp.:	12 to 27
Soil texture:	fine textured sands to gravel
Soil reaction:	
Soil drainage:	alluvial silty loams to sands to gravel
Other soil requirements:	highly calcareous soils
Main wood uses:	fuel (1): timber
Forage uses:	browse (3)
Other uses:	windbreak (1): stream bank stabilization; tools (2) handles (2)

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Casuarina equisetifolia Forst.

Center of origin:	Coastal dunes of S.E. Asia and Australia
Latitude range:	31.5 to 12 C
Environment zone:	humid and sub-humid tropics
Minimum rainfall (mm):	
Annual rainfall:	750 to 2500 mm
Dry season tolerance:	3 to 4 months
Mean maximum temp.:	20 to 35 C
Mean minimum temp.:	10 to 20 C
Mean annual temp.:	18 to 28 C
Soil texture:	Light
Soil reaction:	Alkaline/neutral
Soil drainage:	Seasonally water-logged
Other soil requirements:	Tolerates slightly saline soils and poor, dry soils. Not tolerant of heavy clay soils.
Main wood uses:	fuel (1); timber (1); pulp (2); poles (1)
Forage uses:	
Other uses:	Tannin (2): dyes (): medicine (): 'Cones' (1.8 t/ha/an) for fuel)

Casuarina glauca Sieb. ex Spreng

Center of origin:	Coastal Eastern Australia
Latitude range:	36.5 to 23 S
Environment zone:	semi-arid, sub-humid and humid tropics
Minimum rainfall (mm):	
Annual rainfall:	900 to 1150 mm
Dry season tolerance:	3 to 4 months
Mean maximum temp.:	20 to 30 C
Mean minimum temp.:	10 to 20 C
Mean annual temp.:	18 to 24 C
Soil texture:	Heavy/medium
Soil reaction:	Neutral/alkaline
Soil drainage:	Seasonally water-logged
Other soil requirements:	Saline and swampy; also tolerates shallow, dry soils
Main wood uses:	fuel (1); poles (1); thorny (2)
Forage uses:	
Other uses:	Tannin (): windbreaks (1); ornamental (2) erosion control (1)

Casuarina junghuhniana Miq.

Center of origin:	Central and East Java
Latitude range:	5 N to 2 S
Environment zone:	humid tropics
Minimum rainfall (mm):	
Annual rainfall:	750 to 2000 mm
Dry season tolerance:	4 to 6 months
Mean maximum temp.:	25 to 28 C
Mean minimum temp.:	19 to 22 C
Mean annual temp.:	22 to 26 C
Soil texture:	Light/medium
Soil reaction:	acid/neutral/(alkaline)
Soil drainage:	Free draining
Other soil requirements:	Adapts to various sites
Main wood uses:	
Forage uses:	
Other uses:	shade; shelter; ornamental

Dalbergia sissoo Roxb.

Center of origin:	Indus to Assam; Himalayas
Latitude range:	23 to 30 N
Environment zone:	semi-arid, sub-humid and humid tropics
Minimum rainfall (mm):	
Annual rainfall:	500 to 4000 mm
Dry season tolerance:	3 to 6 months
Mean maximum temp.:	35 to 45 C
Mean minimum temp.:	−2 to +5 C
Mean annual temp.:	18 to 26 C
Soil texture:	Light to medium
Soil reaction:	Neutral to acidic
Soil drainage:	Good; seasonally inundated
Other soil requirements:	River beds and river flats
Main wood uses:	timber(1): fuel(1): furniture (1): cabinet work (1)
Forage uses:	leaves(3); pods (4)
Other uses:	honey flora, (); erosion control, shade

Gliricidia sepium (Jacq.) Steud.

Center of origin:	Tropical Americas Naturalized in Philippines and W. Nigeria

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Latitude range:	6 to 19 N
Environment zone:	sub-humid, humid tropics
Minimum rainfall (mm):	800 to 2300 mm
Annual rainfall:	
Dry season tolerance:	4 to 6 months
Mean maximum temp.:	34 to 41 C
Mean minimum temp.:	14 to 20 C
Mean annual temp.:	22 to 28 C
Soil texture:	Medium
Soil reaction:	Alkaline/neutral/acid
Soil drainage:	Free draining; moist
Other soil requirements:	Tolerates poor fertility soils
Main wood uses:	fuel(1): timber (1)
Forage uses:	leaves(2)
Other uses:	Bee pasture (): green manure (2): fodder (): rat poison (): shade (1):

Inga vera Willd.

Center of origin:	Caribbean, Mexico, Central America
Latitude range:	
Environment zone:	humid tropical
Minimum rainfall (mm):	
Annual rainfall:	high
Dry season tolerance:	some drought tolerance
Mean maximum temp.:	
Mean minimum temp.:	
Mean annual temp.:	
Soil texture:	
Soil reaction:	
Soil drainage:	many soil types in cluding limestone soils
Other soil requirements:	timber(2): fuel(1):
Main wood uses:	
Forage uses:	
Other uses:	agricultural shade(2): timber( ): bee pasture(2): Food

Intsia bijuga (Colebr.) D. Kuntze

Center of origin:	Southeast Asia, Southwest Pacific Islands
Latitude range:	
Environment zone:	humid tropics
Minimum rainfall (mm):	2000 mm
Annual rainfall:	2000 +
Dry season tolerance:	
Mean maximum temp.:	
Mean minimum temp.:	
Mean annual temp.:	
Soil texture:	
Soil reaction:	
Soil drainage:	
Other soil requirements:	
Main wood uses:	timber(1)
Forage uses:	
Other uses:	

Leucaena diversifolia (Schlecht.) Benth.

Center of origin:	Central America
Latitude range:	
Environment zone:	humid and sub-humid tropics
Minimum rainfall (mm):	500 mm
Annual rainfall:	
Dry season tolerance:	4 to 8 months
Mean maximum temp.:	
Mean minimum temp.:	
Mean annual temp.:	18 to 30 C
Soil texture:	
Soil reaction:	unknown
Soil drainage:	
Other soil requirements:	
Main wood uses:	poles (4): timber (3): fuel (2)
Forage uses:	
Other uses:	green manure (2)

Leucaena leucocephala (Lam.) de Wit (Salvador type)

Center of origin:	S.W. Mexico and Central Guatemala
Latitude range:	15 to 17 N
Environment zone:	semi-arid, sub-humid and humid tropics
Minimum rainfall (mm):	400mm
Annual rainfall:	600 to 1000 mm
Dry season tolerance:	2 to 6 months
Mean maximum temp.:	24 to 32 C
Mean minimum temp.:	16 to 24 C
Mean annual temp.:	20 to 28 C
Soil texture:	Light/medium/heavy
Soil reaction:	Alkaline/neutral
Soil drainage:	Moderately free draining
Other soil requirements:	will not tolerate strongly acid soils or waterlogging

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Main wood uses:	fuel
Forage uses:	leaves(2)
Other uses:	ornamental(4): food (2):

Parkinsonia aculeata L.

Center of origin:	Central and South America, from Texas to Peru.
Latitude range:	10 S to 30 N
Environment zone:	arid and semi-arid tropics
Minimum rainfall (mm):	
Annual rainfall:	250 to 800 mm
Dry season tolerance:	6 to 8 months
Mean maximum temp.:	22 to 32 C
Mean minimum temp.:	18 to 24 C
Mean annual temp.:	20 to 28 C
Soil texture:	Light/medium
Soil reaction:	Alkaline/neutral
Soil drainage:	Free draining
Other soil requirements:	Tolerates moderately saline soils but not waterlogging.
Main wood uses:	fuel( ):
Forage uses:	pods( ): leaves( ):
Other uses:	ornamental(2): erosion control(2): windbreaks( ): living fence( ) food

Pithecellobium dulce (Roxb.) Benth.

Center of origin:	Central America, South America
Latitude range:	
Environment zone:	arid and semi-arid tropics
Minimum rainfall (mm):	450 mm
Annual rainfall:	450mm minimum
Dry season tolerance:	6 to 8 months
Mean maximum temp.:	
Mean minimum temp.:	
Mean annual temp.:	20 to 30 C
Soil texture:	
Soil reaction:	can tolerate saline soils
Soil drainage:	clay, limestone, sands, brackish sands
Other soil requirements:	windthrow danger, waterlogged soils
Main wood uses:	fuel (3): poles (2): construction (2)
Forage uses:	pods (2): leaves (2)
Other uses:	human (2): tannin (2): shade (2): ornament medicine honey

Prosopis chilensis (Mol.) Stuntz

Center of origin:	Pacific coast of South America from southern Peru to central Chile
Latitude range:	25 to 15 C
Environment zone:	arid tropics
Minimum rainfall (mm):	
Annual rainfall:	200 to 600 mm
Dry season tolerance:	8 to 10 months
Mean maximum temp.:	22 to 30 C
Mean minimum temp.:	10 to 20 C
Mean annual temp.:	15 to 25 C
Soil texture:	Light/medium
Soil reaction:	Alkaline/neutral
Soil drainage:	Free draining
Other soil requirements:	Poor soils
Main wood uses:	fuel
Forage uses:	pods(2): leaves( ):
Other uses:	

Prosopis cineraria (L.) Druce

Center of origin:	India and the Near East
Latitude range:	10 to 30 N.
Environment zone:	arid tropics
Minimum rainfall (mm):	
Annual rainfall:	100 to 800 mm
Dry season tolerance:	8 to 11 months
Mean maximum temp.:	40 to 50 C
Mean minimum temp.:	−4 to 6 C
Mean annual temp.:	21 to 28 C
Soil texture:	Light/medium/heavy
Soil reaction:	Neutral/alkaline
Soil drainage:	free draining; seasonally waterlogged, sandy
Other soil requirements:	Tolerates high alkalinity and some salinity
Main wood uses:	fuel (1) timber (2)
Forage uses:	leaves(1): pods(1):
Other uses:	food(1): green manure erosion control wind break

Prosopis juliflora (Sw.) DC.

Center of origin:	Southern Western USA through Central America to Ecuador, Jamaica
Latitude range:	4 S to 35 N
Environment zone:	arid tropics
Minimum rainfall (mm):	
Annual rainfall:	150 to 1200 mm
Dry season tolerance:	6 to 8 months
Mean maximum temp.:	22 to 34 C
Mean minimum temp.:	14 to 22 C
Mean annual temp.:	16 to 28 C
Soil texture:	Light/medium/heavy
Soil reaction:	Alkaline/neutral
Soil drainage:	Free draining
Other soil requirements:	Tolerates moderately saline soils
Main wood uses:	fuel(1): posts(1):
Forage uses:	pods(2)
Other uses:	honey flora ( ) shade; windbreak; anti-erosion

Prosopis tamarugo F. Phil.

Center of origin:	Northern Chile, S. America
Latitude range:	21 to 15 S
Environment zone:	arid tropics
Minimum rainfall (mm):	
Annual rainfall:	10 to 300 mm
Dry season tolerance:	10 to 12 months
Mean maximum temp.:	24 to 32 C
Mean minimum temp.:	−1 to +5 C
Mean annual temp.:	15 to 18 C
Soil texture:	Light/medium
Soil reaction:	Alkaline/neutral
Soil drainage:	Tolerates seasonal waterlogging
Other soil requirements:	Tolerates highly saline soils
Main wood uses:	fuel (1) timber (3)
Forage uses:	pods(2): leaves (2)
Other uses:	

Pterocarpus indicus Willd.

Center of origin:	Southeast Asia, Solomon Islands
Latitude range:	
Environment zone:	humid tropics
Minimum rainfall (mm):	
Annual rainfall:	
Dry season tolerance:	
Mean maximum temp.:	
Mean minimum temp.:	
Mean annual temp.:	
Soil texture:	
Soil reaction:	
Soil drainage:	moist, wet well-drained sites
Other soil requirements:	
Main wood uses:	timber
Forage uses:	
Other uses:	

Robinia pseudoacacia L.

Center of origin:	Appalachian and Ozark regions of USA
Latitude range:	34 to 40 N
Environment zone:	temperate
Minimum rainfall (mm):	500 to 700 mm
Annual rainfall:	
Dry season tolerance:	2 to 6 months
Mean maximum temp.:	25 to 35 C
Mean minimum temp.:	0 to 5 C
Mean annual temp.:	10 to 18 C
Soil texture:	Light/medium
Soil reaction:	Alkaline/neutral/acid
Soil drainage:	Free draining; moist
Other soil requirements:	Tolerates slightly saline soils, limestone most favorable
Main wood uses:	fuel (1) timber (1)
Forage uses:	leaves(2): pods( ): seed
Other uses:	honey flora (1) ornamental (2) Erosion control.

Samanea saman (Jacq.) Merrill

Center of origin:	Ecuador; Guatemala; Venezuela; S. Mexico
Latitude range:	5 S to 11 N
Environment zone:	sub-humid and humid tropics
Minimum rainfall (mm):	
Annual rainfall:	760 to 3000 mm
Dry season tolerance:	2 to 4 months
Mean maximum temp.:	24 to 30 C
Mean minimum temp.:	18 to 22 C
Mean annual temp.:	22 to 28 C
Soil texture:	Light/medium/heavy
Soil reaction:	Neutral/acid

Soil drainage:	Free draining; seasonally waterlogged
Other soil requirements:	indifferent to soil types
Main wood uses:	fuel(1) timber (1) roundwood (2)
Forage uses:	pods(1)
Other uses:	Fodder (pods) () agricultural shade (1) ornamental

Sesbania grandiflora (L.) Poir.

Center of origin:	South East Asia from India, through Malaysia, Indonesia to the Philippines.
Latitude range:	10 S to 20 N
Environment zone:	humid and sub-humid tropics
Minimum rainfall (mm):	
Annual rainfall:	1000 to 2000 mm
Dry season tolerance:	2 to 3 months
Mean maximum temp.:	26 to 36 C
Mean minimum temp.:	18 to 24 C
Mean annual temp.:	22 to 30 C
Soil texture:	Light/medium/heavy
Soil reaction:	Acid
Soil drainage:	Tolerates seasonal waterlogging
Other soil requirements:	Very adaptable
Main wood uses:	fuel (3)
Forage uses:	leaves(1) pods (2)
Other uses:	green manure (1): gum (2): tannin (3) pulp (3), ornamental (2) human (1)

NFT HIGHLIGHTS

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SESBANIAS - A TREASURE OF DIVERSITY

Fast growth, wide soil tolerances, multiple uses, and a wide range of growth habits and adaptabilities make Sesbania a treasure of diversity and versatility.

The genus Sesbania contains about 50 annual and perennial species spread throughout the tropics and subtropics. Perennial woody sesbanias include S. grandiflora (pantropical), S. javanica and S. formosa (Australia), S. arborea (Hawaii), some little-known African species, and the S. sesban group (Africa and Asia).

Sesbania grandiflora

Annual species include S. speciosa, S. pachycarpa and S. rostrata (Africa), S. bispinosa (India), S. exaltata (North America) and S. emerus (Central and South America).

Africa has the greatest species diversity within this genus, and Asia has the greatest utilization of sesbanias in cultivation. Both Australia and Hawaii contain endemic groups of species.

Out-of-date names are common and add to some confusion about species nomenclature. For example, "Sesbania aegyptiaca" is an old name for S. sesban, which is a complex of fast growing trees. Species within this complex are not readily distinguished.

Sesbanias are adapted to diverse, "difficult" sites. Many species tolerate soil alkalinity and can be used in soil reclamation programs. Unlike other legumes, sesbanias survive waterloggings and flooding and continue to fix nitrogen, which makes them useful in lowland rice cultivation areas and seasonally flooded lands. The large-flowered S. grandiflora is a tree of the humid and semi-humid tropics up to about 800 m. S. sesban is adapted to arid and semi-arid regions up to about 1200 m and to acid soils (NAS 1983). There are indications that low levels of soil phosphorus do not severely inhibit growth of certain species (Evans, personal observations).

Sesbanias have diverse uses in cropping systems. As green manures they are unsurpassed in moist environments and grow very rapidly during hot weather. Two-month-old foliage of S. bispinosa grown in a field and

plowed under prior to planting rice increased yields to levels equivalent to fields receiving from 60 to 120 kg/ha inorganic N fertilizer (Beri and Meelu, 1979; Khind, et al, 1982). Similar use of S. rostrata, which nodulates on stems and roots, doubled rice yields in small experimental plots (Dreyfus et al., 1984). S. speciosa and S. grandiflora are planted on field margins and periodically lopped for green leaf manure in many parts of Asia.

Agroforestry applications of perennial Sesbanias have only begun to be explored. Perennial sesbanias are planted in Indonesia and India as shade or windbreaks for vegetable gardens, coffee, turmeric, oranges, and cotton; and to support black pepper, cucurbits and betel vines.

Flowers and young leaves of S. grandiflora and S. sesban are eaten as vegetables in Southeast and South Asia. Leaves of both species, as well as other sesbanias, can be lopped as ruminant fodder. S. sesban provides better yields but about 20 percent lower leaf nitrogen levels than S. grandiflora. Some S. sesban varieties produced more than 20 t/ha/yr in dry matter (50 percent leaf) during the establishment year in trials in Hawaii (Evans, unpublished data).

Both perennial and annual species can provide fuelwood and pulp fiber. S. grandiflora fuelwood plantations in Indonesia yielded 20-25 m3/ha/yr (NAS, 1980). The wood's rather low specific gravity of 0.42, however, makes it poor for fuelwood. The S. bispinosa group is a promising pulp fiber crop for paper. The pulp is similar to that of birch, and the trees mature in five to six months, are easily harvested and stored, and can be managed to provide seed and some fodder as well. In a screening trial conducted in Hawaii, fast-growing annuals produced from 8 to 17 tons/ha dry matter in a 14-week growth period in the summer. They were sown at 125,000 plants/ha and at harvest were in the pre-flowering stage, averaged 3.3 m in height, and contained 150-245 kg/ha N in the above-ground growth, with 33 percent of the dry matter and 75 percent of the nitrogen in the leafy fraction (Evans, unpublished data).

Localized cases of insect and disease problems in sesbania are only occasionally reported. Stem borers, leaf-webbing insects and seed chalcids are the most notable pests. S. sesban might be susceptible to Sclerotum rolfsii, a stem-rot fungus, during hot, dry seasons.

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*Abstracts have been made by author Dale Evans from documents or observations by the authors cited; for further information, write NFTA, P.O. Box 680, Waimanalo, Hawaii, 96795 U.S.A.

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NFT HIGHLIGHTS

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DIFFICULT SITES ARE HOME TO CASUARINA

Sand, sun and salt spray are part of home to the Casuarina spp. that thrive on beaches from the tropics to temperate zones. The ability to tolerate diverse and difficult niches such as seashores characterize the genus. Casuarinas also have been grown on limestone quarries and infertile tin mine tailings.

C. equisetifolia

C. equisetifolia, which occurs naturally on coastlines from India to Australia, is the most widely used species. A 3000 km shelterbelt was built mainly with C. equisetifolia along the People's Republic of China's southern coast to stop encroachment of sand dunes and to decrease strong winds. A similar shelterbelt in Taiwan reduced downwind salt deposition by 60 percent (Koki, 1978).

In Egypt, C. glauca and C. cunninghamiana shelterbelts protect farms, highways and irrigation canals from clogging by sandstorms.

Casuarina has been called the best firewood in the world. Its wood is very dense, splits easily, burns when green, has low ash content and makes excellent charcoal (NRC, 1984). It is the main plantation species in peninsular India, where 7-15 year rotations yield 100-200 tons of fuelwood per ha (NRC, 1984) and even the roots are sometimes harvested for charcoal. Yields of 7.5-year-old stands in Florida were up to 17 dry t/ha/yr (Rockwood, et al., 1985).

In Thailand, hybrids of C. equisetifolia and C. junghuhniana grow on heavy acid soils and are harvested five years after planting for posts, firewood and other products. Villagers in southern China gather four tons/ha/yr of casuarina litter from shelterbelts and use it for domestic fuel (NRC, 1984).

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Most casuarina wood is hard, heavy and difficult to saw. It also tends to split, crack and warp as it dries. However, the wood is used for fencing, pilings, beams, rafters, ship masts, scaffolding, flooring, particle board, roof shingles and pulp.

C. oligodon shades coffee trees and is a fallow-improvement crop in Papua New Guinea. Soil samples collected after five years of such a fallow show substantial increases in soil nitrogen and organic matter (NRC, 1984).

Casuarina roots are nodulated by the nitrogen-fixing actinomycete, Frankia. Annual nitrogen fixing rates for established C. equisetifolia stands has been estimated near 60 kg/ha (Dommergues, 1963). Inoculating seedlings with Frankia and mycorrhizal fungi promotes faster growth and survival, and seedlings are ready for planting in six months or less.

Suitable growing conditions for C. equisetifolia in the tropics and subtropics include: temperatures of 10-30° C with no frost, 200 to 5000 mm annual rainfall, 6-8 month dry season, sea level to 1500 m, and sandy, calcareous soils. C. cunninghamiana tolerates about 50 light frosts annually and survives periodic inundation in fresh water. C. glauca survives tidal inundation and is very drought tolerant. C. oligodon grows well in humid highlands up to 2500 meters above sea level, and C. junghuhniana grows in drier highlands up to 3000 meters.

Casuarinas normally are propagated by seeds. C. equisetifolia produces seed prolifically by the age of 5 years. Most species have separate male and female trees, but some species have both flowers on one tree, and C. equisetifolia is reported as fitting into both of these categories. Seeds of different species vary greatly in size. C. equisetifolia has between 300,000 to 450,000 seeds/lb. Germination generally takes 2-3 weeks. Germination rates for C. equisetifolia range from 75 percent for fresh seed to 30 and 40 percent for stored seeds.

A male clone presumed to be a hybrid of C. equisetifolia and C. junghuhniana is reproduced by young, short cuttings in Thailand and India. Vegetative propagation efforts with C. equisetifolia have not been very successful, although rooting of properly treated young lateral shoots has been as high as 90 percent (Somasundaram and Jagadees, 1977). Trees coppice poorly or not at all. The root-derived shoots of some species allow for a type of "coppice" management, however (NRC, 1984).

Pest problems on casuarinas have been minor. Root rot in Florida and a blister disease in India have occurred. Many species survive fires well, but even light fires kill C. equisetifolia.

Some casuarinas can become pests. C. glauca's vigorous root suckering has created problems in Hawaiian pastures and in Florida, where some counties have banned its planting. Additionally, leaf litter of some species may be toxic to some plants and increase soil acidity or salinity.

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Appendix II

A Tentative Assessment of the relative value of Eucalyptus camaldulensis and Cassia siamea grown on farmland

(Graduation from 0-10, with the highest mark indicating the greatest impact in respect of benefit (credit) or expense (debit), respectively)

Credit	Eucalyptus	Cassia
Simplicity of establishment	3	7
Ability to coppice	10	9
Resistance to pests and diseases	5	9
Growth rate premium	10	5
Value of good produced	8	4
Yield of other benefits:		
recycling of mineral nutrients	2	7
fixation of nitrogen	0	8
	36	49
Balance	21	

Debit	Eucalyptus	Cassia
Cost of Establishment and upkeep	8	3
Time interval between investment and returns	2	3
Susceptibility to pests and diseases	6	1
Occupation of space:		
above ground	4	6
below ground	8	2
Competition for light	2	5
Competition for water	10	2
Exuding inhibitory substances	8	1
Indirect cost (need for protection)	5	5
	53	28
Balance	17	

N.B. An analysis as carried out here must necessarily remain of a subjective nature. However, if the same approach is applied by the same evaluator for a considerable number of species, he may still arrive at a better evaluation of their relative value, or ranking, than by a rough comparison of the compound merits of the species in question. The method could almost certainly be improved by giving different weight to different features according to their importance to the farmers.

Agroforestry intercropping systems

Descriptions and illustrations

This chapter describes in detail how to lay out an agroforestry *shamba* using the management techniques discussed in Chapter 3.

Introduction

Thus far, this guide has been mainly concerned with providing general information about agroforestry and with describing different techniques of caring for the trees before and after they are planted in the *shamba*.

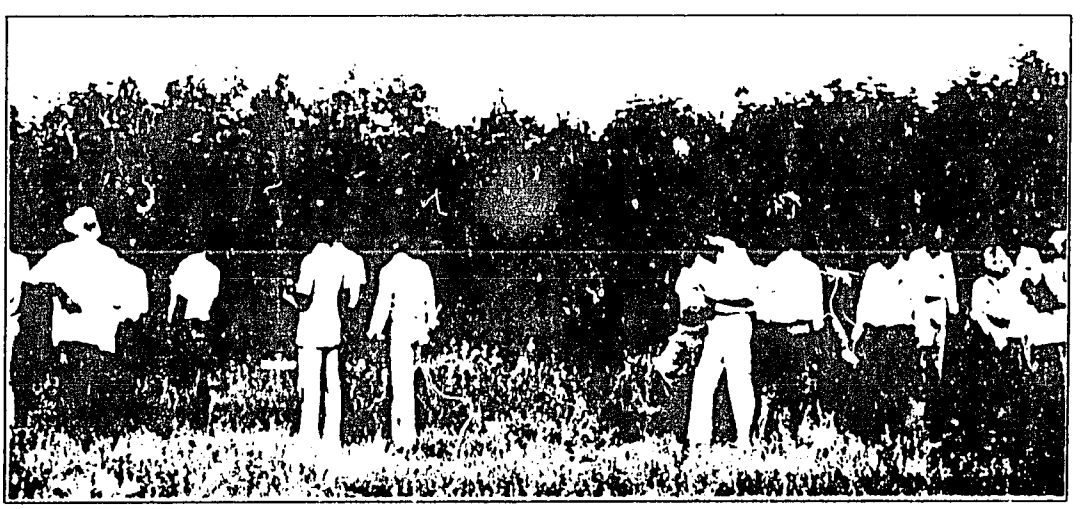
In this section on (practical application of) agroforestry intercropping systems, these ideas are combined to show how the trees are arranged and managed in the *shamba*.

When the extension worker is talking with a farmer who is interested in these agroforestry intercropping systems, the following pointers may help and should be kept in mind.

Even though agroforestry is not an entirely new system to Kenya, it is a different way of managing trees in the *shamba*. Perhaps traditionally, trees are left in the *shamba* when it is cleared for farming but it is not as many as is suggested for agroforestry management practices, and the farmer may, or may not, be aware of the various management techniques that can be applied as well as the many new multipurpose tree species profiled in this guide.

The extension worker should not approach the farmer as if agroforestry is a new and completely different farming system. Instead, the extension worker could begin by discussing with the farmer why certain species of trees, such as *Sesbania sesban*, *Acacia spp.*, *Grevillea robusta*, *Markhamia lutea*, and *Cordia abyssinica*, are allowed to remain when land is cleared. Once there is this understanding, the extension worker can go on to explain how additional benefits (increased soil conservation, steady supply of fodder,

Field Days for farmers and NGOs to research and demonstration plots are important in extension and training.



fuelwood, etc.) can be gained by incorporating the intensified agroforestry systems into the agricultural practices which are presently being used.

Above all, the final decision of what to plant and where to plant should be made by the farmer. The farmer knows his/her *shamba* and is very likely to have suggestions on how an agroforestry intercropping planting scheme can be fine-tuned or changed to suit his/her needs. If, for example, a farmer is hesitant to plant many trees at close spacings, as is often the case, he should be encouraged to plant at first a smaller number using wider spacings. The agroforestry plots can always be expanded.

A good rule to bear in mind is that agroforestry is site-specific:

- specific to the growing and farming conditions
- specific to the wants and needs of the farmer.

The extension worker should be certain that the farmer is fully aware of, and understands both what can be gained and how to properly manage the agroforestry *shamba* (the latter is discussed in this section, using methods from Chapter 3) so as to reap maximum benefits. A poorly managed agroforestry plot can lead to drastically reduced crop yields due to over shading of the crops by the trees and/or by a tree/shrub becoming weedy or highly competitive.

Talking about agroforestry may be enough to convince a few farmers. However, many more will be interested in and become enthusiastic about agroforestry if they see it in practice. The extension worker should have at least one well-managed agroforestry plot that can be used as an example to demonstrate correct management techniques and what can be gained from agroforestry. The plot or plots could be on the extension worker's *shamba*, on the *shamba* of a contact farmer, at a Farmers Training Centre, or all of the above.

Finally, some difficulties of working with agroforestry that an extension worker may encounter are:

- social constraints (difficulty in introducing agroforestry intercropping systems to an area, taboos about certain species, etc.).
- educating people about agroforestry.
- availability of tree seeds or planting material.
- Lack of information on particular areas and species.

The agroforestry systems discussed in this section are:

A) Intensive hedgerow or alley cropping with leguminous shrubs
B) Wide alley intercropping.
C) Planting trees and leguminous shrubs together.
D) Varying the row spacings and within row spacing of trees.
E) Hedgerow (strip) terraces.

Intensive Hedgerow (Alley) Intercropping with Leguminous Shrubs

Hedgerow (alley) cropping is a farming system in which rows of trees or shrubs are planted along contours between rows of crops for soil and crop yield improvement. This section describes a hedgerow system where fast- growing, nitrogen-fixing shrubs are grown in closely spaced rows with crops such as maize, beans, or cassava.

Intensive alley cropping provides a variety of benefits to the farmer. The leguminous shrubs are a regular supply source of fodder, fuelwood and poles.Equally important are the soil and water conservation measures effected through the ground cover, nitrogen-fixing and available mulch. This system provides soil improvement similar to that of leaving the land fallow for two or three years, but without the loss of cropping seasons. Improved crop yields have been observed by intercropping with and properly managing leguminous shrubs in areas with good rainfall.

Some points of interest:

Close spacings of 0.5m within rows between trees and 2-4m between rows of trees are recommended except in arid/semi-arid lands, (see Table 1, Appendix 2). High densities of trees/shrubs when properly managed, provide a better microclimate in the *shamba*, than lower densities. When the trees/ shrubs are nitrogen-fixing, the

higher densities and closer spacings allow for the distribution of the nutrients among a greater percentage of the intercrop. However, wider spacings may have to be chosen if a tractor is used to prepare the land. In this case, there should be at least 3 or 4 metre-wide alleys resulting in 3 or 4 rows of crops between rows of trees (hedgegrow).

The shrubs should not be harvested for the first time until they are at least 3m high (except those species which do not generally grow to heights greater than 2.5m such as *Cajanus cajan* (pigeon pea), and *Flemingia congesta*). The time will be 1-3 years after establishment, depending upon species and location (see Table 1, Appendix 2). At this height, the shrubs will have a well- established root system and large size (DBH) so that they will coppice vigorously (refer to section in Chapter 3 on coppice management).

Examples of leguminous shrubs for intensive hedgerow inter-cropping are: *Calliandra calothyrsus, Leucaena leucocephala, Sesbania sesban, Flemingia congesta, Cassia siamea, Gliricidia sepium* and *Mimosa scabrella.*

The cropping sequence diagram on page 29 illustrates an intensive hedgerow alley cropping system for the Kenya coast in which the shrubs were harvested for the first time at the beginning of the 3rd year, and the key events and activities are summarized below

Year 1: First season (main growing season)

a) Prepare the *shamba* and plant the crop according to the specifications of the Ministry of Agriculture.

b) Plant the seedlings, seeds or cuttings immediately after the onset of the long rains.

c) See Table 1 for spacings and harvesting times of shrubs in different ecozones.

d) Plant the shrubs within the rows of crops the first year to ensure they receive maximum care and protection.

Year 1: Second Season (Minor growing season)

e) In this model, beans have been planted after the maize was harvested. Maize or cassava are good nurse crops to use.

Year 2: First season

f) For the second year, and each subsquent year, rows of the crop are planted on either side of the rows of shrubs, that is, disregarding the presence of hedgegrow.

g) The shrubs are harvested one week before ploughing the field. (See chapter 3 section on coppice management).

h) During the cropping season, branches are pruned to minimize shading and thus yield fodder and fuelwood. During the dry season the shrubs are allowed to grow, providing ground cover for soil and water conservation and weed control.

Year 3: First season

Leguminous shrubs are harvested.

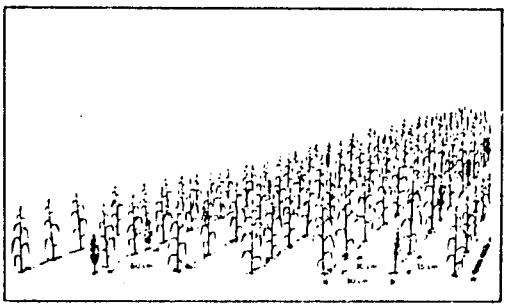
Year 4 or 5: First season.

Coppicing or leguminous shrubs are harvested. Trees are either completely harvested or are pollarded. The trees will then either coppice or will have to be replanted.

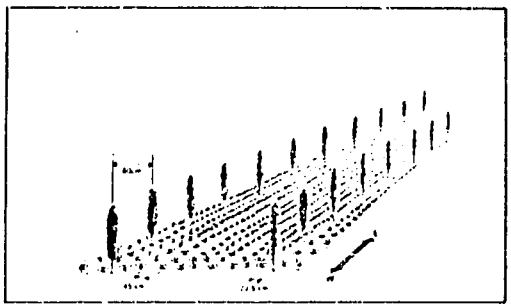
Wide Hedgerow (Alley) Intercropping

Species recommended for wide alley intercropping are mostly those which are referred to as "trees" (Chapter 2).

Wide alley planting is similar to intensive hedgerow intercropping discussed in the previous section. It differs in that the trees are planted in widely spaced rows of 8-20m between rows, and the species are chosen because of the wood and tree products (fruits, seeds, poles, timbers, etc.) they will provide. The trees are allowed to grow large in order

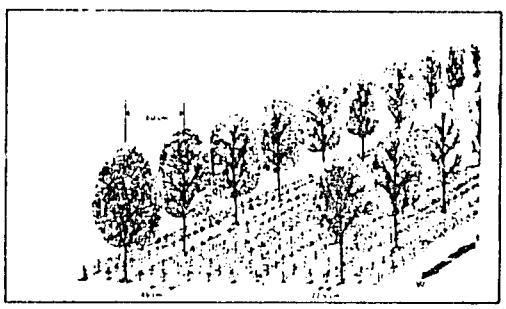


Year 1 First season

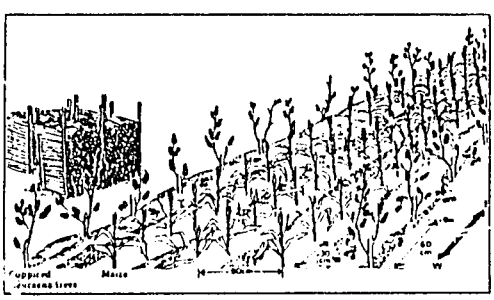


Year 1 Second season

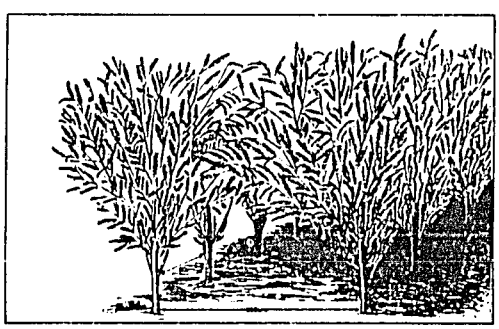
Year 2 First season



Year 2 Second season



Year 3 First season



Year 3 Dry season

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to produce these products, which can take from 4-6 or more years before the first harvest, depending upon species and ecological condition.

Wide alley planting does not directly improve crop yields much as intensive hedgerow planting with leguminous shrubs can, but it provides many of the benefits described in the last section (e.g. fodder, green manure and soil conservation). Leaf litter from trees such as *Cordia abyssinica, Markhamia lutea* and *Grevillea robusta* have been shown to provide over 2 tonnes of green leaf manure per hectare per year when managed intensively.

As the trees grow big and tall, they will have some shading effect upon the crops. The farmer, however, will be able to sell or use the wood products which can compensate for the loss of the crop. Some canopy management (side pruning, pollarding; refer to sections in Chapter 3) can be practiced to reduce the shade. The trees should only be planted along east-west contours (as ploughing is done along contours) so that the sun follows the lines of trees. This also minimizes shading on the associated crop.

When selecting species for wide alley planting, tree products or marketable should be given the first consideration. Exotics such as *Grevillea* and *Casuarina equisetifolia* and indigenous species such as *Markhamia, Cordia* and *Croton macrostachyus* are used in these systems to be regularly pruned for fuelwood and for their poles and timbers. Fruit trees (e.g. *guava, avocado, citrus*) can also be planted in rows to make the *shamba* function as a fruit-producing orchard. Beehives in the wide alley planted systems provide a source of honey while ensuring pollination of crops.

Planting and Establishment of Leguminous Trees and Shrubs Together

Leguminous trees and shrubs can be successfully planted together within the same row. This is traditionally practiced widely in the field by farmers, though not in single rows. It provides the benefits of both trees and shrubs at the same time. Two or more tree species can also be planted. In the Kenya coast, for example, a mixed planting of *Casuarina equistifolia* and *Conocarpus lanceifolia* gives overall higher biomass yield compared to pure stands.

These benefits are:

Nitrogen fixing, a relatively quick supply of fodder and fuelwood, etc., from the leguminous shrubs as well as the wood products of the trees.

Varying species gives the farmer a wider choice of products and minimizes loss if disease or insect outbreak occurs among one tree/shrub species (as opposed to monocropping the trees).

Guava (Psidium guajava) does not improve crop yields. But establishing two rows of Leucaena in an 8m block Guava is being tried to improve soil fertility at Mtwapa.

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- It imitates the natural mixture of woody species which can help to stabilize the environment.

- As was stated in the section on intensive hedgerow management, the higher densities of trees and shrubs create a better microclimate than lower densities. This can result in greater amount of improvement.

The trees and shrubs are managed according to the recommendations given under Intensive Hedgerow (Alley)-Intercropping and Wide Alley Intercropping. The trees are planted at wide spacings with closely spaced leguminous shrubs intercropped both within rows of trees and between rows of trees.

Varying row spacings of trees and spacings within rows of trees, through management.

This management practice works with tree species that are planted for their wood products such as the ones used in wide alley planting. At first, the trees are planted with close spacings of 1 x 4m or 2 x 4m. They are managed so that rows and individual trees within rows are entirely removed to widen the spacings. This system is being tried, using *Grevillea robusta*. The system resembles relay planting/harvesting.

Advantages:

- the farmer is able to harvest some small poles at an earlier stage, and timbers at a later stage.

- increases the overall yield of the land as compared to initially established 8m alleys having a lesser tree population.

- also, remember that a greater number of trees especially within rows creates a better microclimate for the crop land

The farmer may be concerned about the shading effect of so many trees on this *shamba*. Since the row spacings are widened before the trees become very large, the effect of shading is not as great as a farmer might expect from such close initial spacings. Shading is also kept to a minimum by east-west contour planting, canopy management, and because the closer initial spacings forces the canopy up, allowing greater penetration of light to the *shamba*.

Tree species such as Grevillea can be first established with close spacings. After every 2 or 3 years, every other row is harvested for pole and thus allowing contineous intercropping.

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Two methods will be discussed:

a) Varying spacings between rows of trees - for which all species suggested for wide alley planting can be used
b) Varying spacing between rows of trees and within rows of trees. Trees that should be planted at very wide spacings such as *Acacia albida*, and *Acacia tortilis* are best suited to this method

Varying Spacings Between Rows of Trees is done as follows:

Year 1 The trees are planted at spacings of 2 x 4m.

Year 3 or 4 Every other row of trees is harvested for poles, leaving a spacing of 2 x 8m.

Year 5 or 6 The rows that were left are now harvested (for timber/poles). Meanwhile, the first rows harvested have either coppiced or heref been replanted. The cycle continues like this.

Varying Spacings Between Both Rows of Trees and within Rows of Trees is done as follows:

Year 1 Every other row is removed and every other tree within the remaining row is removed, leaving a spacing of 4 x 8m.

Year 5 or 6 Either all remaining trees can be removed or the spacings can be widened further to 8 x 16m.

Hedgerow (strip) Terraces

(See Wide Hedgerow intercropping)

The soil conservation aspect of agroforestry has been stressed throughout this guide. In addition to the soil conservation that is achieved from the mulching, ground cover, and root systems, the trees/shrubs can be managed so that they create natural terraces on sloping lands.

Leguminous shrubs such as *Calliandra, Leucaena* and *Flemingia* are most commonly used. Tree species (e. g. *Grevillea, Casuarina equisetifolia*) have also been successfully planted to form hedgerow terraces. The trees/shrubs must be regularly pruned to avoid overshading of the crop.

Some important points are:

- Seedlings are planted, or seeds are drilled, at very dense spacings of 10-20cm to 50cm within the rows in a staggered double row. Spacing between hedgerow

Close planting within rows, of woody legumes such as Leucaena soon develop into strip terraces and can replace or reduce the need to construct and maintain Fanya Juus while providing useful products such as fodder and mulch.

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terraces are the same as are recommended by the MOA for *Fanya Juu.*

- Over time, a natural terrace will form from the build-up of soil and refuse against the tree/shrubs. Within 18 months, a functional structure will be well under way. As weeding and land clearing is done, the farmer can push the stovers and compost against the line, thus speeding up the strip terrace build-up process.

- Hedgerow terraces can be constructed between *Fanya Juu* for efficient soil conservation thus, with much less labour than would be needed if the farmer constructed 100% *Fanya Juu.* On steeply sloping lands, grass strips can be planted between the hedgerow terraces and *Fanya Juu.* If the farmer constructs *Fanya Juu* (with or without hedgerow terraces), agroforestry tree/shrub species can be planted along their edge or in the trenches in dry areas.

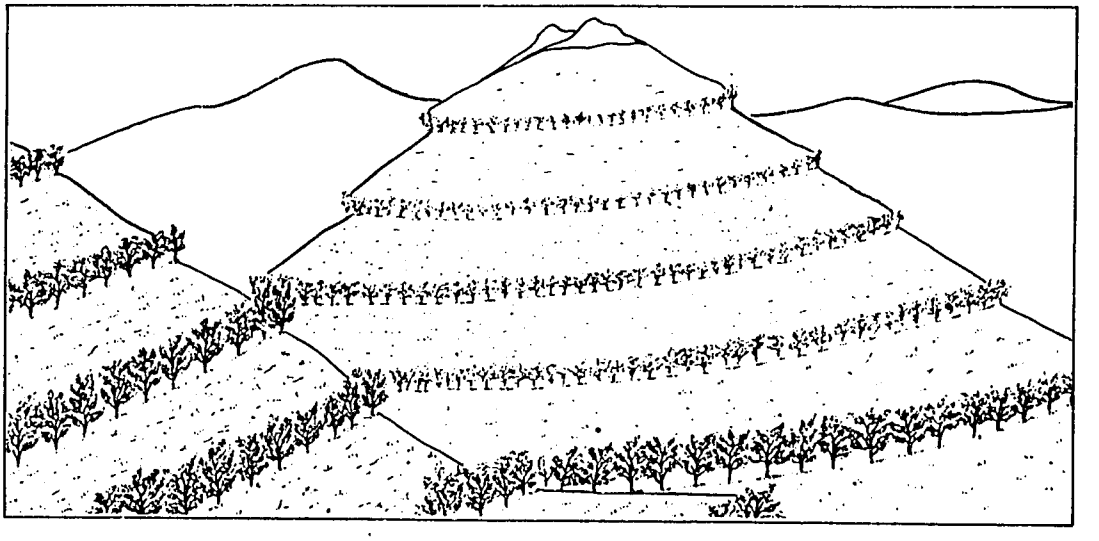
To establish Hedgerow strip terracing with *Fanya Juu.*

1) Hedgerow terraces are constructed between *Fanya Juu.* The spacing within double rows of trees/shrubs is 20cm. Trees/shrubs are planted for stabilization on the *Fanya Juu.*

2) The trees/shrubs are coppiced first when they reach a height of at least 3 metres.
   - small twigs and leaves are incorporated into the soil.
   - larger branches are used for poles or fuelwood.

3) Over time, a build-up of soil and organic matter creates a natural terrace.

Hedgerow terrace



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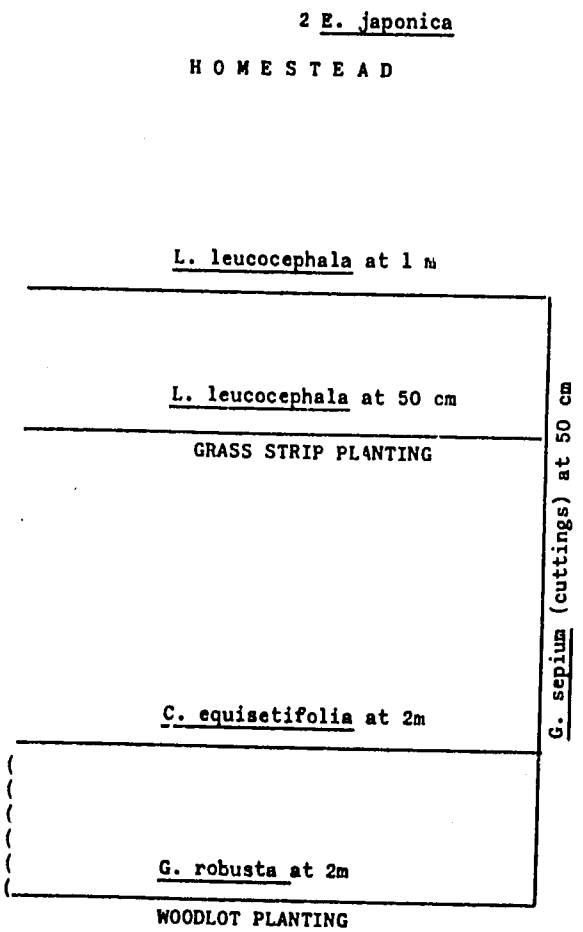
AGROFORESTRY TRIAL DEMONSTRATION FARMERS: D & D SUMMARY - NYERI

FARMER	DIAGNOSIS		DESIGN		
	Primary Problems	Secondary Problems	Components	Functions	Management
Paul Gature N-6	Land scarcity. Poor soil fertility	Scarcity of cash. Insufficient fodder. Insufficient shade in homestead.	1. Fodder production by planting of Leucaena leucocephala along two grass strips. First grass strip at 1m and second one at 50 cm within row spacing. 2. Trial of Giliricidia sepium as a living fence at 50 cm also for production of fodder and firewood. 3. Timber/pole production using Grevillea robusta and Casuarina equisetifolia planted in two rows at 2m within row and 3m in between row. 4. Shade establishment using Eryobotriajaponica planted in homestead.	1. To provide dry season fodder and firewood sticks, also for soil conservation. 2. To provide fencing service against livestock and to provide fodder and firewood. 3. To provide timber and poles for sale and for domestic use. 4. To provide shade and fruits.	1. Harvested at 60 cm. high during dry season prior to long rains. Feed leaves to livestock and remaining sticks for firewood. Use brown manure to improve soil fertility. 2. Pollard trees at 1m. 3. Prune lateral branches to encourage development of straight stems. 4. Protection against animals needed during early period of establishment.

AGROFORESTRY ON-FARM TRIAL DEMONSTRATION : DIAGRAM A
November 1983, Design

Site : Nyeri
Farmer : Paul Gatue
No. : 6



11	Casuarina equisetifolia
50	Gliricidia sepium
11	Grevillea robusta
61	Leucaena leucocephala
2	Eriobotrya japonica
135	Total No. of trees planned

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DESIGN FOLLOW-UP : NYERI

Farmer	Recommended Design	Actual Planting Configurations	Reasons for change
N-6	1. Grass strip planting using Leucaena on two grass strips. On 1st grass strip, 20 Leucaenas to be planted at a spacing of 1m. On 2nd grass strip, 41 Leucaenas to be planted at a spacing of 50 cm. 2. Woodlot establishment using 11 Casuarina equisetfolia in one row at espacement of 2m within row. A second row to be established using 11 Grevilleas at 2m espacement within row. Between row spacing to be 1m. The trees should be planted in a triangular configuration. 3. Living fence establishment using 50 Gliricidia sepium cuttings at 50 cm along a path that runs through the middle of the shamba.	1. The farmer planted the trees as per the recommendation. 2. This recommendation was adhered to strictly. 3. Planting not yet effected.	1. None. 2. None. 3. Head of household left for a ten day trip before planting. He left instructions for his daughter-in-law to do the planting. She had not done it due to other farm work.

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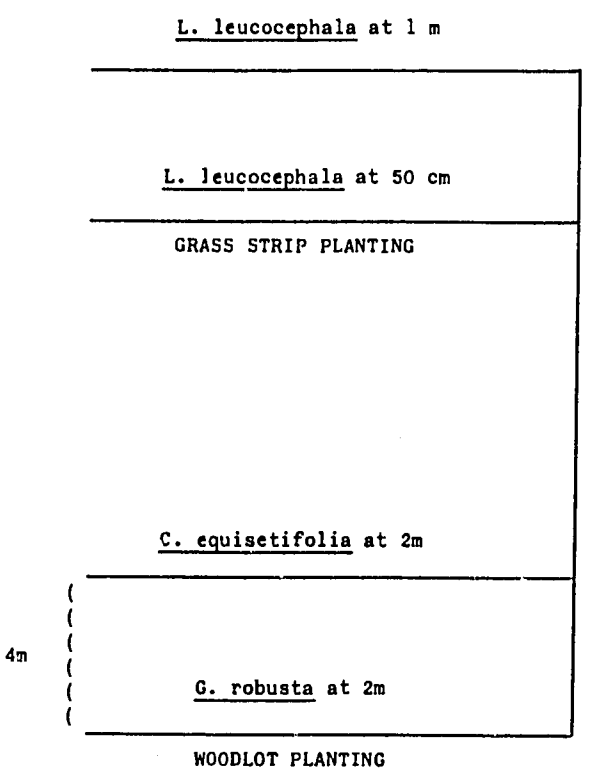
AGROFORESTRY ON-FARM TRIAL DEMONSTRATION : DIAGRAM B
November 1983, Implementation Scheme

Site : Nyeri
Farmer : Paul Gatue
No. : 6

2 E. japonica

H O M E S T E A D



11	Casuarina equisetifolia
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61	Leucaena leucocephala
2	Eriobotrya japonica
135	Total No. of trees planned

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"On-Farm Demonstrations"

OVERVIEW

On-farm demonstrations are effective means of reducing the risks farmers perceive. They are designed to take new innovations out of the 'unreal', scientific realm of the research station and place them firmly within the bounds of a farmer's everyday experience. They are used first to display the results of adopting a new practice and then to give the farmer an opportunity to practice new methods. Both types of demonstrations serve to make clear to a farmer exactly what is entailed in opting for a new farming innovation.

Chapter One describes the research-extension chain. Result demonstrations are the link in that chain at which the active promotion of innovations in farming practices begins. Practically speaking, result demonstrations are side by side comparisons of new and traditional techniques. They are conducted in farmer's own fields or barns to show that experimental results can be reproduced locally. Even though crop farming examples will be used throughout this section, result demonstrations can be very creatively employed by livestock extension agents as well. (See Chapter Three under "Testing Recommendations").

On the surface, a result demo might seem fairly straightforward, but there are actually a number of factors that can serve to reduce their effectiveness. First, the demonstration must produce results that are visible and significant enough to convince farmers to try the new practice themselves. If the practice is, for instance, not fully tested before hand under local conditions, the demonstration runs a high risk of failure.

Second, the innovation has to satisfy the farmer's own criteria in terms of the other risks associated with it. That is, it must promise an immediate return, fall within the farmer's financial means, and suit prevailing cultural patterns, to name but three.

Third, the demonstration should not be run by an extension agent. Farmers will be more impressed by results obtained by their peers than by supposed agricultural experts. Fourth, the farmer on whose land a result demonstration is conducted cannot be extremely wealthy or progressive; nor should the plots receive an undue amount of attention and care. The idea of the demonstration is to show a group of farmers what results can be obtained by a normal farmers under normal conditions. Hence, the choice of demonstration farmer needs to be made with care, the site should be typical of surrounding lands and the crop itself must be managed at a realistic level. Any other arrangement will undermine the demonstration's effectiveness.

In setting up a result demo with a cooperating farmer, it is important to establish who is responsible for the labor involved in maintaining plots and who will provide necessary inputs. In order to make the demo credible, the farmer must do most of the actual work. Inputs are a stickier problem. Ideally, the demonstration farmer will provide his own. Realistically, there may be some instances where the extension service might need to donate inputs as a courtesy for a farmer's cooperation. Two questions need to be considered: Will a gift of inputs have a negative effect on the agent-farmer relationship? How will other farmers perceive such a gift? Whatever the choice, arrangements must be made explicit at the outset.

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The next set of practical considerations in setting up a demonstration focus on the plot: its location, its layout and its size. A conspicuous or readily noticeable site is crucial in attracting maximum attention. Locations near roads or footpaths or on the immediate outskirts of a village are ideal. Visibility is the key factor in plot layout. When viewing from the most prominent vantage point, from a road, for example, the traditional and improved plots should be side by side rather than front and back. Signs can be erected to attract further attention and provide explanations of the demonstration. (Note that signs need to meet the visual literacy levels of a majority of the farmers observing the demonstration).

The size of the plot may be influenced by several factors: the labor constraints of the demo farmer and the amount of land she has available; the size of the group that will eventually observe the formal presentation of results; the type of crop; and the overall impression the demonstration is intended to create. In general, the plot should be large enough to be impressive without being toolarge to take in both parts of the demonstration with a single glance. Rough estimates suggest that one or two hundred square meters would be enough for an effective demo of field crops, with less area required for demonstrations with vegetables.

Throughout the planting and maintenance operations connected with the demo, the farmer needs to be thoroughly familiarized with the what, why, when and how of what is going on. In particular the extension agent should check that needed inputs are prepared and applied on time. The entire process needs to be documented accurately so that results can be adequately explained when the demonstration is completed. Rainfall figures for the duration of the demonstration crop's growing cycle, for example, are of crucial significance.

If the demonstration farmer has been adequately trained during the course of the growing season, she can play a central role in the use of the demo as a promotional tool by providing testimony to a particular method's effectiveness. There may be opportunities early on in the demonstration garden's growth cycle for her to show preliminary results to some of her neighbors. Pointing out differences in plant size and color at various stages serve to heighten interest in a demo as it progresses towards completion.

The main presentation of results should, however, be conducted at harvest time. The farmer should be prepared to help the extension agent through four steps: an explanation of the new practice focusing on amount of labor required, materials needed and changes from traditional methods; a conservative estimate of costs and returns; a question and answer period; and an offer of follow-up visits to other farmers interested in adopting the new practice themselves.

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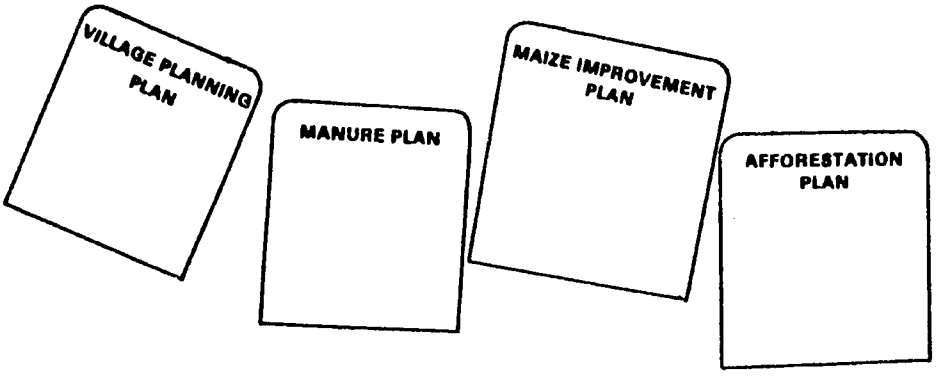
LESSON PLAN FOR : PROGRAM PLANNING AND EVALUATION

TOTAL SUGGESTED TIME : 5 Hours

RATIONALE : Extension workers who are capable of preparing quality program plans will be in a better position to succeed in the implementation of those plans. Extension workers who are able to evaluate their programs can produce valuable feedback on program strengths and weaknesses. This feedback can then be used in preparing future plans.

CONTENT : Activity P : Presentation on Program Planning, Work Plans, Calendars of Work, and Program Evaluation in Extension.

Activity Q : Program Planning Exercise.



ACTIVITY P : PRESENTATION ON PROGRAM PLANNING: WORK PLANS, CALENDARS OF WORK, AND PROGRAM EVALUATION IN EXTENSION

SUGGESTED TIME : 2 - 3 Hours

RATIONALE

Following information collection the next step in the extension cycle is developing the extension program. Thus, the program planning lesson follows the presentation on data collection.

OBJECTIVES

Trainees will understand the importance of program planning.

Trainees will be able to write their own program plans.

Trainees will be able to describe the extension process from surveying to evaluation.

PREPARATION

Use flip chart or blackboard to illustrate examples of an extension program plan, plan of work, and calendar of work. If possible, copy and distribute examples of these forms to each student.

CONTENT

In extension work there are 6 activities which comprise the extension cycle. These are:

1. **The survey:** from which we deduce the conditions and needs of the people.

2. **The extension or program plan:** a general statement describing what should be done and why it is needed.

3. **The plan of work:** a detailed statement of how the program will meet its objectives (including activities, manpower requirements, sequence of events, etc).

4. **The calendar of work:** a timetable showing when the work will be done.

5. **Implementation:** putting the plans into action.

6. **The evaluation:** (or impact) in which we assess whether the program accomplished its objectives (and if

not, why not).

A program plan contains a great deal of information about projects which will be undertaken by villagers as part of their program. As an example, the MATI Mlingano Farmer Training Wing decided with farmers, after completing our surveys, that the most feasible and needed programs were in the following areas: coconut establishment, nutrition, rabbit raising, grain storage, and IST for Extension Workers. This program was decided upon after consulting with farmers, E.W.'s, MATI tutors, research experts, the RADO, DADO, and members of the National Coconut Development Project.

But why bother with these cumbersome plans? First of all, they furnish a clear concise statement for all who are connected with or interested in the project. The DADO, project leader, E.W., village chairman, and local farmers all know what has been agreed upon. Secondly, plans help E.W.'s see what they are to do everyday on their job. Thirdly, plans help supervisors evaluate progress against the objectives of the plan. Lastly, program planning ensures continuity when staff changes take place. Extension is a continuous process and the continuity of the program must not be broken due to transfers.

Now that we have established the value of program planning, lets look at some examples: This is a table taken from Extension in Rural Communities, by A.H. Savile. Study Table 1 (a) for ideas on how to create your own program plans.

Table 1 (b), also from Savile, uses the examples of fish farming, vegetable growing, and cooking to illustrate one type of format used in program planning.

Note to Instructor: After distributing the two forms, work out on the board with the students a program plan of their own choice. A flip chart would be preferable for this exercise since it can be saved for reference.

Program Planning:
Another example of a program plan is the type used by L.C.Pickett in the Tutor's Guide to Extension Programme Planning and Evaluation. Included is a copy of the Range Destocking Program Plan for 1984 for your reference. Note how the plan distinguishes between long range objectives and objectives to be accomplished this year.

Plan of Work:
After the program plan is completed we have enough information to make the plan of work. The plan of work tells us who is responsible for what, how, when and where. The plan of work will provide a detailed breakdown showing how the extension program is to be carried out. It deals with projects of immediate importance and should be rewritten every 6 or 12 months. Please study carefully Table 2 from Savile, which is also a good example of a plan of work.

TABLE 1 (a)

PROGRAMME PLANNING IN A NUTSHELL
SOME BRIEF NOTES FOR EXTENSION WORKERS

st find the facts by survey, interviews and observations. Then prepare a programme jointly with the ple.

tension programme for .....(Any community). Stage..... (Indicates progress and helps continuity)

Their projects	Their situation	Their problems	Our solutions	Our objectives	
Statement of their expressed needs .	1.Reasons why they want or need each project.	1.List difficulties which prevent the people from doing projects themselves.	1.Each solution must be agreed to by project leaders.	Long term aims stating clearly: 1.Who and how many will be taught.	WHAT
What the people want to do or to learn from the workers.	2.Excluding factors which are problems hindering progress.	2.Include reasons for past failures.	2.Each solution must be within the people's capacity.	2.What they will be taught.	IT
Stated in order of their priority.		3.List problems in numbered sequence.	3.Outside help should only supplement the people's efforts.	3.When teaching will be completed	IS
Yet maintaining balance between needs of all sections.			4.State solutions in corresponding numbered sequence.		
A clear statement for all who are interested .	1.Shows that projects are really needed.	1.Teaches local leaders to analyze local problems and	1.Solutions must be shown to solve the problems.	Results must be capable of evaluation of progress made by the people towards the objectives.	WHY
Provides reasons for spending public money.	2.Shows that sufficient numbers of people want the projects.	2.To seek suitable solutions	2.They must assist in training local leaders.		ITS
	3.Ensures continuity after changes of staff.	3.Encourages communal effort.	3.Help to avoid needless expenditure of public funds.		NEEDED
		4.Helps continuity of work under local leaders.			
By joint efforts of extension workers and the people through their project leaders.	By survey, interviews and observation to find the facts regarding: 1.Living conditions and 2.People's wants and needs.	By public meeting to: 1.Explain situation and facts. 2.List people's wants in order of priority 3.Elect project leaders. 4.Consider problems involved.	Discuss and agree with leaders: 1.Suitable solutions and objectives 2.Best teaching methods. 3.What outside help is needed 4.Draw up extension programme 5.Prepare detailed plan of work. 6.Prepare calendar of work.	Avoid slogans and vague policy aims.	HOW IT IS DONE

TABLE 1 (b)

EXTENSION PROGRAMME FOR VILLAGE
STAGE 1

What they want to learn)	(The reasons why they want or need the project)	(The difficultics which may hinder the project)	(How we have decided to overcome these difficulties)	(Who, what and when are we teaching)
1. Fish farming	Fresh fish unobtainable. Dried fish very expensive. The people are very poor. Too little protein in diet.	A.Pond owners discouraged by past failures. B.Lack of knowledge and skill in construction and management of fish ponds. C.Too poor to hire machinery. D.Shortage of equipment for construction of pond E.Lack of local feeding stuffs for fish ponds. F.No local suplies of fry.	A.Arrange visit to fishery station and successful fish farmer. B.Give talks, film show and demonstration. C.Start self-help groups. D.Obtain on loan or issue from agricultural department. E.Collect rice and maize bran. Grow ipomoea, tapioca etc F.Start fry ponds.	1.To teach 12 farmers yearly, for 3 years how to construct ponds and produce fish successfully.
2. Vegetable growing	Wild vegetables scarce Vegetables only planted annually after rice harvest. Need to overcome vitamin deficiencies in diet. Opportunity to increase income by selling surplus production.	A.Lack of knowledge and skill in growing vegetables. B.Unsuitable varieties tried in the past. C.Losses from uncontrolled attacks of pests and diseases. D.Unsatisfactory methods of seed preparation and storage	A.Talks, demonstrations and practical work. B.Obtain varieties tested by agricultural department. C.Obtain equipment and chemicals from agricultural department. D.Talks, demonstration and practical work.	2.To teach 25 members of youth club to grow vegetables during the next 12 months.
3. Cooking	Unbalanced diet. Unappetizing meals Little variety in food. Symptoms of protein and vitamin dificiencies.	A.No knowledge of nutrition. B.Do not know how to cook appetizing meals. C.Limited variety of foods normally available.	A.Talk and film show. B.Method demonstrations and practice cooking. C.Obtain additional foods from projects 1 and 2 above.	3.To teach 20 women to cook nutritious and appetizing meals during the next 12 months.

Extension Team ..... Date .....

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SAMPLE NUMBER 1

EXTENSION PROGRAM PLAN # 5 FOR YEAR 1982

MLALI WARD, MPWAPWA DISTRICT, DODOMA REGION, EXTENSION WORKERS: ....., ..., ..., ...,
NAME NAME NAME NAME

EXTENSION PLAN FOR: Range Destocking

SITUATION PROBLEM	LONG RANGE OBJECTIVES:	ANNUAL OBJECTIVES	ACTIVITIES TO REACH OBJECTIVES:	DONE	ACCOMPLISHMENTS
There are 101,000 cattle, and 42,000 sheep and goats in the Mpwapwa District, grazing an area of 83,000 Ha. (1.4 AU per Ha.) The range has deteriorated rapidly in recent years to a point where shrubs and leafy annuals dominate. (80% of total cover.) The offtake of TDN is ESTIMATED BY FINCH TO BE 13% of what it would be in climax condition. Erosion is serious in spots. Cattle are sold or butchered at an average weight of 359 Kg after 5 years growth. Thus they consume 3.2 times the food necessary to raise an animal to this weight if done in 2½ years (where abundant food is available). 50% destocking could increase the offtake of meat by 3.7 times within 10 years (see the Finch report, 1967). Cattle distribution would improve if water was more widely available.	1. To develop a keen awareness of the importance of range management among the people (as measured by their expressions and actions). 2. To develop knowledge and skills about range management (to be measured by informal questioning at meetings and at farm visits as well as by actions). 3. To destock 20% by 5 years, 25% by 10 years and 30% by 50 years. 4. To increase offtake of meat by 15% in 10 years and 100% in 50 years. 5. To reseed 2% of the range in 5 years. 6. To develop 13 stockponds or wells in 10 years.	1. To convince the local leaders of the importance of range management practices and of the great potential of increased off-take (measured by the leaders' willingness to persuade others). 2. To develop some general knowledge about how to manage ranges among leaders and others. 3. To develop preliminary plans for a destocking program and gain support for them. 4. No effect this year. 5. & 6. Create interest in reseeding and water development among leaders (measured by their willingness to develop a plan and request government financial support (in January 1983).	1. (a) Continue to make home visits to leaders in 8 villages to create interest. January-March. (b) Tour an improved range site with leaders. March - April. (c) Meet with 9 village Production and Marketing Committees. April - May. 2. Discuss principles of range management during all home visits & meetings. January-December. 3. (a) After gaining approval (legitimacy) from leaders & supervisors to engage in destocking, & after getting leaders' separate ideas, develop a tentative plan of action with Production & Marketing Committees & District Committees by July. (b) Discuss the plan at 3-6 public meetings. Collect ideas for improvement of the plan. Sept - December. 4. - 5 & 6. Part of activities 1 & 2.		1. (a) 23 home visits were made in 9 villages about this program. (b) 14 leaders visited a village where stocking rate has been proper for past 4 years. Visited climax sites at Kiboriani and at airport. Very impressive to villagers. These leaders agreed to push for destocking in this district. (c) Met with 5 committees good discussion but continuing opposition. 2. Done during the 23 home visits, during the Production and Marketing Committee meetings and during the tour. 3. (a) Support gained from 14 leaders, 4 undecided, 5 against. CCM & Committee members all favorable. Ideas were compiled and a plan developed. Plan approved by District Development Committee. (b) The plan was discussed at only 1 public meeting. Lack of time and transport. 4. - 5/6. Did not get to this step.

TABLE 2

VILLAGE WOWOTE PLAN OF WORK FOR PERIOD 1-1-66 to 31-12-66

Projects' immediate goals and teaching steps	Teaching methods to be used	Timetable	Equipment and materials needed	Project leaders and staff responsible
1.Fish Farming To teach 12 farmers how to produce fish successfully by 31. 12.66, in steps.				Leaders - Mr. X and Mr. Y.
a.Selection of site	a.Talk on what to look for and what to avoid. Inspection of possible sites.	a. January	a.Pegs	a.Fishery Officer
b.Clearing of site	b & c. Film show followed by practical instruction.	b. January	b & c. Films and cinema projector, 6 picks and shovels on loan.	b & c. A.A. and F.O.
c.Construction of ponds		c. January-February		
d.Destruction of predators	d.Method demonstration	d. March	d.4 cwt lime	d. A.A.
e.Construction of sluice gates	e Method demonstration	e. March	e.Carpenter and 3 bags cement, trowel, 2 shovels.	e. F.O.
f.Stocking with fry	f.Method demonstration	f. April	f.Supply from F.O.	f. A.A.
g.Maintenance of ponds	g.Lecture, film show and demonstration	g. May - December	g.Films and cinema projector	g. A.A. and F.O.
h.Production of local food stuffs.	h.Method demonstration	h. March-December	h. Planting material	h. A.A.
2.Vegetable Growing To teach 25 young farmers (club) how to grow vegetables by 31.12.66 in steps				Leaders - Master A and Miss B
a.Compost making	a.Demonstration and practice	a. January	a. -	a. A.A.
b.Selection and clearing site	b.Demonstration and practice	b. March	b. -	b. A.A.
c.Sterilizing soil	c.Demonstration and practice	c. March	c. -	c. A.A.
d.Sowing seeds for transplanting	d.Demonstration and practice	d. April	d. Fresh seed.	d. A.A.
e.Making beds, applying compost and fertilizer	e.Demonstration and practice	e. April	e. 1 cwt NPK4 fertilizer	e. A.A.
f.Sowing seeds direct	f.Demonstration and practice	f. April	f. Fresh seed	f. A.A.
g.Pest and disease control	g.Talks and demonstrations.	g. May - August	g. 2 Spray pumps insecticides and fungicides.	g. Assistant Entomologist and Pathologist.

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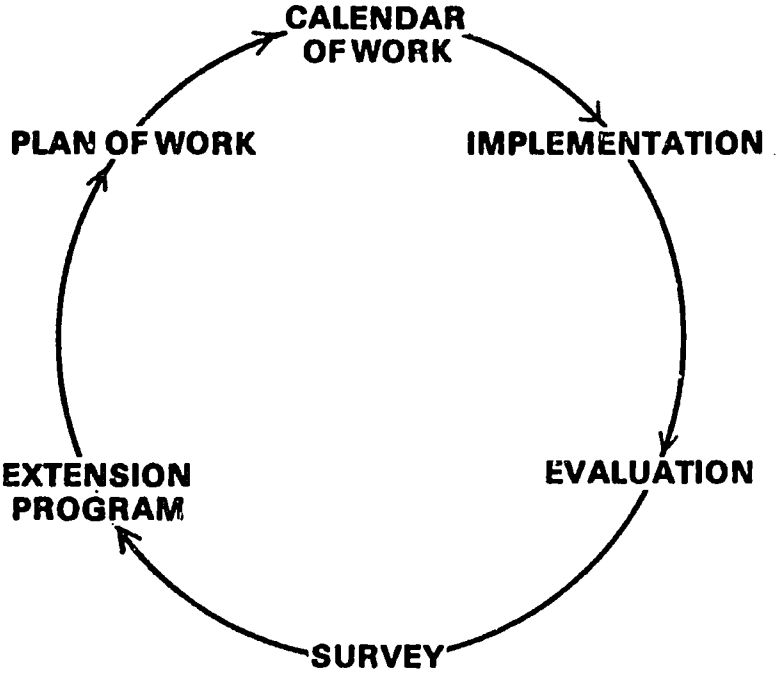
TABLE 2 (Cont...)

VILLAGE WOWOTE PLAN OF WORK FOR PERIOD 1-1-66 to 31-12-66

Projects' immediate goals and teaching steps	Teaching methods to be used	Timetable	Equipment and materials needed	Project leaders and staff responsible
2.Vegetable growing - continued.....				
h.Harvesting & seed selection	h.Demonstration and practice	h. June - August	h. -	h. A.A.
i.Seed preparation and storage	i.Demonstration and practice	i. June - August	i.Air-tight jars and dessiccant.	i. A.A.
j.Rotation of crops	j.Lecture and practice	j. September	j. -	j. A.A.
k.Repetition of all lessons	k. Repeat as above	k. AAugust - Septem.	k. -	k. A.A.
3.Cooking To teach 20 women to cook nutritious and appetizing meals by 31.12.66 in steps.				Mrs.H and Miss M.
a.Food values	a.Talk and films	a. January	a. Films and projector.	a. Information Officer and H.D.
b.Food for adults, and children and babies	b.Talk and demonstration.	b. February	b. Pictures and magnet board	b. H.D.
c.Various methods of cooking	c.Talk demonstrations and practice	c. March	c. Cookery box & foods for cookery	c. H.D.
d.Combining foods to produce a balanced one dish meal	d.Talk demonstrations and practice	d. April	d. Cookery box & foods for cookery	d. H.D.
e.Special meals for sick people	e.Talk demonstrations and practice	e. May	e. Cookery box & foods for cookery	e. H.D.
f.Vegetable dishes	f.Demonstration and practice	f. June - August	f. Cookery box & foods for cookery	f. H.D.
g.Fish dishes	g.Demonstration and practice	g. Oct - Dec.	g. Cookery box & foods for cookery	g. H.D.



THE EXTENSION CYCLE

Note that the projects are stated in the same order (ie. fish farming) as in the program plan. The immediate goals indicate how far the plan is expected to progress towards the final objectives. Each project is then broken down into the various steps of instruction which will be needed in teaching the people how to achieve the purpose of the project. Remember, the plan of work is concerned with the present and immediate future. Use it for your short term objectives.

The Calendar of Work:
This is simply a day to day schedule of what activities will be taking place. Copies of the calendar should be distributed to all participants and displayed in the extension worker's office. A carefully planned calendar of work is essential to the orderly progress of any plan of work. Without it, local leaders, farmers, and extension workers may not be sure when they are expected to participate in various activities. One suggestion is to make a 2 inch x 2 inch block for each day and pencil in your planned activities for that day. This should be displayed on the office wall for easy reference.

SSM 7.1.1 Scheinman and Mariki p.86

KALENDA YA KAZI (CALENDAR OF WORK)

JINA LA KIJIJI .....

JINA LA BWANA SHAMBA .....

MUDA WA KALENDA YA KAZI .....

TAREHE	KAZI (MAFUNZO)

MPANGO WA KAZI (PLAN OF WORK)

JINA LA KIJIJI .....

JINA LA BWANA SHAMBA .....

MUDA WA MPANGO WA KAZI .....

MALENGO YA MUDA MFUPI NA HATUA ZA MAFUNZO	MBINU ZA MAFUNZO ZITAKAZO-TUMIWA	MUDA (MWEZI GANI)	ZANA NA VIFAA	VIONGOZI WA MIRADI WASHAURI WAHUSIKA

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PROGRAM YA UENEZAJI (EXTENSION PROGRAMME)

JINA LA KIJIJI .....

JINA LA BWANA SHAMBA .....

MUDA WA PROGRAMU .....

MIRADI YAO (Wanachotaka kujifunza)	HALI YAO (Sababu zao za kuhitaji mradi)	MATATIZO YAO (Matatizo yatakayozuia utekelezaji wa mradi)	UTATUZI WETU (Jinsi tulivyoamua kuyatatua matatizo)	MALENGO YETU (Nani watafundishwa; watafundishwa nini, ni wangapi na lini watafundishwa)

Evaluation:
After completing a situational analysis, collecting information, planning an extension program, and developing a plan and calendar of work it is time to begin the implementation phase. Following implementation, the program must be evaluated to see whether the objectives have been met or not. As each planned action is completed, the results must be examined against the objectives of that action. For example, the 1982 Program Plan of the MATI Mlingano Farmer Training Wing stated that 5,000 coconut trees would be planted in 12 project villages. This goal was never realized because demand of other villages exceeded supply and we weren't able to buy enough seedlings. In the 1983 Plan, however, we decided to develop a model coconut nursery at Mlingano in cooperation with TIRDEP. This was accomplished because all parties FOLLOWED THE PLAN which had been developed during the previous year. As a result, we will have 3,000 trees to distribute during the long rains of 1984. Through the evaluation process it was determined that the nursery was an excellent idea and should be expanded in next year's program.

Progress in extension must be measured in outputs, not in terms of how many attend a course on coconuts or rabbit keeping. The evaluation must be based on how much output rose due to the training course, or follow-up. Saying that 50 farmers attended a course on coconuts tells us very little; reporting that 45 of the

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50 each successfully planted 100 trees tells us that productivity will rise. Evaluation is a fundamental tool in discovering how many people actually put into practice what they learned.

It is also essential to know how many of the people have reached the objectives or goals, how many are going to reach them and when, why they have not done so yet, how many have forgotten what they were previously taught, as well as which teaching methods were effective and which were not. If people are not reaching the objectives you should recheck to make sure they were realistic goals. The teaching methods should also be periodically evaluated against the outputs and modified if necessary.

How to Perform a Simple Evaluation:
By asking the following 8 questions and following the sample format, an extension worker can discover what progress has been made and whether the situation has changed.

1. What were the immediate goals?
2. Were they achieved? Why?
3. What goals remain?
4. Did everyone understand the purpose of these goals?
5. What changes have occurred in the knowledge, behavior, and skills?
6. What teaching methods proved most effective?
7. What new problems, or new situations have arisen?
8. What progress has been made in training local leaders?

TABLE 4

VILLAGE WOWOTE EVALUATION OF PLAN OF WORK FOR 1.1.1966 - 31.12.1966

Date .....

1. What were the IMMEDIATE GOALS?	2. How far were these GOALS ACHIEVED	3. What GOALS REMAIN to be achieved?
1. To teach 12 farmers how to produce fish successfully by 31.12.1966	11 farmers now producing fish successfully.	One farmer was prevented by illness but still keen to learn.
2. To teach 25 young farmers how to grow vegetables by 13.12.1966	All 25 have acquired a sound knowledge in vegetable gardening	None in existing plan
3. To teach 20 women to cook nutritious and appetizing meals by 31.12.1966.	15 women have learned and adopted the recipes taught	5 women need further instruction and practice owing to irregular attendance
4.		
5.		

(Reverse side of form in Table 4)

Did the people understand and appreciate the purpose of these goals?
Yes. They are very keen on extension work

What changes occurred in the people?
a. The twelve farmers have taken much more interest in the fish ponds.
b. The young farmers' club has become very keen to take up other agricultural projects.
c. There is much more interest now in cooking and nutrition.

What teaching methods proved most effective?
Method demonstrations, magnetboard, blackboard, coloured slides.

What changes, new situations or problems have arisen?
There has been an improvement in the relationships between adults and teenagers in the community.

What progress has been made in training leaders?
Project leaders have been taught to do each job, but they require further practice in giving demonstrations.

Signed.....

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ACTIVITY Q : PROGRAM PLANNING EXERCISE

SUGGESTED TIME : 2 Hours

RATIONALE

Program planning has been introduced, the class has already developed a program plan together, and now each student should formulate his own plan to show that he understands the concept.

OBJECTIVES

Each student, working alone, will create his own program plan.

Students will know how to make program plans in the field.

PREPARATION

Have flip chart and blackboard ready.

CONTENT

Pick a subject appropriate to your group and have each student formulate a program plan for that subject based upon his knowledge and experience. An example could be Control of Stalk Borer to Increase Yields, or Establishing a Coconut Nursery in a Village. The purpose of this exercise is for students to demonstrate their grasp of the concept, not to create a perfect program plan. This would be impossible without the necessary surveying, meetings, and data collection exercises which preceed program planning.

The instructor should circulate freely through the group, guiding and correcting students where necessary. Since all students will be working on the same subject, plans can be easily compared and the instructor can make a composite plan based on the input received by all the students.

Allow an hour for formulating the plan and an hour for discussion. The program planning chart (use the format you like) should be placed on the board and students will be called upon to fill in the appropriate columns. This is the same format students will be using during their practical exercises in the village, and thus will serve as a useful preliminary activity.

"Planning"

OVERVIEW

Good planning proceeds from careful, continuing research and systematic record-keeping. As is stated in Chapter Two, planning must be done with farmers, village leaders, counterparts and government officials. The extension worker researches carefully and involves local people in planning to maximize local input into the decisions and plans which affect local life. (Consult the I.C.E. manual M-3, Resources for Development, for an in-depth explanation of project planning and resource management in extension work.)

How can local people be included in the planning process realistically? First, the extension worker must become fluent in the local language and comfortable working with interpreters. Language differences can provide a rich diversity of meanings rather than barriers to communication. Secondly, the extensionist should proceed slowly and plan to some degree informally in order to be accessible. It is important to maintain records in such a way that they can be easily shared. Extension workers should be sure to focus all plans on local people's goals, not on their own ideas. This will help local planners maintain interest. Concepts and ideas developed must be cross-culturally appropriate and understandable to local people. Lastly, the extension worker can develop a disciplined habit of always asking others to be a part of the planning process. This may help cultivate a new expectation among village farmers that they should be involved in planning.

Planning involves assessment of community needs and identification of the resources to meet those needs. This can be done using a list of questions the answers to which provide a community with the information it needs to design a project. The extension worker can play a part in articulating these questions. The list of questions is provided as a TOOL in this subchapter.

Planning also involves a selection process. Given the limited resources available to any community, priorities must be set as part of any plan for development. Priorities must be aligned with the interests of participants in a planned project and consistent with the goals and values of the local community. Prioritizing begins with a clarification of goals, values and participant interests. Then it involves brainstorming (listing without argument) alternatives. When goals are clearly understood, a list of best alternatives can be selected to act upon. Those of lesser importance are discarded, included in more important ideas, or held over for future consideration. These prioritized alternatives are often called objectives.

Once priorities are established they are broken down into steps or tasks. As described in Chapter Five, a practical task is immediate, specific and realizable. If it is a group task it also is unifying. By using the CO-WORKERS TOOL which follows, tasks can be assigned to specific people, times and places so a detailed plan of an activity can be kept. The specific responsibilities of each person are charted in this way, making evaluation easy. Just by going back over a task list of this kind a planner can see who did what, when and where and can assess progress toward a goal.

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EXTENSION PROGRAM PLANNING
(From USAID/Kenya Ag Extension Manual)

Analyzing the facts

Let us analyze some of the facts.

If the farmers were asked about the situation they would probably say for example, that coffee growing is becoming less profitable, and in part this may be a fact. A closer look at the situation will reveal other pertinent facts, possibly hidden to them. It is for this reason that the extension worker is needed. You can see things farmers are unaware of. They may not be in touch with world production figures. They may not realize that by increasing the amount of top grade coffee their profits on an equal yield can increase. They may not know how to increase top grades through cultural practices. Extension workers have the know-how. Farmers are not likely to be conscious of the effect of lower grades on the country's foreign exchange situation. These facts are known to the extension workers. For every situation there are basic facts which come to light when the situation is analyzed by the extension worker in cooperation with the farmer.

Identifying the problem

From the situation, the problems can be identified if the facts are properly analyzed. In the analysis above, it is clearly stated that top grade coffee production is declining. Fron the standpoint of the country, the problem seems to be a decline in foreign exchange due to decreased sale of premium priced coffee.

As an extension worker you realize that a decreased premium grade can be caused by poor cultural practices and processing. If the farmer has not been trained to use improved practices he fails to understand why his profits are declining. The role of the extension workers becomes quite clear.

When all of the problems have been identified the next step must be undertaken.

Establishing the objectives

We know where we are by studying the situation. The objectives tell us where we want to go. If grade one coffee is found to be 40% of the total production and we want it to be 100% that would be our objective - to increase grade 1 coffee from 40% to 100%. Although admittedly such a goal would be extremely desirable, it may not be realistic. There are several requirements for setting up good, realistic objectives. They must be attainable. We might be able to increase Grade 1 coffee from 40% to 60 or 70%, that would seem realistic, and consequently more attainable. Having set figures, it gives us something to measure. Just to say: "Increase Grade 1 coffee", is not measureable. We can determine from production figures an amount such as 10 or 20%; that is something measureable. The objective here is to increase grade 1 coffee production. The goal is to increase it some definite amount, 10 or 20%. If the farmers can be made to understand what we are aiming at and what is required to achieve it,

What is Agricultural Extension Program Planning?

It is an outline of activities to be followed by extension workers and farmers toward solving a problem the farmers want to have solved.

NOTE: It has been stated that the problems are those that the farmers want to have solved. Before problems can be solved it is necessary to have a mutual understand of what the problems are. We are walking on dangerous ground when we assume we know what are the farmers' problems. At one program planning session, a group of agriculture officers decided that the cotton farmers' biggest problem was in harvesting the crop. An interview with several of the typical, local cotton farmers revealed that they were more concerned about getting insecticides at the right time and of being able to pay for them. Had the officer group proceeded to plan to solve the harvesting problem, the farmer would probably have lost interest in the final program because it would not have met their most important felt need. We must not presume to know what the problems are until we have the facts to support our appraisal. The use of a systematic approach will strengthen a program with facts.

The Scope of a Program

Before proceeding, there are some important questions to be answered. Who develops this program? It is a task of the extension worker to write down the program, but it must be developed with the farmers, to help them solve their own problems, using your assistance. Not only must it meed their needs, but it must met those of the local area, district and the nation. Should these basic requirements not be met it will be your program and you alone will not be able to carry it through. Thus a well planned program is broad-based and meets the needs of a large number of people. By proceeding one step at a time we can achieve that objective.

A System for Planning Programs

A large number of facts are needed before we can draw conclusions as to what are the problems. We need to know the situation before we can make an appraisal.

The situation

We collect and analyze facts to understand the situation. A study of the situation for one crop will serve as an example for a typical approach.

(Extract from the Kenya Development Plan, 1966-70, pp 53-55)

"Coffee has been one of Kenya's principal export crops for many years. It has enjoyed a considerable share of the world market. This share has been as much as 36% of the total market and not less than 17% since coffee was established in Kenya. The world supply is in surplus, thus competition for the market is increasing. New plantings have been stopped in view of the situation, consequently any increased production must come from the acreage already planted.

"The high quality of Kenya coffee gives it an advantage in competition for the world demand. Unless this quality is maintained it may lose this advantage. Over half of the 250,000 small growers in this country have had little

the objective and goal are understandable. Every objective must be written so it can be understood by those who are to achieve it.

Before an objective will be achieved, it must be desirable. The fact that coffee is paid for on a grade basis and because Grade 1 coffee commands a higher price, you have good reason to assume that it will be desirable.

We can only be sure an objective is desirable when are are certain that the returns are in balance with the effort required to achieve that objective. Further, the increased returns must be wanted enough to cause the farmer to expend the necessary effort. It may require a great deal more effort and expense on some farmer's part to much mulching material for his plantation, if mulching is a requirement for producing an increased amoung of high grade coffee.

Objectives which meet all goals are better founded than those which only partially meet a few. If increased top grade coffee production benefits the nation, the province, district, division and the farmer as well, there is more reason to believe it is to be achieveable than if it only benefits the country at large

When setting up objectives it must be kept in mind that their function is to change the situation from what it is to what is desired. There are three means of moving in the direction of achievement. We, as extension workers can change knowledge, attitudes and skills. Some times all three factors must be changed to achieve an objective.

Determining the solution

Solutions must relate to objectives and the objectives must relate to the problems. We are likely to find some problems which have no immediate solutions. If world markets are flooded with commodity we may not be able to solve their problems. The only possible alternative might be to increase quality and efficiency, thereby becoming more able to compete with declining prices. We may be able to eliminate East Coast Fever in cattle, but we do have a relatively effective control. Even then the alternative solutions must be economically practical. Furthermore, the solutions must be throughly understood before the desired results may be realized. This often requires educating the farmers in the use of the new methods. Our job as extension workers is to teach new and improved methods.

Selecting the methods

When known and practical solutions exist the methods of getting farmers to adopt the practices must be chosen. The more times people are exposed to a new idea through a variety of channels, the more likely they are to adopt the idea. This can be taken to mean that if you use radio, newspapers, meetings, and demonstration, the farmers are more likely to adopt the idea than they are if you reach them with a single method.

Farmers must pass through five stages of adoption before the idea is accepted. If they are not aware of the idea, they will never become interested. If they are not interested, they can't evaluate its usefulness. If they don't evaluate it, they will never try it. If they never try it, they certainly won't adopt it.

These five stages of adoption are as inseparable as the links of a chain. Adoption takes place only after people have successfully passed through the five stages.

The written plan

The written plan for extension program planning can be referred to as the Plan of Work or the Calendar. Which every you prefer to call it, one important feature is that it must be written. It must also include the thinking of the farmers. Involve people in the planning, the operations, and the final evaluation, otherwise, it will be your plan and only yours. Design it so you can say; This is our plan, not mine. A good plan designates responsibilities. It tells who will be responsible for what, how, when and where. Consequently, we plan with people, not for them.

A good program

A good program can be measured by its characteristics. It develops leadership if you plan with people. The leaders come to the top when given the opportunity to participate. Their usefulness to you and the program is almost unlimited. A part of your job is to recognize leaders and to make use of their qualities. It has long been known to extension workers that the local leader has more influence in getting farmers to accept new ideas than has the worker himself.

A requirement of a good program is that it is family directed. In countries where women commonly cultivate the crops it would be a mistake not to include them in the program plans. Demonstrations in the field or courses at farmer training centers may be designed to include them. The importance of youth's influence must be considered when it is known that they are less resistant to change than their parents. Many new ideas are accepted by the parents after seeing their children successfully adopt practices. A program is destined to fail if the women and children who grow and harvest crops reject the idea of planting them.

Who participates?

Certainly the farmers must participate because it is their program. Among the farmers are the local farm leaders. They will be your must useful participants. You, as an extension worker will take a leading role in the plan of action. You give it direction. The district and provincial staff provide coordination by assisting you in making it possible to get seed, insecticide, fertilizer and other materials and assistance beyond your reach. They also coordinate activities from your level up to the national goals. Specialists are needed to help solve problems for which they are more capable and better trained. Others who may be needed are supply house representatives, chiefs, sub-chiefs and occasionally officers of the administrative branches of government. The more people you involve the greater are the chances for a successful program.

Evaluation

Evaluation, the observed measurement of the planned program, must be continuous at every stage of operation. As each planned action is completed, the results must be examined against the objectives of that action. If the activity was successful we should be able to describe <u>why</u>. Equally, if the action was not

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successful we should also be able to note the reasons. Only then can an extension service be truly effective.

Evaluation at any stage may affect the future planned program actions. More activity in the form of demonstrations may be needed; more information media may need to become involved to reinforce the presentations, or it may indeed be that the rate of programmed improvement is faster than anticipated. Source of the features of the plan can be modified as evaluation suggests.

Progress reports at all levels are based on these evaluations; in fact the evaluations are the progress reports.

The Action

The best written program plan is only a piece of paper until it is carried out by action. Hanging it on the wall for all to see creates an interesting room decoration, but it remains only that unless the actions planned are carried into the field. The program plan is your working plan and it must be worked to be valuable.

PLAN YOUR WORK - WORK YOUR PLAN.

LESSON 4 : HOW TO WRITE A PROGRAMME PLAN AND CALENDAR OF WORK

TIME : 2 Hours theory
10 Hours practical

OBJECTIVES :

a.Students will be able to write situation statements that are clear, detailed, and documented.

b.Students will be able to write objectives that are specific, measurable and realistic.

c.Students will be able to write activities that are comprehensive, yet specific, that specify who is responsible, and that will reach the objectives set.

d.Students will be able to develop a suitable calendar of work.

ADVANCE PREPARATIONS:

--Make forms available to students for writing programme plans.

--Have samples of good and bad situation statments, objectives and activities available. These could be displyed on an overhead projector.

--Students should have their own 8 week practical data tabulated, analyzed and ready to use in writing programme plans.

LESSON CONTENT:

We already noted that necessary components of a programme plan include:

- -A situation statement
- -long range and annual objectives
- -activities.

If space allows, it is wise to have an evaluation or report column on the same page as the plan (see Appendix A). Other information, such as funding and staffing requirements, is sometimes required. In fact, specially funded projects may require a special and different format.

In this lesson, students will study and practice writing each of the major component parts of a plan. Also, each student will select one extension programme useful to the village he/she surveyed, and write a complete programme plan for it.

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PLANS FOR PRACTICAL: **WRITING SITUATION STATEMENTS**

TIME : 2 Hours

SUGGESTED PROCEDURE:

-Review the lesson content with the students
-Show students examples of good and bad situation statements.
-Have students improve one or more poorly written situation statements. Collect and critique these statements.
-Have students write a situation statement based upon information the tutor provides to them. Critique several sample statements written by students, then return all the statements to the students for rewriting. (See Appendix A for a few samples).
-Have students write a situation statement based on their village data from the 8 week practical. Collect and assess these. Let them see the assessment scheme.

LESSON CONTENT

The Situation Statement

For each extension programme, one must write a clear, detailed and documented statement of the problem and its potential solution. Vague statements and unsupported opinions are indicators that programmes are being selected and planned on the basis of unchallenged and unverified assumptions. This is very risky. It is the reason many programmes fail. Facts and figures are needed. If one lacks facts, he probably shouldn't initiate a programme, but rather should collect further information.

The situation statement describes:

1.the severity of the problem

2.actions already taken, and

3.possible solutions. (See sample statements in Appendix A).

ASSESSMENT SCHEME FOR SITUATION STATEMENTS

	Possible points
-The statement contains:	
1.a description of the problem or constraints,	
2.action already taken, if any	
3.probable solutions	20
-The statement is clear detailed and documented vs. vague, general and based on unproven assumptions	50
-The statement makes a strong case for action to be taken	20
-The statement is well written (uses good English or Kiswahili)	10

	100

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PLAN FOR PRACTICAL: WRITING OBJECTIVES

TIME : 3 Hours

SUGGESTED PROCEDURE:

-Review Lesson Content with students
-Show students examples of good and bad objectives.
-Demonstrate how to improve the objectives appearing in the exercise in Appendix B and have students do the exercise (30 minutes). Collect and critique the students' work.
-Have students write objectives (long term and annual) based on their village data, from the 8 week practical. Collect and assess these.

LESSON CONTENT:

Programme Objectives:

Objectives tell us and others what we want to accomplish. They should :

- Be specific (tell what, when, where, how much)

- Be measurable (for example - increase ward maize yields 30% by 1986).

-Be realistic

-Provide a means for evaluation. (for example, if the objective is improved leadership it might be indicated by increased meeting attendance, amount of discussion at meetings and problems solved. These could be used as a basis for evaluation.)

-Be expressed in terms of changes to be brought about in people. Desired changes are often stated in terms of knowledge, skills, attitudes, yields, etc. Seldom should they be expressed as numbers of extension activities (eg.100 farm visits).

-Include purely human development objectives (give examples), also organizational improvement and staff development objectives where these are important.

-Include women and children.

ASSESSMENT SCHEME FOR OBJECTIVES

	Possible points
-The objectives are aimed at solving the problems mentioned in the situation statement and are compatible with the probable solutions.	10
-The objectives are realistic.	20
-The objectives tell what, when, where and how much.	30
-The objectives are expressed in outputs such as yields or changed behavior, never in activities.	10
-The objectives are measurable and specific. (Example: X will happen by .....date or X will happen, as measured by.....).	10
-Human development objectives are included (Example: training, awareness, etc.).	20

	100

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PLAN FOR PRACTICAL : WRITING ACTIVITIES (PLAN OF ACTION)

TIME : 2 Hours

RECOMMENDED PROCEDURE:

-Review the Lesson Content with the students.

-Have students practice improving the "activities" which appear in the exercise in Appendix B. Demonstrate techniques for improving the first 2 or 3 activities, have them practice on the remainder, then hold a critique of their work.

-Have students write activities for their own programme plan. (Based on 8 week practical data). Collect and assess the students' work.

LESSON CONTENT:

Extension Activities

--Activities are our means of reaching objectives.

--Numerous activities are normally directed toward reaching an objective. These should be stated in detail (what, when, where, how much and who is responsible). We need to repeat ideas and reinforce experiences in order to move farmers from initial skepticism to acceptance of a new way of doing something (adoption).

--The activities typically specify a method (Example: visit farmers, demonstrate fertilizer response, conduct six meetings, obtain technical assistance, help village leaders procure inputs).

--Multiply your efforts by building many people into your plan of action.

--Use a numbering system that indicates which activities go with each annual objective. This insures you don't forget to deal with each objective. See the example in Appendix A.

ASSESSMENT SCHEME FOR WRITING ACTIVITIES

	Possible points:
-There are adequate numbers and appropriate types of activities planned to reach each objective	40
-The activities show what, when, where, how much and who is responsible as opposed to being general and vague.	30
-The activities are usually expressed in terms of extension methods (Example: conduct 6 meetings).	10
-The activities indicate that farmers and others will participate in the extension programme.	20

	100

PLAN FOR PRACTICAL : DEVELOPING A CALENDAR OF WORK

TIME : 3 Hours

RECOMMENDED PROCEDURE:

Have the students construct an annual calendar of work from the programme plans they have developed. See samples in Appendix A (1 hour).

LESSON CONTENT:

The Calendars of Work

A calendar of work places all the activities in an extension worker's various programme plans into a single calendar sequence. While each individual programme plan helps us to see each programme as a whole, our calendar helps us to quickly see the work we must do during any particular period in all programme areas. This is a necessary time management tool. One should be written for each year and one for each month or quarter. Calendars of work need to be added to and updated continuously because details change and are confirmed as the time of an activity draws nearer.

Every planning unit (village, district, etc) should produce an annual calendar showing approximate dates for major extension assisted activities to take place. If too much work falls in one period and none in another, some changes in timing or even types of programmes may be required.

A copy of the annual calendar of work should be attached to the annual programme plans when they are submitted to one's supervising officer and one copy posted in the extension office for reference.

The monthly calendars of work should specify the days on which activities are to occur. At least 2"x 2" of space per day is recommended. Start filling in events on new calendars as soon as their dates are set. Save expired calendars for the record of activities they provide.

ASSESSMENT SCHEME FOR ANNUAL CALENDAR OF WORK

	Possible points:
-All major activities shown in the programme plans are listed on the calendar.	50
-Entries represent the full range of roles an extension worker has.	10
-The activities are specific.	10
-The activities are allocated to the week or part of the month when they will be accomplished. Most activities cannot be assigned yet to the day or hour.	10
-The calendar has adequate space to make the needed entries.	10
-The calendar is neat and attractive.	10
	100

REVIEW OF KEY POINTS FOR LESSON 4

--Situation statements must be clear, detailed, and documented. If one cannot document the problem, he/she hasn't collected enough information to justify the selection of extension programmes.

--Long term objectives (one to several per programme) and annual objectives (one to several per long term objective) must be specific, measurable and realistic.

--Extension activities are our means to reach objectives. They must be numerous and specific. They should specify what, how many, when, where, how and by whom.

--The components of a programme plan are inter-related. One component flows out of the previous component. (Eg: objectives from the situation and activities from objectives.) Note how the numbering scheme on example plan number 1 in Appendix A ties objectives and activities together.

APPENDIX A (Continued)

Part 2 -

Month of JANUARY

ANNUAL PROGRAMME CALENDAR FOR [illegible] VILLAGE 1984

SAT	SUN	MON	TUE	WED	THU	FRI
	1	2	3	4	5	6
		Demonstrate weeding with ox-cultivator on 4 fields.			(with committee) →	
				Supervise fertilizer application s on cotton demo. plots		
	8	9 Supervise staking tomatoes in communal plot Speak at village meeting. Survey plans and plow parts needed.	10	11	12 (Help committee. Place signs on cotton demonstrations)	13
14	15	16 Check up on irrigation Committee's Progress. Select trainees for ox cultivation demonstrators Make 5 farm visits per day to teach farmers and make a survey of maize cricket & bean beetle.	17	18	19 Potato beetle control Observe spraying & assist farmers)	20
21	22	23 Plan with village ag committee about crop storage for upcoming crop.	24	25	26	27
28	29	30 Start a record of farmers who weed & don't weed. Compare with yields at end of season.		write a monthly report	Visit District Office for monthly training & supervision. Check on storage facility funding. Check up on insecticide delivery. Visit Research station for fertilizer info.	

SAMPLE NUMBER 1

EXTENSION PROGRAM PLAN # 5 FOR YEAR 1982

MLALI WARD, MPWAPWA DISTRICT, DODOMA REGION, EXTENSION WORKERS: ....., ..., ..., ...,
NAME NAME NAME NAME

EXTENSION PLAN FOR: Range Destocking

SITUATION PROBLEM	LONG RANGE OBJECTIVES:	ANNUAL OBJECTIVES	ACTIVITIES TO REACH OBJECTIVES:	DONE	ACCOMPLISHMENTS
There are 101,000 cattle, and 42,000 sheep and goats in the Mpwapwa District, grazing an area of 83,000 Ha. (1.4 AU per Ha.) The range has deteriorated rapidly in recent years to a point where shrubs and leafy annuals dominate. (80% of total cover.) The offtake of TDN is ESTIMATED BY FINCH TO BE 13% of what it would be in climax condition. Erosion is serious in spots. Cattle are sold or butchered at an average weight of 359 Kg after 5 years growth. Thus they consume 3.2 times the food necessary to raize an animal to this weight if done in 2½ years (where abundant food is available). 50% destocking could increase the offtake of meat by 3.7 times within 10 years (see the Finch report, 1967). Cattle distribution would improve if water was more widely available.	1. To develop a keen awareness of the importance of range management among the people (as measured by their expressions and actions). 2. To develop knowledge and skills about range management (to be measured by informal questioning at meetings and at farm visits as well as by actions). 3. To destock 20% by 5 years, 25% by 10 years and 30% by 50 years. 4. To increase offtake of meat by 15% in 10 years and 100% in 50 years. 5. To reseed 2% of the range in 5 years. 6. To develop 13 stockponds or wells in 10 years.	1. To convince the local leaders of the importance of range management practices and of the great potential of increased off-take (measured by the leaders' willingness to persuade others). 2. To develop some general knowledge about how to manage ranges among leaders and others. 3. To develop preliminary plans for a destocking program and gain support for them. 4. No effect this year. 5. & 6. Create interest in reseeding and water development among leaders (measured by their willingness to develop a plan and request government financial support (in January 1983).	1. (a) Continue to make home visits to leaders in 8 villages to create interest. January-March. (b) Tour an improved range site with leaders. March - April. (c) Meet with 9 village Production and Marketing Committees. April - May. 2. Discuss principles of range management during all home visits & meetings. January-December. 3. (a) After gaining approval (legitimacy) from leaders & supervisors to engage in destocking, & after getting leaders' separate ideas, develop a tentative plan of action with Production & Marketing Committees & District Committees by July. (b) Discuss the plan at 3-6 public meetings. Collect ideas for improvement of the plan. Sept - December. 4. - 5 & 6. Part of activities 1 & 2.		1. (a) 23 home visits were made in 9 villages about this program. (b) 14 leaders visited a village where stocking rate has been proper for past 4 years. Visited climax sites at Kiboriani and at airport. Very impressive to villagers. These leaders agreed to push for destocking in this district. (c) Met with 5 committees good discussion but continuing opposition. 2. Done during the 23 home visits, during the Production and Marketing Committee meetings and during the tour. 3. (a) Support gained from 14 leaders, 4 undecided, 5 against. CCM & Committee members all favorable. Ideas were compiled and a plan developed. Plan approved by District Development Committee. (b) The plan was discussed at only 1 public meeting. Lack of time and transport. 4. - 5/6. Did not get to this step.

(Fictitious plan written by L. Pickett while teaching at MATI Mpwapwa in 1977.)

SAMPLE NUMBER 2

A PROGRAMME PLAN FROM KENYA[1]

Problem	Objectives	Plan of Action	When Days	Persons Responsible	Evaluation
Farmers are not aware of the advantage of using hybrid maize seed and fertilizer, consequently many are still planting their native seed which yields about 5 bags per Ha.	To teach farmers to use hybrid seed and fertilizer to be able to get 20 bags.	Staff meeting to organize details	Early Dec.	DAO & Staf	Feedback from officers. Plans for Jan. 16 meeting discussed Poster being designed to show value of hybrid seed by AIC.
		Meeting to introduce idea of growing hybrid maize. Have native and hybrid seed cobs. Handout details for planting. Use farmer testimonials. Get estimate of seed and fertilizer needs.	Mid-Jan.	DAO down thru AAI to farmers	Meeting held Jan. 15. Over 250 farmers on hand. Maize planting demonstrations announced. Farmers related experience with hybrid seed. Created great farmer interest. Got farmer commitments for seed and fertilizer needs for 2350 acres. Suppliers notified. Got seed and fertilizer commitments earlier next year. Suggest refresher course for TAs and ATAs.
		Maize planting demonstration announcement by chiefs at market. Use posters	Mar. 1st	DAO thru AIs to farmers.	Attend chiefs meetings. Talk with local leaders and farmers. DAO spoke at 3 chiefs barazas* 175 posters placed.
		Conduct method demonstration on planting and fertilizing hybrid maize. Recognize the cooperating farmer. Plant half acre native seed for check plot.		DAO thru AAIs on a farmer's Shamba.	Mobile van called in to create interest. Questions and answers from the farmers. *Farmer worries about price . 12 result demonstrations. Ongoing radio announcement made about demonstrations. Next year, organize FTC course for farmers. Response to mobile cinemas indicate need for increased van use.

1 - Taken from, Agricultural Extension Training, by J.D. Fisher, R.A. Wesselman and others, USAID, Nairobi Kenya, 1968.

Problem	Objectives	Plan of Action	When	Days	Persons Responsible	Evaluation
		Farm visits to assist farmers with planting. Note problems.	April		AI and AAI	Report findings of visits to DAO. TAs report hybrid seed plantings up 35% in area. *Rains arrived. Most plantings made in good time. Next year use van before planting.
		Farm visits to check progress. Note pests and other problems. DAO makes a few visits. *Suggest sample form of reporting.	March 15 to June 10	5	AI and AAI	View growth and note plant progress. Compare native to hybrid growth. *Rains appear to be normal. Test plots look promising. Farm plots appear normal. Dusting demonstrations 15. Insect presence normal.
		Announce yield inspection meeting through chief. Use posters	Aug/ Sept	1	DAO to chief.	Note response of chief and a few successful farmers. *Farm tour conducted from 3 locations. Expand number of tours next year. *Posters attracted much interest. Expand use of posters next year.
		Hold meeting to inspect yield. Display yields. Make comparison of hybrid plots. Use farmer testmonials, photos recognition, speech by public officials, press release, radio spots, announce expansion plan for next year.	Sept 15	1	DAO supported by full staff.	*Native test plots averaged 7 bags. Hybrid plantings averaged 18 bags. Test plots averaged 21 bags. Next year give more emphasis to storage problems. Attendance, satisfaction of adopting farmers, increased yield estimate. *DC awarded 50 farmers achievement certificates for yields of 25 bags. *Plans for coming year announced. *Radio release announced program a success.

Problem	Objectives	Plan of Action	when Days	Persons Responsible	Evaluation
					*PAO gave talk at final meeting. *Article appeared in the planning period. *Higher yields more than offset lower prices. *Encourage attendance at final meeting by VIPs.

*Items indicated find evaluation results.

Sample 3

FARMER TRAINING AND PRODUCTION PLAN (OVERALL)

Period covered: _____

Farmer Training Wing: Uvole Agricultural Centre

SITUATION	LONG TERM GENERAL OBJECTIVES	WORKING OBJECTIVES (This Year)
Interviews with 237 men and 196 women in the five FTP villages have directed attention to the major constraints in farming. They appear to be 1) labor, especially in land preparation and weeding operations 2) technical knowledge of vegetable and potato production, particularly among women 3) inadequate supply of inputs such as fertilizer, pesticides, seeds and oxen equipment. The on-farm labor problem is exacerbated by time spent by women in collecting firewood (often necessitating one day's trek to the Usangu plains) and in grinding maize.	To support oxen traction To demonstrate approved practices in vegetable, potato and maize production to women. To reduce the labor load on women	Establish 5 ha. demonstration pastures (zero-grazing) in each village. To assist farmers in the repair and acquisition of farm equipment To test the use of a UAC row-weeder in the villages To provide training in animal traction and animal care To establish 2 ha. communal plots which will be used by tutors as land laboratories To provide new varieties of beans & maize for production and palability testing by women To demonstrate the use of urea, especially in maize. To establish tree nurseries in two villages to serve future forestation In the five villages. Increase the number of grinding mills in assisted villages by helping leaders to acquire loans.

Sample 4: EXTENSION PROGRAM PLAN FOR CITRUS PRODUCTION PROGRAM Year 1982/83
F.T. WING - MTWARA

Persons responsible: Mlozi, Mtukwe, tutor of Hort, Ag Research representative,& representative from DADOs office

SITUATION (PROBLEM)	LONG RANGE OBJECTIVES	THIS YEAR'S OBJECTIVE	ACTIVITIES TO REACH OBJECTIVE
1. Researchers confirm and home visits and personal observations have verified that citrus grows well, but farmers have little interest in its husbandry.	1. By the end of 1983 90 farmers will know the importance of good husbandry - use of proper varieties, use of manures and commercial fertilizer when planting, control of insects and diseases.	1. Same as at left	1. Plan and sponsor a 2 day citrus production short course at the Wing for 90 people in 4 groups Make a plan for post-course action (by farmers and extension workers)
2. Sources of vitamin C among farmers in Mtwara area are scarce since the presently raised citrus receives little or no care and hence has low production.	2. By the end of 1983, each of 90 farmers who attend a short course will have grown 5 citrus trees of different varieties.	2. At least 50% of farmers attending short courses will grow citrus in their backyards by the end of this year.	2. Meet with village leaders to assess the type and number of citrus trees required in each village.
3. There is a great demand of citrus products in villages and towns.	3. Production of pawpaw will increase, 50% in the 6 project assisted villages by 1986.	3. 500 new pawpaw seedlings will be planted in the 6 villages this year.	3. Liaise with the RADO/DADO on the acquisition ofcitrus seedlings.
4. There is a district citrus nursery around Mtwara which is stocked with seedlings for distribution. (Nachenjele).			4. Meet with crops tutors to see where students can assist.
			5. Follow-up in villages by conducting group discussions. making home visits and providing direct assistance to farmers
			6. Show pictures and charts of successful citrus production at the Saba saba celebration.

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APPENDIX B : EXERCISE AND DISCUSSION PAPER FOR WRITING OBJECTIVES AND ACTIVITIES FOR AN EXTENSION PROGRAMME PLAN

(For use in Lesson 4 practicals)

I.Exercise on Objectives

Keeping in mind the criteria for good objectives, especially specificity, measurability, and realism, improve the following objectives. Add additional words where needed, delete or change where needed.

A.Long Range Objectives (District Level)

The original objectives are shown first and improved objectives and comments are shown second for the benefit of the tutor.

1.To castrate more cull cattle each year. **(too vague)**
Improved : By 1988, farmers in the district will increase the castration of male cattle from the present 15%. Or by 1988, 50% of livestock growers will be castrating their non-breeding stock.

2.Increase the district's milk production by 15%. **(no target date)**
Improved: By 1990, 100 livestock keepers will be involved in the small-dairy project and will be obtaining a 100% increase in production, or 4.8 liters per day.

3.By 1984, increase the peoples' awareness of nutritional requirements of pregnant and lactating mothers.
Improved: Add - This will be indicated by changes in diets noted between the pre and post-project surveys.

4.By 1985, all livestock keepers will be using animal manures on crops . **(too idealistic)**

5.By 1986, farmers will have reduced losses of grain in storage by 50% **(unrealistic goal)**

6.After five years, the district's farmers will have gained the confidence and ability to solve many of their own problems, as noted in their daily operations. **(Not readily measured, but this may be the best that one can do with this type of objective).**

7.Farmers receiving training will understand the plan-

ning and record keeping process.
Improved: 20 farmers will keep farm records by 1986.

8.To conduct demonstrations in every village once each 5 years. **(This is an activity not an objective).**

B.Annual or Present Year Objectives (District Level)

Make The Corrections Needed:

1.Make land use maps of X, Y, and Z villages.
Comment: This is acceptable. It tells us what, where and how much. We know when, because this is an annual objective.

2.To vaccinate the villagers' cattle when disease outbreaks threaten.
Improved: Prevent disease outbreaks from occuring by vaccinating exposed cattle.

3.Train farmers from six villages in farm record keeping.
Comment: This is an activity. It would be better to identify expected end results. Example: Farmer will keep farm records.

4.Assist researchers to find improved varieties.
Improved: To initiate verification trials on maize in 2 villages with researchers.

5.Improve cassava yields.
Improved: Increase district yields of cassava from 2.7 to 5 tons per acre in 10 years.

6.Develop the leadership skills of all people involved with extension projects.
Comment: Although this objective is general and vague, it could be allowed as a reminder that in every activity, we extension workers need to develop leadership.

II.Exercise On Activities

Improve the wording of the following "Activities," if needed, or comment on them. The activities should be specific; i.e. state what, when, where, how many and who is responsible.

1.Visit leaders to convince them to support a wood lot project.(March - April).
Rewrite: Visit six leaders in March - April to convince them to support a wood lot project. (Bwana Shamba and Production and Marketing Committee chairman).

2.Establish 6 grass variety demonstrations in January (Ward Bwana Shambas)
Comment: Quite good. Change to: (Ward Bwana Shambas and villagers).

3.Conduct a 2 day short course for all 10 cell leaders on livestock management.
Comment: Add - (November) (Bwana Shamba and Livestock specialist).

4.Reduce grain storage losses (Nd. Jamal)
Comment: This is a poorly written objective, not an activity.

5.Teach the Production and Marketing Committee members how to plan while meeting with them regularly. (All Bwana Shambas)
Comment: OK as it is.

6.Procure feed supplements for the farmers.
Improved: Assist livestock keepers to obtain feed supplements by going to the oil factory in March to arrange monthly purchases. (Bwana Shamba and Livestock Committee)

7.Tell farmers how to store grain (March) (Bwana Shamba).
Comment: Tell is neither a good term nor a wise approach. Use an appropriate extension method, eg.conduct one demonstration per village on grain storage (February) (3 extension auxillaries, Bwana Shamba and Production and Marketing Committee chairman at each village).

8.Conduct a demonstration on each of the 35 10 cell leaders fields (November) (Bwana Shamba).
Comment: This is probably more than can be acomplished.

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LESSON 5 : PROGRAMME EVALUATION

TIME : 2 Hours theory
3-6 Hours practical (Tutors choice based upon local opportunities)

GOAL :

Students will understand the purpose of evaluation, when to do it and how to do it.

ADVANCE PREPARATIONS:

Collect samples of good and bad programme objectives

LESSON CONTENT:

1.When to evaluate

--At the end of each programme year.
--At the end of a major project or campaign, especially funded ones.
--At the completion of each activity or event.
--Continuously. One should be constantly alert to what is working best, what worst, noting why and making corrections in implementation.

2.Purpose of Evaluation

--To improve our future effectiveness by modifying our programmes or methods as needed. Evaluation may be able to show why we are failing or succeeding. (Give examples to students).
--To provide information for reporting
--To meet the requirements of a project
--To justify further funding
--To satisfy scientific inquiry
--To motivate and teach the people involved

3.How to Evaluate Programme Success

--Evaluation normally starts with the collection of the information that is needed to compare the situation at the conclusion of a period, project, or event, with the situa-

tion at the beginning. Objectives should indicate what information is required. If our objective was to promote the use of oxen plowing on 5% of village acreage, we need only know the amount (and thus %) of land plowed with oxen after intervention. If the objective were to increase the amount by 5%, then we need acreage both before and after intervention. If we set out to put 100 new plows into use, our evaluation will be easier yet.

--As we saw when we studied objectives, we sometimes have to rely on indicators of qualitative improvement. If one sets the objective "To increase farmers' self reliance" he/she should have also determined the indicators. For example, one might have added to the objective "as measured by the increase in direct actions taken by village committees, by an increase in contacts outside the village," etc.

--Evaluation is the measurement of results. But it should also include a determination of why we failed or succeeded. We will study this in Lesson 7.

--Once our information has been collected extension workers, their supervisors, advisory committees and task force committees should compare accomplishments against the objectives set and activities planned in the annual extension plan (or in the project paper, or in the committee minutes). This can be done only if:

1.the objectives and activities were measurable and specific,and

2.the necessary data is available for the periods both before and after intervention.

--At annual programme planning meetings or at committee meetings, the chairman should ask participants (recipients) to discuss programme sucesses and failures for the past period. Consider "why?," then plan ways to do better next time. The discussion leader must ask numerous and specific probing questions.

--Persons in charge of events should ask for feedback from participants attending and participating in each events (example: have them evaluate their 2 day short course or demonstration). This helps an extension worker to improve his/her methods.

--At all times, the extension worker should observe critically, ask questions and take notes.

4.Potential problems in evaluation

--Problems of assuming cause and effect. Did extension services cause a crop yield increase or did they fail when

there was a crop decrease? Typically, many factors influence crop yields. Many are completely unrelated to extension interventions. So, instead of setting an objective to increase village maize yield by 10%, one might specify: "15% of the village farmers will use the recommended package of practices on maize." Use of recommended practices will be influenced primarily by extension and can be considered a result of extension intervention. The yield of maize itself might be influenced mostly by drought or other environmental factors.

--Evaluation can be time-consuming. One must build into his plan the use of those indicators which will be time efficient.
--One can get unintended outcomes from interventions. These can be positive or negative. If significant, they should be measured and reported.

[+Tutors are alerted that Lesson 7: "Using Plans and Reports as Management Tools," is very pertinent to evaluation and contains a brief practical exercise+]

A REVIEW OF THE KEY POINTS FOR LESSON 5:

--Good extension programme plans make good evaluation possible and vice-versa. The objectives especially must be specific and measurable.

--Evaluation must be planned and implemented as part of the programme activities in order to ensure that it will occur in a thorough and timely fashion.

--Evaluation is not possible without adequate information on the period both before and after extension intervention.

[+Discuss with students how each of several sample objectives provided by the tutor might be evaluated, and how the objectives could have been written to make them easier to evaluate+]

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LESSON 6: : REPORT WRITING

TIME : 1 Hour theory,
6 Hours practical

GOAL :

Students will know the types of reports required of extension workers and know how to write them.

ADVANCE PREPARATIONS:

-Collect samples of the types of reports which are expected of extension workers.
-Consider asking the RADO or DADO, who was used as a guest lecturer in Lesson 1, to discuss reporting with the students (one visit can cover both topics)
-Prepare a practical on report writing

LESSON CONTENT:

1.Annual Progress Reports

One's written end-of-year progress reports should report on the basis of the objectives and activities shown in his/her extension programme plans. For each plan, one should report the following:

-Were the annual objectives reached? Why or why not?

-Were the planned activities carried out? Why or why not? With what results? What lessons were learned?

-Recommendations for the conduct of this programme next year.

2.Crop and livestock data reports

These reports are necessary for higher level planners. They must be submitted on time. Make the surveys necessary to collect reliable data and then fill in the forms.

Do not accept a farmer's statements of yield amounts, field sizes, etc. Use your own judgement and the judgements of others. Take yield samples or other measurements to improve your judgement. Such techniques will help one to improve his skills in estimating field sizes, yields, etc.

3.Special Reports:

(Information about special reports required of extension workers is to be provided by RADO, DADO or Tutor).

PLANS FOR PRACTICAL: WRITING PROGRESS REPORTS

TIME : 6 Hours

PROCEDURE:

-Review the characteristics of a good progress report.

-Show students samples of progress reports. Discuss their strengths and weaknesses.

-Have each student write a hypothetical progress report for the programme plans they wrote earlier. This report should include progress on each programme objective and be based on information gained during their 8-12 week village assignments. Estimate what the outcomes may have been and write a report based on them.

ASSESSMENT SCHEME FOR WRITING REPORTS:

	Possible points:
-The report concentrates on describing the extent to which annual objectives were reached.	40
-When objectives were not reached, the report explains why.	10
-The report specifies which activities were carried out and which activities were not carried out, and notes why in each case.	20
-The report notes lessons learned and recommendations for the next year.	30

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LESSON 7: : USING EXTENSION PLANS AND REPORTS AS MANAGEMENT TOOLS

TIME : 2 Hours theory
3 Hours practical (tutors choice)

OBJECTIVES:

-Students will be able to identify some of the weaknesses in the plans and in the implementation strategies of case studies (sample plans and reports provided to them by the tutor).

-Students will be able to recommend improved extension strategies for these case studies.

ADVANCE PREPARATIONS:

-Make copies of several extension programme plans and related narrative reports of accomplishment.

LESSON CONTENT:

1.The Supervisory Follow-up Meeting

-We have written plans, evaluated progress, and written reports for good reasons. These are management tools that can tell us a great deal. Supervisors should call subordinates in one at a time for in-depth discussion of their reports. With a subordinate's plan and report in hand a supervisor can ask probing questions to uncover good or bad extension techniques, good or bad work habits, faulty assumptions, etc. Together, they can then devise ways to reduce the weaknesses and make use of the strengths next period. Good programme planning, good evaluation and supervisory follow-up make extension workers more accountable and more successful. Nothing less will do.

-During the end-of-year evaluation session with a subordinate, the supervisor should encourage self evaluation. He should emphasize programme strengths and weaknesses more than personality and personal habits. However, a supervisor should not refrain from pointing out where a change in personal behavior may increase programme success.

2.Possible Reasons For Not Reaching Objectives:

a.Poor Planning

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-Objectives were not realistic .
-The activities planned were not sufficient to accomplish the objectives.
-The programme was built on false assumptions, that is, the cause or solutions of the problem were misjudged.
-The recommended practices were not truly beneficial to farmers.
-There was no significantly improved technology available.
-The programme was not based on a felt need.
-The people affected did not adequately participate in the planning.
-The required inputs were not available.
-Inputs or other requirements were not available only because they were not planned for far enough in advance.

b.Poor Implementation

-The planned activities were poorly carried out
-The planned activities were not carried out due to:

1.the extension worker's negligence
2.an unexpected situation, or,
3.bad planning.

-The extension worker lacked leadership.
-The extension worker tried to do everything himself and did not involve farmers and others in implementation.
-Poor technique was used. Example: too much information given and little else.
-Insufficient reinforcing activities were conducted.
-Farmers rejected the improved practices because of prejudices upon which the extension worker should have concentrated.
-Activities were not conducted on time.
-Inputs weren't available on time
-The extension worker failed to obtain the support of local leaders for the agricultural development programme.
-The extension worker was used for non agriculture programme duties.

[+Discuss the Lesson Content, then break the students into discussion groups of 6-10 each. Provide each with one sample programme plan and report. Have them analyze the plan and its implementation from a supervisor's perspective, then report back to the entire class. Write all different points on the chalk board. Critique the students' results. This might be best done during a practical period+]

LESSON 8 : REVIEW

TIME : **1 Hour theory**

CONTENT :

The tutor can use his/her judgement in selecting content for review. The following points are also offered for review. They also qualify as:

Principles of Extension Programme Planning

1.A sound programme is based on a careful analysis of the local situation. (Problems, resources, chances of success, people's felt needs and farmers' knowledge, attitudes and habits).

2.The PEOPLE who benefit from a programme must assist fully in its planning, implementation and evaluation.

3.A programme should not be selected for extension attention unless it offers satisfaction to the people. Its innovations should provide adequate advantage or improvement, be compatible with existing values and life styles, be reasonable and simple in their demands and be communicated easily. Preferably the innovations should first be tried on a small scale to reduce fear of failure.

4.Only a few of the highest priority problems having the best chance for solution should be selected for extension attention (so that concentrated and comprehensive effort is possible for each.)

5.Programmes should start where the people are and with what they have. Consider their present level of technology and their resource base.

6.The programme plan should be long range with final objectives set as well as annual ones.

7.A programme plan should give serious attention to the selection of the best extension methods and approaches and should specify these. Innovative approaches such as use of "contact farmers" or "farmer demonstrators" should be considered.

8.Programme plans should include the interests and needs of all ages and groups, not forgetting women and youth.

9.The evaluation of results from one year or one experience should be used to plan a better programme for the next.

10.Programme planning and evaluation is a continuous process. One should continuously evaluate one's results and methods and readjust plans to meet new insights or changing situations.

11.A programme plan must provide sufficient reinforcing activities to move farmers from initial skepticism to acceptance or adoption of recommended practices.

12.Programme plans must include human development objectives for it is humans who manage agricultural enterprises.

13.The extension officer provides leadership throughout the conduct of the programme planning process but places as much responsibility as possible on his clients.

14.Objectives should emphasize education for self reliance. The education is provided by successful and positive involvement in agricultural development activities.

15.Extension work is most successful when the extension worker deliberately wins and maintains the confidence and support of leaders, then conducts his activities with them. The successful extension worker coordinates, motivates and assists these people in the conduct of their agricultural development work.

16.Extension workers are responsible for maintaining linkages with agricultural research and for building researchers into the district plan or even the village programme plan. Every interaction should be mutually beneficial to researchers, extension workers and villagers. Extension involvement can help agricultural researchers to understand the local situation and to conduct trials relevant to farmers' conditions and values. Researchers in face to face dialogue with farmers and extension workers can improve the quality of extension programme decisions.

APPENDIX A : SAMPLES OF PROGRAMME PLANS AND CALENDARS OF WORK

PART I : PLANS

While the plans which follow vary somewhat in format, each generally meets the minimum requirements. These are referred to in several Lesson Plans. Choose the format you like, keeping in mind that the more columns one has, the less space there is for adequate details in each column. Sample 1 lacks a time schedule and a list of persons responsible, but substitutes for this approximate dates in the activities column and by attaching a separate annual calendar of work, which shows both dates of activities and persons involved. Sample 2 has a column for stating the evaluation criteria while Sample 1 only hints at the evaluation criteria in the objectives columns. Some objectives have obvious evaluation criteria already stated in them, eg. destock 20% this year).

Sample 3 has a good situation statement and good annual objectives. The long term objectives are non-measurable, serving rather as major plan categories. Thus, according to the definition of a programme plan given in Lesson 1, this sample is actually three programme plans on a single sheet. The writers added a "scheme (plan) of work" to this cover page and thus listed the specific activities, their dates, and persons responsible for each.

What is important in any format is respect for the principles of programme writing, as discussed in Lessons 2 and 4 especially. This writer likes the Sample 1 format for its inclusion of accomplishments and its single page format which makes it an ideal tool for extension supervisors to use in evaluating the programmes carried out by their subordinates. For these reasons and others the Sample 1 format is called for in the practice writing of plans in Lesson 4.

APPENDIX A, PART 2
SAMPLE CALENDAR OF WORK

ANNUAL CALENDAR OF WORK*
Farmer Training Project

Date Submitted .....

Key: Planned time .....
Actual time .....

October 19.. to September 19..

ACTIVITY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	COMMENTS on Action, Materials, Agents

* Should be accompanied by monthly calendars, showing each day's activities, or by calendars of work for each Extension Program or Project.

10 SMALL-SCALE EXPERIMENTATION

The fundamental problem confronting agriculture is not so much the adoption and spread of any particular set of physical inputs or of economic arrangements or of organizational patterns or of research institutions. Rather it is to build into the whole agricultural process . . . an attitude of experiment, trial and error, continued innovation, and adaptation of new ideas.

Report of a Conference on Productivity and Innovation in Agriculture in the Underdeveloped Countries. Massachusetts Institute of Technology[1]

Once the technology has been chosen, the job of introducing it to the people begins. From the start, we must remind ourselves that our job is not just to teach people technology, even less to be "salesmen" of technology. Much more important than selling any particular technology is teaching the people a method of village research with which they can continue to try out new innovations year after year. Once again, *we are not here to develop their agriculture, but to teach them a way in which they can develop their own agriculture.*

In this role we should never try to convince a farmer to change over entirely to some new practice (except in the rare, usually avoidable cases in which the nature of the technology requires it). Instead, all we need to do is to convince the farmer or group of farmers to try out an innovation on a small piece of land, usually 1/20 hectare or less, or on two or three animals, and to keep a simple accounting of the results.

The temptation always exists to try to introduce an innovation on as many acres of land as possible. It makes our program statistics look better. But we should not be any more interested in one person's innovating on a hundred hectares than we are in one person's learning a hundred ideas. Objectives and results expressed in areas of land rather than in numbers of farmers once again exert pressure on a program to work with the larger, more prosperous farmers.

There are many reasons why we should promote small-scale experimentation rather than large-scale adoption.

WHY TEACH SMALL-SCALE EXPERIMENTATION?

Teaching small-scale experimentation provides advantages for everyone involved: the small farmer, the villager extensionist, and the program.

Advantages for the Small Farmer

The first advantage for the small farmer is that it reduces his or her risk; it protects him or her against major economic failure. Innovations can fail for many reasons. They may not have been tested sufficiently by the program. Those that have been well tested can fail because of differences in weather, topography, microclimate, or soils between the time and place the innovation was tested and the time and place it was put into practice. An innovation can also fail because of the specific situation of the individual farmer, such as his or her seasonal labor availability, the possibilities and cost of transportation to market, his storage capability, or the presence of disease organisms or stray neighborhood animals. Furthermore, farmers may not have accurately understood or remembered the extensionist's recommendations or may make any of dozens of possible mistakes in applying them.

Any of these errors, whether caused by the program, the extensionist, the farmer, or nature, can result in the farmer's losing not only a crop or some animals, but all the capital

invested in them besides. When a subsistence farmer loses a year's harvest, it is a deep personal tragedy. It can mean that his family will go hungry for weeks or even months. It can also mean he will have to borrow money or food that will take years to repay, often at usurious rates of interest.

On the other hand, if the farmer starts by trying the innovation on a limited quantity of land or with two or three small animals, he can make sure he knows how to do it and what the probable results will be before he risks an entire year's income. If there is a loss, it may hurt, but it will not affect his well-being for months and years to come.

A second advantage of small-scale experimentation is that a farmer can learn much more in this way than by experimenting with his entire crop. If a farmer makes a change in his entire crop or all of his animals, he can try out only one change or one combination of changes each year. If, however, he devotes just 1/20 Ha. to small-scale experimentation, he can do as many as ten different 5x10 mt. experiments each year. I have seen a single small farmer experiment with three different vegetables, five varieties of pasture grass, three or four soil conservation methods, and various plant populations for his corn all at the same time.

Thirdly, a farmer who makes a change in an entire crop or with all of his animals has no way of comparing the results of the new production system with those of his previous one. If the harvest or the animals improve, the farmer may never be sure whether the improvement is due to the innovation itself or to fortuitous circumstances, such as good weather or less disease. On the other hand, even a very good innovation can fail when conditions turn bad. If, however, a farmer tries out the innovation on a small scale, he has a natural control plot: the rest of his farm.

Advantages for the Extensionist

With so much at stake, small farmers are much more likely to try innovating if they can do so on a small scale. Thus the extensionist can get a much larger number of people to try out innovations. The extensionist's job is less frustrating and difficult, and his rewards are greater.

Secondly, small-scale experimentation helps the extensionist preserve his credibility and prestige. In order to convince a farmer to adopt an innovation wholesale, an extensionist must usually assure him that the innovation involves very little risk. In practice, the extensionist usually promotes it as being a sure success. On the other hand, if all he needs to do is convince the farmer to try it out on a small plot, he can present the innovation as an idea worth trying. After all, it presumably has already been tried out successfully by the program, by other small farmers, and by the extensionist himself. The extensionist can even afford to admit, as he should, that there is a chance the experiment could fail. After all, most farmers will understand that the possibility of learning about an innovation that can improve all their harvests of a given crop for years to come is well worth the risk of losing just once the harvest on a 5x10 mt. plot. Thus farmers try out the innovation because past experience has proven it an "idea worth trying," not because it is a guaranteed success.

When a farmer loses his entire crop or his animals die, he has failed in his responsibility to his wife, his children, and

often the entire extended family. He has failed in what is often the one thing he prides himself in doing well. He may have to watch while his family members reduce the quantity or nutritional value of the food they eat, perhaps endangering their health. And he loses prestige. Such a failure usually causes intense feelings of hurt and frustration, which in turn create a deep emotional need to blame someone for the failure. Any extensionist even partially responsible for such a failure should not be surprised if his reputation is attacked with a vengeance. Those he caused to fail may become enemies overnight. In the case of a villager extensionist, these new enemies may well have been his best friends, his relatives, and those with whom he had the most influence. Furthermore, if the extensionist promoted the guilty innovation as a sure success, the villagers' own experience has proven to them that he is either ignorant or untruthful.

The extensionist has lost his credibility, his prestige, and his friendships. Even though the fault may lie with the program rather than himself, he has lost much of his value as a leader.

On the other hand, an extensionist who promoted an unsuccessful innovation as an idea worth trying out on a small scale, and who had warned farmers it might fail, has not ruined his credibility. Nor has he caused major economic failure, hunger, or suffering; presumably, people have risked what they could afford to risk. Furthermore, a crop failure on a 5x10 mt. plot, although unfortunate, will cause no major hard feelings. Thus the extensionist has likely retained all of his credibility and a good part of his prestige.

Small-scale experimentation also protects the extensionist from being blamed for a crop failure caused by unfortunate circumstances, such as bad weather or insects. Since the rest of the crop will have suffered equally, farmers will realize that the innovation itself was not responsible for the loss.

Advantages for the Program

A program whose extensionists have been protected against a loss of credibility, prestige, and friendships is, of course, immensely benefited itself, as is a program whose technology is reaching a wider audience because farmers risk less in trying it out. Furthermore, since farmers are prevented from losing an entire crop or herd of animals, the program avoids being responsible for villagers' suffering major losses. The program thus avoids seriously damaging both the people's good feelings toward the program and their enthusiasm for agricultural improvement.

But still further advantages accrue to the program. First of all, it is able to reach the poorest farmers because small-scale experimentation makes it possible for them to begin innovating with a very small initial investment. Nor need they feel ashamed for starting on a very small plot.

Secondly, should a loan service be provided by the program, it will be greatly simplified. By using small-scale experimentation, most farmers will be able to try out

technology without a loan. For those who do need a loan, a maximum of $30 should be enough for any small-scale experiment with a truly appropriate technology. Frequently, $5 to $10 will suffice. Not only is the program thereby able to assist more farmers with a smaller outlay of money, but smaller loans tend to be easier to collect. We also avoid the danger of inadvertently getting small farmers into debt over their heads.

Thirdly, as farmers do more and more experiments, the program will get more and more feedback about its technology. Increasingly, it can learn from the villagers about new solutions to its technological problems and new ways of adapting its technology to different farm conditions and to the particular needs of the small farmer. In South America, a program promoting the transplanting of clover for pastures learned from the villagers' experiments that the clover would grow better if it was pastured down to a height of twenty centimeters just before transplanting. Program leaders also learned that if they planted clumps of three to four stems rather than single-stemmed plants, the clover would be ready to pasture a month or two sooner. In a World Neighbors program in Guatemala, villagers using improved techniques for growing black beans discovered a native variety capable of producing up to 3,200 kilograms per hectare. After this variety proved itself superior to scores of varieties imported from the seed bank in Colombia, the national basic grains program began recommending it as the best variety for the western highlands of Guatemala. The improvement of technology by villager farmers not only increases a program's effectiveness, but increases the farmers' sense of self-esteem as they realize they have turned the tables and are now teaching technology to the program.

Even more important, however, for villagers, extensionists, and programs alike, is that the villagers are learning an attitude of experimentation, a method of scientific inquiry. They are learning a way of mathematically evaluating innovations so they can make increasingly precise farm management decisions in the future. The program is thus achieving what is at once the most difficult, least often accomplished, and most important goal of agricultural improvement work: *to teach people to carry on, by themselves, the never-ending process of developing their own agriculture.*

And this is happening. In some program areas, whole villages or clusters of villages are taking off on their own, developing technology far beyond what the program taught them. In San Martin Jilotepeque, Guatemala, wild rabbits were wiping out program-introduced soybeans. One day a local farmer smelled a horrible odor as he was walking by a drug store. It was iodine. He bought a pound, mixed it with water, and spread the solution around the borders of his soybean field. The rabbit problem was eliminated. Some of his neighbors discovered that burning sulfur at the edges of their fields provided the same happy results. Another farmer found that he could intercrop peanuts among his beans. The beans matured before the peanuts needed the space, increasing his per hectare harvest by 50% over that of separate plantings. Still another villager found that he could construct simple trellises over his coffee trees and grow passion fruit on them. The passion fruit not only shaded his coffee but also more than doubled the net income from his coffee field. Meanwhile, other villagers near San Martin are experimenting with cauliflower, cabbages, native herbs, and native root crops. Successful innovation creates enthusiasm, and the increasing enthusiasm pushes people to innovate more and more. The process gathers a momentum of its own.

HOW TO TEACH SMALL-SCALE EXPERIMENTATION

In the beginning, villagers only need to learn to:

1) measure off several plots of land or separate out two or three animals,
2) plan experiments so that only one production factor varies between each two plots or groups of animals,
3) weigh or measure the results, and
4) write down and add up all the expenses and income of both the experimental crops or animals and the controls.

Farmers of nearly any educational level can learn to do this. Even illiterate farmers have been taught to read and write numbers and then use mimeographed sheets with drawings that depict the various cultural practices and inputs. In time, as

they become willing to learn and able to understand more, they can keep more exact accounts and use more complex, scientific experimental designs.

Small-scale experimentation should be an integral part of the program's training process. No technology should be taught or classes given unless the students are experimenting with the technology on their own farms. Once again, our goal is not merely to impart knowledge, but to help villagers learn how to improve their own agriculture. The first step in that process is for them to learn about an innovation and try it out through small-scale experimentation.

INTRODUCTION

Let's begin by asking you, the reader, to answer the question: "What has been your experience with evaluation?"

If you are involved in a community development project, you will already have some experience with evaluation. This may include activities you have participated in yourself. Or, evaluation of your project may have been carried out by others, perhaps outside visitors.

In either case, what effect did the evaluation have on you and others involved in the project? Did it lead to changes in the way the project is run? Or were most people not even aware of the findings and recommendations of those who carried out the evaluation?

Perhaps, to your knowledge, there has not been a formal evaluation of your project. But even if there has not been a major event which may have involved the visit by one or more "experts" to evaluate your project, chances are you and others have been carrying on evaluation at an informal level all along. In a sense, every time a decision is made, it is based on some level of evaluation.

We all do evaluation. If a farmer decides to adopt a new practice, he or she will do so after becoming convinced that that practice will be better for his or her needs. Many factors will have influenced such a decision. These may include learning about the experiences others have had with the new practice and testing it on a small plot. The process of obtaining the information needed for the decision is what we will refer to here as "evaluation."

At the project level some form of evaluation takes place before the annual report is written each year. An opinion is formed, based on whatever information has been obtained, on how well the project has met its objectives. This assessment is kept in mind when objectives are set for the next year.

But because we all do evaluation does not mean that we are doing it as well as we could. Many decisions are made based on inadequate information. This applies to individuals as well as to administrators and others with responsibilities which affect many people.

How much time and effort did the farmer put into seeking all relevant information before making the decision whether or not to adopt a new practice? How much do those who write the project's annual report really know about the impact of the project on the community it serves? Unless the results of last year's objectives are measured and analyzed, how can subsequent objectives be realistically set?

The basic purpose of this manual on self-evaluation is to help those involved in running rural community development projects to learn how to do more effective and appropriate evaluation themselves. This should lead to evaluation's becoming a natural, built-in process in a project which provides timely, relevant information to those who need to make decisions which affect that project. And it aspires to the ideal that all those participating in a community project will play an active part in the self-evaluation and the decision-making process.

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CHAPTER 1

WHY EVALUATE?

The TAHID project may be typical of many rural community development projects. It has a paid staff consisting of a director, three agricultural extension agents, two family health promoters, and a secretary/accountant. The project is run under the auspices of a church, but the local staff have quite a bit of autonomy in running the project as they see fit. In addition to funds received through church channels, two outside funding agencies provide some support: one mainly for the agricultural side, the other mainly being interested in health education.

Though there have been some changes in the staff during the past few years, most of them have been involved in this project for more than five years.

Unless the host church or one of the funding agencies insists on it, why should the staff decide to evaluate the project?

The easy thing would be to just let things keep going on as they have been. After all, the staff say they feel pretty good about what they are doing: going out to villages two or three times a week, meeting with farmers and women's groups, as well as maintaining the demonstration farm and training center.

But one might pose questions such as these:

-- In what ways are your project's activities affecting the lives of the people in the villages?
-- What opinions do the villagers have about the extension staff?
— Do they feel that improvements are being made in their lives? If so, what are the specific improvements?
-- What image does the project have in the minds of others in the community who are not now being reached?
-- Is staff attitude and morale as high as it should be? If not, why not?
— When outsiders visit, do you find yourself telling them about things the project did a year or more ago, or about an idealized view of what it could be doing, rather than the present reality?
— When it comes time to make your annual report and to set objectives for the next year, do you really know enough about the impact of the project to be able to report it, and to make plans for ways to improve its effectiveness?

These are some of the kinds of questions a process of self-evaluation can help to answer

Key Reasons

Let's identify some of the reasons that projects need to be evaluated. You will be able to add to the following list:

1. For decision making: Those responsible for a project need to be able to identify its strengths, its weaknesses, its impact and its relevance to the lives of the intended beneficiaries in order to make sound decisions concerning methodology, training, staffing, logistics and other aspects of project management. More realistic and relevant objectives can be set for next year if we have the results of periodic evaluations of what we have done so far.

2. For improvement of performance: Are our project's activities achieving what we intended? How could we be doing a better job? Ongoing self-evaluation helps assess the productivity of a project and helps us determine whether or not we are making progress towards our goals.

3. For personnel evaluation: Those responsible for directing the staff of a project need to base their decisions on objective assessments of the performance of each one. Self-evaluation can enable both the staff members and the director to see what areas need improvement and suggest what might be done about it. A positive consequence of self-evaluation can be to boost job satisfaction by enabling staff to see indications of progress.

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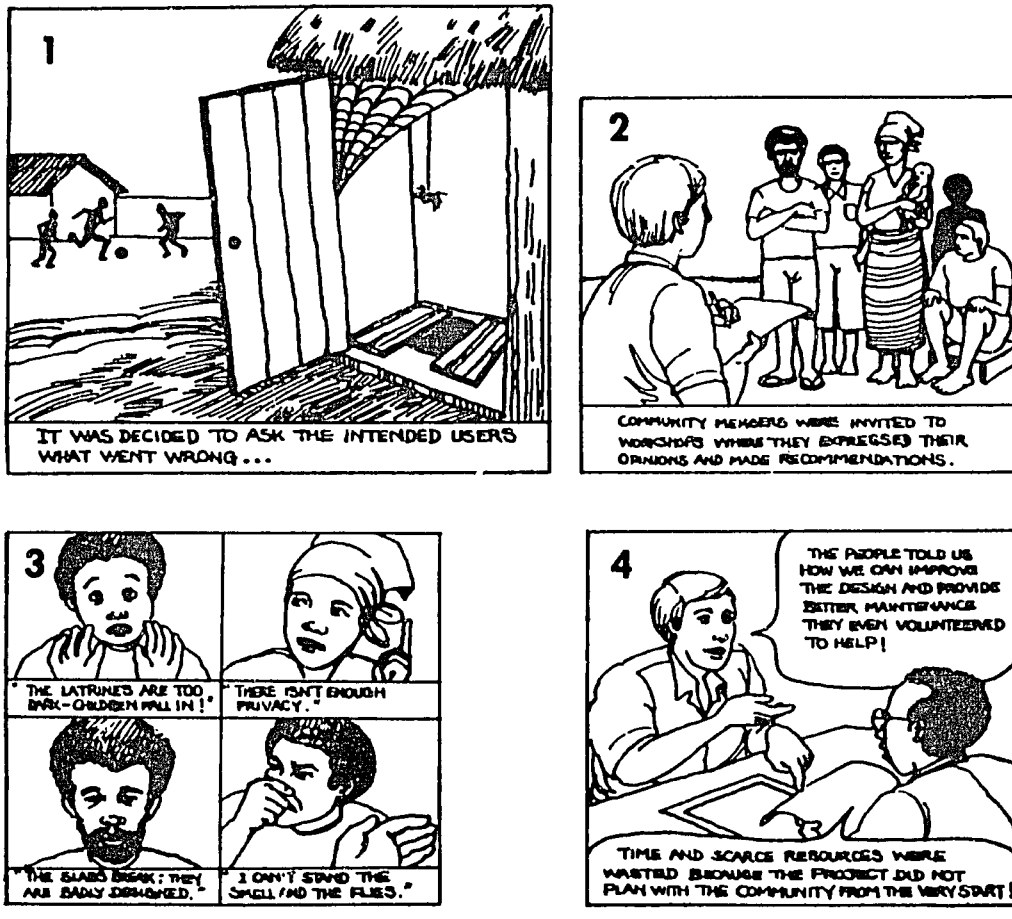
4. For allocation of resources: Our projects do not usually have enough money, people, materials or time to do all we'd like to do. Thus, we have to set priorities to separate what is most essential from that which would be nice but may not be possible just now. The results of an evaluation should help us to determine how our limited resources could be used most effectively.

5. For program justification: We do have to account to the supporters of our project. The impact of the project on the lives of local community members needs to be assessed so that participants, implementers and donors can make informed judgments concerning the project's worth.

6. For determination of policy: Those involved at the local level need to learn enough about the effects of a project to be able to determine whether or not to continue as is, modify, expand or abandon the approaches being used. Also, those responsible for other projects want to learn from the experiences of this project in order to make informed decisions concerning methods which might be applied elsewhere.

LESOTHO: WHY SANITATION FAILED

After four years, only 86 of the 206 schools that had been given materials to build latrines had built them, and half of these were in disrepair. A UNDP/World Bank team was asked to investigate.



From "Decade Watch," Sanitation Special, Vol. 2, No. 4, Dec. 1983. International Drinking Water Supply and Sanitation Decade. Published by the United Nations Development Program, Division of Information, One UN Plaza, New York, NY 10017, U.S.A.

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CHAPTER 2

EVALUATION FOR WHOM?

Now that you are convinced that there are good reasons why your project should set up a process of self-evaluation, let us consider whom the evaluation will be for.

As we've said, the TAHID project is sponsored by a church, and receives financial support from two outside agencies. It is obvious that the funding agencies are interested in having the project evaluated to justify to their donors the expenditure of their funds. They are also interested, for reasons of policy considerations, to learn from the experiences of this project what approaches should be replicated elsewhere. The church leaders are interested in the results of the evaluation of the project for the same reasons. If things are not going well, they need to decide whether or not to continue to sponsor the TAHID project. If, on the other hand, the church leaders learn that good things are happening in the lives of the beneficiaries of this rural development project, perhaps they will decide to initiate similar projects elsewhere.

The results, and the evaluation process itself, will, of course, be valuable for the staff of the project. They are the primary implementers of the TAHID project. As such, they need the feedback and program assessment which evaluation will provide in order to make decisions concerning minor or major modifications in the work they are involved in.

But perhaps those who stand to benefit most by the evaluation of the project are the members of the communities where the project works. Too often they are left out of the picture, seen only as objects in a project run by outsiders who make all management decisions. But the TAHID project has encouraged and facilitated the formation of an Association of villagers who are taking increasing responsibility for the operation of the project. Since these village leaders are involved in the decision-making process, the results of the evaluation are for their benefit. And, as we shall see in the next chapter, their involvement in the evaluation process will strengthen their leadership roles.

The self-evaluation process which is being designed for the TAHID project will be aimed primarily at the needs of the community Association leaders and the staff of the project. But the results will also be of special interest to the outside supporters.

Various Groups Interested in Self-Evaluation

1. Community members involved in the project: Ideally, these are the people who should initiate the call for evaluation. They are the ones who have the most at stake, since the project's goal is to help them improve the quality of their lives. It is in their best interest that the project be evaluated in order to determine how it might better respond to their needs.

2. Community members not yet reached by the project: Hopefully, those directly involved with the project will not forget that the project should benefit their neighbors as well. How can it reach the wider community? Can the results be multiplied? An evaluation might prove to others that there are, indeed, benefits being gained by those participating in a project, and convince them to join in. Or, it might indicate that there are aspects of the project which limit the benefits to only certain members of the community. Those outside of this circle would be glad to see this remedied.

3. Project staff: If the community participants have the most to gain by evaluation, the local staff can potentially benefit just about as much. They are devoting full time to this project as facilitators, trainers, extensionists or administrators. The normal day-to-day activities may not be providing sufficient feedback to reveal the effects of their efforts. The more disciplined procedures of a self-evaluation process can provide the information the staff needs with more objectivity on how things are going. This may give them positive rewards with confirmation that they are doing good and significant work, or it may point out areas for improvement.

4. National headquarters: Many rural development projects are affiliated with some national organization, whether a church, other non-governmental body, or government. In reality it is often leadership at this level which was primarily responsible for initiating the project and which makes major decisions concerning the project's future. Too often such decisions are made without adequate input from the local level. A well-instituted process of self-evaluation would provide information about the project — and involve local participation — leading to more realistic decisions for the benefit of the project.

5. Donors: Those who have contributed funds to support a project have legitimate needs for information which will guarantee that their funds are being used for the agreed purposes and that progress is being made towards the stated objectives. Ideally, the findings of an objective self-evaluation by the local project staff and participants can satisfy the needs of the donors. In fact, they should be impressed by the process itself as an indication of the local community's ability to be responsible for its own development progress.

6. Development agencies: International organizations which assist development projects, even those not directly involved in a particular project, are interested in learning from its experiences. The results achieved, the activities and methods which produced those results, and the process of self-evaluation which revealed these findings are all of interest to people who are eagerly looking for successes in order to multiply them elsewhere. A well-communicated self-evaluation can spread the effects of a project far beyond its own limited area of operation by convincing governmental and non-governmental agencies that this approach is effective. (Where "success" is not so evident, even documented failures contribute to the learning process.)

7. General public: Even beyond all of the interested parties we have listed above, there are others "out there" who are interested enough in the problems of the Third World to want to learn more about how some groups are working to solve some of those problems. A well-written project self-evaluation might serve as the basis for articles in various publications which reach such people. This can help to educate the public about conditions in rural areas and what is being done about them. It could also convince potential donors to support this project, or other projects using this approach.

Hopefully, the ideas presented in this manual will promote the concept that all the groups of people listed above are "partners," that each has an interest in participating in the self-evaluation, and that all will benefit from its findings.

Community leaders, like these farmers attending a meeting in Miniaba, Niger, have the most to gain from program self-evaluation. Information revealed during the evaluation process can benefit the community as a whole, with program participants leading the way as more of their neighbors become involved.

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CHAPTER 3

EVALUATION BY WHOM?

We have seen that quite a few different people will be interested in the results of an evaluation, but who should actually carry it out?

Here is a negative example of how "evaluation" has sometimes been done in the past. Unfortunately, this is all too common an experience in many rural development projects:

The representative of one of the agencies which funds the TAHID project wrote to tell the director that an official from his headquarters was going to be making a tour to evaluate the projects they were funding. He would be spending ten days in the country, during which time he hoped to visit five projects. Due to the uncertainties of other responsibilities, he couldn't say exactly when he would arrive, but it would probably be during the next few weeks.

Just one day after this letter reached the project director, a car rented in the capital city arrived at the station. It was the official from the funding agency! He was sorry for the short notice (hadn't realized that mail takes four weeks to reach here). He announced that he needed to reach the next project by the next evening, but he was sure that 24 hours would be sufficient time for him to evaluate this project. "After dinner I would like for you to show me all you have in your files about accomplishments over the past five years. Tomorrow morning I'd like to visit one of the villages where you work. Before I leave at 3 p.m., please call together all of your staff so that I can interview them."

The project staff all breathed a sigh of relief as his car drove off into the dust the next afternoon! Nothing more was thought of that brief visit until, quite by chance, six months later the TAHID project director happened to see a copy of the report that official wrote when he got home. What he said about the TAHID project was so different from the staff's perspective of the project that they wondered if he had confused it with another!

The saddest part of this experience was that there was virtually no participation by those involved in the project at the local level. It gave them the impression that if that is what is meant by "evaluation," it had little relevance to the realities of the TAHID community, or to how the project is run.

But now the staff and community leaders in the TAHID project area are developing a better system of evaluation. They have agreed to set up a process of self evaluation which will involve each of them. This idea was shared with the national headquarters and they were enthusiastic about it! They have offered to help find a qualified person to facilitate the local staff and community leaders in initiating the self-evaluation process.

Potential Partners

In Chapter 2 we saw how many different people can benefit from the results of evaluation. Let us now consider which partners have a role to play in carrying out self-evaluation:

1. Community members involved in the project: Ideally, these are the people who should not only initiate the call for evaluation, but who should play a major role in implementing it as well. This contributes to their abilities to manage their own process of development, giving them a greater critical reflection capability. Though one would assume that the local residents already know their environment well, the process of self-evaluation can reveal factors which they otherwise may not have perceived. The leaders of the Utooni community in Kenya, amazed at the results of a survey they had carried out, exclaimed: "The survey showed us more about our community than we knew after living here all our lives!"

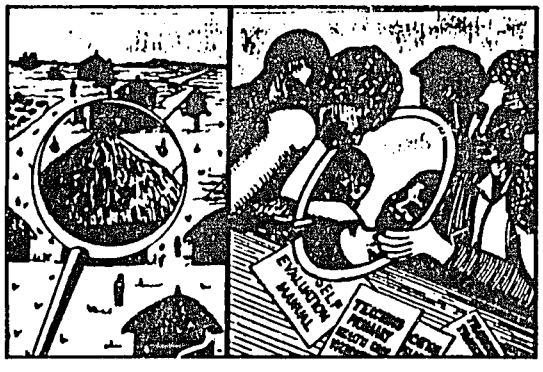
It is extremely important that this category of partners be actively involved in defining what, how and when to evaluate, and that they be instrumental in the process itself.

2. Community members not yet reached by the project: Though an evaluation would likely be initiated by the active participants and staff of a project, they should seek ways to include members of the wider community in the process.

Various sub-groups within the community should be considered, and ways designed for each of their voices to be heard. This may include women and men, youths and elders, different ethnic groups, adherents to different religions, those of greater and lesser economic and political power, etc. This can bring a broader perspective to the evaluation, indicating ways others could be included in and benefit from the project.

3. Project staff: Those evaluations which are conducted internally by the staff of a project are much more likely to enlist staff commitment than evaluations which outsiders impose and implement. By asking their own questions in cooperation with their partners, staff members are also more likely to utilize the answers. As self-evaluation becomes an integral part of the responsibility of all staff members, their role in the management of the project is enhanced. When they see how such self-evaluation can benefit them and enable their work to be more effective, they will more willingly build it into their regular activities.

We must be willing constantly to ask questions, even if they may prove embarrassing to ourselves, such as why the attendance at our meetings is dropping off, or why villagers are not adopting the new techniques we have tried to teach. Our projects can become stronger if we are willing to put a high value on villagers' opinions, take criticism well, and make decisions accordingly.



4. National headquarters; other supporters: As we have said, those participating in an evaluation exercise are more likely to respond to the message it brings. This is why those at the local level need to be the primary participants. This is why others who are responsible for (or are at least supporters of) a project should also be involved. The decisions they have to make concerning the project have a greater chance of being influenced by the findings of an evaluation if they were (are) a part of it. Besides, self-evaluation (and self-criticism) should not be confined to the local level. There may be indications that some changes are needed at other levels as well.

5. Other services: Whether or not a project is directly linked to government, or to other agencies working in the area, it would be well to include in the evaluation process such agencies whose activities do (or should) relate to those of the project. This can encourage closer cooperation with the relevant services, inviting them to participate more actively in the work of the project, and helping the project implementers to see how they might tie in with these services.

Even casual visitors from other rural development projects do, from their own perspective, "evaluate" a project, whether formally or informally. They leave with definite impressions and judgments concerning what they saw during their visit. Project leaders should benefit as much as possible from this, asking the visitors to share their impressions. This can have two advantages: (1) correct any misimpressions the visitors may have picked up during their short stay, and (2) give the local project leaders added perspective on their work.

On a more formal basis, one or more colleagues from sister projects may be invited to participate in certain stages of a project's self-evaluation exercise. Such "evaluation teams" can bring added perspective, along with an understanding of the realities of running similar projects in the nearby areas. Leaders of the project being evaluated might then be invited to participate in the evaluation of the other projects. This kind of sharing develops a professional fellowship. And when you are helping to evaluate another project, you can't help but reflect on your own. So the individuals involved are learning from the project being evaluated as well as contributing to its evaluation.

6. Evaluation facilitator: As we are seeing, there are definite advantages to the participants in a rural community development project carrying on their own process of self-evaluation. This does not negate the advantages of an outsider who comes occasionally to help set up the process, train the participants in implementing it, and help bring an added degree of objectivity. This we'll call "assisted self-evaluation."

An evaluation facilitator does not substitute for the partners mentioned above. He or she only has a task of facilitation: to aid the partners in using methods best adapted to evaluate their activities. He/she should desist (as much as possible) from any value judgments, lest the partners be led to feel that they are being evaluated, as that would be contrary to the principle of self-evaluation.

An evaluation facilitator can add insights from his/her own experience, bringing new perspective. This person should not be a disinterested observer, nor a judge of the appropriateness or effectiveness of a project. In contrast with a classical "hired gun" outside expert sent to evaluate a project on behalf of the donors — whose conclusions are made independently — an evaluation facilitator serves as a colleague, a challenger, a mediator, an assistor, an advisor, a trainer. The goal is to enable the local participants to continue their own process of self-evaluation.

How it works

A participatory monitoring and evaluation system is something which may not be possible to implement with a new group, still coming to grips with internal and structural problems. Instead, participation itself may need to be built up first. When the time comes to begin monitoring and evaluation, some elements of the system may be initiated by introducing the group to the idea. A good start may be a Task Monitoring Sheet, as shown in Figure 3. This includes specific tasks and deadlines for the group to maintain. After discussing each task assigned within a project, a chart is made with space to record progress. Variations can be developed with a little imagination to suit literacy levels, numeracy skills and the needs for a particular group.

Figure 3 Task monitoring chart (reduced from wall chart size). Colours may indicate progress or otherwise, if these are available.

TASK MONITORING SHEET

GROUP : Meijo Groundnut Group PROJECT : Agric. Prodn. YEAR : 1988

JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
Cut fence posts.	Erect fence and treat posts with G. oil	Weeding	Weeding	Harvest	Repay loan to bank
Dig holes for posts	Plough and form mounds	Watering	Watering	Dry gr. nuts	Distribute profits to group
Order wire staples, wire strainer	Purchase fertilizer	Check and repair fence and gate	Check and repair fence and gate	Negotiate selling price and check local market price	Meet to decide on new work plan
Plough the land	Apply pre-planting fertilizer	Pest control	Apply fertilizer.		
Dig drains	Plant groundnut seed	Pile earth on mounds	Pest control		
Cut palms for shade.	Collect bank loan		Pile earth on mounds		
Apply for bank loan			Purchase packaging for harvest		
			Check market		
Accounts & Records	Accounts & Records	Accounts & Records	Accounts & records	Accounts & Records	Accounts and Records.

SSM 7.3.3 Stephens and Putnam p.25

Another simple system of monitoring progress is shown in figures 4 and 5. These charts monitor progress made by a group in various aspects of a small community forestry project. The chart shown under figure 4 is generally used each month for groups unused to assigning a numerical value to their achievements. After a few months, one chart as in figure 5 may be made for several months.

Figure 4 One month chart for monitoring progress in a community forestry project.

COMMUNITY FORESTRY MONITORING CHART Month June	NURSERY	TREE PLANTING	FERTILIZER	EXTENSION SUPPORT	GROUP MEETINGS	LOAN REPAYMENTS	FUELWOOD	FODDER	FRUITS	SOIL IMPROVEMENT	VISITORS
5			✓	✓	✓						
4	✓										✓
3							✓	✓		✓	
2									✓		
1		✓				✓					

Figure 5 Six months chart for those more used to using a rating scale.

COMMUNITY FORESTRY MONITORING CHART	NURSERY	TREE PLANTING	FERTILIZER	EXTENSION SUPPORT	GROUP MEETINGS	LOAN REPAYMENTS	FUELWOOD	FODDER	FRUITS	SOIL IMPROVEMENT	VISITORS
5 January	3	3	4	5	4	2	2	3	4	3	1
4 February	3	4	4	4	4	3	3	3	4	4	2
3 March	4	4	3	5	5	3	3	4	4	3	3
April											
2 May											
1 June											

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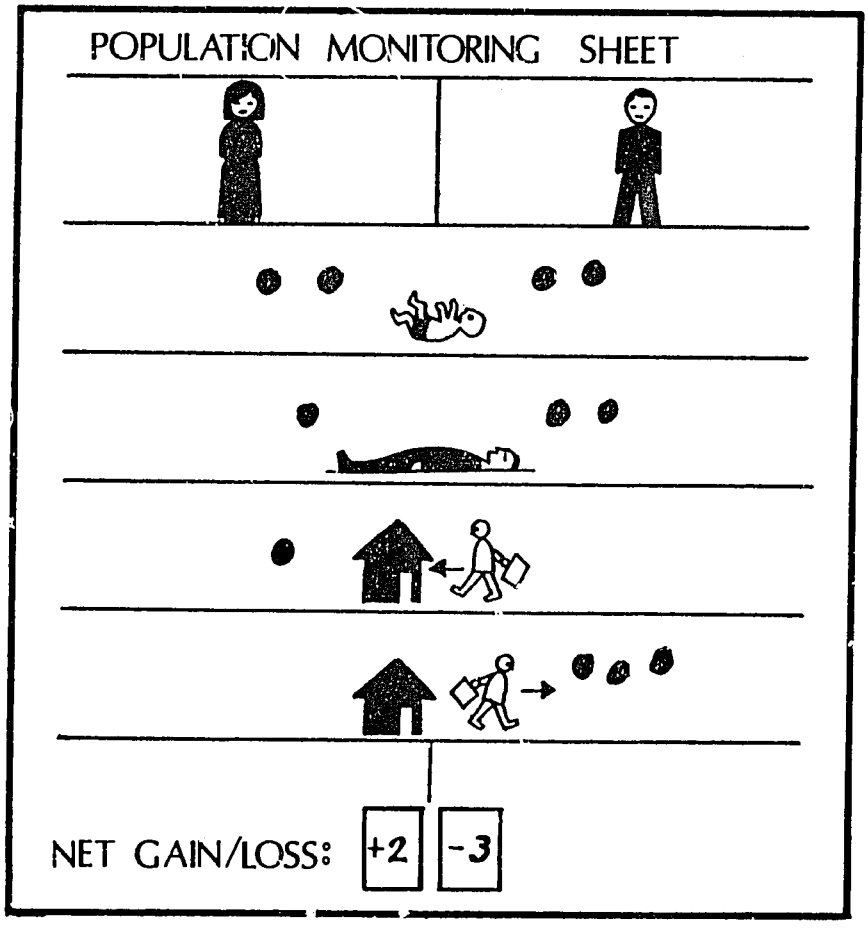
For monitoring population changes, charts such as that shown in figure 6 may be used. This is suitable for people, for livestock or fish, or even adapted, for produce and yields. Each time there is a newborn, a death, inward or outward migration, a dot or mark of some kind may be added. Monthly or annual totals can be indicated as shown at the bottom of the chart. For evaluation purposes, the total change over a period of time provides necessary data to monitor population increases, a decrease, changes in gender balance, mortality and migration rates. Overall trends may be presented from the data obtained on this chart.

Figure 6 Population information chart



Population data may be recorded regularly e.g. monthly, or a census can be taken, say annually, to monitor change and trends. The chart in figure 6 may therefore be adapted to suit a group's needs, but generally changes in birth, deaths, inward migration and outward migration are recorded. Once data is analysed, findings may be presented in a variety of ways for group discussion - see figure 12 on page 23.

Monitoring change which lends itself less readily to quantification presents some challenge. The group process for example, or peoples' participation in development is often difficult to quantify. Figure 7 shows how various small farmer groups monitor attendance at their meetings. Various levels of precision are achieved, but since accuracy is more important than precision, these methods are usually adequate.

Figure 7. Various ways of monitoring "attendance" at meetings.

Recorded Data/symbol	Meaning
● ● ●	Two short, one full length meeting attended during the month.
7 6 6 7 / 6.5	Attendance at four meetings was 7,6,7 and 6 - an average of 6.5 for the month.
OK	Group considers attendance rates are satisfactory.
	Group considers attendance is quite good. (colour normally used rather than shading)
✓ ✓ × ✓	Group considers attendance at 3 out of 4 meetings was satisfactory/good.
90%	Ninety per cent average attendance for the month.
7/8 6/8 7/8 8/8	Of 8 group members, weekly meetings were attended by 7,6,7 and 8 respectively.
5 4	On 1-5 scale, attendance was rated excellent (5) and good (4) for the 2 meetings held.
☺ 😐 ☺	Attendance at 3 meetings held was excellent on 2 occasions, good on one occasion.

Participation in meetings or project activities is more difficult to monitor and evaluate, since each person may define participation differently. Further, criteria, standards and expectations may vary considerably. Labour participation is not difficult in terms of time input, but skills are less easily measured except in terms of concrete outputs. Participation in decision making is extremely difficult to monitor accurately.

Among some of the small farmer groups, the example in figure 8 has been found useful to increase awareness of the relevance of participation, and the part it plays in promoting cooperation and self reliance among members.

Figure 8. Participation monitoring chart

MAEJO DEVELOPMENT COMMITTEE

Adult population 1/1/88 436 Adult population 31/12/88 _____

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of members	54	57	62									
Per cent of total	12·6	13·4	14·5									
Average attendance at meetings	44·1	49	52·4									
Labour contribution (person/days)	475	1320	842									
Participation in training (number and person/days)	60	20	95									
	15	–	3									
Leadership and participation (5-1)	3	4	3									

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Another aspect of participation which should be monitored is equity the distribution of benefits of a project. Figure 9 shows one method used to record the distribution of the benefits of a poultry project.

Figure 9 Participation in sharing the benefits of a project

MAEJO POULTRY GROUP

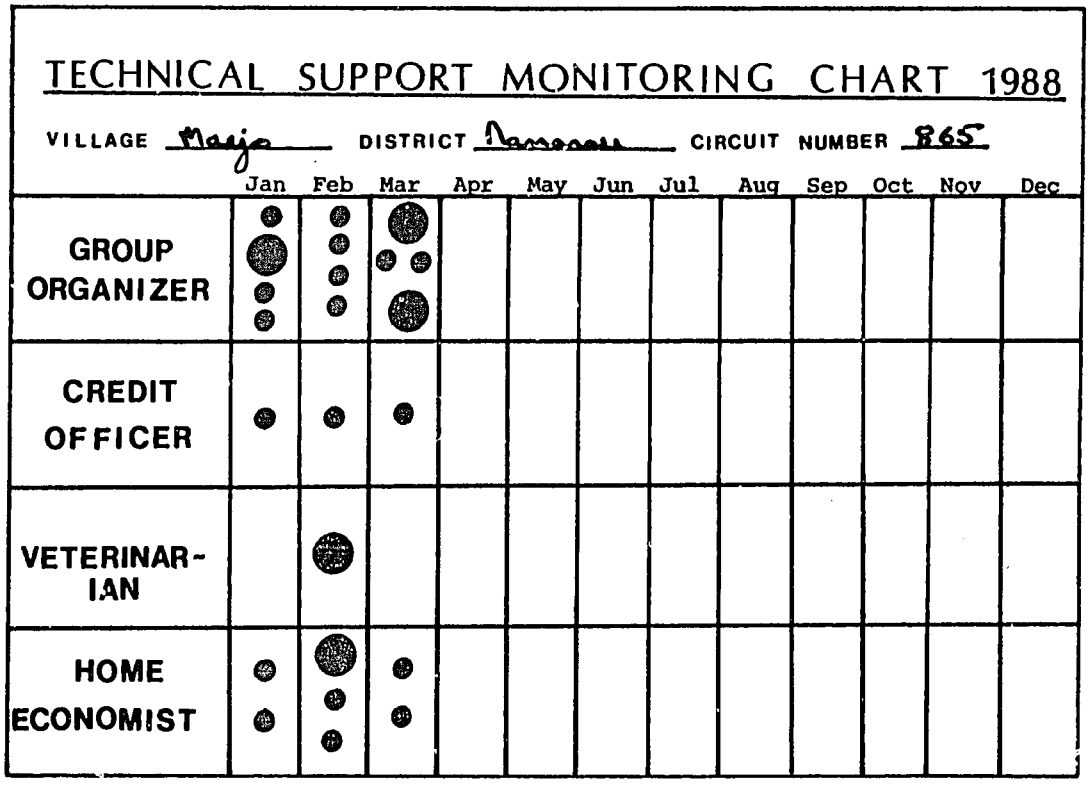
DISTRIBUTION OF EGGS AND CASH PROFITS		January	February	March	April	May	June
Monthly production		1,295	1,341	1,348			
Monthly sales		1,065	1,065	1,093			
Jonati	00	60	60	60			
	$	$2.60	$3.60	$3.60			
Elimo	00	24	36	36			
	$	$4.04	$4.56	$4.56			
Mari	00	48	60	48			
	$	$3.08	$3.60	$4.08			
Tinat	00	60	60	60			
	$	$2.60	$3.60	$3.60			
Misama	00	24	36	24			
	$	$4.04	$4.56	$5.04			
Lanio	00	12	24	24			
	$	$4.52	$5.04	$5.04			
Total eggs consumed		228	276	252			
Total net income		$42.60	42.60	43.92			
Broken, damaged eggs		2	—	3			

Responsibility for initiating a participatory M and E system is usually with a trained field worker, but eventually the system must be managed by the group carrying out the project. They therefore need to participate in the development of the various parts, and in the system itself. The group organizer or field worker's responsibility is to exchange ideas and information with group members about:

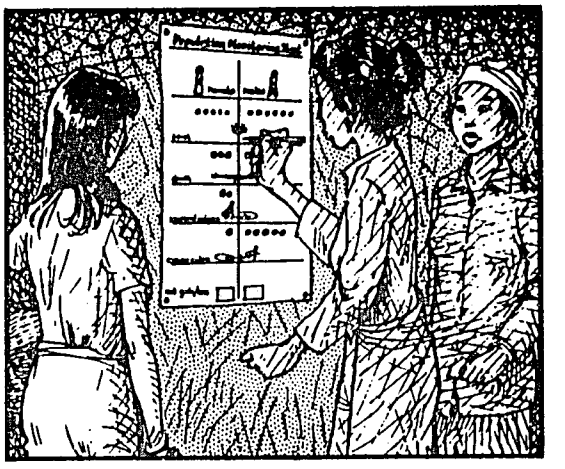
- the elements of the M and E system
- how this can be done
- who should be responsible for each part
- to whom data might be available
- how the data will be used
- where the system will be physically based
- when to begin and to end the process

In addition to monitoring group progress, the group members may also wish to monitor the provision of services from agencies and institutions set up to serve them. Figure 10 shows one such chart used to monitor technical support. A small dot indicates a brief visit by a technical officer. A large dot indicates a substantive technical support visit.

Figure 10 Chart for monitoring technical support services



Women in Development



The monitoring and evaluation of women in rural development remains problematic for many small farmer groups. Their participation as a frequently disadvantaged group is not always easily differentiated, and quantitative data needs to be disaggregated by sex where possible. Institutionalized discrimination against women is not easily recognized by those whose own customs and prejudices reinforce it by attributing discrimination to biological differences and therefore "in the natural order of things". Monitoring and evaluation of women in development therefore can be a very enlightening process for both women and men who accept as "natural", centuries of discrimination which constrain their productivity. It is in the interests of all therefore to try to break down such prejudice with the data from the M and E system. The following are some indicators used to gather data:

1. <u>General items</u>

   * percentage of funds earmarked for women
   * percentage of funds spent on women
   * number and percentage of households headed by women

2. <u>Project inputs and outputs</u>

   * percentage of women members receiving direct benefits
   * percentage of women receiving credit
   * percentage of recipients of inputs who are women
   * percentage of women with access to extension services
   * percentage of trainees who are women

3. Impact

* income, expenditure, savings
* health and nutrition
* access to land and other production resources
* employment and remuneration
* time allocation
* participation in rural organizations
* participation in decision-making

A PLANNING PARTNERSHIP: APPROACHES, TOOLS, AND SKILLS

OVERVIEW OF THE PROCESS OF VILLAGE-CENTERED PLANNING

This chapter presents a few practical ideas on steps that foresters and other facilitators can take jointly with rural communities to identify and solve local problems through self-help projects. An overview of the tasks that the community and the forester/facilitator face in undertaking this process is summarized in a brief guideline, as shown in Figure 2.

Although the guideline is presented in apparently linear fashion within five main components, it must be emphasized that these steps encompass a continuous and reflective process:

> It is a main characteristic of participatory projects that planning, implementation, monitoring and evaluation are inseparable, since all these phases and aspects are carried out with the active participation of the project beneficiaries (Huizer, 1983).

In particular, monitoring and on-going evaluation should take place periodically throughout the project. This allows direct action to be taken to modify or discontinue activities that have not shown positive results, and to strengthen those which have proved successful.

In the following sections, some of the important aspects of facilitating self-help projects are brought out in more detail. Not every element of the planning guideline is elaborated here. Instead, certain difficult issues and key skills are discussed, to provide guides to getting started in the process of facilitating self-help activities.

The methods presented here may be most useful for the forest extension agent or facilitator who can enjoy a long-term assignment in one area. It helps greatly to have time and freedom to become well-acquainted with the needs, problems and politics of a particular area, to "learn by doing," and to gradually develop appropriate programs for outside support. However, good skills for learning, communication and planning are important in the forester's tasks listed in Figure 2, even if time limitations cut the ideal process short.

PREPARATION: UNDERSTANDING THE LOCAL SITUATION

Sharing knowledge implies a two-way flow of information. This is most crucial, since understanding based on traditional practices and local technical knowledge is as important as

Figure 2. SELF-HELP FORESTRY: A PLANNING PARTNERSHIP

Village Community	Forester / Facilitator
PREPARATION	
Hold informal meetings Examine past experiences Form beneficiary groups Identify common problems and needs Identify leadership	Obtain and analyze existing information Identify sources and forms of assistance from government and non-governmental agencies Identify local land/tree tenure systems Determine rights and practices relating to use of common resources Determine attitudes and beliefs relating to tree planting and management Identify local technical knowledge Identify local facilitators Provide guidance in technical/managerial inputs
FORMULATION	
Clarify goals and objectives Identify and compare alternative projects Reconcile conflicting interests Establish linkages with credit/technology institutions and markets Determine methods of sharing labour and resources Determine methods of distributing benefits Negotiate for consensus on working plans Delineate and formalize specific roles and responsibilities Determine incentives and penalties to encourage participants to hold up negotiated agreements	Determine soil capability and water availability at alternative sites Do a simple inventory and management plan of a local tree stand Support a market study Determine alternative tree species and sources Work out animal grazing/fodder alternatives Work out protection mechanisms Determine technology alternatives for cooking Help villagers evaluate the costs/benefits of alternative work plans Assist where needed in the discussions and negotiations on alternative issues and projects
IMPLEMENTATION	
Review and correct rules and procedures Continue negotiations Keep systematic records Expand additional individuals' exposure to new skills	Strengthen linkages with external institutions Suggest formats for record keeping Help identify training opportunities in record keeping and related skills for village coordinators Transfer implementation responsibilities to villagers
MONITORING AND ONGOING EVALUATION	
Keep records and monitor progress Assess project impacts and benefits achieved Evaluate distribution of costs and benefits Monitor and evaluate participation Share training in new skills	Suggest formats for group involvement in monitoring and evaluation Transfer evaluation responsibilities to local leaders Provide backup to eliminate bottlenecks Assist in securing training opportunities Reduce dependency and monitor participation
CYCLIC PLANNING	
Foster organizational growth by initiating "second phase" projects	Provide guidance as needed for new projects Help to monitor and widen participation

insights gained from new scientific discoveries. Participants at the Workshop felt that local knowledge does not generally filter into departmental projects and programs. A forester is in a good position to share and exchange information with local people to arrive at alternative working options. New opportunities can be developed through jointly-managed field trials, as in the CARE Mae Chaem project, or introduced through demonstrations which allow families and local groups to experience and see the results directly. This implies interactive research including development of a local data base on soil conditions, alternative species, harvesting practices and the like.

A Bare Beginning: Existing Information Sources

A facilitator first entering a particular locale can gain initial awareness of the local situation through existing sources. Formal sources of information such as official statistics, published articles, and aerial photographs can provide a starting point. Such references usually provide a range of useful information on the area, both quantitative and qualitative. Patterns and variations emerging in this search may be instructive. Added sources include research from regional universities (anthropological or ethnographic studies, research on cropping patterns, economic conditions, and the like) and reports from previous and ongoing development projects. Useful insights can also be obtained through informal discussions with local fieldworkers, government officers, or other outside researchers, such as university staff and graduate students.

The need to test the accuracy of existing data through direct observation on the ground and sustained dialogues with village residents is exemplified in an evaluation of **Van Panchayats** (village forest associations) in a north India district (Morse et al., 1987). After compiling data on panchayat administration and performance from forest division records, the study team held on-site meetings with village association members in four distinct ecological areas. Important differences were found between actual use and control of land for trees and recorded uses, where indeed such data existed. Local residents provided insights on the relevance of existing data, and perceptions on factors underlying existing patterns. Wide differences among villages in the operating effectiveness of Van Panchayats could be understood only through such repeated discussions with representative villagers.

Rapid Rural Appraisal and Other "Quick" Techniques

A number of techniques have been developed to help researchers from outside the village gain a rough understanding of the local situation fairly quickly. Variations on these techniques have appeared under such names as "Rapid Rural Appraisal" ("RRA"), "Sondeo," "Informal Agricultural Survey,"

and others. In fact, some of the steps in RRA were adopted in the field visits of the Self-Help Workshop, as described earlier.

Conducting a comprehensive RRA can provide many insights into local conditions, though it requires the intensive involvement of a trained multi-disciplinary team. (Rapid appraisals by skilled and experienced individuals are, however, possible on single topics to give added insights into special issues.) Although rapid appraisal may be beyond the scope of the forestry extension officer, existing studies based on RRA may be available for various areas. If so, they might be found through regional universities (such as Khon Kaen University in Thailand) or government agencies such as the Department of Agriculture.

If no such studies are available, following some of the points of RRA techniques may still be beneficial for gaining an understanding of a new area. Many references are available that discuss RRA methods, and a brief overview appears in Appendix G. Short courses in RRA methods may also be available in certain areas, such as those offered periodically at Khon Kaen University in Thailand.

Intensive Dialogues with Villagers: The Heart of the Matter

Most of the foresters' responsibilities in the preparation phase of self-help projects center around gaining a solid understanding of local perspectives and conditions, including identifying indigenous technical knowledge. Traditional approaches to obtaining information have stressed questionnaires and formal interviews. But such techniques have great limitations. In a classic description of "Survey Slavery," Chambers describes an all-too-typical experience:

> Under pressure for "findings," [researchers] take figures as facts. They have neither time nor inclination to reflect that these are aggregates of what has emerged from fallible programming of fallible punching of fallible coding of responses which are what investigators wrote down as their interpretation of their instructions as to how they were to write down what they believed respondents said to them, which was only what respondents were prepared to say to them in reply to the investigators' rendering of their understanding of a question and the respondent's understanding of the way they asked it (Chambers, 1983).

This complaint describes the dangers of quantification and aggregation; but an even more crucial drawback is that formalized techniques are generally based on questions that the forester or other outsider considers important, such that issues felt by villagers to be of greatest local concern are overlooked. Initial probes should therefore devote adequate

time and attention to determining the range of issues villagers feel are important. Two helpful approaches for this include open-ended discussions with little or no pre-set agenda, or discussions focusing on a pre-determined set of topics, but in no particular order or priority. Both allow village residents the primary role in discussing their own concerns. Chambers discusses both in more detail ("How Outsiders Learn"), suggesting that good researchers must be "eclectic and inventive," in divising methods to gain an accurate understanding of local perspectives (Chambers, 1983).

Getting Started...Discussing and Helping to Clarify Villagers' Perceived Needs. To develop a partnership style in needs-assessment, it is well to get to know people informally for awhile, in general discussions and through attentive listening to casual conversations. More of substance may be revealed during villagers' daily talks among themselves than during discussions which are led by and focused on the forester and forestry topics. In this process, the forester/facilitator can keep track of the issues that seem to concern people, and the contrasts between different individuals, social groups, men and women, and so on. Contrasts can in fact provide telling information regarding peoples' priorities and desires: as people discuss how their lives compare to those of neighbors, their likes and dislikes will surface strongly.

All of the issues revealed through these casual questions can be recorded in checklists as a basis for more structured interviews, in which the forester or facilitator can mention points that have come up in other conversations, and ask people to elaborate. A focus on the most urgent problems and concerns should evolve naturally from this process.

An Entry Point -- Dealing with the Past. An important first step before attempting to encourage new activities in a village is to know <u>what has gone wrong in the past</u>. In most regions of Asia, a bulk of villages have already had some direct experience with an outsider or government official attempting to promote local action...and in many cases these efforts have conspicuously failed. Villagers may therefore be very skeptical of outside involvements, and may also have unsettled issues and social tensions (land disputes, political disagreements, and the like) that dampen their enthusiasm for new projects. In the words of a project facilitator in India:

> Poor people are mostly not in their present difficult situation because of lack of initiative or potential, but rather because their initiatives have in the past been frustrated by too-powerful competitors who had contrary interests. Therefore, studying carefully the past experiences of the local communities is an absolute must for the promotors.

Skepticism toward outsiders, and other associated barriers to action, should be well-understood before too much effort toward initation of new projects is begun.

Achieving Representative Involvement. Given the many types of "interest groups" and individual concerns at play in the village, the forester/facilitator will have to be careful to foster "representative" involvement in dialogues and in projects. There is no simple technique to ensure this. The importance of meeting with groups that have a natural collective interest reduces the usefulness of traditional methods such as random sampling. One approach to deal with this is to begin by sensing a general picture through meetings that occur under natural social situations and then use sampled, semi-structured interviews as a check on the information received.

Persons in diverse situations should be sought out to discuss village problems and opportunities for self-help projects, including:

- Elders, recognized leaders, religious heads, and other such "key informants." Such high-profile individuals have contact with villagers from a range of wealth groups, locations, and social standing. They can therefore be a good initial source of information and opinions. However, they do not represent the norm, and may skip over the points of view of various sections of the population.

- Contrasting persons, households or communities. In most villages, it is much more common to encounter certain groups and individuals than others. To counter this, "seek the hidden voices." If men are more public, one must seek out women; if the rich are most vocal, one must listen for the poor; if the persons close to the main travel routes are often encountered, one must travel to the distant households and immobile individuals, and so on. Casually holding discussions with people "on their own ground" naturally focuses topics on the specific activity, location, season, and so on, and can point out issues that may not be clear in an abstract, formal interview. A gathering of family members will bring out different concerns than individual discussions, and may illustrate social relationships (the relative voice of women, for example) that would not necessarily be expressed one-on-one.

- "Natural" social groups -- those who work together or interact socially on a regular basis. "Group interests" and group dynamics are revealed by group discussion. The important point is to focus on groups that have a natural common interest or affiliation. A "women's meeting" that cuts blithely

across strong ties of kinship, economic groups, or ethnic groups, for instance, may not reveal the "common interests of women" so much as the conflicts inherent in the women's other social connections.

- Existing project-centered groups. In some villages, organizations already exist that have a specific interest in village development issues. Women's groups, marketing collectives, political committees, and other such groups may already have done much groundwork toward organizing village residents.

FORMULATING PROJECTS

Tools to Facilitate Villagers' Diagnosis of Causes of Problems and Possible Solutions

In initial dialogues, villagers will identify certain problems they wish to address. The next question is: How to understand the problem and its causative factors, both social and biophysical? The forester will have certain technical information to share with villagers at this stage, including evaluations of site limitations, species options, and so on. But the understanding of problems and search for solutions will be more successful when local people themselves are encouraged to probe the causes of the problem in depth. Such diagnosis by villagers will also uncover constraints they perceive in working toward solutions. Villagers' diagnosis of problems is therefore a key step to increasing their involvement in project planning and implementation.

As an example, when farmers in the Eastern Visayas region of the Philippines were actively consulted in classifying soils, slope, and crop sequences, they themselves identified possible solutions for controlling Imperata, including experimental designs for testing on their own farms in relevant agro-ecological niches (Lightfoot et al., 1987). Extension linkages included on-farm demonstrations of Leucaena contour plantings, Gliricidia, and creeping legumes. The guiding lesson in this systems approach to diagnosis is "to listen unencumbered to the farmer". Farmers got more involved in experimenting with solutions that lay within their own capacity than experimenting with high input solutions.

The forester or other facilitator may provide tools and guidance to villagers in conducting such diagnosis. First, s/he might encourage very open exploration of system interactions, socioeconomic and biophysical, that influence the problem. A step here is to ask residents who know the problem from various perspectives to voice all the factors they connect with it in any way, even remotely. For example, if the problem is one of species adaptation to particular sites, farmers can be asked to explain the full range of experiences they have encountered with

this species in different areas. If scientific capabilities of analyzing soil characteristics are available, these can be incorporated with villagers' local knowledge and problem assessment.

"Active," participatory methods of discussion, including manipulation of movable figures and sketches, can be a great aid in the discussion process. Villagers themselves, for example, can use a board with detachable symbols that depict different sites and tree species, to associate and compare successes or problems they have experienced. (Examples of active discussion techniques were presented in the workshop by Alexandra Stevens of FAO, who is presently developing a handbook of such techniques.)

These discussions can be expected to result in a listing of numerous causative or constraining factors. Establishing and assessing the range of variations is important at this stage; visual representation on a village sketch map can help clarify the complexities. As discussed in a later section, land use planning can be carried out by different groups [including foresters], in part by marking such maps with land use propositions and identifying similarities and differences. Where there is agreement, activities can begin. Where there are differences, they can be identified and negotiated. New factors in land use planning could emerge from such exercises that would greatly facilitate self-help forestry.

Once the range of basic limiting factors has been identified, a larger number of residents might then be asked to rank the importance they attach to identified factors. The pooled ranks can be charted on a blackboard, perhaps in a pie diagram or bar graph that represents the rated importance of each issue. A village meeting might then be convened to discuss the identified factors, first using the diagram to stimulate assessments on the importance of each factor, and next, hopefully, gaining as wide a consensus as possible on these factors as a basis for action toward solutions.

Group Self-Selection and Formation

The stages of identifying problems, causes, and constraints, involving as many of the population as feasible, will begin to clarify the common interests of various subsections of the population. Villagers will naturally wish to focus on the particular issues of greatest personal concern. Groups who share a common concern and are in a position to evolve a common solution will begin working more closely together. Where problems and activities clearly span the interests of existing social groups, villagers may wish to form new associations that can deal with the problems and options available. For example, a traditional forest management committee, originally composed of only a few village members, evolved in the mid-1980's in Sangar, North India, into a

village-wide body which assumed responsibility for protecting overgrazed slopes by constructing stone walls, then planting and maintaining 12,000 seedlings of multi-use tree species (Morse et al, 1987).

The important elements in group organization can differ dramatically from village to village and culture to culture. In Java, Indonesia, one group of extremely poor landless people were uncomfortable because they had no papers and therefore could not be officially married. The facilitator helped regulate this matter -- which created trust that the outsider was concerned about their problems. They then formed a group and carried out new activities, including raising high-quality fruit tree seedlings to sell.

In the process of group formation, a forestry officer or facilitator may be helpful in pointing out new ways of organizing to deal with mutual problems. There are a few points to consider that may improve chances for the successful formation of groups with a long-term dedication to the problems at hand. For instance:

- Start with "natural" social groups -- groups of people that share a common interest. These may be labor-sharing groups, groups of related households, "political" organizations, small communities that jointly conduct religious activities, and so on. Sometimes a "natural group" will coincide with a house cluster or some other settlement such as a "neighborhood," village or even village cluster with some strong mutual interest, such as the community that formed a rice bank in Nong Khong.

- Groups will be more likely to form when some tangible immediate benefit is available and recognizable. So don't be afraid to start small, even with projects that seem slightly peripheral to forestry. Sometimes small projects with quick results can be an irreplaceable prelude to planning and implementing efforts on a larger scale.

- Being part of a recognizable social group does not necessarily imply a sense of "community." Common characteristics such as poverty, gender (the "women's group"), landlessness, or residence in a single village do not necessarily inspire people to band together for joint activities. Although this may be a desirable way to lend more voice to the voiceless, trying to form groups that are based on an outsider's perceptions of common interest may be a frustrating and fruitless experience.

As "natural groups" begin to address particular issues and their solutions, it is important for them to communicate their

ideas and plans with one another. The use of community resources may be involved, and the activities of one section of the population will very probably affect the resources available to another. Potential conflicts have to be faced squarely at an early stage, before temptations arise for one group to sabotage the activities of another -- not an uncommon reaction to projects that fail to deal with conflicting changes in the distribution of resources.

When conflicts in attitudes or beliefs hinder group organization for a village-scale project, a facilitator may help clarify the underlying concerns or perceptions and encourage their resolution. For instance, in Nong Yang village, Sisaket province, Thailand, a researcher-facilitator helped village elders and others at a community-wide meeting defuse fears that ghosts would be offended by tree planting in the village burial ground (Morse et al, 1987). He also helped resolve boundary disputes and established liaison with the nearest Forestry Research Center to obtain Eucalyptus seedlings for planting in the burial ground and an additional village site.

Helping Villagers Identify, Evaluate and Compare Alternative Projects

Through the process of discussing the causes of problems and constraints on action, practical solutions to address these causes will naturally begin to evolve. Many possible solutions will be identified directly by villagers through discussing the problems themselves; in addition, solutions can be suggested by the forester or other outside technical representative from the Department of Agriculture, Animal Husbandry or others. A variety of options should be brainstormed to provide a basis for comparing alternatives and suggesting priorities.

Active discussion techniques can be used for keeping track of project options, discussing their ramifications, and coming to some general agreement. Often, this process takes place already on an ad hoc basis, but this may reinforce the power of high-status individuals who are already the strongest and most vocal. The use of new organizing tools may provide an alternative method for decision-making that grants more voice to those who tend not to speak out. Though types of approaches with which villagers are comfortable will differ, the forester or facilitator can help use such active methods in many of the tasks involved in project identification and assessment, such as the following:

- Brainstorming on potential projects with individuals or small groups. Keeping paper and a pencil handy, or other sources of making symbols, each suggested option can be given a visual designation. If tree species are being discussed, each can be represented with a different sketch, leaf, or other evocative symbol. Since local tree names often indicate a main use or

characteristic of the tree, these can be an excellent choice. If locations for a tree plantation are being considered, symbols that indicate the place can be used: a pencil for the schoolyard, a bunch of twigs for unused shrubland -- whatever villagers suggest as a meaningful representation. Every time a new idea is suggested, new symbols can be chosen to provide a focus for comparing alternatives throughout future discussions.

- Eliminating the "impossible or improbable." From the basic collection of alternatives, those which are clearly not feasible can be culled right away, before endless discussion ensues. If, for instance, villagers would like the government to build a road but no project funds are available, that option can be set aside.

- Comparing general benefits and impacts. For each alternative, some of the ramifications of such a project can be symbolized. Projects with more than one benefit can be given due credit: if a plantation provides fuel, fruit and fodder, each of these outputs can be represented. If soil conservation is important, a dish of soil may suffice. On the negative side, if trees on farm boundaries shade crops too badly, a withered leaf could represent the problem. If grazing land would be encroached by a community plantation, a bunch of grass might symbolize the issue.

- Considering how a project may affect different people and groups. Since the benefits and impacts of a project will probably affect different villagers differently, these can be summarized through symbols for the individuals, households, or groups being affected. Symbols of the benefits and impacts of a project can be placed next to the symbols for individuals, households, or groups in question. This may help clarify the "winners" and the "losers," and give specific points of discussion for balancing the outputs of a project to meet peoples' voiced concerns.

- Identifying the tasks and inputs involved in different projects. Each of the necessary inputs (land, labor, materials, and so on) can be symbolized. The relative amount required of each might be represented by the relative sizes of the same symbol in different projects. The source of each input (government, particular households, etc.) could be represented by the "personal" symbols used for comparing impacts.

- Clarifying the time constraints and other barriers. Some difficulties may pose particularly serious problems in implementing a project. Time constraints

during the prime agricultural season may impair tree-planting activities. Certain inputs (such as tree seeds or plastic bags for a nursery) may be difficult to obtain, and so on. It is helpful to pay special attention to the concerns that people voice regarding the feasibility of various tasks.

- Ranking projects. With many of the issues, inputs, and implications summarized symbolically, each of the persons involved in comparing projects can rank the options according to their preference or priority. This can be done visually by placing the project symbols in the order in which the person would be most willing to get involved. The facilitator or a village member can help to compile the rankings for the entire group in an understandable form. A pie chart, bar chart, or physical collection of items like same-sized stones may represent the number of people in favor of the different project options. This can be an initial focus for comparing the most popular projects.

- Evaluating practical realities: inputs, outputs, distribution of benefits. With the ranking as a focal point for choosing between or prioritizing different projects, the actual sources of inputs, funding, and so on can be addressed, along with the specific question of who will ultimately get what. As a part of the negotiation process, this will make the real trade-offs as clear as possible, and can again be symbolized to keep track of the gains and losses of each of those involved.

- Working toward consensus. The ranking need not be taken as a "final vote" with majority rule, but rather as a focus for negotiation. If most put priority on one project, the concerns of others can be addressed directly, or agreements which "trade off" one project for another might be made. The clear presentation of inputs and outputs will make this easier. Ultimately, it is helpful to decide upon the priorities and particulars of projects in a way that those involved can all agree with. Otherwise, participation will be limited to those who can "gain," while the "losers" will bitterly withdraw.

The above examples are by no means the only way to proceed with participatory planning activities. For every group and every facilitator the process will differ in a way that reflects the style and preferences of those involved. Creativity and flexibility are the most versatile tools at the facilitators' disposal.

IMPLEMENTATION: ASSISTING WITH SETTING UP PLANS

The project comparisons discussed above embrace many of the steps necessary to generate implementation plans. By this point, the inputs will already have been identified, the contributions of different participants clarified, and some agreement negotiated on how to distribute outputs fairly. If this was done thoroughly in the negotiation phase, it need only be summarized and formalized prior to initiating action.

Continuing with an illustration of what might be done, the villagers may set up specific plans of action and establish methods for seeing the project through to completion and dealing with unexpected contingencies. If no natural leader has already emerged, someone may be chosen by the group to act as the coordinator of the work, presumably with some special benefit provided by the others in return. Training in methods of record-keeping might be sought for those overseeing the project.

Before initiating work, a formal record of promised inputs can be drawn-up that is clear to everyone. This could use the symbolic representations from the discussion phases, with numerals or symbols to indicate expected quantities of inputs (e.g., person-days of labor per household). Tasks to be completed in certain blocks of time can be clearly represented in calendar form or another locally-understandable representation, such as columns that signify different months or other recognized time-frames such as holy days, cropping activities, or other time yardsticks as reckoned locally. The forester's assistance may be important in this phase, to help secure special training for villagers doing project coordination or record-keeping.

Once this has been accomplished, a mechanism might also be set up to handle those who later turn back on their agreements, even if inputs and their timing have been set out formally for each person involved. People may withhold their promised inputs for many reasons, from gradual disinterest, to personality conflicts, to unexpected family tragedies. Some means to decide on incentives for follow-through, or penalties for withdrawal, are best set up <u>before</u> such issues arise.

PARTICIPATORY MONITORING AND ONGOING PROJECT EVALUATION

Monitoring the progress of a project and evaluating the results are often the domain of officials who examine a situation "objectively" from the outside. But this kind of approach often fails to determine what is going "wrong" and what is going "right" in a project, <u>from the perspective of those actually involved</u>. Although agencies that support village projects have their own issues and agendas against which they need to measure project "success," the bottom line in evaluating self-help rural development projects rests in the perceptions of

the villagers. Within the village, participatory monitoring and evaluation can provide the basis for keeping track of the progress of existing projects, improving their implementation, identifying rising issues, and suggesting the next priorities. And for outside evaluators, truly participatory evaluations can improve the information that they bring away from a project, when it is necessary to report on results to sponsoring agencies. As an instance, the villagers' and study team's assessments of Van Panchayat performance mentioned earlier in this chapter yielded information relevant to a state legislative review of the forest association system (Morse et al., 1987).

The art and techniques of participatory monitoring and ongoing evaluation (sometimes referred to as PMOE) are not new. Many techniques have been developed for engaging villagers in evaluating their own performance, as well as the performance of outside facilitators and agencies. Participatory evaluations frequently rely on active, visual discussion techniques, as discussed earlier. Systematic assessments of participation (as suggested in FAO/ACCRA, 1986), combined with group members' self-evaluation -- through techniques such as "analytical polling," role playing, "conversation charting," and "empathy practice" (United Nations Department of Economic and Social Affairs, 1978) -- are all practical tools that can be used. A summary of the concepts and certain basic techniques of PMOE appears in Appendix F.

CYCLIC PLANNING: ENCOURAGING ONGOING EFFORTS AND NEW PLANS

Planning self-help projects is never a one-shot deal. Development efforts are mutually reinforcing and self-regenerating: each successful activity provides a foundation for beginning another. The process of project identification and evaluation will have pointed out a number of options for self-help projects. During the implementation of the first-priority project(s), such additional options can be considered as a menu of future directions. These and additional ideas that come to light during the implementation of initial projects can be used to initiate "nested" planning cycles for new projects. One effort may not have reached the final stage of completion before new work is begun. The approach of "cyclic planning" allows the enthusiasm that may be generated during initial work to spill over naturally into new projects.

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SOURCEBOOK SUPPORT MATERIALS - MODULE 8

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LEUCAENA LEUCOCEPHALA

Native Range
Originally from the drier western side of Central America, leucaena is now perhaps the most widely spread exotic in the tropics. It has become indigenized in the Philippines, Indonesia, Hawaii and even the Kenya coast.

Uses
There is little doubt that leucaena is a very useful, very fast growing tree. Yields of wood from leucaena on an annual basis by volume exceed that from almost every other tree. Considerable research has been done on the tree, which can make selection of the right variety difficult. Varieties K8, 28 and 67 (and many others) are giant types, producing fuelwood, timber, shade and windbreaks, as well as fodder and nitrogen-rich, green manure. Varieties Peru and Cunningham are primarily fodder producers. (Overfeeding cattle or goats with leucaena can cause problems due to the mimosine content. Rabbits should not have more than 20% Leucaena and chickens 5%). Leucaena tolerates poor soils and steep slopes. It coppices readily and recovers quickly from dieback caused by drought or hungry goats. Browsing animals can cause many problems.

Preferred Climate Types
Leucaena has an undeserved reputation for drought tolerance. It does best near the coast and in places like Kitui, Kisumu/Murang'a climate types. It does not grow well in areas of cool temperatures (Nairobi) or places with droughts of four months or more. (Zone I, 1-3; II, 1-3; III, 1-3; IV, 1-3;). (Note: with some irrigation, it will grow well in drier zones. This is only recommended in places with easy access to water.).

Seed Information
Leucaena seeds prolifically, especially the fodder varieties, even in the first year. It is best to get seeds from trees about 2 years old.

Soaking or nicking speed germination. Seeds store well. Growth in the nursery is very fast, 10 weeks being sufficient.

Seed Sources
Baobab Farms Limited, P O Box 90202, Mombasa (K8, k28)
EMI Forestry Project c/o Provincial Forest Officer P O Box 2 Embu
East Pokot Agricultural Project, Kositei Catholic Mission, Nginyang via Nakuru, P O Marigat
Ministry of Energy Agroforestry Centre, Mtwapa, P O Box 90290 Mombasa
Ministry of Energy Agroforestry Centre, Ngong, P O Box 30582 Nairobi

MARKHAMIA PLATYCALYX (Siala)

Local Names
Moo, Muu (Embu), Siala (Luo), Mabet (Mas), Lusiola (Luh), Sogdu (Som), Ekokwait (Turk).

Uses
Siala is perhaps the most widely used indigenous tree near Lake Victoria. It coppices well if cut properly and produces durable poles much liked by local carpenters. Timber from larger trees is also well liked. B.A.T. rates *M. platycalyx* as the best local tree for tobacco curing. Siala is often seen growing in cultivated fields where the leaves are used for mulch and the narrow crown limits shade impact. Its bright yellow flowers make it a good ornamental as well as providing a nectar source for honey bees.

Preferred Climate Type
The natural range of *M. platycalyx* is difficult to determine. It does very well in many climate types, the best perhaps being Kisumu/Murang'a and Migori. (Zone I, 2-5; II, 2-5; III, 2-5; IV, 2-4).

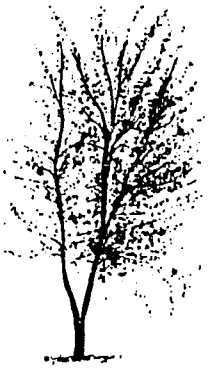
Seed Information
Siala produces seed prolifically in long, pod-like capsules. It is easy to collect at almost any time of the year. Fresh seed germinates

readily without pre-treatment. Storing seed is not recommended.

Seed Sources
As the tree is common in almost all its natural and planted range, we recommend personal collection. These sources can be used if you cannot find the tree.

District Forest Officer, P O Box 490 Kakamega
District Forest Officer, P O Box 376 Siaya
District Forest Officer, P O Box 66 Homa Bay
District Forest Officer, P O Box 110 Meru
The Silviculturalist, Forest Department (KARI) P O Box 74 Kikuyu

SESBANIA SESBAN



Local Names

Mwethia (Kik), Munyongo (Kam), Osawo Oyiko, Sao-sao (Luo), Mwathia (Mas), Walbaiyondet (Nan), Labiyero (Luh), Natiatia (Elg), Daisa (Bor).

Uses

S. sesban is one of a few Kenyan trees already being used as an agroforestry tree, especially in Western Kenya. It is known to be a good coffee shade tree and soil improver. Wherever it grows it is left standing, even in fields of maize or sugar-cane. It is also a soil stabilizer and grows well in swampy sites. Though soft, the wood provides firewood. A fast growth rate and quick return of fuel make it a very interesting tree for planned agroforestry strategies. Nearly all currently growing trees are naturally distributed.

Preferred Climate Type

Thrives in the mid-lands of Kenya especially in the Migori and Kisumu/Murang'a climate types, though its range is considerably broader. Plants have been found near Ngong, on the shores of Lake Victoria and Baringo, at the Coast and on Yatta Plateau. (Zone I, 3-4; II, 1-4; III, 1-5; IV, 1-4 and along streams).

Seed Information

The tree seeds abundantly, the long cylindrical pods containing many small, green, black-specked seeds about 3 mm long, also cylindrical. Damaged seed is often found in the pod, necessitating sorting and cleaning. When kept dry and cool, the seed has long viability. Because of its quick germination and fast growth it is best to plant *Sesbania sesban* directly in the field rather than in a nursery.

Seed Sources

Mr Erasto Ajwang, P O Box 50 Oyugis
Mr Abner Mango Opot, P O Box 194 Yala

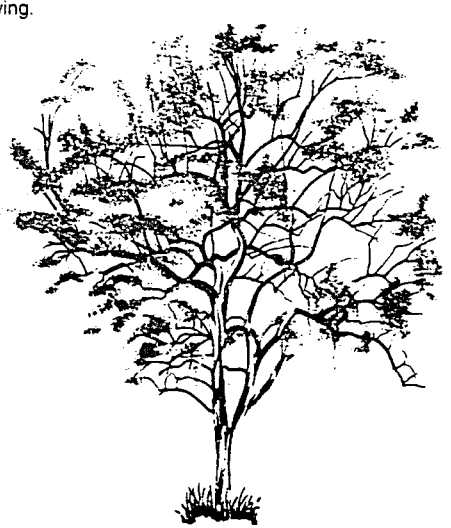
How to select a good mother tree

It is important to collect seed from healthy trees which are already good seed producers. Avoid isolated, poorly shaped, low seed producing trees. The best trees for seed collection are those growing in the midst of a healthy stand of the same species.
The quality of a mother tree depends on how you wish to use the tree.

Timber:

Trees intended for timber are best when they grow very straight, with few branches and are fast growing.

A good timber mother tree



A bad timber mother tree

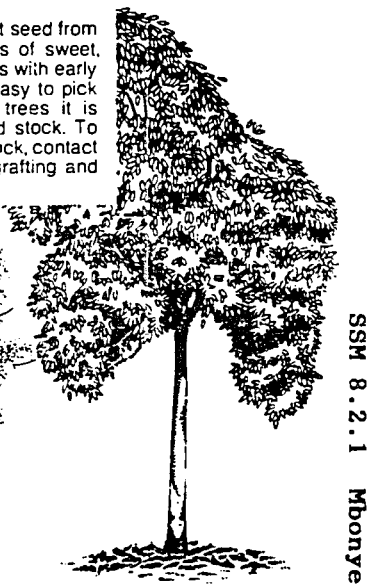
Fodder:

Trees intended for fodder should be fast growing, profuse branchers, multi-stemmed, evergreen and able to coppice easily. The multi-stems and profuse branches ensure ample availability of green leaves all the year round. Fast production of leaf matter, pods and the ability of the tree to recover after the cutting of branches are the most important factors.

Fruit:

If you intend to grow fruit trees, collect seed from those trees producing good quantities of sweet, healthy fruits of marketable size. Trees with early branching are preferable since it is easy to pick fruits from low branches. For fruit trees it is preferable to have budded or grafted stock. To obtain the best budded and grafted stock, contact centres that deal with professional grafting and budding.

A good fodder mother tree



A healthy fruit mother tree

Timing of seed collection:

The optimum time for seed collection is as soon as the seed is mature and ready for harvest. Some type of seed will not germinate if they stay on the tree for too long. Seeds of dehiscent fruits have to be carefully timed since collection of the seed is difficult. Such seeds are light and easily blown away by the wind e.g. *Grevillea robusta*.

The seed of *Combretum spp.* and *Terminalia spp.* appear brown even when unripe. Careful observation must be done to ensure that the seeds are mature before harvesting.

Other types of seeds appear cracked and attain a dark-brown colour when mature e.g. *Acacia spp.*

In *Acacia senegal*, seed is viable before they have fully matured i.e. when the seed coat is still relatively soft and pale in colour and the swollen pods are just beginning to turn brown. Severe insect attack is thus minimised and pre-sowing treatment is avoided.

Combretum spp.

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Questions and Answers

NATURAL FOREST

Nearly everyone has taken a walk through a forest or woods growing naturally near their home. Perhaps we can take a little walk now—if only in our imagination. The types of trees we see on our walk will depend on where we live. In the hot, dry north east, we would see mainly thorny acacia trees and rubbery branched commiphoras. In the wet highlands of Mt Kenya or Mt Elgon the forest is far denser, with bamboo, podo and other species. Yet everyone would see similar things as well.

Natural forests have a mixture of species of all sizes. If we look on the ground we might see the young shoots of newly germinated seed. In more open areas, young seedlings and small, immature trees are abundant. Older stands of mature trees may be in flower, or we might see fruits, seeds or pods hanging from branches. Occasionally we see an old tree, many of its branches dead and it may or may not have flowers or seeds. Also in this forest are many shrubs, perhaps some grasses and a wide variety of birds and animals.

These natural forests are shrinking for a variety of reasons. People need more land for cultivation, so trees get cut down and the bush with its young trees is cleared. Trees provide the most important source of fuel as well. If you look in areas where the woods are gone, except for a few scattered trees, many problems are evident. Perhaps the main ones are soil erosion and the need for women to walk many miles to get firewood.

Think of all the ways you use trees. Now think what your life would be like without trees of any kind.

Can we help the trees to start again?

Yes. Without our help the existing trees will not be able to regenerate fast enough to keep up with our demand for fuel, timber and farmland. We can grow new seedlings in a nursery, plant them and protect them from damage by people or livestock until they are large and sturdy enough to grow on their own. But before we begin, we must select the right indigenous and exotic species to grow in our areas and then find good quality seeds.

The following 40 questions and answers should help us make a good start and see us on the road to good tree planting.

CHOOSING THE RIGHT TREE SPECIES

1 How do we choose tree species to grow in our area?

The best trees to grow in any area are often those found growing naturally in that area. The uses of such trees will be well-known: fuelwood, fodder, fruit, shade, medicine and many others. Select those species which meet the major needs you have in your area.

2 Are all trees good?

Not necessarily. Some trees, like *Acacia hockii* (Muraa-Kikuyu) when it grows in the highlands, turn weedy very quickly and may be difficult to remove or control[1]. It is best to select those trees that are regarded as valuable and which do not pose problems for agriculture or your animals. As an example, *Cassia siamea*, a common exotic species, should never be grown near a place where pigs are kept because the leaves and pods are poisonous to them.[2]

3 Can any tree species grow anywhere?

No. Every tree is adapted to a certain climate range in its natural distribution. It is important to select those species which could grow naturally in the climate of your area. To help you do this we have in this book divided Kenya into a number of Climate Types, derived from the *Agroclimatic Zone Map* published through the Kenya Soil Survey

A climate type is determined by rainfall, potential evaporation and temperature. To find your climate type, look at the Locational/Climate Type List in Chapter 2, pages 27–36. Find your province, district, and the town closest to your home. In the third column will be the Climate Type designated by a major town. Turn to the climate type species lists in Chapter 3 pages 38–56 and find the page corresponding to your location's type. This will have a list of species suitable for your type. From there you can look up the individual

1 Kenya Trees and Shrubs
2 Firewood Crops

species listings in Chapter 4, which provide local names, uses and groups or persons who are seed sources.

4 What are indigenous and exotic species?

Indigenous trees are those which have always grown and reproduced naturally in Kenya. In the individual species profiles (Chapter 4), they are indicated by having 'Local Names' as their first piece of information.

Exotic species are those which were imported to Kenya from suitable locations around the world. For example all ecalyptus trees are exotics from Australia.

Fruit trees are listed separately even though many of these are exotics, because of their importance.

5 What are the important characteristics of a growing site?

The most obvious variables in a planting site are rainfall, temperature and potential evaporation. (The last variable tells us how much water the land could lose, if water lay open on the surface.) These variables were used to determine the climate type lists. Other important factors to consider are soil and slope. Tropical soils vary greatly from place to place and some species are well-adapted for a certain soil type. For example, *Acacia nilotica* (Burguge-Boran), does well in black cotton soils in Zone V-2, while *Terminalia brownii* (Muuku-Kamba), growing in the same climate type, needs sandier well-drained soil. Where soil requirements are known, they are listed with the species. However our information on soils is incomplete. You should therefore, make certain a tree will grow in soils of your area before proceeding with planting. (See p 21 for simple soil test).

6 What are the differences between home areas of tree species?

Sometimes trees grow in areas widely separated geographically, but still in the same type. For instance, *Maesopsis eminii* (Musizi)grows in the Western Province, Meru and in Taita Hills. It has been found that seed from Taita Hills, germinates more readily than seed from Kakamega even though conditions are similar.[3] In this case Taita Hills seed is better. When getting seed from outside your area it is advisable to obtain it from more than one source.

Some species grow over a wide range of climate type. *Acacia tortilis* (Kura-Somali) can be found from Siakago (Kisumu/Murang'a climate type) to North Horr (Wajir climate type). However trees growing in one type are adapted to that type, so select seed from your type or perhaps, a drier one. *Acacia tortilis* seed for example, from Wajir type trees grows well in Taveta/Isiolo type but, if you reverse the situation Taveta/Isiolo type seed, does not produce good trees in Wajir type.

3 Forest Department Studies Unpublished

SEED: PRODUCTION, PROPAGATION AND USES

7 Where do seeds come from?

All tree species reproduce in one form or another. The process by which seeds are formed is well known. First, the mother tree flowers. Often trees are hermaphrodites, meaning they have both male and female flowers (or the flower has both male and female parts). Some trees like pawpaw or *Chlorophora excelsa* (Mvule) are divided sexually. Once open, the female flower receives from the male, pollen which is carried by insects or birds, or borne on the wind. After pollination, seeds take from one month to one year to mature before they are ready for harvest.

8 Do all trees produce seed?

No, some trees produce only male flowers and do not bear seed. Other trees may be injured, diseased or genetically incapable of producing seed. Some types of citrus fruits do not reproduce from seed and require grafting or budding. An example we see everyday is the edible banana, which reproduces from root suckers.

9 When do trees begin to produce seed?

This is highly variable and dependent upon the species. Fast-growing, short-lived species, like *Sesbania sesban* (Sao-sao —Luo), begin producing good seed in their first year. Slower trees like the mango may take up to seven years and large forest species may require an even longer period.

10 How many seeds do trees produce?

Again this varies according to species and conditions. Big-seeded fruits like mango and avocado produce relatively few whereas *Acacia tortilis* can produce up to 100,000 per tree in one year. Very small-seeded trees, like *Conocarpus lancifolia* or *Casucrina equisetifolia*, provide nearly uncountable amounts.

11 When are seeds mature?

Each tree species has a set pattern of seed production. Often seed

drops naturally from the tree just before or during the rains. Many species in Kenya have seed which ripen in August or September. For collection purposes, it is important to note the flowering and seeding pattern of trees in your area. A species growing in South Nyanza, like *Olea africana* (Ol-orien—Masai), may seed at a different time to those growing in Central Province. (We have tried to estimate seeding times for each species, but remember that these are subject to variation due to weather pattern changes.)

12 Do trees produce seed every year?
Most trees do, though this too must be watched. Often species go through cycles of seed production, perhaps regulated by weather patterns. *Acacia senegal* appears to have a five-year peak seeding pattern in the Sudan. Avocados produce heavy crops every second year. (Seeding times, where they are known, and patterns for individual species are provided in the listings.)

13 How do seeds spread from the mother tree to different places?
Nature gave trees numerous methods of distributing seeds. Acacia species have hard seeds in pods, which are eaten by goats, wild animals or birds, and deposited ready to germinate with the manure in the rains. Others, like podocarpus or vitex species have seeds readily eaten by monkeys whose messy habits scatter seeds far and wide. Markhamia and terminalia seeds have wings which take to flight on windy days. People, too, distribute seed for nature, often without intention. Having an edible fruit often helps a seed find a place to germinate.

14 What is the difference between a fruit and a seed?
Fruits come in many shapes and sizes and—with the exception of some citrus varieties and bananas—usually contain one or more seeds. When we use the word *fruit* we do not mean only those species which have an edible pulp surrounding the seed. A fruit is the product of a single pollinated flower with either a hard or skin cover, a pulpy interior either surrounding the seed or seeds, or having the seeds embedded in the pulp. Seed can be separated from other parts of the fruit prior to planting without affecting growth. The purpose of the cover and pulp is to provide protection for the seed while it germinates and to attract spreaders of the seed.

15 Are there edible seeds?
Yes, probably more seeds are edible than we know, but those which are known are listed. Cashew nut, Macadamia nut and coconut are the three most often cultivated in Kenya. (The coconut is slightly different in propagation from the other two.) Other edible nut-bearing trees include *Terminalia catappa*, grown at the coast, *Balanites aegyptiaca* (Tuyunuwo-Pokot) whose seed is used for oil and flour in times of drought and *Acacia senegal* (Edad-Somali) whose seed is often dried and eaten as a vegetable.

16 How much do 1000 seeds weigh?
This varies dramatically. One thousand *Eucalyptus camaldulensis* seeds may fit easily into the palm of your hand and weigh less than one gram. But one thousand mango seeds would have trouble fitting into a *gunia*. It is important to know the approximate weight of 1000 seeds to determine the method and cost of transport, calculated by weight, and how many you wish to purchase.

THE MOTHER TREE

17 Do trees grown from seed have the same traits as the 'mother' tree?
The full answer to this question can be quite complicated. Normally, growth patterns of seedlings are similar to those of the mother tree. This is more true if the mother tree stands in the midst of other trees of the same species which have the same traits. If a mother tree is isolated, the offspring could be highly variable. Species which have male and female trees require more observation. A short, twisty or low quality male could provide pollen for a high quality female and produce poor seedlings. In general, however, a good mother tree will produce offspring following the same pattern.

18 What about the father tree?
Since 'father' trees produce no fruit or seed, their importance for non-wood purposes is reduced. Ratios of one male to 50 or more female are usually sufficient for fruits like the pawpaw or the date palm. In wood species, like *Chlorophora excelsa*, an equal mixture of male and female trees is acceptable, and the traits of the father tree are judged in the same manner as the mother tree.

13 Can people control the pollination process?
For most trees it is nearly impossible. In some species, especially the date palm, it is essential for good fruit production. The only effective control consists of removing from seed stands those trees with unacceptable traits. Pollination in fruit trees, or in other types, is often made more efficient by using bees. Bees, taking nectar from flowers, carry pollen on their legs from flower to flower and have the added bonus of producing honey. Good honey trees include *Cordia abyssinica* (Muringa—Kikuyu) and *Prosopis juliflora.*

20 How does one identify a good quality mother tree?
The quality of a mother tree depends upon how you wish to use the tree. Timber trees are best when they grow very straight, with few branches and at a fast rate. If fuelwood production is your goal, then fast growth and high wood yields become more important. Fodder trees however, require a different approach. With them production of leaf matter, pods and the ability to recover after the lopping of branches are the most important factors. For fruit trees, take seed from those trees producing good quantities of sweet fruit, of a marketable size, where it grows within easy picking reach. (Often for fruit trees one should have grafted or budded stock, selection of which is best done by trained people. For the best budding stock, try to locate centres which do grafting and budding professionally.) As a general rule, take seed from healthy trees which are already good producers of the product desired. Avoid isolated, poorly-shaped, or low-producing trees or stands, and remember that often the best trees for seed collection are those growing in the midst of a healthy stand of the same species.

21 Does the place a tree grows affect its choice as a mother tree?
Yes and no. On poor soils or in ecological fringe locations, a seed of high genetic quality may develop on a poorly-formed tree. It will be difficult to know if the seeds of such a tree are of good quality, because we do not know if the poor site or the tree's traits are the cause of its poor form.

Every tree has a range of climate conditions within which it grows. On the edges of the range, the tree is genetically specialized for the dry or wet conditions and has a lower ability to adapt. Trees located in the middle of the range however, called the *climax zone,* have the greatest ability to adapt to a new location within the climatic range. It is best therefore, to collect seed from mother trees in the climax zone, if that is possible. It is still best to get seeds from the same zone as your own and, as far as possible, growing in the same soil type.

22 How do we collect seeds?
There are many ways to collect seed and most of them are very simple. The easiest seeds to collect are large-seed species or those with pods. You should learn the time of the year when the seeds ripen in mass. Pods or fruits are best taken from the tree when their stems break easily from the branch and the pod or fruits have changed colour or are becoming dry. For example *Juniperus procera* turns blue when ripe. The seed can be separated after drying is complete.

Small-seeded species present more difficulties. Often seeds grow in cones (like cypress and pines) or woody, pulpless fruits *(Eucalyptus sp., Casuarina sp.* and *Grevillea robusta).* These normally grow, ripen, dry and open without falling from the tree, dispersing the small, often winged seed in the wind. Because of this it is important to collect the cones or woody fruits after ripening but before they are completely dry. The collected cones and fruits can then be dried in a clean place, out of the wind, and the seed gathered after it has separated.

23 Are there easy ways to collect seed from tall trees?
Unfortunately tall trees, which are often the best types of a species, present many difficulties for the seed collector. Sometimes it is best to collect seed after the tree has been cut down. This method is commonly used for eucalyptus and cypress trees. It is not wise to cut down a tall tree just to collect seed.

A tall tree can be made safer by the use of a safety harness and strap. The harness wraps around your shoulders and hips and it is attached to the strap about your waist level. The strap goes around the tree and hooks into the harness again. A tree climber may also use spurs attached to his boots which provide a good grip on the bark. By leaning against the strap and lifting with his feet then raising the strap, a good climber can swiftly climb a tree to branch level. Once there, seed collection becomes easier, even though most seeds will still be out of reach.

A pruning hook can be taken up the tree or used from the ground. This consists of a long piece of wood or a metal pole (bamboo works well) with pruning shears attached to one end. A rope connected to the movable cutting-blade stretches to the holder allowing him to cut down fruits, pods, cones or any other seed 'container'. The seed can

413

then be picked up from the ground. For edible fruits, a basket can be attached under the pruning hook so that fruit drops into it rather than to the ground.

Pruning hooks are rather expensive. A cheaper, but less efficient option, consists of a long stick with two nails pounded in one end (or simply a wedged 'V'). This is used to break the stem attaching seed to the tree.

24 Can seed be collected from the ground?

Yes, and for some tall trees, like *Acrocarpus fraxinifolius* or *Podocarpus sp.*, this is the best way. These species have hard seed coats, not easily damaged and do not lose viability readily. Podo seed, well liked by Colobus monkeys for food, should be collected from the ground daily or your seed supply may all be eaten up. Some species, like terminalias or combretums are subject to insect attack and should be collected only on the day they have fallen. Sweep the ground under the tree of old seed and collect freshly fallen seed the next day. Seed already on the ground is likely to have a high percentage of insect damage and should be carefully inspected before storing or transporting. (See 25).

Some species cannot be collected from the ground as seed, but as **wildings**. Wildings are newly germinated seedlings found under stands of mature trees. Forest Department nurseries often get their indigenous species this way from stands near the nurseries. These are gathered while still small and with the soil still attached to their roots. They are then transferred to pots in the nursery until ready for transplanting. This can be done for most species and is common for *Grevillea robusta*, *Olea sp.*, and *Prunus africanum*. This is also a good reason for preserving small stands of indigenous trees in your location. Often this is the best way to propagate trees difficult to grow in a nursery or with hard-to-collect seed.

SEED QUALITY AND VIABILITY

25 How can we tell if we have good seed?

The first step is visual inspection. Usually seeds that are smaller than the average, darker or lighter in colour or mis-shappen in some manner are bad and can be discarded. Insect damage occurs often and is spotted by finding a small hole in the seed coat.

For hard-coated species—acacia, podocarpus, baobab and balanites, for example—floating in water is a good test. Normally good seed will sink and the bad float. Simply throw out the floating seed. Dry the remainder thoroughly before storing.

26 Are there differences in seed of the same species?

All seeds are not exactly alike. Those differing greatly in size, shape and colour should be discarded. Small differences create no problems for germination. As mentioned earlier, sometimes the viability of seed varies from one location to another and so acquiring or collecting from two separate locations often eliminates this problem. Be sure though, to keep the collections separate.

27 Are seeds from young trees as good as seeds from mature trees?

Not necessarily. For some species like *Leucaena leucocephala*, seed from the first season of production has a lower viability than seed of successive seasons. The major problem is knowing whether a young tree will exhibit fully the characteristics you desire. A mature tree already displays these clearly, whereas young trees are uncertain and therefore, less acceptable as seed sources.

28 How long do seeds remain viable?

This varies greatly between species. Hard-coated species: acacia, baobab, acrocarpus, podo, etc., have long viability. Some acacia may last 10 years or more—as they sometimes do in the wild—before germinating. Other seed, such as the oily ones or those with soft covers last only a short while. *Azadirachta indica* (neem) remains viable for two weeks to two months only. *Grevillea robusta* can last three months or more if kept in cold storage. Others, like *Cassia siamea* or *Balanites aegyptiaca*, lose viability slowly over a period of two years. (Where the viability duration is known it is listed in this directory under the individual species profile.)

29 What makes a seed go bad (fail to germinate)?

Oily seeds, such as neem, go bad quickly due to a breakdown and loss of oils. Nothing can be done about this. Chemical, fungal, or bacterial action damages seed as well, especially in moist conditions. Insect damage is quite common. Careless handling resulting in cracking or splitting of the seed coat, also can lower germination capacity.

30 How can a seed be stored without losing viability?

The basic rule is to keep seed as clean, cool and dry as possible. Seed should be removed from the pod, cone or fruit and dried quickly.

Some harder, larger types of seed can be washed and dried in the sun as well. Storage is best done in a metal container or paperbag and placed in a cool or cold place—at any rate away from the sun. If seed is to be stored for a long time, chemicals can be used to prevent insect attack. You should not store seed in a plastic bag as this can make seed sweat, causing it to rot or germinate prematurely. Warmth too, will result in the same problems. So always remember the cooler and drier the storage place, the better for the seed.

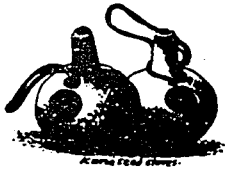
As a general rule using fresh seed is best since the longer the seed is kept the more problems it can develop.

31 Can seed quality be tested?

Yes, and this is important if you have stored seed for a while or received seed from an untested supply.

A simple testing method involves just a cloth, water and a warm place. Take a small counted number of seeds, 20, 50 or 100 and do any pre-treatment required prior to planting. (Pre-treatment techniques are given on page 18.) Put the seeds on a damp cloth in a dish or bowl. Cover with another fold of the cloth; moisten it thoroughly and put in a warm, but not hot, place. Check the seeds daily for signs of germination and keep the cloth moist. When germination begins, keep a record of the day and number. The test usually lasts two weeks but results vary according to species and length of storage. Germination of over 50% means you have good seed. Small-seeded species having only 5%germination are still worth keeping. To obtain complete results for some species like grevillea or terminalia, the test may have to go on for considerably longer than two weeks.

If you are sending the seed to someone else, you should also send your germination test results with the seed. These tests help you to determine the best method of sowing in your nursery. High germination means you can sow directly in the pots. Low germination indicates the need to use a seed-bed.



PROMOTION OF INFORMATION ABOUT SEED

32 How do we handle information about seed?

Seed information is important especially if you are selling or sending seed to someone else. The more concise yet thorough your information the better. Information helps others determine the best time to sow the seed, what soil to plant the seedlings in and gives an idea of the kind of tree to expect. (The sample form provided at the end of chapter 6 helps you record the relevant information for others.)

33 What should you do with new information?

This book does not have complete information about each species. So if you have new, better or more information about a tree species or its seed which would add to our knowledge of the trees, it would be deeply appreciated. KENGO, CARE-Kenya, MCC, the Forest Department and the Silviculturalist at KARI are acting as channels for this information and it can be sent to any one of these groups. Good scientific knowledge of many species is scarce and your knowledge will help fill in many gaps. (see chapter 6).

34 How do we get help for tree seed problems?

This book has not answered all the possible questions about the seed, especially concerning the individual tree species. As new information is gathered, we can improve our ability to answer these questions and be a channel of information exchange about trees. Often answers to tree seed questions come from people working with trees on their own land. For example, in 1982 the Mazingira project was sowing *Podocarpus gracilior* at a nursery in Nyeri. The germination technique consisted of presoaking the seed for 24 hours. No germination resulted. The headmaster of the school where the nursery was located, then decided to grow podo as a project with his 4H club. Instead of soaking the seed, they cracked the hard outer shell lightly with a hammer. Germination was very good in a short time. This knowledge came from local people who are often the experts in tree planting.

The groups listed above (see 33) are providing a channel for this kind of information, so if you have questions, write and they will try to find the answer.

35 How are seeds posted or transported?

Within Kenya this is quite easy, especially for small quantities, since the postal service is quite good. Seeds of one species should be

packed inside a container, like a paper or cloth bag, and carefully labelled with the species name and the source. Plastic bags can be used for hard, dry seeds only if paper or cloth are not available. Do not use plastic for oily seeds like neem, because this will reduce their already short viability. These and other species, packed in separate containers, can then be placed in a cardboard box or wrapped in heavy paper. Small amounts can even be sent in an envelope, if it is sufficiently protected from leakage by double wrapping. The Tree Seed Information Form should be sent with the seeds if they are available, or you can enclose a letter containing the information.

Posting costs should be included in any price charged for the seed. Sending seeds outside the country is more complicated and should be done through groups who know the system. All seed going out of the country must be fumigated and given a phytosanitary certificate by the Kenya Government.

36 Are there quality differences within one species in seed from different regions?

Yes, see question 6. Most of these differences are not known or understood. This explains why it is wise to get seed from more than one source, especially if germination testing data are not available.

GERMINATION AND PRE-TREATMENT OF SEED

37 Do all seeds germinate?

The percentage of seeds which germinate varies greatly between species, as does the time it takes for seeds to germinate. Some species, like neem, germinate vigorously if fresh and at nearly 100% rate. Other seeds require pre-treatment of some kind before a good percentage of the seeds can sprout. Without pre-treatment some seeds may never germinate. The percentage germination results of testing are important in calculating how many seeds will be required to obtain a certain number of seedlings.

38 What kinds of pre-treatment of seeds are used?

CRACKING

There are many methods. The cracking technique used for podo mentioned earlier is one. Actually this treatment may be a copy of how nature stimulates germination. Most of the seeds monkeys crack open are swallowed. However, occasionally monkeys may allow some seeds to drop after cracking and it is these which germinate. Podo will also germinate if left long enough in a seed-bed, but this makes for uneven seedling growth. For a small number of seeds, cracking lightly appears to be the best.

SCARIFICATION

Not all seed can or should be cracked. Other methods, also imitating nature can be used. *Scarification* is the term used by foresters for these techniques. Grazing animals like cattle, goats, camels and others often swallow seeds whole. Acid in the stomach softens the hard seed coat of acacia and other species for instance; then the seeds pass through the bowels and are deposited, with fresh fertilizer, ready to germinate. Tree planters have imitated this by soaking seed in mild acid solutions for 5 to 20 minutes before sowing. This technique is tricky and should be tried only with professional advice.

SOAKING

Soaking is another method used for bulk seed. Water is brought to a boil, then poured over the seed and allowed to stand for 5 minutes. The water is then cooled by adding cold water and the seeds are left soaking up to 24 hours. Hard seeds will swell with liquid and be ready for sowing after this.

NICKING

An efficient but time-consuming technique for hard-coated seed, consists of nicking the seed coat with a knife or fingernail clippers. Only a small nick is required. Care must be taken to avoid nicking the end of the seed where the germ is located. Tests indicate that this method leads to the best germination percentage but demands also the greatest labour input. It is recommended therefore only for small quantities of seed.

These methods work because they improve the water penetration of the seed which in turn stimulates germination. Other methods may work as well. Some seeds however, do not respond well to any techniques. *Melia volkensii* (Mukau-Kamba), a valuable tree of the semi-arid areas east of Mt Kenya, does not germinate quickly or well no matter what is done. Farmers feed the seed to goats, then burn them when they are dropped, soak them for a day or two and then sow them in an isolated spot in their compound and keep them wet. After a week, or perhaps a year or two they may germinate. Growing trees is sometimes a matter of great patience!

Most species respond well to scarification and germinate quickly. The normal length of time is two weeks. Not all seed can or should be

treated; untreated species have a broader range of germination times. (Whether or not a pre-treatment is recommended, the best type of pre-treatment, and a predicted period for germination are given in the individual tree species profiles in this book for those which are known).

39 Do young trees grow only from seed?

Though growing trees from seed is the most common technique, growing them from root suckers and cuttings is also of importance. Root suckers are the primary means of reproducing banana plants. Young plants come up around the mother plant's basal roots and are cut away for planting elsewhere. Some trees produce root suckers naturally. *Ocotea usambarensis* (camphor wood) has copious numbers of root suckers that come up after the parent tree is cut.[4] *Melia volkensii* mentioned above, also reproduces by root suckers without the tree being felled; just cut roots a few feet from the tree and leave the cut end exposed to the surface. These suckers grow far faster than seedlings since they are connected to an already developed root system. They can be cut and transplanted like bananas.

Cuttings are an easy means of reproducing trees. A cutting is simply a section of a young branch—anywhere from 15cm to 2 metres in length—which has at least three nodes or buds. Perhaps you have witnessed the making of a fence using freshly cut logs complete with the bark. With certain species these sections sprout. That is a cutting.

To take a cutting, choose a healthy section of a parent tree. At this stage the longer the better. Strip off the leaves to prevent moisture loss through evapotranspiration, and then make a clean, slightly angled cut. Thin spindly ends can then be removed, for these grow poorly and cause moisture loss. Transport to the place you wish to plant or to the nursery. At this time you can cut the longer sections into three or more nodal lengths. Put the cutting into the soil at least two nodal lengths deep, with at least one exposed. Keep it watered until sprouting occurs and a root system has developed. (see p 92)

Trees commonly propagated this way include many members of the euphorbia family and the moracea family (figs and mulberry). A good clue is the presence of white latex sap. Other trees which reproduce this way are mentioned in the tree species section.

40 How do trees grown from root suckers or cuttings differ from those grown from seed?

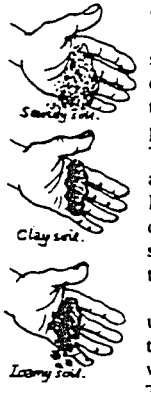
Trees grown in the above manner have exactly the same traits as the parent tree. This is very important for fruit producing species since you know the young tree's potential production. Date palms require reproduction from suckers to be absolutely certain that the seven-year wait for quality fruit production will not be in vain. Root suckers and cuttings are more certain methods of reproduction and often these grow faster than those from seed.

There are two main disadvantages: first, transport especially of root suckers, is more difficult and expensive per plant; second, since they carry the same genetic information, the offspring are equally susceptible to the same diseases and problems as the parent tree. The advantages usually outweigh these problems.

4 *Kenya Trees and Shrubs*

A SIMPLE SOIL TEST

Quite simply, soil is the top covering of earth in which plants grow. However it is made up of so many different components that it is very hard for an untrained person to know exactly their soil type. Soil type may vary within just a very short distance. There are red soils, brown soils, black-cotton soils, sandy soils, white, stony soils and many more. Within these there are variations in organic content (see mulch), acidity, salinity, nutrients and compaction, all of which have an impact on plant growth. (see glossary).



The three basic components of soil are sand, silt and clay and soil types are defined roughly by the ratio of these three ingredients. There is a simple test one can do to determine basic soil type. Take a small amount of soil and moisten it until all the particles are wet, but not so much that it will drip or run off. Then pick up a handful and squeeze. If the soil particles separate easily, with little or no stickiness, then you have a sandy soil. If all the particles stick and you can mould the soil into a desired shape, then it is a clay soil. If there is some tendency to stick, but small chucks fall off and you are unable to mould it then it is called a loamy soil.

Soil colour and its response to the addition of water will usually give sufficient clues about type for most purposes. If there are nutrient deficiencies, however, then one must consult with a trained person or have a sample tested by a laboratory. The Kenya Soil Survey people do a thorough job of this.

(Thanks to Dr. P.K. Nair of ICRAF for the simple soil test.)

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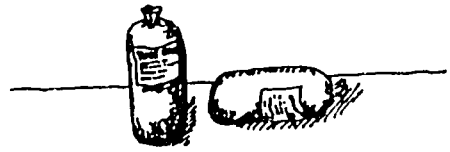
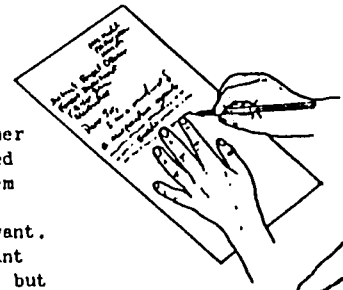
	Learning Element	Code:
	Title: Tree Seeds	
	Occupational Area: GROWING TREES	**Date of Issue:** Nairobi June 1984 / **Page:** 2

1) Once you have chosen the tree species that you want to grow, you need to get the seeds for these trees. You can either get the seeds from groups, such as the Forest Department, who are already working with tree seeds or you can collect them yourself.

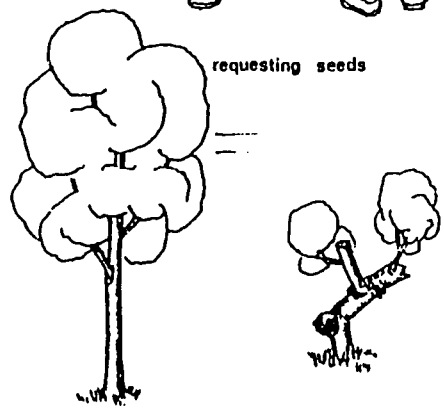




2) To get seeds from other organisations you need to visit or write them and ask them for the seed types that you want. The types that you want may not be available, but the people may know where else you can try. The best person to contact for seeds is your local agriculture or forestry extension officer. If the seeds are there you may have to pay for them.

requesting seeds

3) It is easiest to collect the seeds yourself. This way you know the seeds are fresh, you will know where to get more when you need them, and it will not cost any money. The first thing you must do is locate trees from which you can collect the seeds you want. A good seed tree is one that is very tall and straight. Do not collect from a short, crooked, sick-looking tree. It is always best to collect from a tree near the area where your seedlings will be planted.



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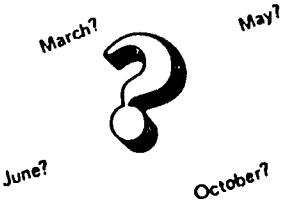
	Learning Element	Code:	
	Title: Tree Seeds		
	Occupational Area: GROWING TREES	Date of Issue: Nairobi June 1984	Page: 3

4) You must now find out when to collect the seeds from the trees. Tree species produce their seeds during different times of the year. The tree seeds are ready for collection when they start to fall from the tree naturally. This is when the seed or fruit is ripe or is starting to dry up. You can find out when a specific tree produces its seeds by asking a forestry officer, looking the information up in a book, asking the local people (especially the old people), or simply by watching the tree carefully yourself.



5) Once you have found a good tree source and the seeds are ready to be picked, it is time to collect the seeds. The simplest way to collect the seeds directly off the tree or wait until the seeds fall from the tree and pick them up one by one from the ground. However, this does not work well for trees with very small seeds.

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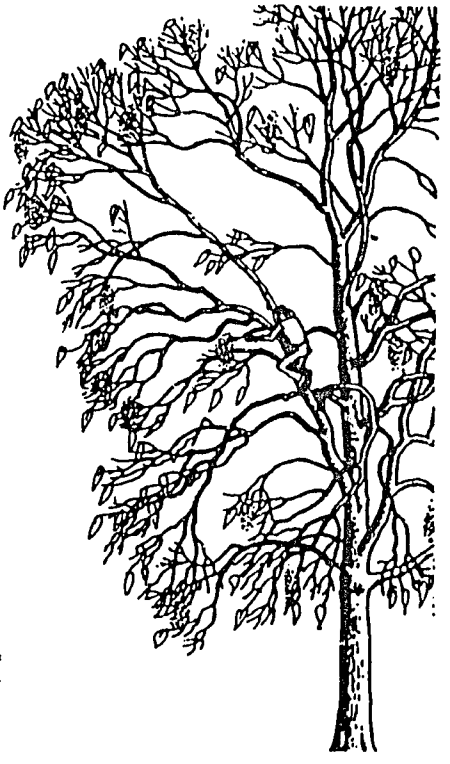
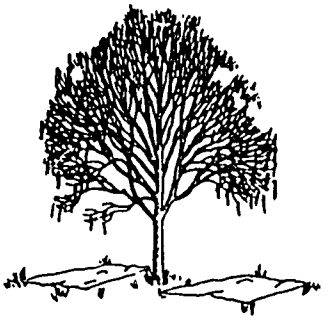
	Learning Element	Code:	
	Title: Tree Seeds		
	Occupational Area: PLANTING TREES	**Date of Issue:** Nairobi June 1984	**Page:** 4

6) Another method of collecting the seeds is to climb the tree and collect them directly. This is a dangerous method. Much care must be taken to prevent falling and injuring yourself. However, there are advantages as well. If the seeds are small and hard to collect, the seed, pod or fruit can be collected just before they open so that they can be dried later where the seeds can be collected easily.



7) Another method is to use a large sheet cloth or tarp. The sheet(s) can be laid out under the tree in order to catch the seeds. Then the tree can be shaken and the seeds will fall down onto the cloth. The seeds must be ready to fall for this method to work. You may have to climb the tree in order to shake the branches. After shaking the tree, pick up the sheet by the corners and all the seeds will collect in the middle.



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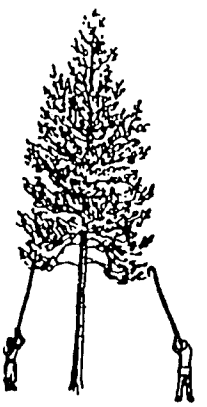
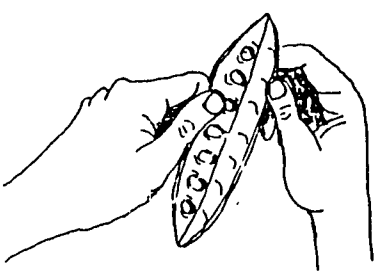
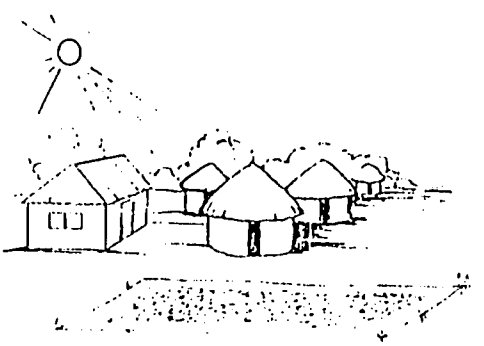
	Learning Element	Code:
	Title: Tree Seeds	
	Occupational Area: PLANTING TREES	**Date of issue:** Nairobi **Page:** 5

b) Finally a last method to collect seed, which can be used in combination with a sheet or tarp, is to use long sticks or wires to knock or pull the seeds from the tree. A long pole can be used to strike the fruit to knock the seeds down, or a hook can be placed on the pole to pull on limbs, shake the limbs or to grab the seeds or fruits.



Once the seeds have been collected they must be processed first. If the seeds are still inside of a fruit, pod or capsule, they must be taken out. This must be done by hand. Often, if the fruit, pod or capsule is left in the sun a few days they will dry and open up by themselves, releasing the seeds. If the covering over the seed is very hard it may have to be removed using a hammer. Often some seeds will have been damaged by insects, these seeds will have a small hole in them where the insect went in. These seeds should be removed for hard, heavy seed, the easier way to find bad sees is to place them in water. Insect damaged and other bad seeds will float while good seeds will sink to the bottom. The bad seeds should be thrown out.





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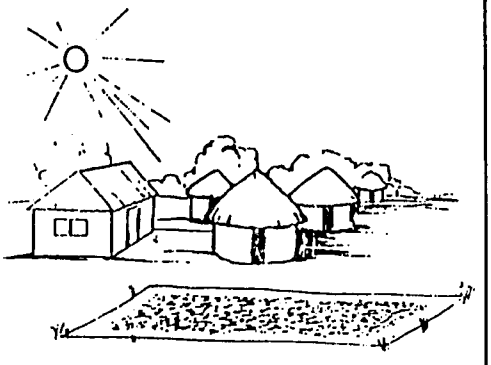
	Learning Element	Code:	
	Title: Tree Seeds		
	Occupational Area: PLANTING TREES	**Date of Issue:** Nairobi June 1981	**Page:**

10) For certain types of seeds they must be planted immediately or they begin to die. This is especially true of seeds from fruits such as oranges, avocadoes, kei-apple and mangoes. In general, seeds that are soft and fleshy are ones that cannot be stored and thus must be planted immediately.

11) Most other seeds have a thick seed coat can be stored for longer periods of time. These type of seeds can also be planted immediately and they will still grow. If the seeds are to be stored, it is best that they are dried thoroughly. This insures that the seeds will last a long time in storage. To dry the seeds, set them in the sun for 2 to 3 days. Make sure the seeds are sorted for insect damaged seeds before storage.



-422

	Learning Element	Code:
	Title: Tree Seeds	
	Occupational Area: PLANTING TREES	**Date of Issue:** Nairobi June 1984 / **Page:** 7

12) The seeds should be labelled with information on species, weight, when collected, where collected and who collected them. Write a label on a piece of paper and include it with the seeds.

Seed Label:

Common Name : _____

Scientific Name : _____

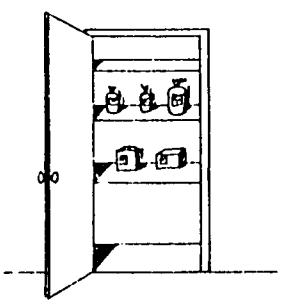
Weight : _____

Collection Date : _____

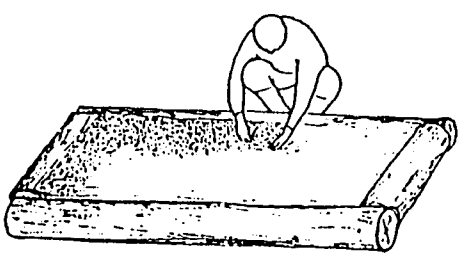
Collection Location : _____

Collector : _____

Store the seeds with their labels in bags or boxes in a cool dry place. It is best to keep them out of the light until it is time to plant.



When it is time to plant the seeds, some types will require pretreatment. If the seeds are very small or have a very thin coat pretreatment should not be necessary and the seeds can be planted straight away.



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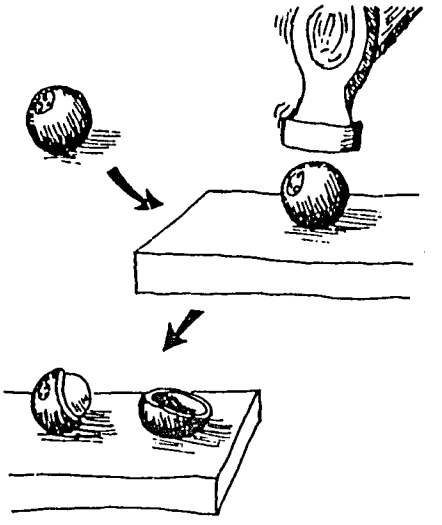
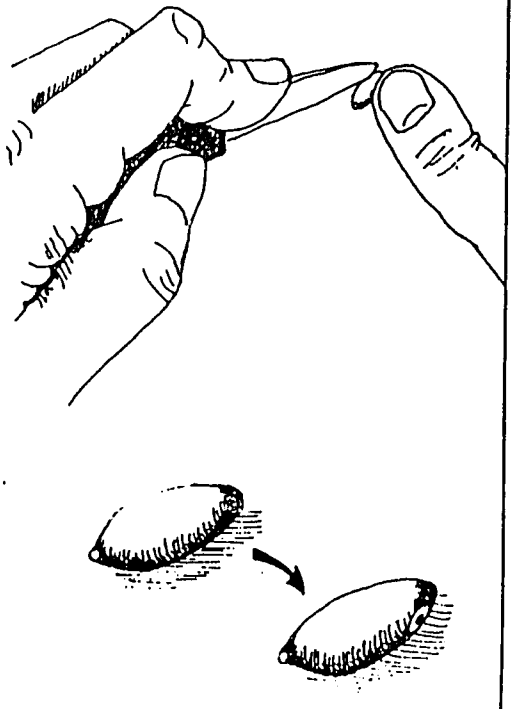
	Learning Element	Code:
	Title: Tree Seeds	Date of Issue: / Page:
	Occupational Area: PLANTS	

15) Seeds that have thick seed coats or shells will need some type of pretreatment. For large seeds with a very hard thick shell, the best treatment is to break the shell and extract the kernel using a hammer or stone. This is necessary for seeds from Podo and Macadomia Nut, for example. The seed should be broken very carefully so as not to damage the kernel inside. These should be planted immediately after cracking.



16) For other seeds which are smaller and have less of a thick coat, there are three possible methods of pre-treatment. One, which is similar to the above method, is to break the seed coat so that water can get in and the seed will germinate. This can be done by making a small break in the seed coat with a knife, scissors or other sharp implement. Only a small cut is needed to allow water to get in. Do not cut the part of the seed that was attached to the pod or capsule. This part, called the eye of the seed, contains the tiny plant and if it will kill the seed. After it is cut, the seed should be planted.



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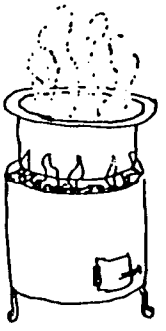
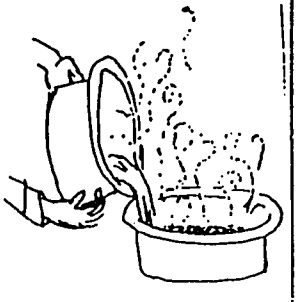
	Learning Element	Code:
	Title: Tree Seeds	
	Occupational Area: PLANTING TREES	**Date of Issue:** Nairobi [illegible] 1984 / **Page:** 9

17) Another method for these seeds is to boil water, then pour it over the seeds and let is sit for 5 to 10 minutes. Then add more water to cool the seeds down. This weakens the thick seed coat so once an it water can enter and the seed will germinate.

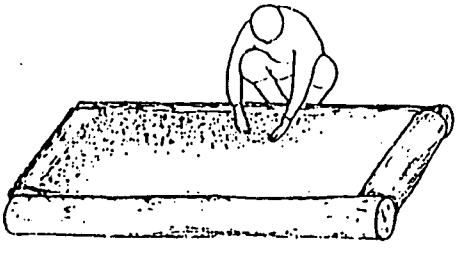


18) The last and most commonly used method is to soak the seeds in regular water for 12 to 24 hours before planting. This can be done along with the method described above for very tough seeds, i.e., soak the seeds in boiling water, cool them, then soak overnight.



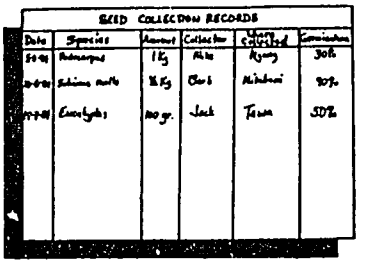
5 min.

19) Now that the seeds have been pretreated, it is time to plant them in the seed beds.



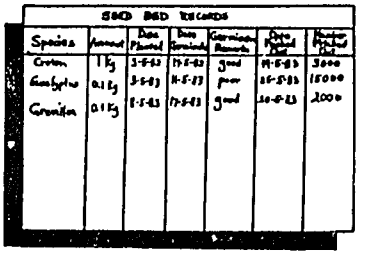
	Learning Element	Code:
	Title: Nursery Management and Record Keeping **Occupational Area:** GROWING TREES	**Date of Issue:** Nairobi July 1984 **Page:** 8

11) When seeds are collected the following information should be recorded : date, amount collected, where collected, name of species and who collected it. If a germination test is done on the seeds this should also be recorded.


SEED COLLECTION RECORDS

Date	Species	Amount	Collector	Where Collected	Germination
5-8-83	Podocarpus	1 Kg	Alice	Kijabe	30%
20-8-83	Sclerocarya caffra	2 Kg	Chris	Mitahoni	90%
17-7-83	Eucalyptus	100 gr.	Jack	Tana	50%

12) When seeds are planted in the seed beds and then pricked out the following information should be recorded : species planted, amount planted, date planted, date of germination, germination remarks, date of pricking out, total number pricked out.


SEED BED RECORDS

Species	Amount	Date Planted	Date Germinated	Germination Remarks	Date Pricked Out	Number Pricked Out
Croton	1 Kg	3-5-83	17-5-83	good	19-5-83	3000
Eucalyptus	0.1 Kg	3-5-83	11-5-83	poor	25-5-83	15000
Grevillea	0.1 Kg	3-5-83	17-5-83	good	20-5-83	2000

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Seeds

NO MEANINGFUL tree planting programme can be achieved without due consideration of seed procurement. Tree planting techniques must of necessity start with seeds from which most tree species are propagated. Perhaps it is fair to generalize that seed procurement is a major problem in tree planting. The point here is to discuss some relevant processes such as seed collection, extraction, cleaning, storage, testing, viability, pretreatment and sowing. The majority of the important tree species produce seeds and it is only in a few cases where a certain species does not produce seeds, or it produces weak ones, that we turn to vegetative propagations, in which case seed provision does not play a significant part. *Poplar* and *Millingtonia* species fall under this category of vegetative propagation.

SEED COLLECTION

Seed collection is an arduous and expensive job and, indeed, one of the limiting factors in the whole process of seed management. One should therefore collect only good quality seeds. In the field one can cut open a seed if in doubt as to its quality. To avoid rotting, seeds should be collected when ripe either from seed orchards or ordinary trees.

Collection of seeds should be selective and timely. Many trees have ripe seeds only for a short time. One may climb a tree and with a hook detach cones or fruits. Alternatively, seeds can be collected from the ground at the bottom of a tree after they have fallen to the ground on their own or after seed bearing branches have been shaken.

It is wise not to mix seeds of different species during collection, otherwise subsequent treatment will present problems because different species have different and important characteristics such as:

a) Flesh pulp or other waste material;

b) viability;

c) germinative capacity;

d) pretreatment quality.

It is also necessary to keep a record of what is being planted for future reference, especially where there is doubt as to the species' ability to grow.

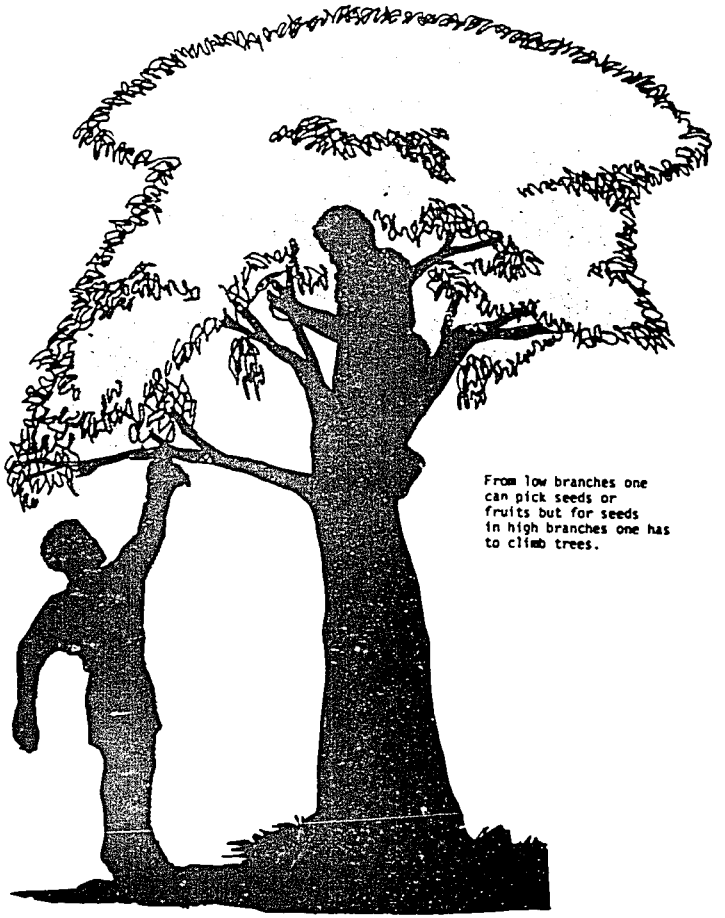


Figure 2: Seed Collection from trees

EXTRACTION OF SEEDS

There are basically three categories of seeds:

a) Those in the flesh pulp of a fruit. The seeds must be extracted by removing pulp and possibly drying the seeds within the fruit. Unless this is done the fruit will ferment and the seeds might decay, thus losing viability. *Chlophora* species, *Ocotea* species, and *Alberia coffra* belong to this category.

b) The indehiscent hard pods or capsules (dry fruit) which dry with the seed enclosed. Seeds would not decay but they should be extracted or the capsule cut at one end to allow seeds to germinate. *Pterocarpus angolensis*, *Gmelina* species and *Juniperus procera* belong to this category.

c) The common deniscent pods from which seeds can be extracted simply by thrashing, and others break out automatically, as in the case of most legumes such as Jacaranda. These are the true seeds.

The point in seed extraction is that seeds should be separated from their container before storing for planting purposes. In the case of pulpy fruits, one can use water to remove pulp, such as in the case of coffee. Fruits like those of *Alberia coffra* are put in a drum and then stirred to separate seeds from fruit. The content is sifted through a wire mesh and waste is subsequently dried to avoid rotting.

Some seeds in cones, as in the case of pines, are dried and then thrashed. Cones can also be rolled in a drum to extract the seeds which can be removed by winnowing.

CLEANING

Most seeds, when extracted, contain some impurities either from the fruit or from the vicinity of work. All these extra materials not necessary for seed germination must be removed to reduce overall weight and volume - a necessary consideration in costing for subsequent handling of seeds. For the purpose of determining the germination rate, impurities must be considered. Some pests can also be removed during the cleaning process.

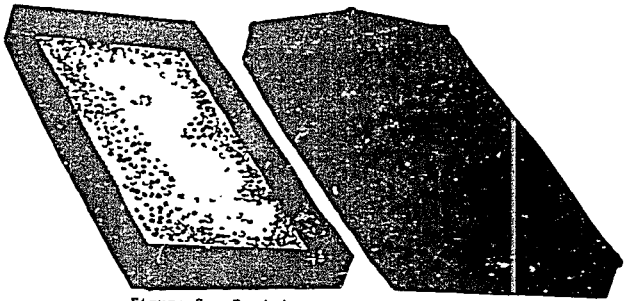


Figure 3a: Seed drying using Solar Energy

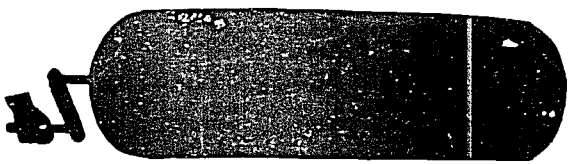


Figure 3b: Seed extraction using Drum

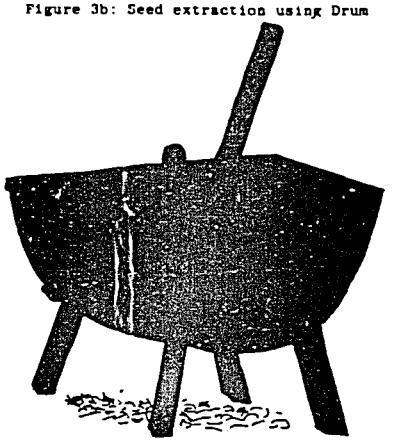


Figure 3c: Seed extraction with wire mesh.

STORAGE

After cleaning the seeds, it is quite common to store them for use later or for distant transportation. Seeds should be stored in cool, dry containers in order to minimize seed metabolism. If an area is humid, some dehydrating substances should be used. Pine seeds, for example, should be dried to between 6% and 10% moisture content and preferably kept in containers at between 3 - 5°C. Although some seeds can be stored for long periods, especially in air-tight containers, it is advisable to use seeds which have not been stored for too long. The shorter the storage period the higher the chances of germination.

VIABILITY

Viability refers to the ability of seeds to germinate once planted. Any seed will lose viability if stored for too long, since it is a living tissue and must respire, thus expending some energy stored in the seed. For example, *Chlorophora excelsa* loses viability within a year and *Grevillea robusta*, a favourite species in some agroforestry systems, must be planted immediately after harvesting. Other species which lose viability quickly are *Khaya* in Nigeria, *Lovoa*, *Entandrophragma* and *Azadirachta* species.

Trees which lose viability easily must be planted without delay. Synchronizing seeds to planting time presents a challenge. The chief problem is when the seeds ripen so quickly that planting in the field will be difficult to synchronize. It is necessary to ensure that seeds sown in a nursery reach planting stage by the start of the rainy season. If the seeds must be sown immediately after ripening and if the planting and sowing of seeds cannot be matched, it is best not to use that species. The species can only succeed if some irrigation or presence of underground water can be relied on.

For some of the seeds which lose viability quickly, refrigeration should be used if they have to be stored, and it might even be effective to coat seeds with glue. For example *Auracarias* seeds are difficult to germinate on a large scale (FAO). Also as a general rule fatty or oily seeds are very perishable, retaining their viability for a very short time.

Occasionally, one may not be sure whether seeds will germinate. It is necessary to test their viability. One may even cut a seed and tell whether it is fresh or not. Floating in water has also been used and in this case sound seeds are heavy and will sink, while non-viable seeds are light and will float on water. A conclusive test is to germinate a sample of seeds and count germination rate. If germination rate is too low the seeds should not be used. It is a good precaution to sow only what will germinate to avoid unnecessary cost and waste of time.

How to prepare seed for storage:

You should always aim to sow or dispatch your seed as soon as you have acquired it. But sometimes for different reasons you may need to store the seed for future use. Remember that the longer the seed is stored, the greater the probability that it will lose its germination capacity.

Seed extraction:

In most cases seed is collected while embedded in ripe fleshy fruits, dried fruits, in pods or as single seeds. Proper extraction and cleaning of seed is of vital importance in seed handling. Most seed extraction requires pre-drying of the fruit. Others may require pre-soaking in order to be able to extract the seed easily. Those that require soaking are generally those borne in fleshy pulpy fruits or pods that have dried and are indehiscent. For pods that split on maturity, extraction is best done when pods are dry.

Use a pestle and mortar to thresh seeds which are strongly attached to the pods.

Fill sack with dry pods and beat it like they do with beans. (The threshing method).

Seed cleaning:

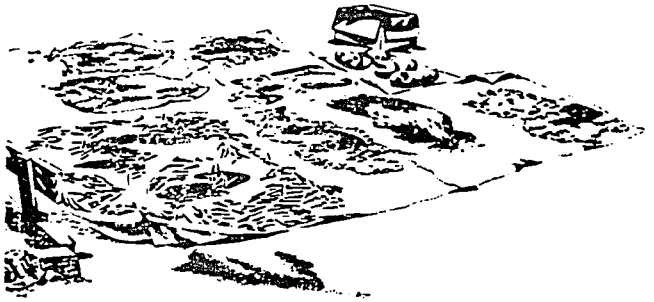
Always remove the damaged seed and all the immature light seeds. Remember that mature seed stores longer.

Winnowing of seeds

Using hands (manual)

Seed drying:

There are many methods of seed drying but sun drying is the most common method used. Do not expose the seed directly to naked flames.



Seed storage:

Always remember that your seed will last longer when stored in a cool dry place. Seed that has dried and is kept in a cool dry place is usually not attacked by fungi and insects.

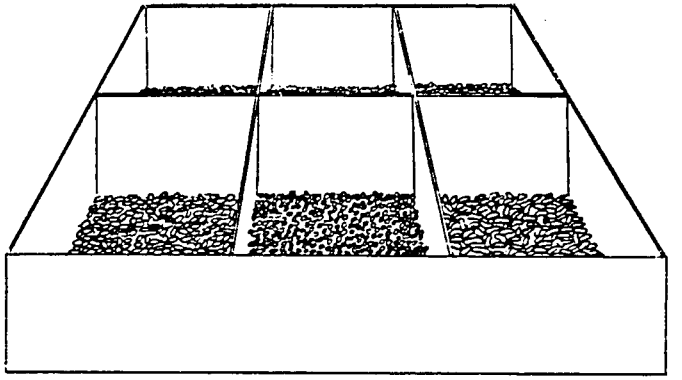
Protection:

Protecting your seed from external agents of destruction is of paramount importance. Always store your seed in a secure place, that is burglar proof, out of reach of insects, rodents and birds. If possible, paint the inner walls with residual insecticides.

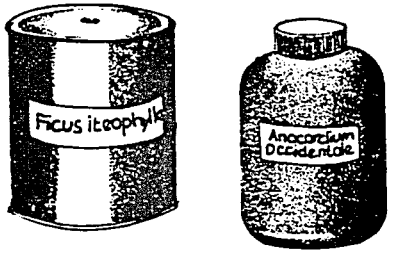
Whenever you receive extra seed, always make sure it is properly cleaned before putting it into the store, otherwise, insects and fungi could easily appear in the store.

Seed storage containers:

Sealed containers: When seed has been dried properly it can then be put into a tin with a lid or into a plastic container that can be sealed.



Metal boxes



Plastic container

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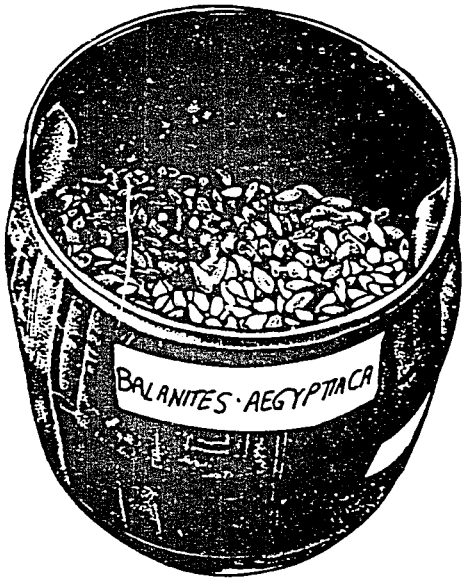
Points to remember when using sealed containers:

a) Never seal-in moist seed.
b) Use air tight containers
c) Make sure that your container is clean.
d) Open the seed containers only when necessary.
e) It is advisable to fill the container with seed.



SECTION 4 NURSERY OPERATIONS

4.1. SEED COLLECTION AND TREATMENT

Obtaining sufficient seed is often a problem for nurseries. The Forest Research Department at Muguga operate a seed collection and storage service but it is not able to cope with the large quantities and range of species required by rural nurseries. Nurseries will therefore have to attempt to collect locally the bulk of their seed requirements. For this reason it is a good idea to plant small plots of the main species in a near-by nursery compound to act as seed source as well as demonstrations (see Section 7). Trees grown for seed should be given plenty of space to encourage branching and early seed production. It is also a good idea to collect a surplus of easily available seeds so these can be exchanged for seeds not available locally.

4.11. Collection Techniques

The first stage in seed collection is the selection of good mother trees. These should be healthy trees showing the desired characteristics (e.g straight with few branches for pole and timber production; heavy leaf or pod production for fodder; fast growth and coppicing ability for fuelwood). This is important as offspring usually inherit the characteristics of the mother tree. Too often mother trees are selected for ease of collection (e.g. near nursery, having low branches) rather than good form. Conversely, it is better to collect from a number of trees, rather than just one, so that some genetic variation is maintained. The ideal situation would be to collect from ten healthy, well formed trees but it is recognised that this is often not practicable. If the trees are growing on private land then permission should be obtained from the owner before collection starts.

The actual method of collection depends on the species, but in all cases seed, fruit, cones or pods should not be collected until they are ripe or nearly so. Most species produce seed once or twice per year but some, in particular some Acacia species, produce a good crop of seed only once every two or three years. With these a surplus should be collected during the 'seed years' for use during the lean years. The normal months of ripening of species in the E.M.I area are given in Table 2.

The best way to collect most seed is to harvest the pods or fruit when they are ripe but before they open or fall to the ground. This is especially so for species such as Cassia siamea, Casuarina spp, Eucalyptus spp. and Grevillea robusta which produce small, light seeds which disperse rapidly from the tree. Many large or hard - coated seeds and fruits can, however, be collected after they have fallen to the ground. e.g. Acrocarpus fraxinifolius, Balanites aegyptinca, Acacia spp. It is helpful to clear the ground below the tree of bushes, weeds and other debris.

Seeds and fruits should be collected quickly after they have fallen to reduce the likelihood of insect or animal damage. With a few fruits such as Balanites aegyptinia and Melia volkensii which are eaten by sheep and goats, often the easiest way to collect is to collect them from the droppings in the boma where the animals are kept at night. This method has the disadvantage that the mother trees are not normally known.

Picking pods or fruits from tall trees obviously presents problems. Most nurseries are not likely to possess specialised seed collecting equipment. A simple tool can, however, be made by lashing one arm of standard shears to a pole and operating the other arm with a length of string. In may cases pods, fruit or seed may be dislodged by shaking or hitting the branches e.g. Acacia senegal, Acacia tortilis, Prosopis spp. An inverted umbrella is a good receptacle for catching seeds, pods or fruits falling from a tree. If there are plenty of suitable mother trees in the area, then it may be worth felling a tree at the right time to facilitate seed collection.

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Good records should be kept of the location and number of mother trees and the date of collection and clear labels attached to the seed container. This is important because trees of the same species growing in different locations, or provenances, often exhibit different genetic and physical characteristics. Trees raised from a particular batch of seed may later be found to be superior to other trees so it is important to know where the seed was collected so further collection can be made.

4.12 Extraction and Storage: Once pods, cones or fruit have been collected the seeds have to be extracted and dried. Most pods and cones will open up after being left to dry in the sun (e.g. Acacia spp., Cassia spp.) Cupressus lusitanica, Leucaena leucocephala, Pinus spp). A simple raised drying rack can be constructed using wire mesh. This is better than laying the pods or cones on the ground as drying is quicker and the risk of animal or insect attack is reduced. Pods of some species (e.g. Prosopis spp., Tamarindus indica) do not open on drying. The seeds of these have to be laboriously extracted by hand, although they can be extracted by feeding them to a goat and collecting the cleared seed from the droppings.

Species with soft, pulpy fruits such as Azadirachta indica, Melia azedarach, Vitex keniensis are cleaned by soaking in water for a day or two - often allowing fermentation to start. The pulp can then be scrubbed off.

After extraction seeds should be sun dried for a further few days. This reduces the moisture content and improves storage ability. Seeds should be stored in a cool, dry, rat-proof place. Metal or paper containers are best. Polythene bags can be used for most hard coated seeds but tend to ' sweat ' especially if the seed is not fully dried, and seeds can either rot to germinate in the bag. Seeds prone to insect bores attack such as Acacia tortilis, Tamarindus indica can be protected by mixing with an insecticide dust such as " Mutano". Care should be taken to avoid inhaling such dusts and to wash hands after handling.

Most seeds will store successfully for a year or two although germination ability generally decreases with time. Some hard coated acacia and pines can remain viable for over 10 years. A few species, normally those with a high oil content in the seed, lose their ability within a few weeks, no matter how good the storage. Examples are Azadirachta indica, Vitex keniensis, Araucaria spp. These should be sown as soon as obtained.

4.13 Pre-germination Treatments: Many tree species particularly those growing in Arid and Semi-Arid zones have seeds with hard or thick skins or ' seed coats ' e.g. Acacia spp., Parkinsonia aculeata, Prosopis spp. These protect the seeds from the harsh environment but conversely, inhibit the uptake of water during germination. This is an inconvenience in artificial propagation where quick and even germination is desirable. A number of pregermination treatments have been found to improve germination with these hard coated seeds. These normally involve heating, soaking, cutting or exposing to acid in order to break or soften the seed coat. In nature such conditions are provided by fire, ingestion by animals or just the passage of time. Although quite sophisticated treatments such as bathing in acid, nicking with nail clippers have in some cases been found to be the most effective, satisfactory germination of nearly all the species requiring treatment can be achieved by immersing in hot water. In this method, water is brought to the boil and the seeds immersed in it while boiling. Immediately the seeds are immersed the container should be removed from the heat and the seeds left soaking in the cooling water for one day. Remember that once seeds have been treated in this way the germination process has started so they cannot be stored any longer and should be sown straight away.

TABLE 2 SEED INFORMATION FOR SPECIES USED IN E.N.I. AREA.

SPECIES	TIME OF COLLECTION	NO. OF VIABLE SEEDS PER KILO	NO. OF SEED TO SOW PER TUBE	PREGERMINATION TREATMENT
Acacia albida	Not available locally	6,000	2	Boiling water + overnight soaking
Acacia nilotica	Feb, March/Aug.,Sept. (Seed year)	5,000	3	Boiling water + overnight soaking.
Acacia saligna	Not available locally	20,000	3	Boiling water + overnight soaking
Acacia senegal	Jan., Feb.,/July, Aug. (Seed year)	5,000 - 10,000	2	None
Acacia tortilis	July, August	4,000	4	Boiling water + overnight soaking
Acrocarpus fraxinifolius	Nov., December	10,000 -30000	4	Boiling water + overnight soaking
Albizzia lebbek	Not available locally	5,000	2	Boiling water + overnight soaking
Azadirachta indica	April/Sept.,October	3,000	1	No treatment. Seeds must be fresh
Callistemon phoeniceus	Jan.,Feb.,March/August	20,000	10 Approx.	None
Cassia siamea	Dry Seasons	20,000	2	Old seed only - Boiling water
Cassia spectabilis	Dry seasons	10,000	2	None
Cassia sturtii	Not available locally	15,000	3	Boiling water + overnight soaking
Casuarina equisetifolia	Dry seasons	300,000	10 Approx.	None
Cordia abysinnica	Dry seasons	4,000	2	None

SPECIES	TIME OF COLLECTION	NO. OF VIABLE SEEDS PER KILO	NO. OF SEEDS TO SOW PER TUBE	PREGERMINATION TREATMENT
Croton megalocarpus	Jan., Feb.,March	1,000	2	None
Cupressus lusitanica	Jan.,Feb.,March/Aug.,Sept.,	30,000 -40,000	Not Reccommended	None
Delonix regia	Jan.,Feb.,March	1,000	2	Soak 3 hours in Conc. Sulphuric Acid
Eucalyptus camaldulensis	March	150,000	10 Approx.	None
Eucalyptus globulus	Dry seasons	70,000	10 Approx.	None
Eucalyptus maculata	Dry seasons	80,000	10 Approx.	None
Eucalyptus microtheca	Not available locally	150,000-500,000	10 Approx.	None
Eucalyptus paniculata	Jan.,Feb.,March/June,July	100,000-350,000	10 Approx.	None
Eucalyptus saligna	Dry seasons	500,000	10 Approx.	None
Grevillea robusta	Jan., Feb., March	60,000	2	None
Jacaranda Mimosaefolia	March,April,Aug.,Sept.,	50,000		None
Leucaena leucocephala	All year	8,000	4	Boiling water + overnight soaking
Markhamia platycalyx	August	50,000	2	None
Melia azedarach	May,June/Dec.,Jan.	3,000 - 9,000	2	None
Melia volkensii	Wet seasons			
Morus alba	Not available locally	150,000 - 450,000		Cutting prefered
Parkinsonia aculeata	Jan. /June	8,000	3	Soak cold water, for 3 days
Pinus patula	Feb.,March	130,000	2	None
Prosopis juliflora	Not available locally	10,000 - 18,000	3	Boiling water + overnight soaking

SPECIES	TIME OF COLLECTION	NO. OF VIABLE SEEDS PER KILO	NO. OF SEED TO SOW PER TUBE	PREGERMINATION TREATMENT
Schinus molle	Jan., Feb.,March	18,000 - 35,000	3	None
Spathodia nilotica	Feb., March/August September	10,000	4	None
Tamarindus indica	July,August,Septemebr	2,000	1	None
Tecoma stans	Jan., Feb., March	10,000	2	None
Vitex keniensis	June - December	1,000		None - Must be fresh
Ziziphus mauretiana	September	650(fruits)	3	None

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SOURCEBOOK SUPPORT MATERIALS - MODULE 9

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Small scale nursery management

by Andreas Speich
Rural Forestry Adviser, Nairobi

1. Organization Structure of Tree Nurseries:

A tree nursery, like any other place of activity in the rural economy, is in one way or another situated in the

- rural-ecological space, and in the
- rural society.

This situation may be named "the external organizational structure".

A tree nursery, like any other form of production organization has also its "inner structure" which has various aspects, such as the

- social structure of the group of persons working in the nursery.
- their participative attitudes in the tree-seedling production.
- the structure of production planning, supply, supervision of work and distribution of the tree-seedling.

Behind the theme of "Small Scale Nursery Management" seems to be a certain picture and the idea of a certain external and internal structure of Tree Nurseries in Kenya, which may be expected to be the "ideal" form of tree seedling production.

2. Why Nurseries?

Rural Wood and Tree Development is a landuse and a form of rural production which is technically not very complicated. Growing tree-seedlings and rooting cuttings is a type of work which does not need any special skills, other than the general techniques of plant production. Every farmer can grow his own tree-seedlings, provided he has the proper:

- know how, labour force
- access to seed supply
- access to water
- . . . and he wants to do it.

Some important species for Rural Wood and Tree Development are propagated without passing through a nursery (e.g. Cashewnut). Transport of container-raised tree seedlings from the nursery to a farmer's planting site is economically very costly, even if no money is involved in such transport.

It could be a policy of Rural Wood and Tree Development to disseminate know-how and some of the facilities in order that (in the long term planning) the farmers become self producers of tree-seedlings. Who knows if the large number of trees, which have already been planted in the rural areas of Kenya, have ever passed through a nursery?

The establishment and exploitation of tree nurseries however is a justified temporary measure in order to:—

- disseminate know-how of seedling production
- produce rapidly a large number of seedlings
- experience economic nursery techniques for various species
- build a spirit of cooperation among the interested persons, and provide the motivation for Rural Wood and Tree Development, through a physically established center of activities (nursery).

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In the long run it may only be justified to have centralized tree nurseries for the following reasons:

- exceptionally difficult-to-raise tree species (and graftings of cultivars)
- no access to water for individual farmers nurseries
- achieved experience by the rural population, that a central or a community tree nursery is a useful place for development and maintenance of community spirit in Rural Wood and Tree Development.
- economic advantages in division of labour.

3. The Economy of Tree Nurseries:

Which external structure and which internal structure, which size of a tree nursery is the *best?* Is the lowest cost-production of a tree nursery economically and also in terms of absolute values the best one? Let us avoid approaching this question in a deterministic, scientific manner.

If we look at the question of the best tree nursery structure in a pragmatic way, and if we take into consideration what we said under 2 (Why Nurseries) the answer becomes quite obvious. (I have found this answer — in Kenya — while travelling from Lokochogio to Taveta, from Malindi to Homa Bay and from Busia to Loitokitok and having visited hundreds of tree nurseries of various structures).

Of course tree nurseries shall be designed and structured according to the local conditions and according to the available resources and in order to serve the long term Rural Wood and Tree Development best. In many cases I have found that certain elements contribute much to the success of a nursery, although there are not many examples where such positive elements are in an optimum combination, but still there are.

Let it be described by an example:

A local leader has discussed the matters of Rural Wood and Tree Development with some of his open-minded friends. The message has spread in a sublocation that some of the respected persons would like to promote Rural Wood and Tree Development, and that they therefore plan to establish a nursery. Accelerated by some external inputs (e.g. one skilled labourer from a FD-RAES nursery, the promise to supply a watering can, some seeds, etc.) the local leader calls for harambee work to prepare the nursery site. Some 100 persons are attending the first day. After two weeks, only ten persons remain interested to contribute their labour in the nursery. The local leader (encouraged by an external person) calls for a second effort of the population. He succeeds to win the commitment of thirty individuals and of small, organized women groups.

A local Rural Wood and Tree Development society is formed. A nursery labour roster is decided among the members. 50% to 70% of the trees which will be produced in the nursery will be at cost-free disposal of the society members; those who have worked the most get more tree-seedlings. The remaining trees will be sold to the local population at -/50 each.

The revenue will be used for the further development of the water supply (serving the nursery and the nearby primary school). The FD confirms, that a skilled labourer (paid by FD) will continue to be seconded, at least part time, to the nursery.

The nursery produces in the first year some 20,000 trees. More than one third are fruit trees; less than 20% are Eucalypts and almost 50% are various indigenous trees, some are ornamentals. The nursery does not produce cypress for fencing. All trees are grown in containers, most of them in empty school milk packs, others in tins and also in PVC tubes (supplied from government).

All activities, and the nursery stock is carefully recorded in a book. According to the experiences of the first year, planning and timing of sowing and pricking out is improved. The preferred tree species are again discussed and contacts are established with friends in other areas who exchange tree-seeds, which are not found locally.

After the tree planting campaign, the committee of the RWTD Society follows up the survival rate of the planted trees, and elects a first prize winner. The womens group who has raised their tree-

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seedlings in their own nursery beds, attached to the nursery, in a co-operative way, plant almost all their trees in a community wood-lot. The nearby primary school includes RWTD in the practical work programme. The school establishes a small nursery (4 trees for each child). Every child will take the trees home and plant in the family's land. Other trees are planted by the children around the school.

After the third year the enthusiasm for the tree-nursery flattens down. Only the womens group continues their nursery, combined with vegetable gardens. The Rural Wood and Tree Development Society decides that, instead of running one nursery, some of the active members should start their own private nursery near their homes. The main task of the Rural Wood and Tree Development Society will be on an education level. The Society will continue to elect annually prize winners for the best tree planting and for the best tree-seedling production. Also new tree species are introduced by external assistance through the society.

This scenario may be a very economical process of reaching self-sufficiency in Rural Wood and Tree Development. The cost of seedling production only is not the true scale whereby to measure the economic efficiency of the operation. But even in terms of seedling cost it is evident, that (e.g. government) tree nurseries will not be able to produce containeraised seedlings for less than 1/- to 1.5 Shs. On the other hand, the cost for government or another organization to promote and monitor the minimal inputs of a self-help-group nursery (as described above) may not exceed – .20 to – . 40 shs. per tree seedling.

4. Management of a Small Scale Nursery:

For the success of a nursery serving Rural Wood and Tree Development, a few rules and guidelines, beside proper nursery techniques and species selection, have to be respected:

- The nursery has to be considered as a sector of the local Rural Wood and Tree Development (RWTD). RWTD is not just tree-seedling production, but a socio-ecological programme.
- The nursery has to fit into the local socio-ecological space. Its location has to be accepted by the majority of the involved population.
  It must be technically suitable (soil, water, access, wind-protected, etc), and at a site of high community communication intensity (many people passing by).
- The local RWTD Programme and especially the RWTD Society and the group of persons involved in the nursery production should be based on a very clear organizational (internal) structure: it must be very clear who is in charge of what, leadership is essential, the repartition of contributions and benefits must be clear from the beginning; the organizational structure and the group of the active persons must remain open for expansion and transition into other forms of activities.
- External inputs (physical, educational) are in most cases needed over a certain period. The extent and duration, especially of labour secondment, material supplies, etc., must be made clear from the beginning with the local leaders, without raising unfullfillable future expectations. External inputs should always be connected with the request of proper record-taking by the local RWTD committee.
- It is not possible to manage exclusively by external inputs and guidance a local RWTD Programme. Although it is possible to produce tree-seedlings without local participation and to distribute them, the survival rate of such trees will not be high!

  Patiently built up local participation in a true and not over-ambitious self-help spirit is the only key to successful RWTD.

  Tree-seedlings which have been raised by the owner of the future tree-are loved trees. They may have a much higher chance to develop than trees given out free of cost, or sold at a cheap price from a nursery which is not integrated socially and ecologically into the community.
- Know-why comes before know-how!

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Small scale nursery management

by Andreas Speich, Wayne Teel and Cyrus Ndegwa

The seedling nursery has been the focus of expansion of government tree-planting activities. These large-scale nurseries, with their use of industrial production technology and their three-tiered division of labour (the manager, his assistants and the labourers) differ markedly with the small-scale nursery which can be managed by one person with limited personnel and expenditure. In the small-scale nursery, there are generally no irrigation facilities, water pumps, storage facilities, fertilizer application, etc.

The KENGO Kitui workshop aimed at improving the efficiency of these small-scale nurseries run by NGOs, self-help groups and individuals. Wayne Teel, working in Machakos District, Andreas Speich from Forestry Department Headquarters, and Cyrus Ndegwa of E/DI outlined an approach to the effective establishment and management of a small nursery in the semi-arid lands.

The following technical points were raised:

1. Selection of a Suitable Nursery Site

The nursery site should be close to a water source if possible. Since soil erosion is a particularly bad problem in semi-arid zones, the nursery should not be sited on too steep a slope. A supply of soil, sand and manure should be available nearby, and in order to avoid excessive transport of the seedlings, the nursery should be situated as close as possible to the planting site. Fencing for protection against grazing animals and any other improvements (e.g. construction of a dam) should be done before planting of the seeds.

2. Water Sources:

When planning a nursery site, it is necessary to locate it next to a water source, e.g. a river, spring, swamp, or dam.

3. **Planting the Seed Beds:**

The potting soil should be mixed at the nursery site. If good manure is available, there may not be any need for bringing in good top-soil especially for planting. Nursery beds measuring about 1m x 3m in area can then be prepared. In the sunken-bed nursery, the seedlings are grown in containers which are set into a sunken area, about 4–6cm deep (see photo). This type of bed has the advantage of helping maintain a cooler temperature for the seedlings in a hot climate, thereby inhibiting the growth of fungus and reducing evaporation. The seeds must be planted in containers however, otherwise their root system will penetrate the soil and will be broken off when the seedlings are removed for transplanting.

4. Containers for Planting:

Closed-end polythene tubes, about 8cm in diameter and 20cm long, with drainage holes on the sides, are recommended for planting. If kept upright in the seed beds, the roots of the seedlings will not grow through the holes. The closed end helps conserve water and ensures better protection for the seedling during transportation.

Open-ended polythene tubes; although cheaper, are not advisable for the semi-arid nursery, since some of the root system may have to be cut off before the tube can be removed from the seedbed.

Other seedling containers which can be used are tins and milk packets, with about 8 holes for drainage poked in the bottom. If tetrapak milk packets are used, they should be washed with water, followed by old engine oil, to prevent attack by termites and fungi.

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In Lamu, each farmer brings to the nursery an empty tin can in exchange for a seedling grown in a tin, thereby ensuring a steady supply of tins.

5. Securing the Seeds:

The seeds can be sown directly into the pots in the case of some species (*Acacia*, *Prosopis*, *Leucaena*, *Croton*, etc). Two seeds can be planted per pot, then one of the seedlings later transplanted into another pot or discarded.

6. Shade:

Shade is essential for young seedlings in a hot climate, both for preventing water loss and exessive build-up of heat in the containers. Natural shade can be used if the seedbeds can be sited under a tree; Acacias are good trees for this purpose. Otherwise, shade can be produced by erecting a wooden support on which sisal poles or grass can be laid. (see photos). The seedlings should be removed from the shade about 2 weeks before planting out.

7. Preventing Attack by Pests and Disease:

Cutworms are a prevalent problem in manured soil or soil with a high organic component. To rid manure of cutworms, the manure should be left to stand in water for 1—2 weeks, with daily stirring. The plants can then be fertilized with the liquid from this manure, rather than putting the manure itself in the potting containers. Biogas sludge can be treated in the same way as manure. An alternative method for controlling cutworm is by the application of a pesticide (e.g. Algocide) to the soil to kill larvae.

If "damping off" (a fungal disease) is to be prevented, the seedbeds must be kept well-drained, and the seedlings protected from over-heating. The sand used in the potting soil mixture should be washed with water before use in order to remove the alkalinity, which promotes the growth of this fungus. If the damping off is a persistent problem, then a fungicide may have to be applied.

The menace of rats can be avoided by maintaining a clean nursery.

Termites are attracted to paper tetrapak potting containers, but this can be prevented by treating the paper with old engine oil, as described above.

8. Preparing the Seedlings for Planting:

Before the seedlings can be removed from the nursery, for planting, they must be "hardened off". In the semi-arid areas, this means that the seedling must get accustomed to a scarcity of water. This hardening off process is done by gradually decreasing the frequency of watering in the nursery, until eventually the seedlings are watered only when the soil in the container is almost dry.

The seedlings must also adjust to intense sunlight, so about two weeks before transplanting, they should be taken out of the shade in the nursery and left to direct exposure to the sun.

The workshop participants were of two minds about the need for root-pruning. If open-ended pots are used, the roots extending from the bottom of the tube must be cut off before the pot can be removed from the seedbed. Care must be taken not to damage the main tap root, however, as it is essential for survival in a dry place. NGO's working in Turkana felt that it is good to use long tubes, but to transplant the seedlings before the roots reach the bottom of the pot.

Top-pruning, especially of the leaves of broad-leafed trees, may help in their survival by reducing the leaf area exposed to the sun. This pruning should be done before transplanting.

9. Record-Keeping:

Andreas Speich emphasized the need for good record-keeping. A record of the rainfall, growth of the seedlings and survival rate is important if even a small nursery is to operate efficiently. Additionally, a record of labour (who is working each day) in the nursery should be made, so that those people who

work will get priority for the seedlings. In this way, a scheme of "trees for labour" can be devised.

A suggested form for nursery record-keeping is included in the Appendix.

10. Transport of Seedlings from the Nursery:

The last step in the nursery operation, that of the transport of seedlings to the planting site, is unfortunately often the cause of failure of otherwise careful tree-planting efforts. Transportation of the seedlings is now often carelessly done, with bags being crammed into cars or lorries, or into carrying baskets, then left in the hot sun to wilt or dry up. For this reason, it is a good idea to site the nursery as close as possible to the planting site to avoid the hazards of a long journey.

If seedlings must be transported, they should be thoroughly soaked with water at the nursery beforehand, and then re-watered immediately on reaching home. Seedlings should be planted as soon as possible after reaching their destination.

It was suggested by workshop participants that the nursery provide small boxes for 20 — 25 seedlings to ensure their safe transport by individual farmers.

Workshop participants studying nursery management at the Kitui Agroforestry Centre. Note the natural shade provided by the trees growing at the nursery site.

Question: What if only saline water is available for watering? How can damage to the seedlings be prevented?

Answer: If only saline water is used, the frequency of watering must be decreased in order to prevent the accumulation of salt in the potting container. The selection of halophytic (salt-loving) species like *Casuarina* and doum palm would also be a good idea. Try and discover which species in your area can tolerate salty conditions.

Question: How does working in the nursery affect or interfere with a farmer's other responsibilities?

Teel: Fortunately most of the major operations of the nursery can take place during the period of low activity for the farmers. The best time for planting trees is the same as the crop-planting season. The nursery should therefore be geared for tree-planting during the rainy seasons, which means the nursery preparations need to begin at least about two months before the rains. Bag or pot filling need only take about 2 — 3 sessions. (About 5000 pots can be filled by 30 people working for 2 — 3 days). Sowing the seeds needs another 2—3 sessions.

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Question: How can our small nursery ensure a steady supply of volunteers?

Teel: Labour constraint is one of the biggest obstacles for a self-help or NGO nursery. One volunteer farmer can only properly handle about 50 trees per season. One way to encourage participation in the nursery is to instill a sense of ownership in the trees. The farmer's contribution to the nursery can be repaid by the seedlings they receive.

Speich: Therefore it is important that the nursery is integrated into the local community. Self-help nurseries are the best for good management, since they are based on a joint ownership of the trees. This ownership or personal interest is the motivating force for concern for the survival of the trees.

Question: Our group has very limited funds. How can we manage to start a nursery?

Gitundu: A small nursery does not really need much capital input. The soil, containers, etc., can all be locally provided. The seeds may be the only expense. Your nursery can even become a money-making scheme if you sell the seedlings you raise.

Amare: A water supply may involve some expenditure. Check with the Ministry of Water Development to request a government subsidy for a water source for the nursery.

Question: How can a farmer go about establishing his own nursery on his shamba?

Amare: An individual nursery should be sited near the farmer's house, with close access to manure and kitchen waste matter. In this way, also, the children of the household will be able to help work in the nursery. The seedlings should be watered in the evening to help minimise the loss of water by evaporation. Fencing is a must, for protection against goats.

Seedlings placed in Sunken beds to help conserve moisture. Sunken beds are suitable for arid areas.

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SPECIES SELECTION

Before anything starts in the nursery one has to select species appropriate to your area. In almost all cases trees which grow naturally near your community make the best choice. Often the use and value of these trees is well-known, especially by older persons. Usually each tree has many uses. Exotic or imported trees may be useful as well, but care must be taken before growing these. Often they become pests by reproducing too rapidly since seeds are not eaten by local insects or birds. Or sometimes they prove to be unsuitable to local conditions and die before they reach a useful age. Local trees are already known to be able to handle local conditions and can provide homes for local birds and animals which normally shun imported trees. Local trees may grow slower than exotics, but usually have wider uses and are more beneficial to the local environment. Exotics can have their place too, if wisely selected and used.

There are no hard and fast rules about establishing small scale nurseries. In fact it is best if a flexible approach is adopted so as to remain responsive to local conditions. The guidelines which follow are just that; suggestions which can be altered if you find better ways. Although there are many things to consider when starting a nursery, the best rule of thumb is to keep it simple. Many of the topics which follow can be considered in a different order as well. They are presented in this form for convenience, not because things need to be done in this order.

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NURSERY SITE LOCATION

Three basic items are required for a good nursery; water, soil and shade. Selecting a site means finding a place with access to these three items. Water is a constant need, especially in dry sunny climates. If the nursery is very far from a consistant water source people get tired of carrying it and do not do it as often as needed. The closer your nursery site is to a good water source, the more likely it will be watered well. Soil, which will be detailed later, is a heavy item that often must be transported to the site. If good soil is close by it reduces the labour input for this part of the nursery. Lastly, shade must be considered. Young seedlings are burned easily by intense sun. If your nursery is located under some trees, building shades will not be necessary. So three things are to be looked at in selecting a good nursery location; access to water, proximity to soil and possibilities for shade.

PROTECTION

Many things can damage young seedlings. Goats, sheep and cattle may graze them off. Dik-dik, rabbits and ground squirrels may damage or destroy them. At one nursery a person backed his car over a seed bed. To prevent such damage some sort of protection is needed. Usually a fence already in place can be used. Sometimes one must be made. One idea is to use thorn tree branches as a temporary fence allowing living fence plants, like pencil euphorbia or certain thorny shrubs, to grow up between the branches. If resources are available a wire fence can be made. Whichever

you choose, make sure you prevent entry of the animals most likely to damage your young seedlings, as well as people.

NURSERY SIZE

The area needed for your nursery depends, of course, on the number of seedlings you wish to grow. It takes a lot of labour to do a nursery and you should keep in mind how many people can help and how much time each person can give. Most work goes into four duties; building a fence (and shades if needed), collecting and mixing soil, filling the pots and planting the seeds. Watering usually involves just one person for a short period each day. If you choose to have a nursery containing 5,000 seedlings it will take about 70 person - days to do all the work until seeds are planted. A nursery of this size can fit into a space of 10 X 12 meters. This includes space for mixing soil, allows for good maneuverability between nursery beds as well as a space between the fence and nursery beds. Variations can be easily made from this according to the size of the nursery you wish to make. (See the Nursery Plan Diagram).

SOIL MIXTURE

To assure fast growth of the seedlings in the nursery a proper soil mixture is essential. Usually this involves a mixture of 3 ingredients; topsoil, sand and manure. The exact proportions vary according to the types of soil found in the particualar area of your nursery. A common mix is 4 parts topsoil, 1 part sand and 1 part manure. If the topsoil is sandy and water soaks through quickly the sand component

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can be dropped. On the other hand, if the topsoil contains a lot of clay more sand may be needed. A rich topsoil may require no manure. A poor topsoil might require more. Whatever your specific topsoil type, start by aiming for a 4: 1: 1: mix and vary according to conditions.

TOPSOIL

The best topsoil is usually found under stands of indigenous trees which seasonally loose their leaves. Often one can find good topsoil by looking for specific trees. In the Kenya highlands a tree called Dombeya always has high quality, fertile soil under its canopy. Other locations may have trees which would help you find good soil. Usually, government or private nursery managers know where to look and it would be wise to ask their advice.

Once you have found a good patch of soil, sweep off the top layer of unbroken-down twigs and leaves and surface vegetation. Take only the top 10 to 20 cm of soil, depending on its quality. Nurseries need considerable amounts of soil, about five, 15 liter buckets for every 100 bags, so do not be afraid to collect a lot. Topsoil should be brought to the nursery 1 or 2 months before use. Sift it into a pile to remove larger sticks and stones, then cover with a thick layer of grass and water it well. This causes weed seeds to germinate and rot, reducing the amount of weeding you will have to do in the nursery. Also, occasional watering helps pre-moisten the soil and aids worms and bacteria which act to make the soil more fertile. After a month or more the soil will be ready to mix.

MANURE

Any manure used should be well rotted, sifted and checked for beetle larva. Cow and goat manure is usually the best These types rot quicker, provide good balanced nutrients and carry less harmful bacteria. Sheep and camel manure also work well. Chicken manure is so high in nitrogen that, used too soon, it damages the young plants. Normally it takes 3 months for cow or goat manure to rot properly.

As an alternative one can use a good compost. Compost consists of manure, food scraps and peals, all mixed with crop residues, then rotted and cured by turning once a week over a few months. This makes a nutrient-rich, non-burning fertilizer for your nursery seedlings.

SAND

Sand is added for one purpose; to improve drainage of your soil mixture. It helps ensure that water reaches all parts of the pot and, at the same time, that excess water drains out without waterlogging the seedling. A medium to coarse grained construction sand works best. This can often be found in local stream beds. Sand is not needed if the topsoil you choose to use drains well already. This, too, should be sifted to remove stones and other unwanted items.

Once your topsoil, manure and sand are piled in a convenient corner of the nursery you are ready to mix. Put the decided upon amounts of each ingredient in the pile and mix thoroughly with a shovel. All the ingredients and the mixing area should

be located in one corner of the nursery for easy access. The pots can then be filled and placed in the nursery bed.

POTS

Nurseries which deal with large numbers of seedlings generally do not use pots. They select, instead, an open-rooted system. On a small scale this is not practical as too many seedlings are lost in transplanting or transporting. Pots are bulkier and take more time to prepare, but have the advantage of better protection of the seedling root system and grant it a better chance of survival.

Many things can be used for pots; polythene bags, school milk containers and used tins to name a few. Whichever you choose, for your pots, there are two basic ways to use them; open or closed ended. The advantages and disadvantages will be discussed in turn.

Open-ended

This type of pot is basically a tube filled with soil. The square school milk container with the bottom punched out works well. So does a tin with both ends out. A roll of polythene tubing which is cut into desired lengths is often used in nurseries. The basic advantage of this method occurs with watering; it is nearly impossible to waterlog open-ended pots. Also, if you choose to use polythene, open-ended tubes are cheaper. With open-ended pots, however, one must be careful to do occasional root-pruning.

Many tree species, especially those which do well in dry areas, have roots which grow down very quickly. In fact, in the plants' initial growth, more energy goes into making a good root system than producing leaves or wood. In open-ended pots the roots reach the bottom quickly. If left to grow they can enter the soil under the pot, or if prevented from going down, even grow into other pots. This can cause problems when transplanting. At one nursery near Marigat in Kenya, there were a number of trees growing where new pots should have been placed because nursery workers failed to root prune and could not move the pots.

To root prune one must lift the pots about once a week to break off lead roots penetrating the soil, or cut those roots escaping the pot growing sideways. It is a simple job, but somewhat time consuming. If your seedling bed is lined (next section) the root pruning need only be done about once a month.

Closed-ended

These types of pots have two major advantages over open-ended types; they are easier to fill and one does not have to root prune. However, some disadvantages also exist. Water does not drain as well, so holes must be made in tin bottoms or the sides of polythene bags. Roots, especially those with a long tap-root, curl at the bottom and must be straightened or snipped before transplanting. Also, it is a bit harder to remove the seedling from the pot when transplanting, especially if you use tins. Even with these disadvantages the closed-end pot can be left alone in the

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nursery longer than open-end and is choosen more frequently as the system to use.

Pots can be of any shape and size, but the most versatile are those small enough to handle easily yet still give the tree a good root system. The best size, on average, is one about 8 cm in diameter and 20 cm high. For long rooted trees a longer, narrower pot is fine. Small seeded species, like Casuarina at the Coast, can be grown in smaller pots. Choose the type easiest for you to get which is convenient for growing and transplanting.

If you choose polythene bags there is a colour choice. Black bags block the growth of algae but overheat, so must be well shaded. White bags prevent some algae growth on their sides and do not heat up, but they tend to get brittle and crack sooner than the other two. Clear bags are most readily available (in Kenya at least), but do nothing to stop algae growth. Any of these three types will work.

NURSERY BEDS

A 'bed' is simply a term for the place where you put your pots. They can vary in size and shape according to preference and nursery location. The plan diagram shows the beds being 1 meter wide and 3 meters long. With pots of 8 cm diameter about 500 will fit in each bed. The width and spacing between beds is designed to make watering easier.

Beds are often sunk into the soil about 20 cm, the height of a pot. This makes stacking the pots easier and prevents outside pots from drying out faster than those near the center.

The bottom of each nursery bed should be lined to prevent escaping roots from penetrating the soil. This is especially important when using open-ended pots. Lining with gravel, plastic sheets or flat rock all work well.

If plastic pots are used, be sure to make them stand as straight as possible. Angled stacking leads to poor watering and angled transplanting. With tins or school milk containers the vertical problem is not so great. These normally are not as long so the bed need not be dug as deep.

If your nursery has good shade, is quite flat and the pots stand upright without problems you may have no need for a nursery bed at all. The advantage of a bed is chiefly organizational, stacking and in keeping the side pots from drying out faster than pots nearer the center.

PRE-WATERING

Once your pots are filled and organized in the nursery as you have planned, then pre-watering can start. Before seeding, the soil in each bag should be well moistened throughout. The time this takes depends on your soil mixture permeability. The best way to do this is to water the pots in small doses 3 to 4 times a day until the water reaches the bottom of the pot. In some cases only one day

of this is needed. After this water daily for about 1 week. This will make certain that all the soil is well moistened. Also, any weed seeds not previously killed in the soil pile will sprout here and can be removed when putting tree seed in the pots.

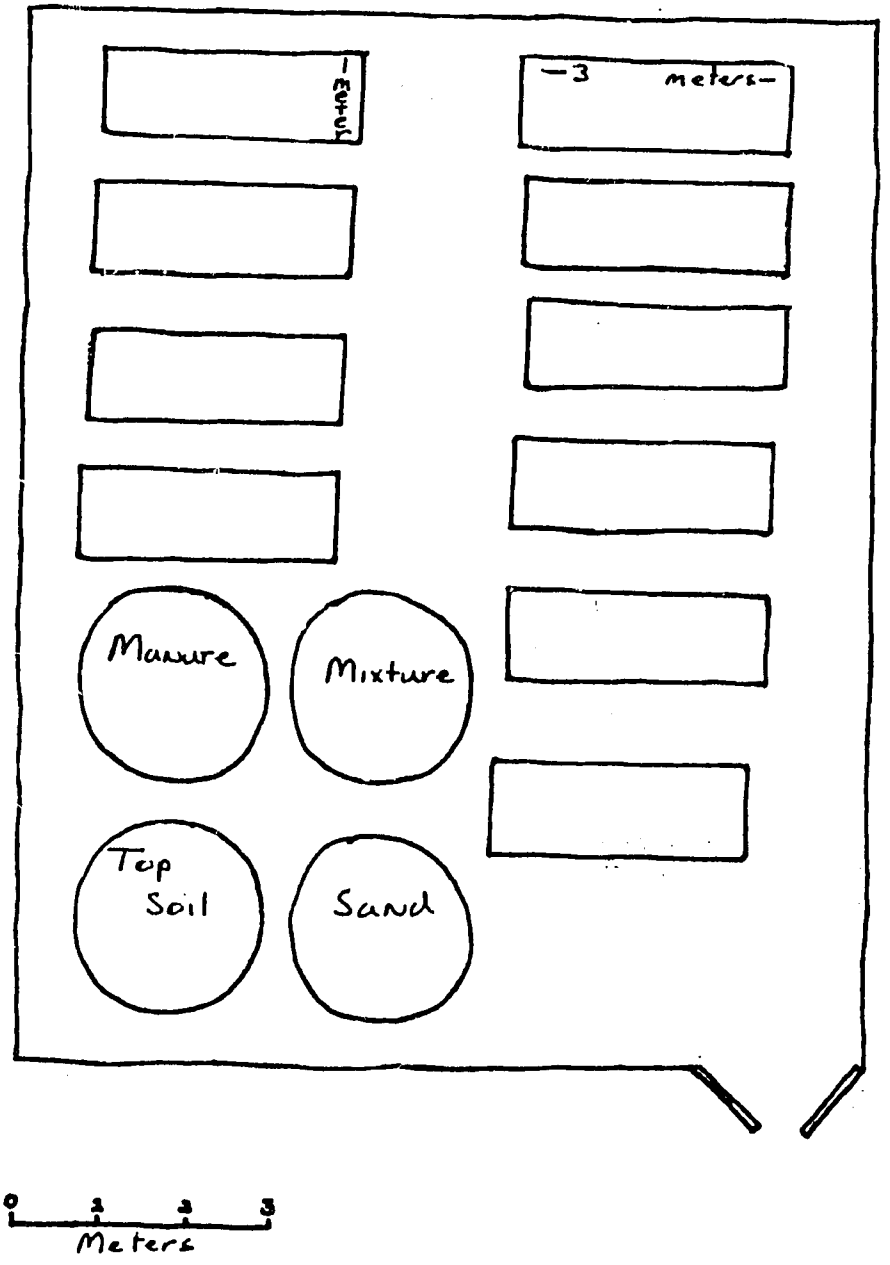
PLANTING SEEDS

Every tree species has its own unique seed and every one gets planted a slightly different way. In this guide there is not room to suggest all the possible ways to plant seed, so several rules and suggestions will be given using some common Kenyan species as examples.

The first general rule concerns seed depth. The smaller the seed the shallower you plant. Normally, planting a seed 2 to 3 times as deep as its length works well. For instance *Acacia albida*, a riverine tree of semi-arid areas, has a seed slightly less than 1 cm. long. Planting 2 cm deep is nearly perfect. Exceptions occur however *Grevillea robusta*, planted in the highlands, has a seed about the same length as *Acacia albida*, but it is very thin. *Grevillea* is planted less than ½ cm deep.

Seed depth is important. Too deep and the seed might germinate, but never break the soil's surface. Too shallow and the young seedlings will be damaged when watering. To ensure proper depth at planting make a devise that can be marked to the proper length and move enough soil out of the way to drop the seed in. A fresh stick with bark removed works very well.

Nursery Plan Diagram



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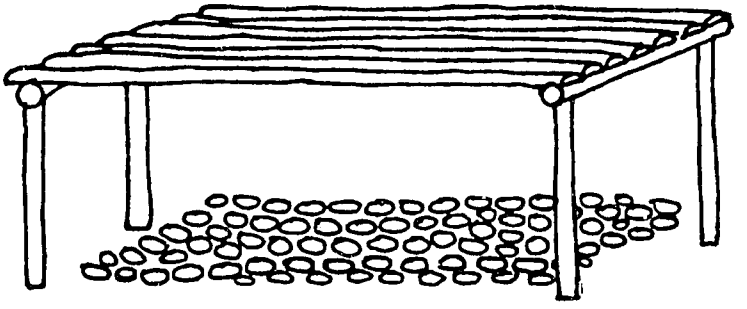
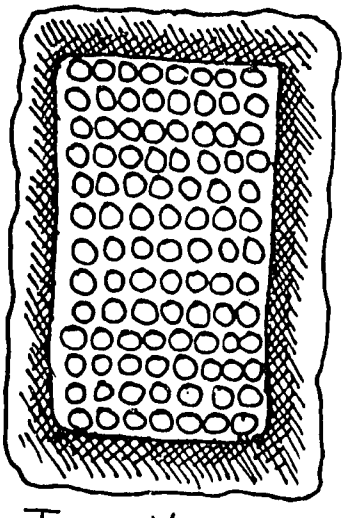
Nursery Bed



Bed with a Sisal Shade

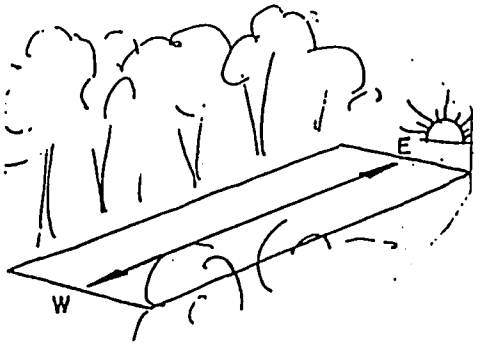
Cut-away End View



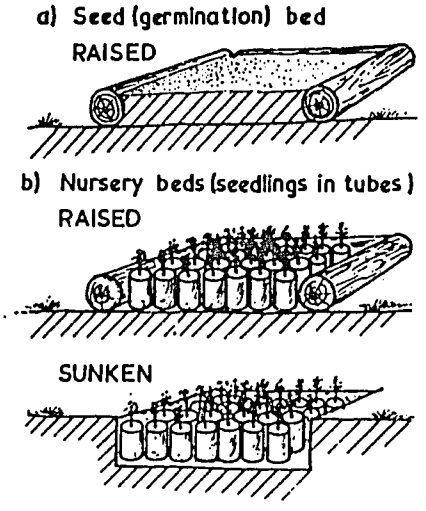
Top View

	Learning Element	Code:	
	Title: Selecting and Planning a Tree Nursery Site **Occupational Area:** GROWING TREES	**Date of Issue:** Nairobi April 1984	**Page:** 4

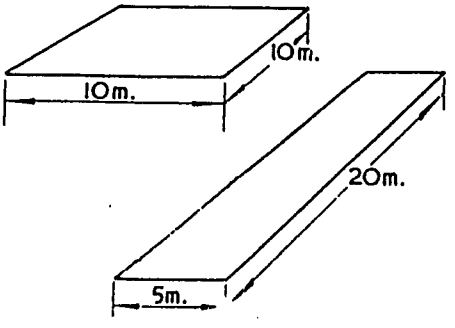
6. When making your nursery and seed beds, the beds have to run East-West. This is to make sure that equal sunlight reaching all parts of the seedlings.



7. The type of nursery beds you will use will depend on the amount of rain the area gets. In arid and semi-arid areas sunken beds will be used, in medium and high rainfall areas level or raised beds will be used. Your seed-beds will be raised also.



A 100 square metre piece of land (10 metres by 10 metres) is enough to produce 5,000 seedlings each planting season. A planting season is determined by the number of rainy seasons an area gets. A piece of land 20 metres by 5 metres, or a piece of land 12 metres by 8 metres will also produce the same amount of seedlings as the 10 metres by 10 metres.



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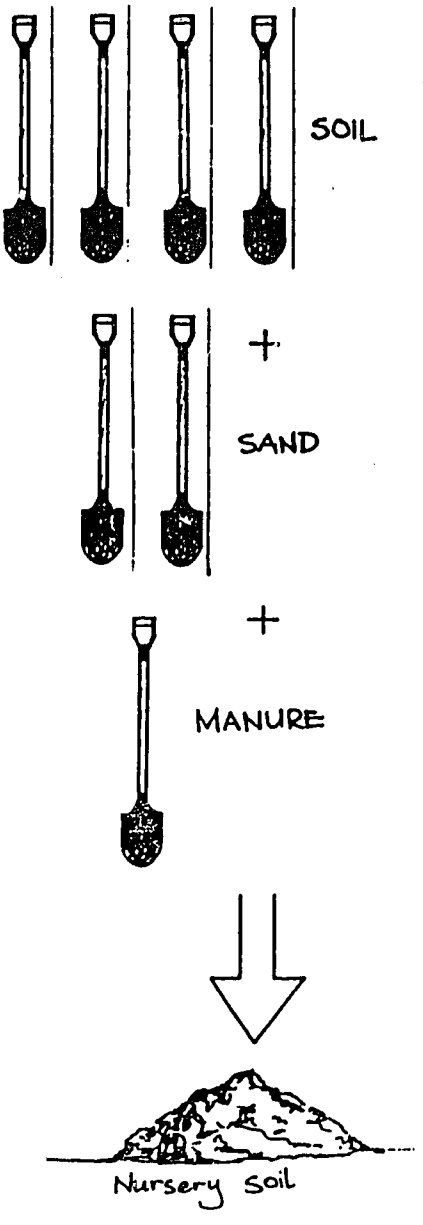
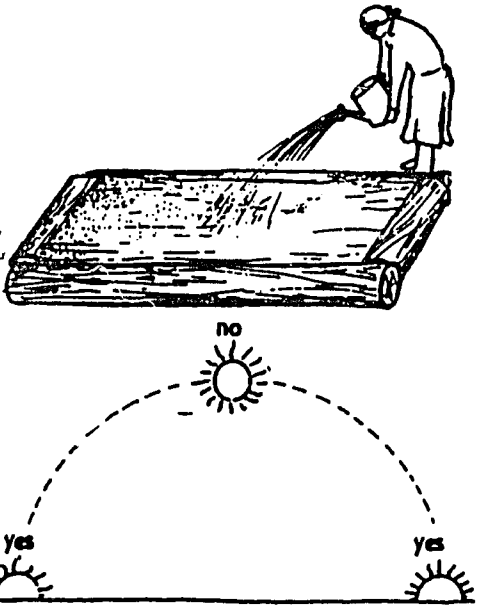
	Learning Element	Code:	
	Title: Building a Tree Nursery		
	Occupational Area: GROWING TREES	**Date of Issue:** Nairobi April 1984	**Page:** 6

11. Soil used in your nursery has to be able to have good drainage. The source of your soil should be close to your nursery site. You can use forest soil (top 15 cm). If forest soil is not available you can make nursery soil by using the following items. 4 shovels of local soil, 2 shovels of sand and 1 shovel of cow manure. When making a large amount of nursery soil keep the same ratio 4 shovels of soil, 2 shovels of sand and 1 shovel of cow manure, and example is 40 shovels of local soil, 20 shovels of sand and 10 shovels of cow manure. In all cases the soil, sand and cow manure must be mixed well.

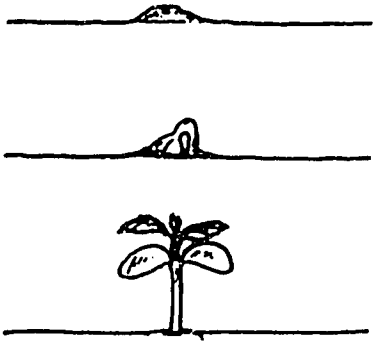


	Learning Element	Code:
	Title: Planting Seeds and Early Care of Seedlings **Occupational Area:** GROWING TREES	**Date of Issue:** Nairobi May 1984 / **Page:** 4

4) After the seeds have been planted, water them right away. Afterwards watering must be done once a day unless it rains. In arid and semi-arid areas you may have to water twice a day. You do this until the seedlings are transplanted or pricked out. When watering, use just enough water to keep the soil moist until the next watering. Too much water can be harmful to the seedlings. Water in the early morning or later afternoon. Never water during the hotest part of the day.



5) Most types of seeds will germinate in two to three weeks. However, some types of seeds will germinate in only a few days while others can take 2 to 3 months or more. If you are not sure how long it will take the seeds you planted to germinate ask your local forestry officer.



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SECTION 3

NURSERY LAYOUT AND CONSTRUCTION.

This section deal with the way that a nursery should be laid out and the jobs involved in the construction phase.

3.1 Terracing: The first task in nursery construction will be terracing if the general slope is more than 10 degrees. The aim should be to make the terraces s wide as the slope will allow. A single nursery bed on each terrace will slow the rate of working and lead to inefficiency. Terraces should be at least 5m wide to allow sufficient room for two beds to be laid out with adequate room for access paths. On steep sites the minimum terrace width should be regarded to be about 2½m.

Following the levelling of the site all large stones should be set aside and the soil compressed prior to the construction of the nursery beds.

After the construction phase has been completed the [illegible]ace banks should be planned up with a suitable binding grass. The banks should not be regarded as waste land but can be used for the multiplication of fodder grasses.

3.2 Seed Beds: It should be made clear that infact seed beds are not always necessary. When containerised stock is being raised it is more efficient if seed is sown directly into the container itself, thereby eliminating the seed bed stage. There is,however, a tendency in Kenya to still use seed beds and prick out (transplant) the germinated seedlings to the container as a second operation. The use of seed beds can only be recommended when seed is of doubtful viability, or is known to germinate irregularly or where Swaziland Beds or boxes are to be used instead of tubes.

It is however sensible for every nursery to have a small seed bed so that when doubtful seed is being used additional seed can be sown as an insurance against too many failures with direct sowing.

The seed bed should be surrounded by stone blocks and filled to a depth of about 10cm with a very light loam soil. The soil must be freely draining and should contain a high percentage of sand (i.e. 60-75%).
The practice of using wooden planks or poles to surround the seed bed should be discouraged unless the wood is first seasoned and well treated with a suitable preservative. Untreated wood will encourage insect and fungal damage.

To promote good drainage the soil can be laid on top of layer of crushed stone at least 5cm deep. The need for good drainage is to reduce the possibility of damping-off (fungus attack).

3.3 Transplant Beds for tubed stock: The transplant bed for containerised stock can be nothing more than a levelled area of ground, on which the tubes can be set out in a block about 1.3m wide and as long as desirable but usually 10-30m.

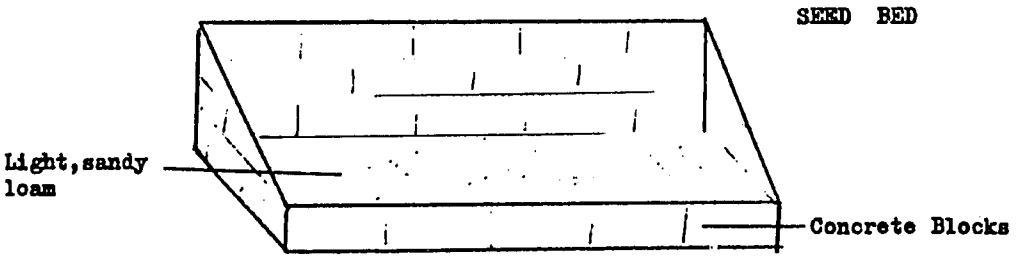
It is important that localised hollows are avoided since if water is allowed to collect then tubes will be waterlogged and growth and survival will suffer. Ideally the base of the transplant bed should be compacted and given a very slight camber (i.e. like a road surface). In nurseries subject to poor drainage either because of the nature of their soils or their position then it is worth building a raised bed of compacted stone and murram.

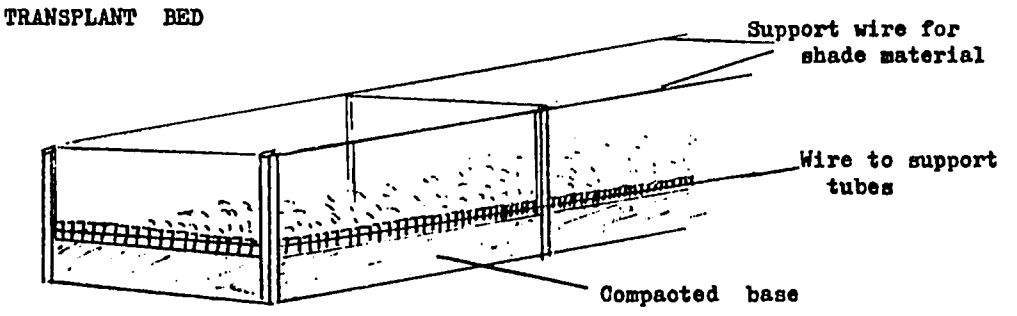
Supports for shade will be required in those nurseries located within the A.S.A.L. In the higher altitude nurseries the need for shade is less necessary. The shade supports should be set about 50cm above the level of the tubes. A length of plain wire can be set to run around the perimeter of the bed at a height of about 5cm. This will ensure that the tubes are neatly arranged within the bed. A second wire is then attached near the top of the supports for attaching the shade material. Hessian cloth makes an ideal shade material though it is expensive and it can only be expected to last 2-3 years. For small nurseries, local material such as grass or bamboo, can be utilised.

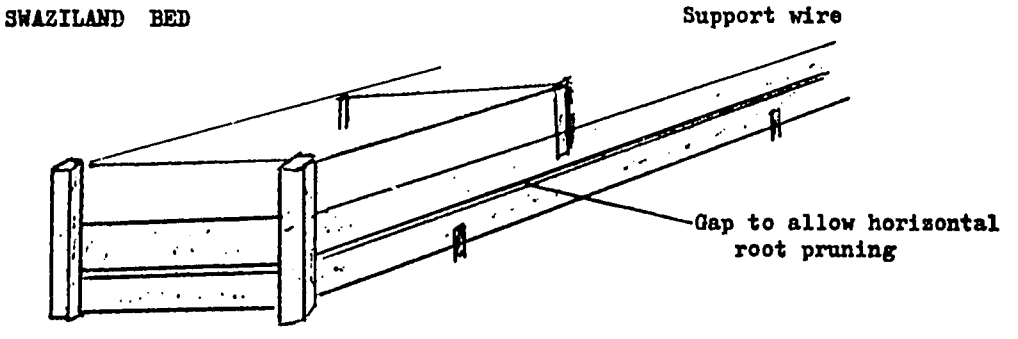
3.4 Swaziland Beds: This type of transplant bed should only be used in the higher areas i.e. about 200m where rainfall is adequate for open root planting. It has the advantage that the cost of containers is eliminated since the intention is to raise the seedling in a ball of earth.

The Swaziland Bed is laid out on levelled ground. A series of wooden planks about 15cm in depth encloses the bed which should be made 1-1.3m in width. The planks should be postioned using wooden pegs and the base of the plank should be raised 1-2cm above ground level to enable horizontal root pruning to be carried out. The timber used should be treated to reduce pathogen build up. The water soluble preservative are best for this since they are less phytotoxic. If creosote has to be used, several weeks should be allowed for the timber to properly dry out after treatment.

FIGURE I NURSERY BEDS







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The beds should be filled firstly with a basal drainage layer of small stones sunk 5cm below ground level. This overlaid with a 2cm deep layer of unsieved forest soil or loam. The remainder of the bed is then filled up with a suitable growing medium. Since the same soil will be used for many seasons it is worthwhile experimenting with the most suitable soil mixture. The ' Muguga Mixture ' was mentioned in section 2.3 but forest top soil will always be principal ingredient.

3.5 Access and Paths: When laying out the beds, thought should be given to access by vehicles so that soil can be centrally dumped and seedlings can be loaded. Access paths of about 50cm should be left between adjacent beds to allow for tending operations.

There is a tendancy in many nurseries to have unnecessarily wide paths often combined with nursery beds that are less than 1m wide. This is a waste of space and should be avoided. Even if land is not a limiting factor a nursery that is too spread out will lead to workers having to walk further during tending operations and additional pipes will be required for the irrigation system. It is therefore more efficient and economical to keep the nursery as compact as is practical.

3.6 Nursery Buildings: The simple school or village nursery will not require any buildings providing a suitable room can be found to be utilised for a nursery store. This should be a lockable room, suitably shelved for the storage of chemicals.

Other building that might be required are:-

a) Pricking out shed

b) Nursery Headman's house

c) Watchmans house

The pricking out shed is an open structure principally to provide shade for seedlings when they are being transferred from the seed beds or boxes to tubes. This structure is not always necessary if direct sowing into tubes is the standard technique being used or if sufficient shade can be provided within the beds themselves following pricking out. However such a shade structure is useful for workers to rest out of the rain or hot sun and will be necessary if fruit trees using grafted material are to be raised. A shed of about 4 x 8m would be adequate for all but the largest nurseries.

The pricking out shed is usually best located centrally within the nursery to be close to the seed and transplant beds. Housing should be kept out of the main working area.

3.7 Irrigation Methods: The method used for watering nursery stock will largely depend on the size of the nursery and of course the financial resources available. The most sophisticated would be a high pressure sprinkler system, the simplest the humble watering can. For the smallest nurseries a watering can is all that is required but when production exceeds 50,000 a hose pipe fitted with a rose attachment or connected to a sprinkler becomes essential.

When water is being obtained under pressure, whether it is by gravity or a pump there are two alternatives. Either the water is stored in an elevated tank prior to distribution through a series of stand pipes or it is delivered directly to the nursery beds. In the case of the later method it might be possible to use a high pressure system such as oscillating sprinklers, whereas with the elevated tank pressure will be low - moderate, and the irrigation method must be suitably designed.

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METHOD DEMONSTRATIONS

This follow-up often takes the form of a second type of demonstration the method demonstration. Method demonstrations allow farmers to learn by doing. The extension agent physically demonstrates a practice - how to determine a goat's age, for instance, by checking its teeth - and asks the farmer to try the same practice herself. The agent watches and corrects the farmer until she can do the practice properly, and then moves on to the next step of the demonstration.

Only one topic is covered at a time in a method demo. Checking a goat's teeth is one aspect of the topic: "Determining what livestock to buy at an auction." Goat buying and goat breeding are different topics. Each method demo is timed to coincide with the operations farmers are involved with in their individual farming cycles. Planting demonstrations are conducted a week or two before most farmers begin planting; weeding demonstrations are conducted just before the optimum time in a plant's growth cycle to do a complete weeding operation, In this way, a series of method demonstrations serve to span an entire growing season and keep the extension agent in close contact with his clients.

Being successful in conducting a method demo requires close attention to detail. The site and time of demonstration should be selected on the basis of audience comfort. Shade, heat, and sight lines are three important considerations. Materials for the demonstration should be locally available and arranged conveniently for use in the demonstration. The best way to make sure that nothing will be forgotten is to prepare a written plan (see ILLUSTRATIONS and TOOLS). This may include the step by step sequence of the demo itself as well as lists of materials needed and major points to be covered. Once the plan is written, the extension agent needs to rehearse the presentation in its entirety. Only by actually walking through a demonstration can the agent be sure that nothing has been left out.

When actually conducting the presentation, it is important to encourage as much farmer participation as possible. Points at which farmers can be directly involved should be indicated in the written plan. Other means of accomodating farmer learning styles are to continue to relate new material being presented to a farmer's previous experience and to carefully choose vocabulary with which the farmer is already familiar. Some technical terms may prove very difficult to translate without considerable thought beforehand. A good way to check to make sure that the audience is following a presentation is to pose questions to farmers at regular intervals. The demonstrator can also repeat steps where necessary. Finally, it is important for either the extension agent or one of the farmers to summarize the main points of a presentation at its conclusion.

The ILLUSTRATIONS and TOOLS sections which follow can be supplemented by a review of the adult learning principles and cross-cultural communication techniques contained in other sections of this chapter.

SSM 9.5.1 Gibbons and Schroeder p.182

TOOL

Guidelines for planning and conducting an effective method demonstration:

1. Plan to demonstrate only one topic at a time.

2. Time demonstrations to correspond with farming operations being carried out in the field.

3. Sequence method demos to span the entire farming cycle.

4. Consider ways to make the audience comfortable as they view the demonstration.

5. Prepare a written plan for the demonstration including:

   - a step by step sequence of what will happen in the demonstration

   - a list of materials needed

   - a summary of major points covered in the demo.

6. Incorporate participation of farmers into the demonstration whenever possible.

7. Choose analogies and vocabulary that will help the farmer tie the new information to things she has already experienced.

8. Check periodically throughout a demonstration to make sure the audience is following the presentation by posing questions to them.

9. Repeat steps where necessary.

10. Make sure major points of the demonstration are summarized.

11. Arrange for follow-up visits to farmers interested in trying the new method.

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TOOL

A checklist for all types of demonstrations:

I. The subject:

	Yes	No
1. Is the farmer ready to use the improved practice to be demonstrated?		
2. Does he need the skill or practice?		
3. Can he afford it?		
4. Have you selected a title that appeals to him?		
5. Have you planned to teach only one thing at a time?		
6. Have you collected all available information on the subject?		
7. Have you decided which language or vernacular you will use?		
8. Are you certain the practice or skill to be taught is not too difficult for him to learn?		

II. Plans made for the period before the meeting:

1. Have you arranged the time and date for your meeting?		
2. Have you arranged for the demonstration site?		
3. Will each farmer who attends your demonstration be able to see your actions?		
4. Have you assembled all of the materials you will be needing?		
5. Are you planning your demonstrations to relate to the farmer's experiences?		
6. Have you practiced your demonstration until you can do it to perfection?		
7. Have you developed your demonstrtion using a standard plan?		
8. Did you write down each step?		
9. Have you listed all of the key points?		
10. Are your instructions written in a simple, understandable manner?		

	Yes	No
11. Were signs and/or posters used to direct the farmers to your demonstration?		
III. Plans made for the period during the meeting. Plan before the meeting, check results after the meeting).		
1. Did you present your demonstration with enthusiasm?		
2. Did you act yourself?		
3. Did you talk to your audience?		
4. Was your demonstration explained to the farmers, step-by-step?		
5. Are you certain you were understood.		
6. Did you allow time for questions from the audience?		
7. Did you repeat steps when necessary?		
8. Did you assist the slower persons when they fell behind?		
9. Were faster persons used to assist you?		
10. Were the important steps summarized at the conclusion of your demonstrations?		
11. Were final questions encouraged?		
12. Was reference material handed out at the conclusion of your demonstration?		
13. Were the farmers told where to get additional advice?		
14. Was there a list made of attending farmers?		
15. Was your meeting held without conflict of other meetings?		
16. Were photographs taken of activities at the meeting?		
17. Were records kept of the meeting for future use?.		
18. Were credit and recognition given to local farmers who contributed to your demonstration?		

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	Yes	No
IV. Plans made for the period following the meeting:		
1. When the farmers left the meeting, did they know what to do on their own farm?		
2. Were plans made for the next meeting?		
3. Were they told what material? if any, would be needed for the next meeting?		
4. Were they told to be thinking of the problems involved for the subject of the next meeting?		
5. Was any publicity given to your meeting by the press, news release or radio?		
o Press		
o News Release		
o Radio		
V. Plans made for the follow-up:		
1. Have the farmers changed over to use of the new practice that you demonstrated?		
2. Will you provide additional assistance if requested?		
3. Have the farmers called on you for further assistance in using your new practice?		

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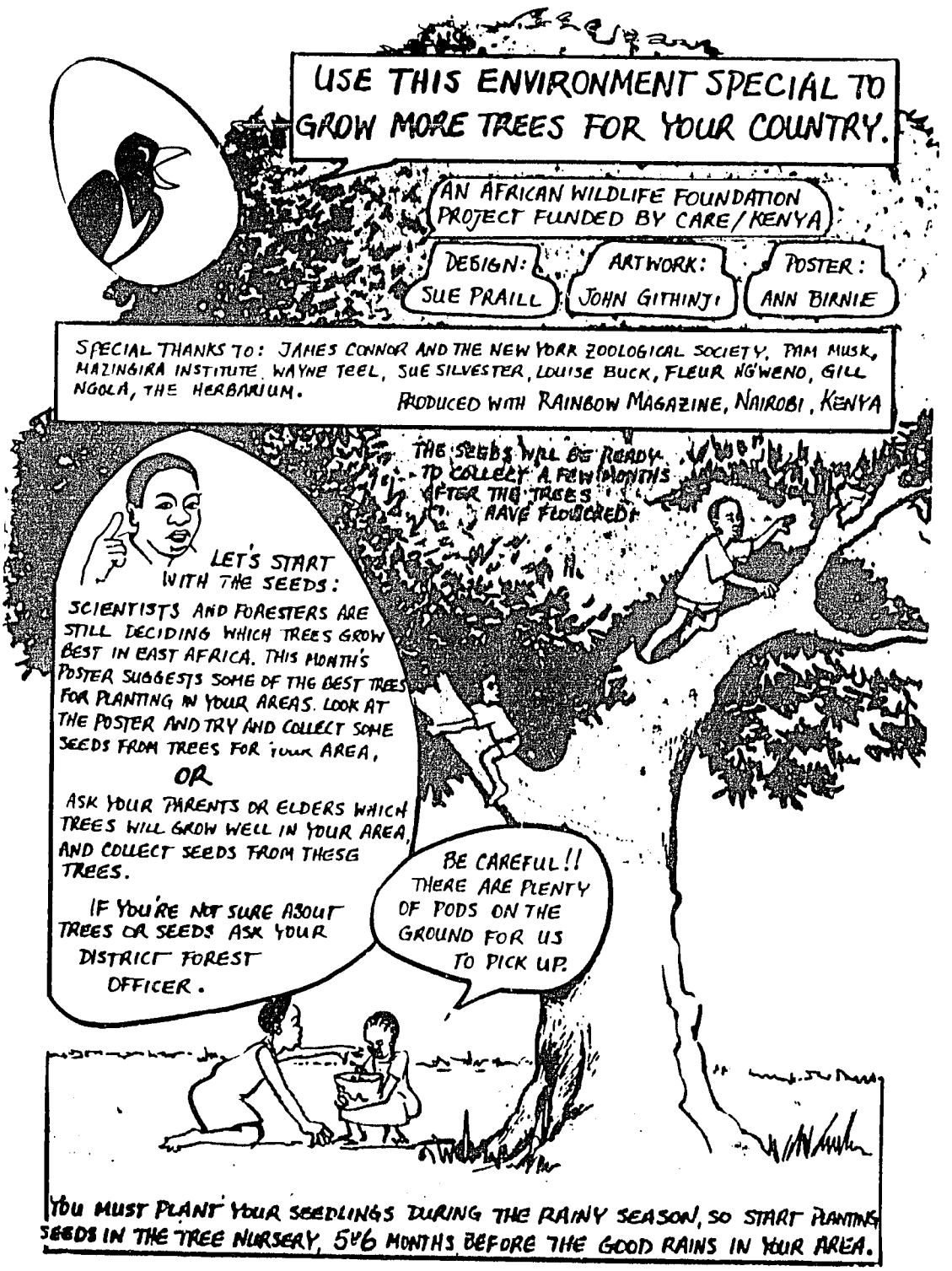
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SPECIAL THANKS TO: JAMES CONNOR AND THE NEW YORK ZOOLOGICAL SOCIETY, PAM MUSK, MAZINGIRA INSTITUTE, WAYNE TEEL, SUE SILVESTER, LOUISE BUCK, FLEUR NG'WENO, GILL NGOLA, THE HERBARIUM.
PRODUCED WITH RAINBOW MAGAZINE, NAIROBI, KENYA
THE SEEDS WILL BE READY TO COLLECT A FEW MONTHS AFTER THE TREES HAVE FLOWERED.
LET'S START WITH THE SEEDS:
SCIENTISTS AND FORESTERS ARE STILL DECIDING WHICH TREES GROW BEST IN EAST AFRICA. THIS MONTH'S POSTER SUGGESTS SOME OF THE BEST TREES FOR PLANTING IN YOUR AREAS. LOOK AT THE POSTER AND TRY AND COLLECT SOME SEEDS FROM TREES FOR YOUR AREA,
OR
ASK YOUR PARENTS OR ELDERS WHICH TREES WILL GROW WELL IN YOUR AREA, AND COLLECT SEEDS FROM THESE TREES.
IF YOU'RE NOT SURE ABOUT TREES OR SEEDS ASK YOUR DISTRICT FOREST OFFICER.
BE CAREFUL!! THERE ARE PLENTY OF PODS ON THE GROUND FOR US TO PICK UP.
YOU MUST PLANT YOUR SEEDLINGS DURING THE RAINY SEASON, SO START PLANTING SEEDS IN THE TREE NURSERY, 5 & 6 MONTHS BEFORE THE GOOD RAINS IN YOUR AREA.

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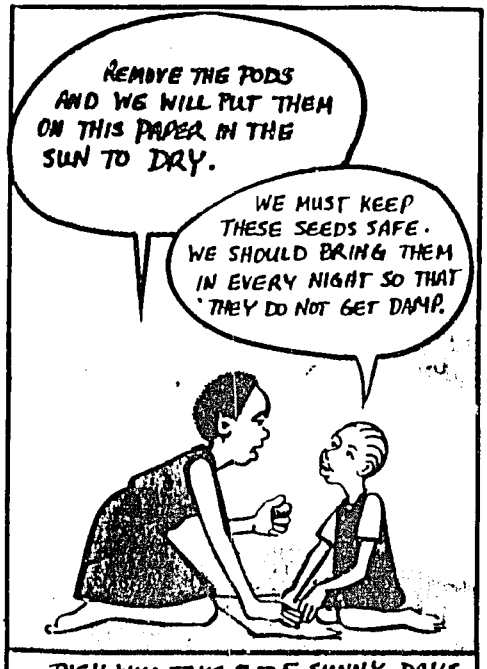
COLLECT, DRY, AND STORE THE SEEDS OF CORDIA ABYSSINICA, CASUARINA EQUISETIFOLIA, AND ACACIA TORTILIS.
(SEE YOUR POSTER FOR LOCAL NAMES.)



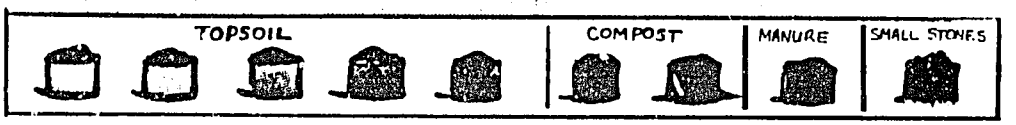
THEY WILL TAKE 3 TO 5 SUNNY DAYS TO DRY COMPLETELY.

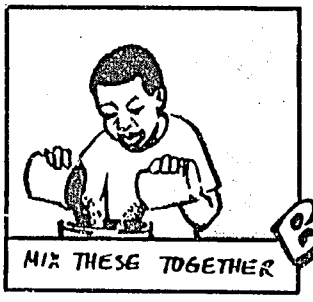
COLLECT THESE SEEDS JUST BEFORE PLANTING:
1. MARKHAMIA LUTEA (PLATYCALYX)
2. CROTON MEGALOCARPUS AND GREVILLEA ROBUSTA.

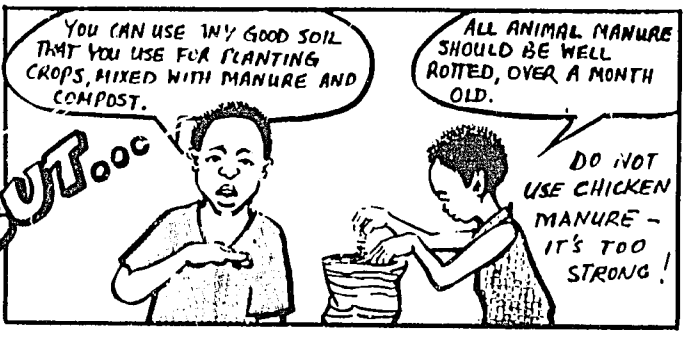
RECORD ON YOUR CHART: THE KIND OF SEEDS, WHEN AND WHERE YOU COLLECTED THEM

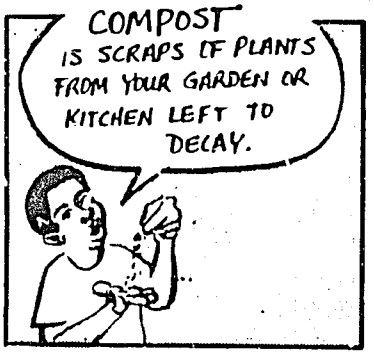
SOIL IS IMPORTANT FOR THE GROWTH OF YOUR SEEDS. CHOOSE THE SOIL CAREFULLY. ASK YOUR PARENTS OR TEACHER WHICH SOIL IS BEST FOR CROPS IN YOUR AREA.

MANY PEOPLE SUGGEST THIS COMBINATION FOR BEST RESULTS:

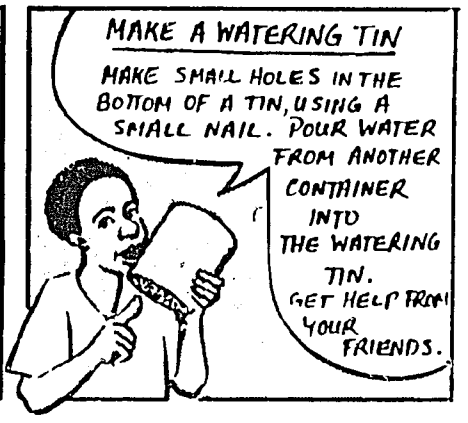


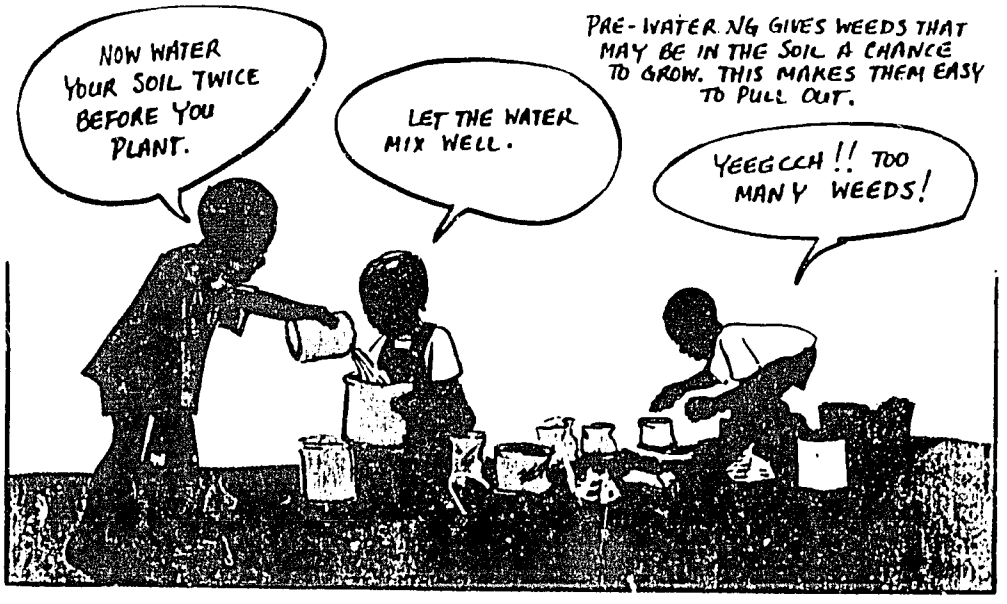






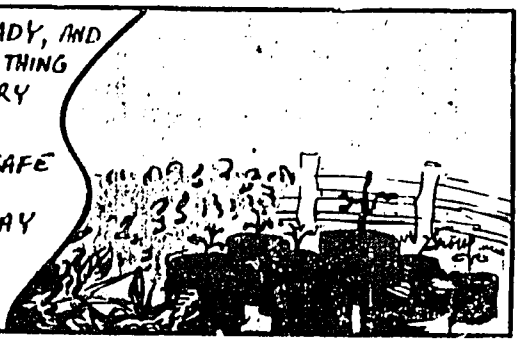
TWO WEEKS BEFORE YOU PLANT YOUR SEEDS...





NOW YOU SHOULD HAVE YOUR SOIL READY, AND YOUR SEEDS COLLECTED... THE ONLY THING REMAINING IS TO CHOOSE YOUR NURSERY SITE ANL... PLANT!

YOUR NURSERY SHOULD BE IN A SAFE PLACE, AWAY FROM BUSY AREAS AND ANIMALS, ESPECIALLY GOATS. KEEP AWAY FROM TREES WITH THICK SHADE. ASK YOUR PARENTS OR TEACHERS FOR ADVICE.



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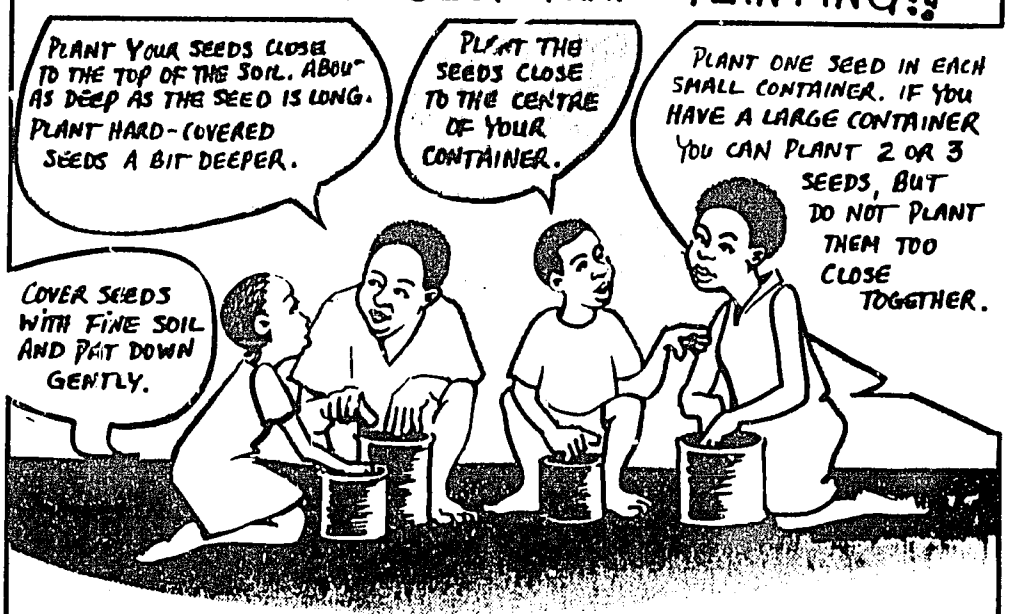
GET YOUR SEEDS READY FOR PLANTING. SOME SEEDS SUCH AS ACACIAS HAVE HARD COVERINGS WHICH MAKE IT DIFFICULT FOR WATER TO GET THROUGH...

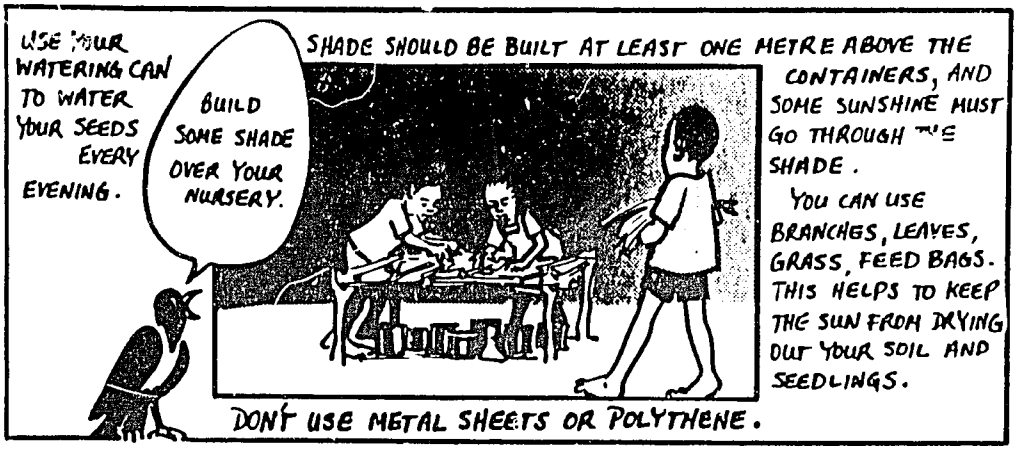
JUST COLLECT AND PLANT CROTON, MARKHAMIA, OR GREVILLEA SEEDS LEAVE CROTON SEEDS IN THE SEED PODS.

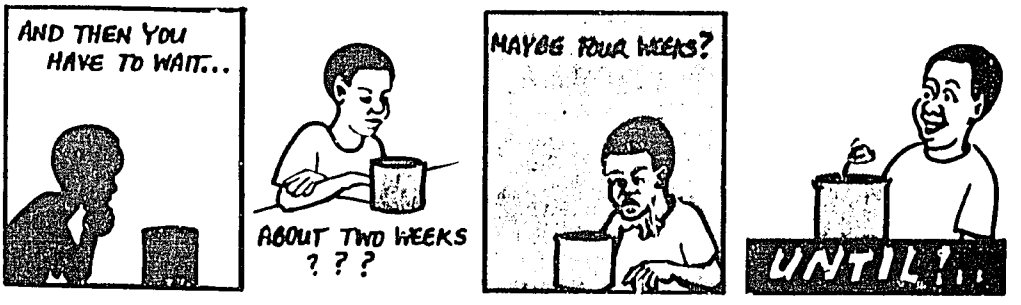
ASK YOUR PARENTS HOW TO TREAT OTHER SEEDS FROM YOUR AREA.

NOW COMES THE BEST PART - PLANTING!!

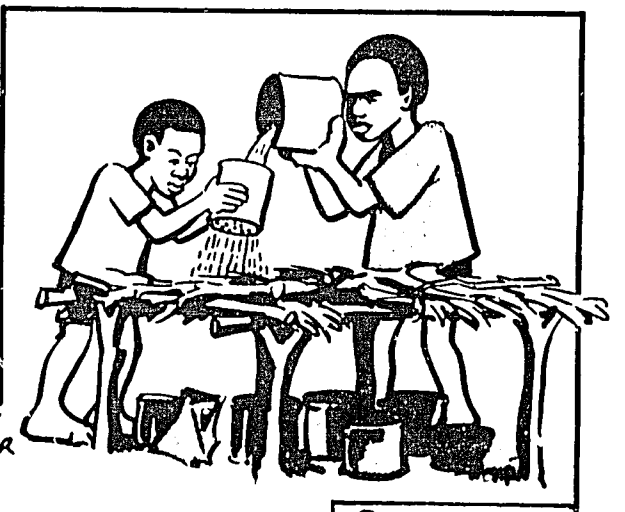


PLANT ABOUT FOUR TIMES MORE SEEDS THAN YOU WILL NEED.





BEFORE WATERING, TOUCH THE SOIL IN THE CONTAINERS. IF MUD STICKS TO YOUR FINGERS, DO NOT WATER THAT DAY.



ONCE YOUR SEEDLING STARTS TO GROW KEEP IT UNDER A LITTLE SHADE. WATER IT EVERY EVENING.

SOME SEEDS NEVER GERMINATE. SOME SEEDLINGS DIE. PLANT ENOUGH.. AND TRY AGAIN.

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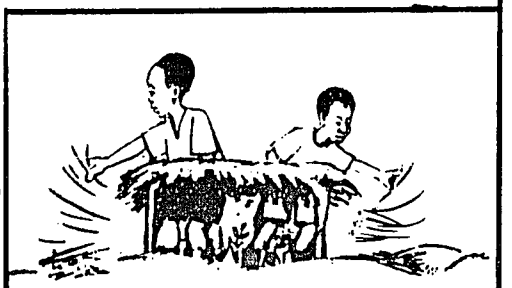
NOW YOU CAN FILL IN YOUR CHART WITH NEW INFORMATION:
1. WHEN YOU PLANTED YOUR SEEDS. 2. WHO IS WATERING THE SEEDS EACH DAY.
3. WHEN YOUR SEEDLINGS GERMINATE. 4. HOW MANY SEEDLINGS SURVIVE.

IF YOU PLANTED MORE THAN ONE SEED TO A CONTAINER, YOU CAN PULL OUT THE WEAKEST SEEDLINGS, LEAVING ONLY ONE.

CHECK THE BOTTOM OF YOUR CONTAINER. CUT OFF ROOTS COMING OUT OF THE CONTAINER.



REMOVE SOME SHADE IN THE RAINY SEASON. REMOVE ALL SHADE FOUR WEEKS AFTER YOUR SEEDLINGS GERMINATE.

DON'T FORGET TO WEED YOUR CONTAINER

MINE IS BIGGER!

BUT MINE HAS MORE LEAVES.

IF YOU PLANTED THE SEEDS WITH YOUR FRIENDS, YOU CAN SEE WHOSE SEEDLINGS CAME UP FIRST.

DURING THE HOLIDAYS, TAKE YOUR SEEDLINGS HOME OR ARRANGE FOR SOMEONE TO WATER THEM.

NEXT ISSUE: WHAT HAPPENS TO YOUR SEEDLINGS WHEN THEY LEAVE YOUR NURSERY

REMEMBER THESE EASY POINTS:

1. COLLECT AND DRY YOUR SEEDS
2. COLLECT YOUR CONTAINERS
3. PREPARE YOUR SOIL
4. TREAT ACACIA SEEDS OR OTHER SEEDS WITH A HARD COVER.
5. PLANT YOUR SEEDS AND WATER THEM.
6. CARE FOR YOUR SEEDLINGS.

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Useful information: MAINTAINING SEEDLINGS IN A NURSERY

In order to maintain a good nursery the following factors should be considered.

1. Watering the nursery.
   - most tree growers try to time the start of the rains so that the seedlings are ready for planting out as the rains begin. Therefore, the seedlings will be growing in the nursery during the dry season and will need to be watered regularly.
   - watering must be carried out in the early morning and in the evening but not in the middle of the day. The seedlings will be damaged if they are watered when it is very hot and sunny.
   - do not overwater the nursery and make the soil waterlogged. Overwatering can cause a disease called 'Damping Off'. Waterlogging of the soil can cause poor root development and can also kill the seedlings.
   - it is best to use a watering can to water the nursery because the fine sprinkle of water will not damage the plants or disturb the soil. Pouring water from a jerry can or bucket straight onto the nursery must be avoided.
   - a nursery measuring 3 metres by 1 metre will require about 20 litres of water in the morning and another 20 litres in the evening.

2. Shading.
   - the seedlings must be protected from strong sunlight for many months. If they are not protected they will be scorched by the sun.
   - after 2-3 months you can remove a small amount of the shade - no more than 25% of the shading material on the roof of the frame.
   - ensure that the frame of the shade is kept in good condition.

3. Weeding.
   - weeds should be removed because they compete with the seedlings for - light
     - water
     - nutrients
     - air
   - weeds can also harbor pests and disease which may infest/infect the tree seedlings.
   - the nursery should be watered before weeding is carried out so that the soil is moist. If the soil is hard and dry the roots of the tree seedlings may be disturbed as the weeds are pulled up.
   - place the weeds in a compost pit.

4. Thinning out.
   - when the seeds germinate you may find that they are growing very close to each other. If they are too close they will compete for air, light, nutrients and water.
   - thin out at the same time as weeding.
   - water the bed or pots before thinning out to avoid damaging the roots of the seedlings which are to be left.
   - thinning should be started one week after germination if possible.
   - remove unwanted seedlings by carefully pulling them out.

5. Soil pests.
   - aphids can be controlled by ash.
   - these can be a problem, particularly in the dry season.

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- where cutworms, termites or white ants are found you should sprinkle ash (or Aldrin 25%) on the soil surface.
  If the seedlings are already transplanted into pots you should stand the pots on soil where ash has been sprinkled.

6. Diseases.
   - tree seedlings, particularly those of indigenous trees are seldom attacked by diseases.
   - where 'damping off' is serious you should reduce the amount of water used, and thin out the affected plants.

7. Record keeping.
   - update your existing records regularly.
   - note further details such as root trimming, incidence of pest and disease attack and dates of thinning and weeding.

8. Root trimming.
   - the tap roots of tree seedlings can grow quickly and will grow very long. As a result they can grow into the soil underneath the pot.
   - to avoid this, move the pots regularly. Where there are long roots you should trim them back. This should be done every 4 weeks.

Useful information: PRICKING OUT SEEDLINGS

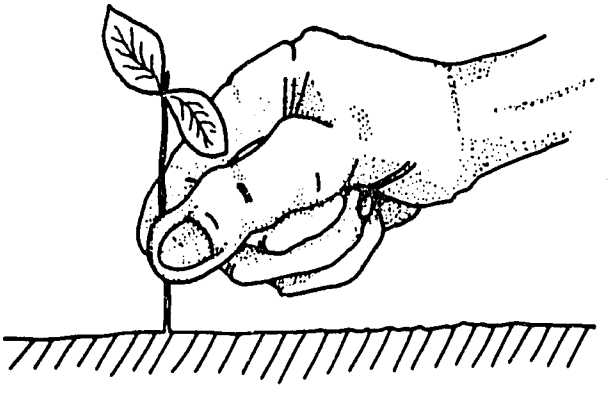
1. What do we mean by 'pricking out'?
   Moving young tree seedlings from the germination bed to pots (containers).

2. How long after sowing should the seedlings be pricked out?
   When seedlings are 25-30cms tall or when they have 2 true leaves. This will be at 2-3 weeks for fast growers and at 3-4 weeks for slow growers.

3. At what time of day should we prick out?
   Avoid pricking out in the middle of the day, because the heat will cause the seedlings which have been transplanted to wilt.
   The best time is late afternoon when the heat of the day has reduced. (We can also prick out very early in the morning).

4. Why should we water the germination bed and pots before pricking out?
   - to soften the soil in the germination bed so that the stick can easily penetrate the soil and so that the roots can be eased out of the soil without breaking them.
   - so that the seedlings can begin growing in the pots as soon as possible after transplanting.

5. How do we prick out?
   Do not hold the seedlings by the stem, because the stem is very delicate and can easily be broken or damaged. Instead, you should hold the leaves of a plant when pricking out. (If a leaf is accidentally damaged or broken off a new one will grow, but if the stem breaks then the plant will die).
   Use a sharp stick (about the thickness of a pencil) or your first two fingers, by pushing into the soil to lift both soil and plant. In this way you will minimise the damage.
   (See the illustration).
   Transfer the seedlings to a tin which has a little water in it. By placing the seedlings in water you will reduce the shock of transplanting and the chances of severe wilting.



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6. Why do we prick out seedlings?
   If the seedlings are left in the germination bed until they are planted out in the field their roots will have grown very long. The roots would be badly damaged as they are pricked out. The reason for this is that tree seedlings need to remain in the nursery a long time (a lot longer than vegetable seedlings) so the root system has a long time to develop. Therefore they should be transplanted into tubes or pots so that the growth of the roots can be controlled.
   Also, the germination bed contains very few nutrients. The pots are filled with a mixture which contains all of the nutrients the growing seedlings will need so that they will grow quickly.
   When pricking out you will also be selecting the strongest and healthiest seedlings.

7. How do we trim the long roots?
   Lift the seedling by the leaves and using a sharp razor blade or knife, nip off a quarter of the tap root and other secondary roots.

8. How do we plant the seedlings in the pots?
   Use a stick (about a pencil thickness) and make a hole in the soil of the same length as the tap root.
   Hold the seedling by the leaves and hold it in the middle of the hole at the same level as it was in the germination bed. Press the soil back around the seedling.

Useful information: HARDENING OFF

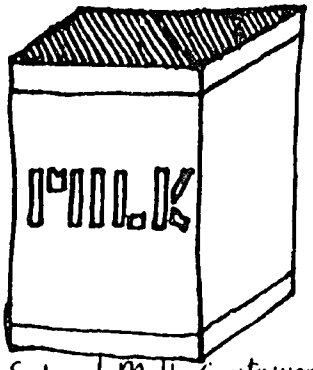
1. What do we mean by 'hardening off'?
   It is the process of getting the tree seedlings used to the tougher conditions they will meet in the field when planted out i.e strong heat and rapid loss of water.

2. Why do we need to harden off?
   - seedlings are protected from the harder conditions of the field when they are in the nursery.
   - when seedlings are exposed to field conditions abruptly, they will wilt and may even die due to the excessive loss of water caused by the direct sunlight.
   - the process of hardening off makes the seedlings get used to the field conditions gradually.

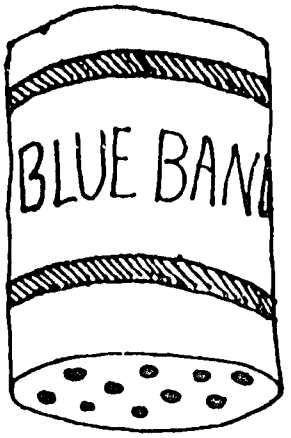
3. How do we harden off?
   The process should take about 4 weeks. It involves reducing the amount of shading material and reducing the amount of water. These are the stages:
   1st week: - remove a little of the shade each day (only half should be left by the end of the week).
   - water only once per day.
   2nd week: - remove a little of the shade each day (there should be no shade left by the end of this week).
   - water once per day.
   3rd week: - stop watering unless it is very hot and dry.
   4th week: - water once per day from 5 days before planting out.
   Remember to trim any long roots well before planting out so that the seedlings have time to recover from this operation.
   Note: If seedlings have 'overgrown' in the nursery (i.e grown very large) it may be best to remove a few leaves to reduce the rate at which the water will evaporate from them.

4. When should we begin hardening off?
   About 4 weeks before you aim to plant out the seedlings. Fast growing plants will be ready in 3-4 months while slow growing species will require 4-6 months in the nursery.

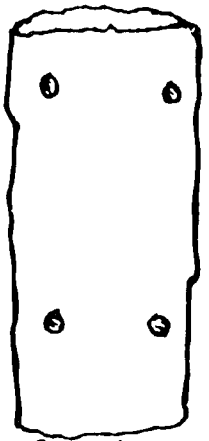
Possibilities for Pots



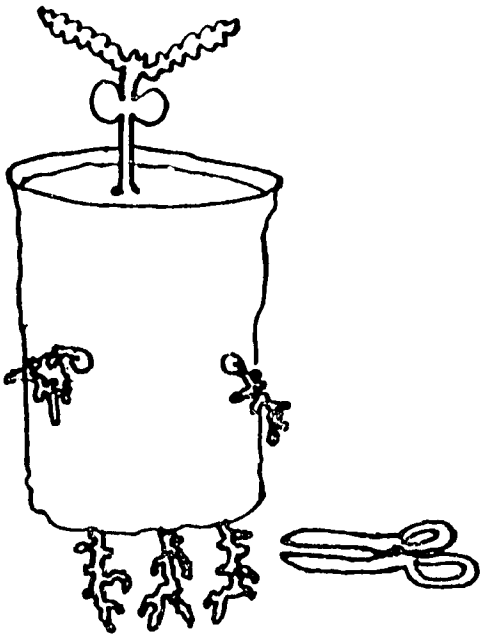
School Milk Containers



Used Tins



Polythene Bags



Root Pruning

Cut all roots escaping the pots regularly.

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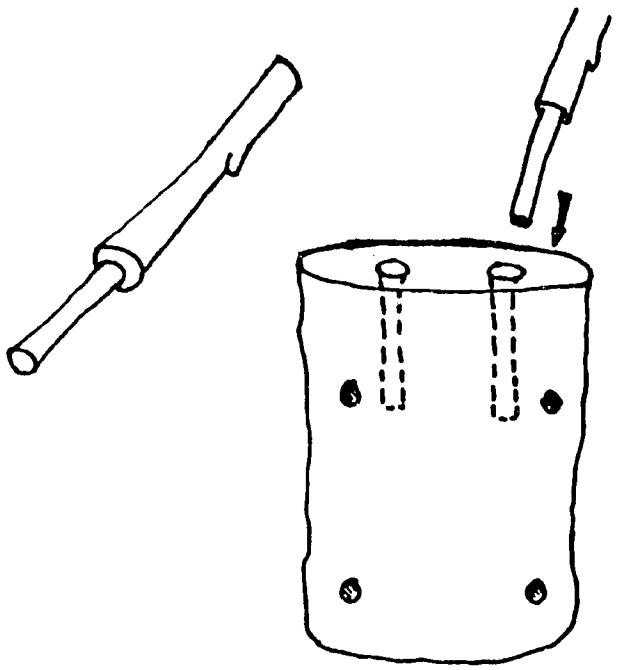
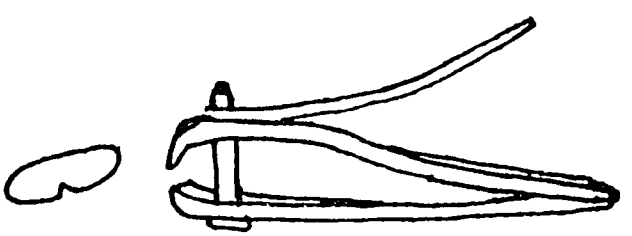


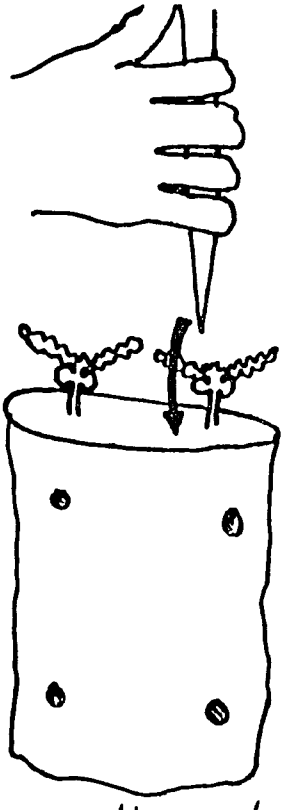
Measuring Seed Depth

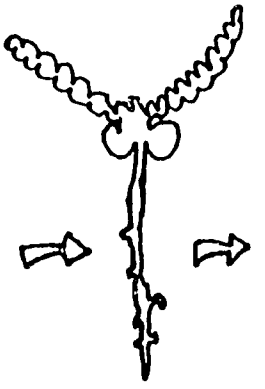
Use a marked stick or other devise to be certain that seeds are planted the correct depth.

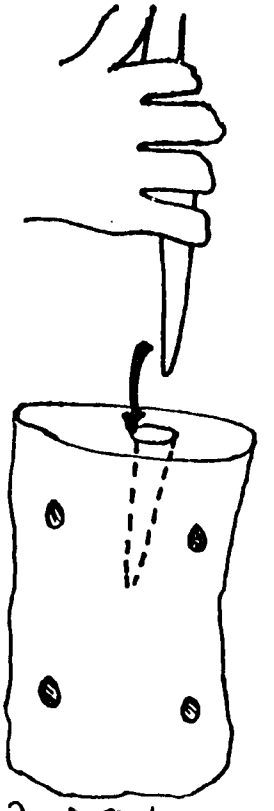


Scarifying Seeds

Put a small nick in the side of hard, shiny seeds to hasten and increase germination.

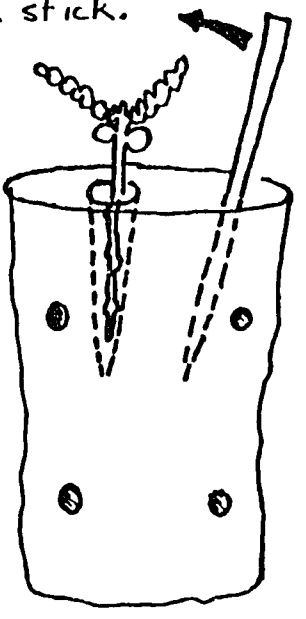






1. Loosen the roots of the extra seedling using a smooth, pointed stick.

2. Make a hole in the empty pot as deep as the root is long.



3. Place the seedling in the hole with care so the roots are not bent or curled. Pack the soil using the same stick. Lastly, water the seedling.

Pricking-out

2.2 Water: An adequate perenial supply of good water is clearly essential for any nursery. In the ASAL this is often the main factor that decides on a particular location for the nursery. The water requirement during the hotter months can be considerable i.e. 30 litres per 1000 seedlings. A large water tank of 10,000 litres capacity can therefore be expected to serve for two days when watering 150,000 seedlings. If water is to be carried and applied by watering can there is an obvious practical limit to the distance of the nursery from the water supply. Ideally water must be available inside the nursery area itself and this is essential if production of more than 50,000 seedlings is anticipated.

The quality of the water is also important. Water should not be saline and it should be of neutral pH (i.e. neither acid or alkaline). This is especially important in the higher altitude nurseries where stock may be kept in the nursery for an extended period enabling a build up of a toxic level of salts.

Nurseries that are dependent on piped water on a share basis are at a disadvantage in that water cuts are inevitable from time to time. Experience has shown that whenever possible a nursery should have its own independent supply.

Temporary storage is sensible for all but the very small nurseries. If pressure is sufficient then the water is best stored in G.I. tanks elevated above the working area. When the pressure is insufficient and a pump is not available then ground level storage in cement lined tanks should be constructed especially if a regular supply can not be relied upon. The different irrigation methods available, and the time and frequency of watering are discussed in Sections 3.7 and 4.41.

2.3 Soil: When seedlings are raised in some sort of container it must be realised that large quantities of soil are going to be required each season. Using polythene tubes of 10cm. layflat width and length 15cm. for example, about 1 ton of soil will be required for every 1,300 seedlings i.e. a full lorry would only be expected to supply enough soil for 9 - 10,000 seedlings. It is therefore important to be sure of a convenient soil source before any decision is made on the location of a nursery.

Basically, the soil used should be a light, sandy loam. The final soil mixture should be light and freely draining but at the same time cohesive. It must be water retentive but at the same time not liable to puddling or develop an impervious skin when drying out. Humic top soil is certainly preferable, if not an acceptable mixture can often be made using a local clay soil mixed with river sand in the rough proportion of 50 50%. Exprerimentation is necessary for each individual nursery.

Where it is intended that seed will be sown into separate seed beds and then pricked into containers after germination, it should be realised that the soil required for the seed beds should be extremely light. Almost pure sand will be adequate since the seed itself contains enough nutrient for germination and early growth.

In the past the emphasis has tended to be on rather complex mixtures. The Muguga mixture for example is composed of 5 parts of forest topsoil, 2 parts chopped peat, 1 part clay crumbs, 1 part of crushed stone and 1 part of rotted manure. Such complex mixtures are only possible when bare root stock are being produced and the same beds can be used over and over again. In the case of container stock it is seldom possible to contemplate using more than two constituents for the final soil mixture.

The inclusion of cow manure, if well rotted, is usually advantageous but seldom practical except for the very small nurseries. The addition of inorganic fertilisers to the soil mixture is generally not recommended. It is seldom required and there is a danger of there being variable concentration, due to insufficient mixing.

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If there should later prove to be a nutrient defficiency then the application of a suitable liquid fertiliser is considered to be preferable. This is discussed more fully in Section 4.44. The inclusion of inorganic fertiliser is possibly worthwhile in the case of citrus where NPK can be added at the rate of 2kg. per cubic metre of soil.

Soil pH (i.e. the degree of acidity) is important. The soil mixture should be slightly acid for most species with a pH of 5.0 - 5.5. Acidity and alkalinity are measured on a scale known as the pH scale. On this scale pH 7.0 is taken to be neutral, pH 1 - 6.9 is acid and pH 7.1 - 14.0 is alkaline. Soils generally fall within the range of pH 5.0 (acid) to pH 8.5 (alkaline). Soils in the more arid areas tend to be alkaline in which case the addition of flowers of sulphur or ammonium sulphate might be necessary.

2.4 Slope: Excessively sloping sites (i.e. more than 25 degrees) should be avoided since they will require extensive terracing if sufficient level beds are to be constructed. A slight slope throughout the nursery is however advantageous since it ensures that there will be no problems with drainage. It is important that individual beds are as level as possible. Depressions within a nursery bed will lead to excessive water collection causing problems with algea and fungal outbreaks.

Where a moderately sloping site is to be used terraces of at least 2½m. are required to ensure that there is adequate access around the nursery bed.

Aspect is of little concern in Kenya since the passage of the sun is mostly overhead for most of the year.

2.5 Access: If a nursery is to be really valuable to the local community good access is essential. A box of 50 seedlings is an extremely heavy and awkward load and farmers can not be expected to struggle over a rough track carrying their seedlings. Ideally the nursery should stand adjacent to a major track and at the same time be as close to the village centre as possible.

For the larger nurseries where soil has to be brought in by lorry good access is obviously essential. In practice the location of the nursery has to be a compromise between the dictates of land and water availability on the one hand and good access on the other.

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4.2 SOIL COLLECTION

Soil collection can be carried out at any time of the year when sufficient labour is available. The job will however be concentrated within the periods of November/December and May/June at the start of the two nursery seasons.

4.21 Soil Mixtures: The location of the nursery should have been selected with a knowledge of the available nursery soil. In practice the nursery will have to utilise soil collected from within a radius of 250 m. from the nursery unless assistance from motor transportation can be expected. As was stated in Section 2.3 the ideal nursery soil for container stock is a light clay loam. The soil must have sufficient adhesive qualities when moist not to run through the tube, but if it contains too much clay then it will be unmanageable and liable to cracking after drying out. The most common problem with murram soils of the semi-arid areas is a tendency for a crust of hard impervious soil to develop at the top of the tube after several watering (known as capping). This problem can be reduced by the addition of sand. The actual proportion will be subject to trial and error but it will probably in the region of 1 part of river sand to 1 - 2 parts of the best available top soil.

If forest top soil (i.e. a dark loamy soil with a high content of organic matter) can be made available it should be used either unmixed if sufficient quantities can be obtained otherwise diluted with the best available local top soil.

Soil destined for use in the seeds beds or seed boxes should be very light and river sand should be added to the locally available top soil to ensure that it is completely free draining.

After dumping the soil within the nursery it should be sieved whilst dry by shovelling it through a 5mm mesh to remove stones, compacted lumps and vegetable matter. Mixing can be carried out at the same time.

4.22 Inorganic and organic fertilisers: The use of well rotted cow manure has been advocated from time and although this might be advantageous in terms of resulting growth it is seldom practical except for the smallest nurseries. When it is available a ratio of 1 part/manure to 5 parts of local soil should be tried. Other organic additions such as chopped peat or well rotted compost will be valuable if the available soils have a poor water holding capability. In some areas where the soils are extremely light and low in organic matter, it may be necessary for a special area to be assigned for the growing of a manure crop for composting. Suitable manure crops would be:- Desmodium (green leaf and silver leaf), beans (i.e. greengram, lab lab) Leucaena and lucerne (Stylosanthes guianensis). It is important that when compost or organic manures are used that they are well rotted. The compost heap should be regularly turned and watered.

Inorganic fertiliser can be added to the soil mixture if past experience has shown the soil to be lacking in sufficient nutrients. The usual additive is an NPK combined fertiliser (Ratio about N 9:P 12:K9) at the rate of 1.5 - 2kg fertiliser per cubic metre of soil. Local experimentation would would be necessary however. The important consideration if an organic fertiliser is to be mixed into the soil mix is that the mixing must be intensive. It is very easy to end up with a highly variable fertiliser concentration throughout the mix. It is recommended that instead of using an NPK concentrate that any nutrient deficiencies be corrected at a later stage with a liquid fertiliser (refer Section 4.44 for details). The possible exception is when citrus trees are being raised.

It should be noted that the soil mix for a seed bed would never be supplemented with organic or inorganic fertilisers. The seed itself should contain sufficient nutrients to enable germination and early growth to develop.

Organic matter can be detrimental to germination in that fungus attack will be encouraged.

4.23 Pesticides in the soil mixture: Termites can be a very serious problem within the ASAL and it is often advocated that the chemical dieldrin or aldrin be added to the soil mix. This is not recommended, since these chemicals are extremely poisonous and it is inevitable that workers will be contaminated to some degree if it is mixed into the soil prior to pot filling. Where termites are a problem it is recommended that aldrin in the form of a wettable powder or a solution is watered into the beds after tube filling. This will minimise contact with the chemical. Rates of application are considered in Section 4.5.

4.24 Soil Sterilisation: Sterilisation of nursery soil is a treatment carried out principally to kill fungal pathogens and most insect pests - particularly nemotodes, eelworms and cutworms. It can have an effect on controlling weed growth by killing some of the weed seed present in the soil.

Soil sterilisation is not normally practiced in Kenyan nurseries and it is likely to be a treatment reserved for seed beds only. There are two types of treatment - heat and the use of chemicals. The simplest and cheapest method of soil sterilisation and the only method likely to be used in most extension nurseries is the heat treatment. The soil mix after sieving is placed in a 44 gallon drum and heated on an open fire for about 3 hours. This 'cooking' will effectively kill any fungal spores, insect pests and some weed seed. It is obviously a method only suitable for treating small quantities of soil and would be reserved for the seed beds or seed boxes.

Chemical are available for soil sterilisation, formalin is the safest but the least effective. Others include methyl bromide and dazomet. Methyl bromide is gas sold in pressurised containers. It is extremely effective but unfortunately it is a dangerous chemical and its use can only be trusted to skilled workers. Since it is a gas it is possible to treat the beds of polythene tubes after tube filling. The beds are covered with heavy gauge polythene sheet and carefully sealed at the edges. A single container of ½kg of gas is sufficient for the treatment of 3 - 5,000 tubes (about 1cu.m. of soil). Sowing can take place after 24 hours. Dazomet is a granular chemical which is mixed with the soil, the soil is then wetted and covered with a polythene sheet and sealed. A gas (methyl isothiocyanate) is produced. Unlike methyl bromide 4 weeks must be left between removal of the gas sheet and sowing. Since the granules need to be incorporated within the soil. Dazomet is not so suitable for treatment after pot filling. It is however safer to use than methyl bromide.

4.25 Types of Container: Following sieving and mixing of the soil ingredients the tubes or pots will need to be filled. The most common form of container is the polythene tube. This is a sleeve of polythene sheet open at both ends. It can be purchased either on the roll in which case it is cut to the desired length with a razor blade or it is obtained cut to size.

The size of tube used is important. If it is too large then it becomes extremely wasteful of soil and inconvenient to transport. If is is too small, the root system may be of insufficient size to support the seedling in the field - especially if rainfall is poor.

The most commonly used size is 10cm. wide by 15cm. long (4 x 6 inches). The width is the layflat size before filling. The size of the tube seems to be satisfactory for the ASAL for the majority of forest tree stock.

Useful Information. MAINTAINING SEEDLINGS IN A NURSERY

In order to maintain a good nursery the following factors should be considered.

1. Watering the nursery.
   - most tree growers try to time the start of the rains so that the seedlings are ready for planting out as the rains begin. Therefore, the seedlings will be growing in the nursery during the dry season and will need to be watered regularly.
   - watering must be carried out in the early morning and in the evening but not in the middle of the day. The seedlings will be damaged if they are watered when it is very hot and sunny.
   - do not overwater the nursery and make the soil waterlogged. Overwatering can cause a disease called 'Damping off'. Waterlogging of the soil can cause poor root development and can also kill the seedlings.
   - it is best to use a watering can to water the nursery because the fine sprinkle of water will not damage the plants or disturb the soil. Pouring water from a jerry can or bucket straight onto the nursery must be avoided.
   - a nursery measuring 3 metres by 1 metre will require about 20 litres of water in the morning and another 20 litres in the evening.

2. Shading.
   - the seedlings must be protected from strong sunlight for many months. If they are not protected they will be scorched by the sun.
   - after 2-3 months you can remove a small amount of the shade - no more than 25% of the shading material on the roof of the frame.
   - ensure that the frame of the shade is kept in good condition.

3. Weeding.
   - weeds should be removed because they compete with the seedlings for - light
     - water
     - nutrients
     - air
   - weeds can also harbour pests and disease which may infest/infect the tree seedlings.
   - the nursery should be watered before weeding is carried out so that the soil is moist. If the soil is hard and dry the roots of the tree seedlings may be disturbed as the weeds are pulled up.
   - place the weeds in a compost pit.

4. Thinning out.
   - when the seeds germinate you may find that they are growing very close to each other. If they are too close they will compete for air, light, nutrients and water.
   - thin out at the same time as weeding.
   - water the bed or pots before thinning out to avoid damaging the roots of the seedlings which are to be left.
   - thinning should be started one week after germination if possible.
   - remove unwanted seedlings by carefully pulling them out.

5. Soil pests.
   - aphids can be controlled by ash.

- these can be a problem, particularly in the dry season.
- where cutworms, termites or white ants are found you should sprinkle ash (or Aldrin 25%) on the soil surface.
  If the seedlings are already transplanted into pots you should stand the pots on soil where ash has been sprinkled.

6. Diseases.
   - tree seedlings, particularly those of indigenous trees are rarely attacked by diseases.
   - where 'damping off' is serious you should reduce the amount of water used, and thin out the affected plants.

7. Record keeping.
   - update your existing records regularly.
   - note further details such as root trimming, incidence of pest and disease attack and dates of thinning and weeding.

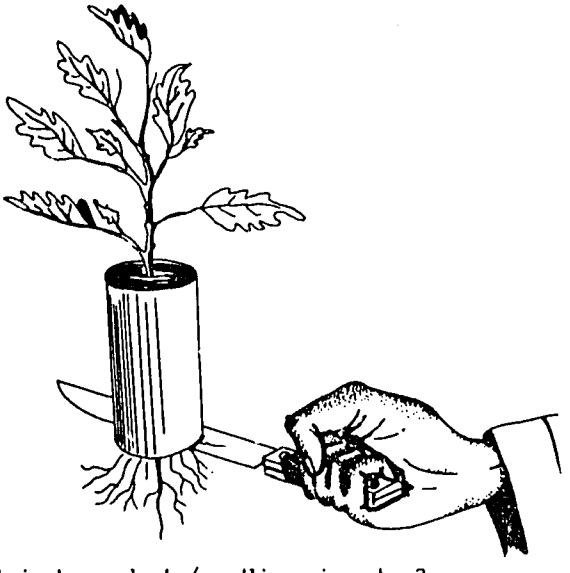
Useful information. ROOT TRIMMING

1. What is root trimming?
   This is the cutting back of long roots of seedlings when still in the nursery.

2. Why is it important to root trim?
   - Trimming of roots stimulates the growth of fibrous root system which are more ideal for feeding the seedlings while still in the nursery.
   - When you trim, you restrain the main tap root from growing deep into the soil and consequently at the time of planting out, a neat seedling with its soil can be separated and planted.
   - Carelessness in root trimming leads to roots being badly bent at planting.

3. How often should we trim?
   The frequency of trimming depends on the types of seedlings you are growing. Ideally, it is important to check your seedlings every month and trim those seedlings with long roots.

4. How do we trim potted seedlings?
   Using a sharp knife or a razor blade lift the potted seedlings and cut off all the roots which have over grown.
   See diagram below.



5. How do we trim transplants/seedlings in a box?
   Trimming is done by passing a fine wire below the box in which seedlings are growing.
   Some of the roots will be cut by the wire and the remaining roots can be cut, or trimmed by lifting the box above the ground and cutting/trimming the remaining roots using a sharp knife or a razor blade.

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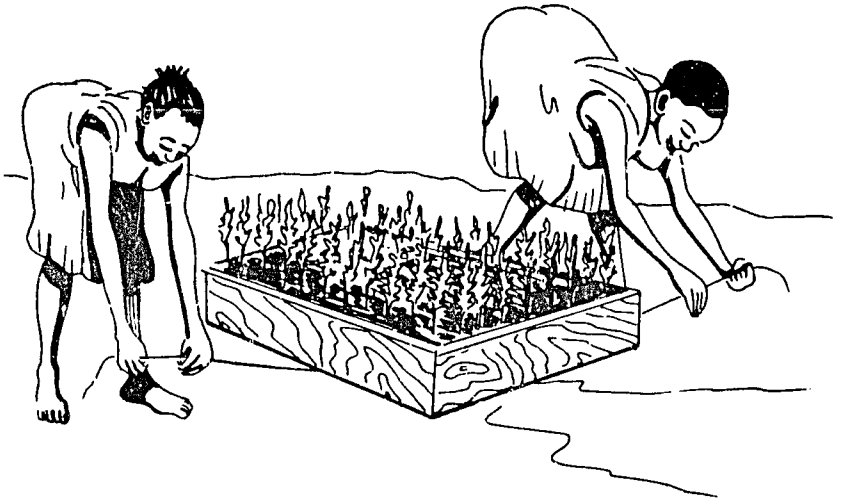

6. It is also important to make sure that roots that have overgrown to a point beyond the edges of the box are also cut using a panga or a sharp knife.

Module 3

Management of Biological Nitrogen Fixation

Session 2: Determining the Need to Inoculate NFTs.

Objective

Readers and trainees will understand the concepts of specificity, infectivity and effectivity with respect to nitrogen-fixing symbionts for NFTs. They will be familiar with the basic components of inoculation technology and the methods for determining whether inoculation is needed.

Background

The capacity to fix nitrogen allows NFTs to grow and be highly productive in nitrogen poor environments. Since the amount of nitrogen available to a tree species will partially determine its biomass production, one goal of NFT management should be to maximize the amount of nitrogen fixed by a particular species. However, because nitrogen fixation by trees is a symbiotic process, maximizing fixation requires consideration of the host plant, microsymbiont and the environment in which the symbiosis will be expressed. Thus it is important to determine if the symbiosis is operating maximally and if not what factors are limiting its expression. As in Session 1 the *Rhizobium*-tree legume symbiosis will be used as the model system in the following discussion.

Rhizobial Characteristics

Nitrogen fixation can be limited by many factors, among the most important of which is the lack of or inefficient performance of the proper rhizobia bacteria in the environment where a NFT tree is grown. Optimization of the nitrogen fixing potential of a species can only be achieved when the most infective, effective and specific rhizobia for a particular host plant nodulates that host plant. Infectivity means the ability of a *Rhizobium* bacteria to penetrate root cells and stimulate nodule initiation. Effectivity refers to the relative ability of a particular strain of rhizobia to fix nitrogen when in association with a particular host plant. Specificity refers to the requirement of certain legume species for specific strains of rhizobia in order to establish an active nitrogen fixing symbiosis.

Rhizobia are rod-shaped bacteria that occur in most soils (Figure 4). Their widespread occurrence in nature is one reason why examining the roots of many species of NFT's in the field will often reveal the presence of nodules. However all rhizobia are not equally good at fixing nitrogen on a particular host species and not all NFTs can form effective symbioses with all rhizobia. The key to optimizing the nitrogen-fixing symbiosis by NFTs is to ensure that the tree is infected with the most effective rhizobia.

Specificity of NFTs for Rhizobia

Rhizobia that infect NFTs occur in both genera of the *Rhizobiaceae*. The genus *Rhizobium* is characterized by fast-growing species that predominantly nodulate temperate legumes such as peas, clover and alfalfa. the notable tropical tree nodulated by rhizobia in this genus is *Leucaena sp.*. The genus *Bradyrhizobium* contains slow-growing bacteria that nodulate some temperate legumes but predominantly tropical species, including most species of NFTs.

Traditionally, temperate legumes were thought to be quite specific in their rhizobial requirements. Each species would nodulate with only one species of *Rhizobium*. Tropical legumes, on the other hand, were found to form symbiosis with several or many species of *Bradyrhizobium* and so were regarded as

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promiscuous in their rhizobial requirements. Since *Bradyrhizobium sp.* are found in most tropical soils and examination of the roots of NFTs in natural ecosystems often revealed nodules, it was erroneously assumed that NFTs could always find the rhizobia needed to establish an active symbiosis in any soil. Based on this evidence it was concluded that adding rhizobia to ensure or foster the establishment of the nitrogen-fixing symbiosis was unnecessary.

Recent evidence, however, has shown that some species are quite specific in their rhizobial requirements, *Leucaena leucocephala* being the best example. Since the rhizobia required by leucaena are not widely distributed, being least numerous in acidic soils, nodulation and nitrogen fixation by leucaena can be poor or non-existent in a site unless the tree is supplied with the correct rhizobia. An example of this case is shown in Figure 5 where adding a rhizobial strain specific for leucaena, TAL 1145, at the nursery stage led to increased growth over that of the control trees that had received no rhizobia or of the trees that received a second, less effective strain.

At the same time, other species of NFTs can nodulate with the native rhizobia in a site but do not fix much nitrogen. These species are known as promiscuous ineffective species (Date 1982). Their capacity to fix nitrogen can be markedly increased by providing them with rhizobia that are more effective nitrogen fixers than the native rhizobia.

Unfortunately, little is known about the specificity of most leguminous NFTs. However, since some leguminous NFTs exhibit moderate and some marked specifity for a particular microsymbiont, it would be unwise to conclude that the presence of nodules on a species in a particular site means that nitrogen fixation is operating at a maximum and no further improvement could be expected by introducing a different rhizobia.

NFTs and Numbers of Microsymbionts

From the above discussion it seems obvious that if the species to be planted has specific rhizobial requirements, then growth should be enhanced if that rhizobia is supplied in sites where it is absent from the native population. However, even promiscuous effective species which form highly effective nitrogen fixing symbiosis with the native bacteria can often benefit and exhibit enhanced fixation if provided with different rhizobia or increased numbers of a native strain. This case is shown for *Acacia pennatula* in Figure 6. Even though Acacia was able to effectively nodulate with the native rhizobia (the control in the figure) it doubled its growth when high numbers of a native strain isolated from the same soil in which the field trial was run was added to the nursery stock.

This effect of numbers is based on the fact that maximizing the amount of nitrogen fixed by a species not only requires that effective rhizobia are present but also that most of the nodules are formed by the effective strain. Therefore, a second goal of the management of nitrogen fixation by NFTs should be to ensure that the most highly infective, effective and specific strain for a particular species forms the majority of nodules on a particular host plant by placing high numbers of the effective strain in the immediate vicinity of the developing plant root. The effect that increasing the number of effective rhizobia available to the plant can have on the number or nodules formed by the inoculant strain is shown in Figure 7.

Inoculant Technology

The practice of placing large numbers of effective nitrogen-fixing rhizobia in the immediate vicinity of the developing plant root is called inoculant technology. The basic components of this technology are: living effective rhizobia, a suitable medium or carrier for the rhizobia and a method for placing the carrier containing the rhizobia, or inoculant, near the plant root so that the majority of nodules formed on the plant contain the inoculant strain.

Carrier materials commonly used include powdered or granulated peat, sand and powdered coal. Because the production of inoculants requires a microbiologist specially trained in inoculant production and appropriate production facilities, it is neither desirable nor feasible for most research institutions or individuals involved in the study or utilization of nitrogen fixing trees to make their own inoculant. Fortunately, several commercial inoculant companies and research institutes are able to provide inoculants for NFTs, in some cases free-of-charge (see Appendix for list of

species, and suppliers). For many NFT species, however, the basic research on host specificity and selection of effective rhizobia has not yet been conducted so inoculants for these species are not available.

Determining the Need for Inoculant

Although inoculation technology is relatively inexpensive and easy to use, it is an additional management practice and should therefore be utilized when it is likely to lead to increased yield. Particularly in cases where inoculant for a particular tree species is difficult to obtain, it is advisable to determine in advance whether inoculation is necessary and will result in enhanced growth.

Determining the need to inoculate can be done quite easily in a small pot experiment Basically, the experiment compares the growth of inoculated trees to that of uninoculated trees and trees supplied with mineral nitrogen. The latter treatment is added to identify whether nitrogen is a limiting nutrient in the test soil and to assess how effective the inoculant strain was in meeting the nitrogen requirements of the host.

Summary

One management goal of those planting NFTs should be to optimize nitrogen fixation by these species. Since rhizobia vary in their ability to infect the host plant (infectivity), optimizing nitrogen fixation requires placing large numbers of highly effective rhizobia in contact with roots of the tree so that the majority of nodules are formed by effective strains. The procedure of providing rhizobia for host plants is known as inoculation technology. However because the native rhizobia may be adequate to support good nitrogen fixation it is desirable to determine whether inoculation is necessary.

A simple pot experiment can be conducted to determine whether inoculation will be beneficial. Methods for inoculating seed and names, of inoculant suppliers and species for which inoculants are available can be found in the appendices. If inoculant is available, it should always be used, since its use is not likely to depress production and may actually improve yields.

Question and Exercises

1. What is the goal of rhizobium inoculant technology?

2. What is meant by species specificity?

3. How can one determine if inoculation is necessary?

4. What is meant by effectivity?

5. Why are high numbers of rhizobia applied in inoculants?

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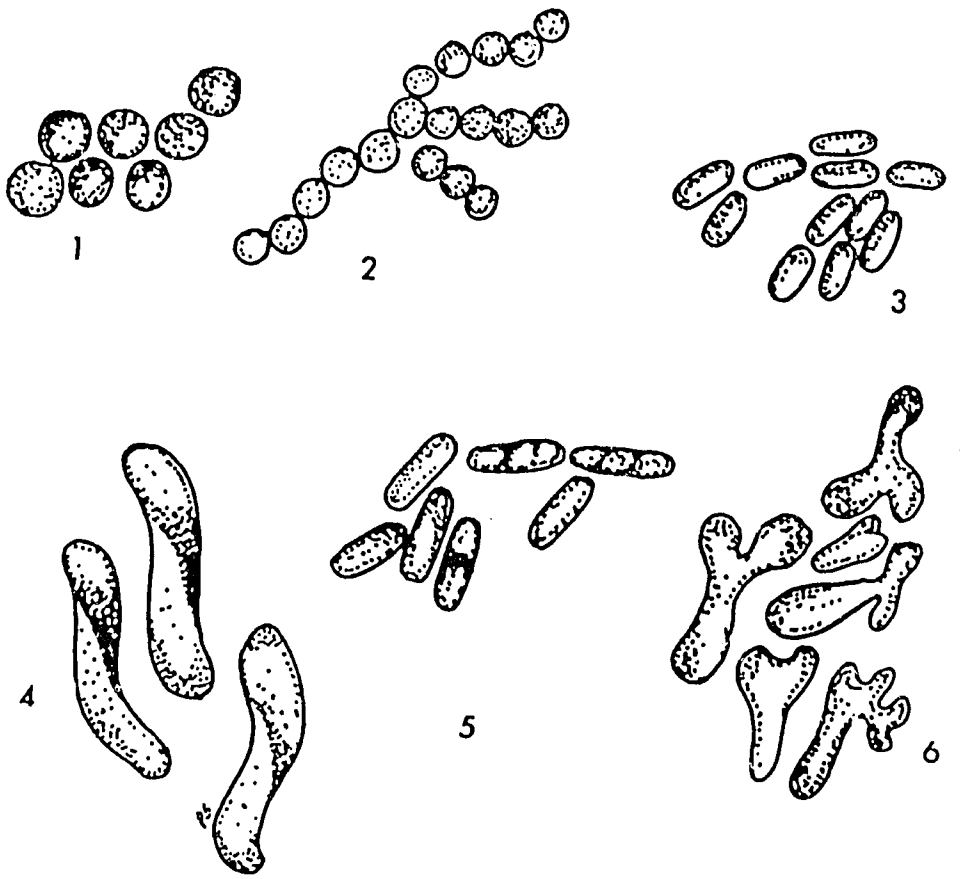

Figure Shapes of bacteria

(1) coccus
(2) Staphylococcus
(3) rod (e.g., Escherichia coli)
(4) Spirillum
(5) Rhizobium cultured cell
(6) Rhizobium bacteroid (e.g., Lens sp.)

Figure 4. Shapes of bacteria. (From Somasegaran and Hoben 1985).

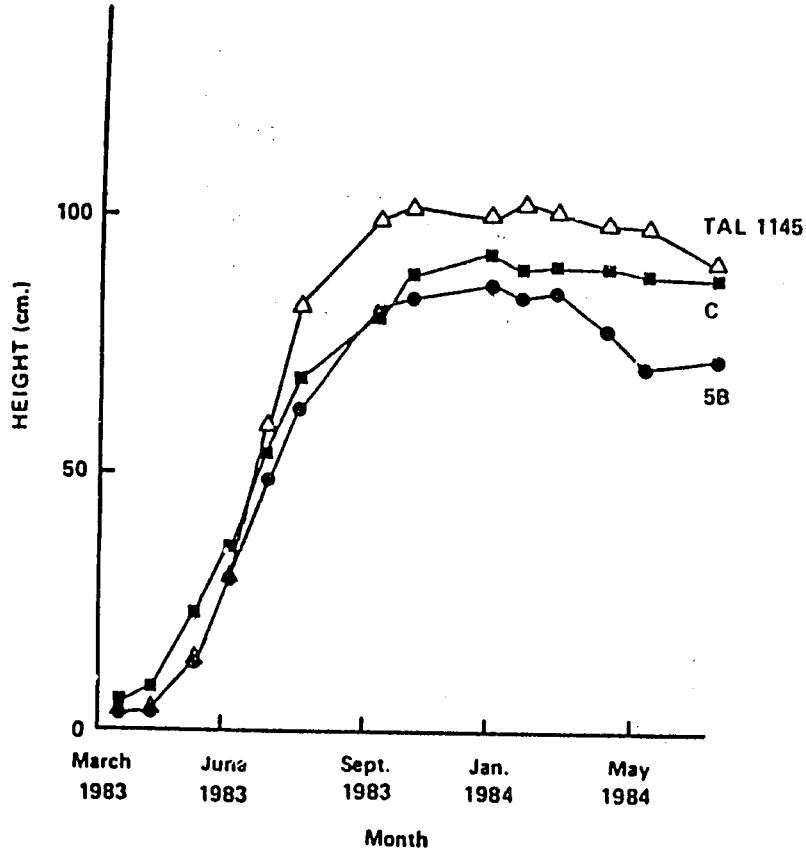

Figure 5. Mean heights of Leucaena leucocephala inoculated with Rhizobium strains TAL 1145, and uninoculated controls growing in Xalapa, Mexico. (From Roskoski 1986b).

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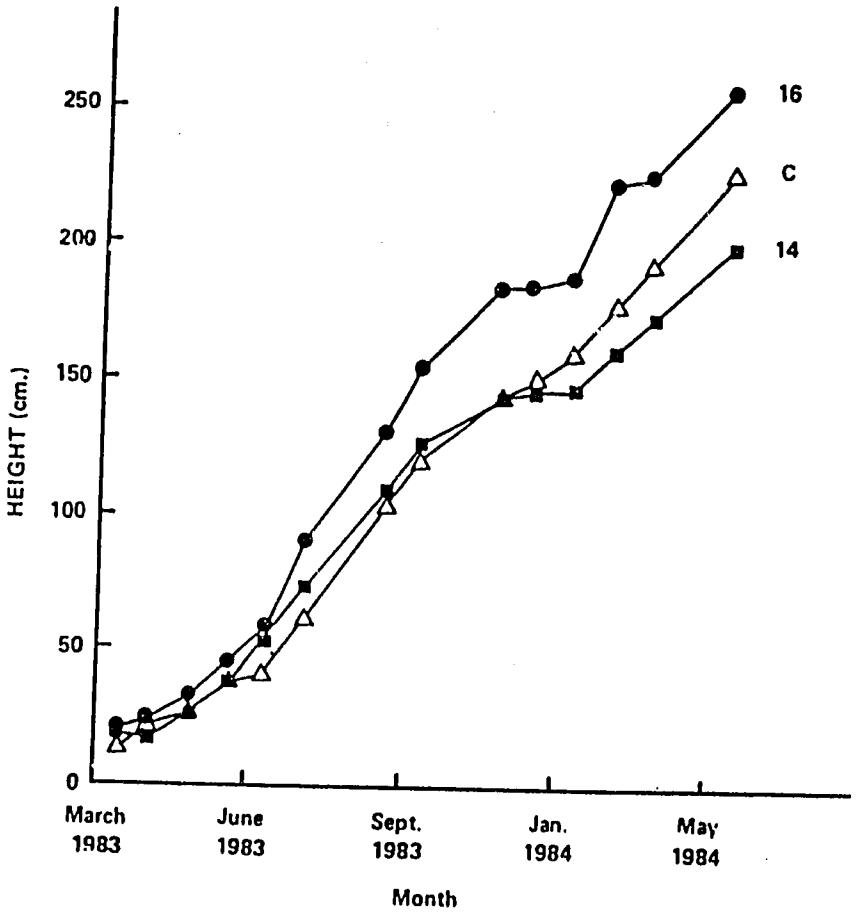

Figure 6. Mean height of *Acacia pennatula* inoculated with *Rhizobium* strains 16, 14, and uninoculated controls growing in Xalapa, Mexico. (From Roskoski 1986b).

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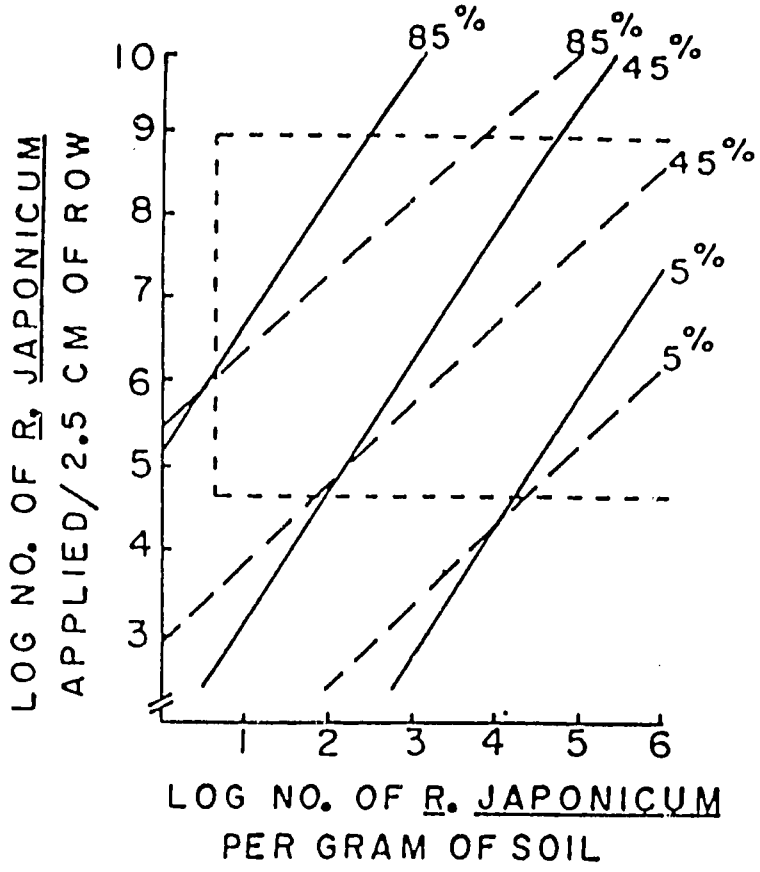

Fig. 1. Relationship between inoculum size of *R. japonicu* strains 110 (———) and 138 (····) and soil *R. japonicu* population on the percentage (5%, 45%, 85%) nodules forme on soybeans by the inoculum strain as calculated from mult ple regression equations. The horizontal and vertical lin denote the area investigated.

Figure 7. Relationship between numbers of rhizobia in inoculant and number of nodules formed by the inoculant strain. (From Weaver and Fredrick 1974).

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APPENDIX

(From Somasegaran and Hoben 1985)

SOURCE OF *RHIZOBIUM* STRAINS

The NifTAL *Rhizobium* Germplasm Resource is a comprehensive collection of *Rhizobium* for numerous legumes (tropical and temperate) and is maintained at the NifTAL Project. All strains cited in the various exercises of this book are available on written request addressed to: Curator, *Rhizobium* Germplasm Resource, University of Hawaii, NifTAL Project and MIRCEN, P.O. Box 0, Paia, Hawaii 96779, USA.

The INLIT *Rhizobium* strains are also available. INLIT is an acronym for NifTAL's International Network of Legume Inoculation Trials in which response to *Rhizobium* inoculation on 18 species of economically important legumes are being tested worldwide. A set of three effective and antigenically distinct strains of *Rhizobium* was selected for the INLIT. Because each set of three rhizobia recommended for each legume is antigenically distinct from one another, serological methods of strain identification can be used to study competition, persistence and other ecological aspects.

There are aiso other laboratories/ institutions which maintain collections of *Rhizobium:*

Dr. Carlos Batthyany Nitrosoil, Florida 622, 4 Piso Buenos Aires, ARGENTINA	Rhizobia for Tropical Legumes
Dr. J. A. Thompson Australian Inoculants Research and control Service Horticultural Research Station Gosford, N.S W. 2250 AUSTRALIA	AIRCS Strains
Dr. R. A. Date CSIRO, Div. Tropical Crops and Pastures Mill Road, St. Lucia Queensland 4067 AUSTRALIA	Rhizobia for Tropical Legumes
Dr. F. Bergersen Microbiology Section CSIRO, Div of Plant Industry Canberra, ACT 2600 AUSTRALIA	Rhizobia for Clovers, Medics and other Temperate Species
Prof. J.R. Jardim Freire Rhizobium MIRCEN IPAGRO Caixa Postal 776 90000 Porto Alegre Do Sul BRAZIL	Rhizobia for Tropical Legumes

Dr. D.J. Hume Crop Science Dept. University of Guelph Guelph, Ontario N1G 2W1 CANADA	Rhizobia for Pea, Lupin, Alfalfa and Soybean
Dr. M Dye Soil Microbiology Dept. Rothamsted Experimental Station Harpenden, Herts. AL5 2JQ UNITED KINGDOM	Rhizobia for Clovers, Alfalfa, Peas Beans, and other Temperate Legumes
Plant Diseases Division D.S.I.R. Private Bag Auckland, NEW ZEALAND	Rhizobia for Clovers,. Alfalfa, and Lupin
Dr. H. Keyser/Dr. D.F. Weber USDA CCNFL Bldg. 001 Rm 309 BARC-W Beltsville, MD 20705 USA	Rhizobia for Soybean and Temperate Legumes

More addresses of institution which have *Rhizobium* collections can be found in: Skinner, F.A., E. Hamatova and V.F. McGowan, 1983. *In:* World catalog of *Rhizobium* collections. V.B.D. Skerman (ed.). World Data Center for Microrganisms at the University of Queensland, Brisbane, Australia.

Module 3

Management of Biological Nitrogen Fixation

Session 3: Field Application and Management of Symbiotic Nitrogen Fixation

Objective

Readers and trainees will be familiar with the methods for inoculating nursery stock, the protocol for running a field trial to determine the effect of inoculation on yield, and the environmental constraints that may limit the expression of biological nitrogen fixation by inoculated NFTs.

Background

Session 1 covered the basic biology of nitrogen fixation and its importance to NFTs and the ecosystems in which they occur. It noted that since NFTs are likely to be grown without fertilizer amendments, enhancing the magnitude of biological nitrogen fixation by these species is not only desirable but might be essential for obtaining acceptable yields.

Session 2 explained why although many NFTs nodulate spontaneously with native soil rhizobia it is often beneficial to provide NFT species with large numbers of selected rhizobia in the form of inoculants. Because inoculants, although quite inexpensive, may be difficult to obtain. However, the overriding management strategy suggested was to whenever possible use inoculants.

Inoculating Nursery Stock

The simplest way to inoculate nursery stock is to inoculate the seeds prior to planting in dibble tubes or nursery containers using the method described in Appendix. Alternately, inoculant can be added to the nursery potting mix in quantities such that each growth unit containing one seedling will contain 1 x 10^6 (to the sixth power) rhizobial cells. A few seedlings should be checked for the presence of nodules with pink, red, orange or brownish, interiors prior to outplanting. For bare-rooted stock prepare a slurry by mixing the inoculant with water: one volume inoculant to two volumes water. Dip seedlings or cuttings in slurry and allow to soak for 1 minute or longer. Plant as soon as possible since the rhizobia will start to die off quickly.

Determining the Effect of Inoculating on Yield

The pot experiment described in Appendix will indicate whether a positive inoculation response could occur in a given soil.

However, because of its necessarily short duration, the pot experiment can only provide a rough estimate of the yield response likely to be obtained in the field. To quantify the effect of inoculation on yield a field experiment should be conducted employing the same three treatments (inoculated, uninoculated and uninoculated with nitrogen fertilizer) used in the pot study.

Aside from generating realistic data on effects of inoculation on yield, the field experimant will also allow periodic sampling. This is advisable since the effect of inoculation on long-lived perennials, such as trees, may only be pronounced during the initial establishment and early growth stages. Unfortunately, whether already established trees can be successfully inoculated or whether it would be beneficial to periodically add inoculant to the soil following planting is unknown.

The experimental protocol for the field experiment is that used by the NifTAL Project in the International Legume Inoculation Trial (INLIT) Program. This protocol can be adapted to meet the needs and resources of the individual investigator. For example, plot size can be increased or only one management level used.

Environmental Effects on Nitrogen Fixation by NFTs

Little has been published on the effects of different environmental variables on symbiotic nitrogen fixation by NFTs. While the following generalities are based primarily on information generated by studies on leguminous crops, they should also apply to tree legumes.

Once the seeds or nursery stock have been successfully inoculated the expression of BNF will be largely determined by the environment. Nitrogen fixation supplies only nitrogen to the tree. All other nutrients must be obtained from the soil. The surest way to maximize nitrogen fixation by NFTs is to grow healthy plants whose growth is not limited by other nutritional factors or environmental stresses.

Both biotic and abiotic factors can limit nitrogen fixation by NFTs. Among biotic factors are competition between the inoculant rhizobia and native strains for nodulation sites, competition with other microorganisms for soil nutrients and the ability of inoculant strains to survive as free-living soil organisms. Several of these factors were briefly discussed in Session 2. Abiotic factors primarily include climatic and soil factors.

Climatic Factors

Temperature. In general, rhizobia are more sensitive to high temperatures than are their associated host plants. Exposing inoculated tree seeds to high temperatures for even a short time can result in bacterial death and reduced nodulation. If the tree species is to be direct seeded into very hot soil with a surface temperature of 35°C or greater, it is recommended that a deeper furrow than normal be prepared. The inoculant should be sprinkled into the furrow, covered with an inch of soil, the seeds sown on top of this soil layer, and then covered with another layer of soil. Alternately, the seeds may be inoculated and then coated with either lime or powdered rock phosphate. This pelleting may help improve rhizobial survival under high temperatures.

Moisture Stress. Generally rhizobia survive at soil moisture levels below the wilting point of the host plant. Similarly rhizobia can survive short periods of waterlogging. However either too much or too little H_2O for even a short while can stress the plant to such a degree that nitrogen fixation ceases or in extreme cases nodules are shed. Nodule shedding is normal in NFTs with a marked deciduous habit, for example, *Erythrina sp.* and *Gliricidia sepium* in Mexico. However nodule shedding by evergreen species may indicate a serious problem with the plant.

Soil Factors.

Low pH, Calcium Levels, High Al and Mn. Many leguminous NFTs are sensitive to low pH primarily when accompanied by high Al and Mn and low Ca levels. The classic example of this is *Leucaena leucocephala* which cannot grow or nodulate well, if at all, in soils with a pH of 5.0 or less. Since rhizobia are markedly more tolerant to high levels of Al, Mn and low Calcium it is assumed, although not proven, that the negative effect of these conditions on nitrogen fixation is largely due to effects on the host plant (FAO 1984).

Amendments such as liming of acid soils can lead to good plant growth, nodulation and nitrogen fixation if the necessary rhizobia are present or supplied in inoculum. Although NFTs show a range of tolerance to Ca, Al and Mn stress, little is known about whether NFTs tolerant to acid soil conditions fix as much nitrogen as species growing in neutral or alkaline soils. With a few notable exceptions crop and forage legumes that grow in acid soils have exhibited poor nodulation. For NFT species tolerant to acid soils, such as *Acacia mangium*, acid soil tolerant rhizobia may be required. Such strains can be obtained from the NifTAL Project, University of Hawaii.

Phosphorus, Sulfur and Potassium. Deficiencies in phosphorous, sulfur and potassium affect the nitrogen fixing symbiosis by decreasing plant growth. Available information on the effect of these nutrients on BNF by NFTs is sparse but suggests that trees adequately supplied with these nutrients will optimally fix nitrogen.

Nitrogen. The presence of high levels of nitrogen delays or inhibits nodulation. Legumes will preferentially use mineral nitrogen even if well nodulated. In this case the nodules remain inactive until the level of available nitrogen decreases to a low level. Given these negative effects it is generally not recommended to apply

nitrogen fertilizer to legumes if they are expected to fix nitrogen. However in the case of NFTs a benefit may be possible from the application of a small amount of nitrogen at the time of planting for direct seeded species. Many of the species likely to be direct seeded, for example *Leucaena leucocephala*, do not form nodules for the first 3 to 4 weeks following germination. The addition of a small amount of nitrogen, for example 25 kg/ha. could help increase early growth so that when nodulation does begin the plant has a relatively high photosynthetic capacity to support vigorous fixation.

It is also logical to assume that the longer the delay in the onset of nodulation the greater could be the benefit of adding starter nitrogen. However since little is known about when the majority of NFTs nodulate, it may be necessary to first obtain this information so that inhibitory levels of starter nitrogen are not applied.

Micronutrients. The nitrogen fixation process requires molybdenum and iron. Without these elements fixation will not occur. Boron is involved in meristomatic activity of the plant and hence nodules will not form without it. Other micronutrients such as Zn, iron and cobalt are all needed for plant growth but affect nodulation only insolar as they enhance or depress plant production.

Fungicides, Pesticides, Herbicides. Fungicides containing mercury, zinc, copper or lead are toxic to rhizobia. If direct seeding is to be used inoculant should be applied below the seeds in the furrow and covered over with soil so the seed and inoculant are not in direct contact. Less is known about the effects or pesticides or herbicides on rhizobia or the nitrogen fixing symbiosis but as a general precaution seed inoculation should be avoided for seeds that have been treated with any chemical agents. In this latter case adding inoculum to the furrows is preferable.

Types of Management

Presumable management activities such as pruning, spacing, and mixtures of species will affect nitrogen fixation by NFTs. For example, studies on Erythrina in Costa Rica have shown that pruning trees leads first to nodule shedding followed by formation of new nodules. However little quantitative data exists to indicate whether these management techniques lead to significantly increased or decreased levels of nodulation or nitrogen fixation.

Summary

A simple field experiment can be used to quantify the benefit of inoculation in terms of actual biomass/production values. The optimal benefit from nitrogen fixation can only be achieved when the plant is fixing as much nitrogen as possible. Since nitrogen fixation only supplies nitrogen to the plant all other essential nutrients should be supplied. Nitrogen fixation is likely to be highest when no other factors limit plant growth. The surest way to optimize nitrogen fixation once the correct rhizobia has been obtained is to grow a healthy plant.

Question and Exercises

1. How much inculum is requred for one ha of direct seeded Leucaena? For 10,000 nursery plants required to plant one ha of Leucaena at a 1 x 1 m spacing?

2. How can nitrogen fertilizer benefit and inhibit fixation by NFTs?

3. What are likely to be the major factors limiting nitrogen fixation in tropical soils?

4. Why are nitrogen controls included in the yield field trial?

5. Given that a NFT fixes 100 kg N/ha/yr and the cost of inoculating the trees is US $10, how much of an economic savings would you realize in your country, given the present cost of nitrogent fertilizer?

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APPENDIX

Protocol for determining the need to inoculate NFTs.

A. Collecting preparing and potting field soil

1. The ideal site for soil collection is the one where the field experiments will later be conducted.

2. Scrape away the top litter layer and with a steel spade or shovel randomly obtain soil from the top 20 cm.

3. Place the soil on plastic sheets and mix thoroughly.

4. Allow to air dry until soil can be passed through a 0.5 cm sieve to remove rocks and other debris.

5. Soil may be amended at fertilizer rates equivalent to field practice but only the nitrogen control plants receive nitrogen equivalent to 50 kg/ha.

6. Gravel or vermiculite may be added to improve drainage in heavy soils.

7. Fill pots or plastic bags having a diameter of 20-25 cm to within 3 cm of the pot/bag rim with the prepared soil.

Note. if bags are used they should be tripled and drainage holes provided.

B. Seed preparation and inoculation.

1. Scarify seeds using methodology normally employed.

2. The inoculation procedure involves coating the seeds with the inoculant containing the rhizobia immediately prior to planting. The use of a sticking agent: 40% gum arabic solution, 5% solution of methyl cellulose, 15% solution of household sugar or honey is recommended to ensure that a sufficient quantity of inoculant adheres to the seeds.

3. The inoculum should be kept refrigerated before coating the seeds and should not be more than 6 months old to ensure that a high number of viable rhizobia is present.

4. The amount of inoculant and sticker to use will depend on the size of the seeds. For leucaena use 10 g of inoculant containing at least 10 !D9!U bacteria/gr and 3 ml of a 40% gum arabic solution for 50 g of seeds. These proportions will ensure at least 1 x 10 to the sixth power bacteria per seed. Variations in the seed/inoculant/sticking agent proportions may be necessary depending on seed size. For reference, one kg of giant Hawaiian leucaena seeds contains about 18,000 seeds.

5. The scarified seeds are placed in a relatively large clear plastic bag. The sticking agent is then poured over them. Next the bag is inflated and swirled around to evenly coat the seeds with the sticker. The inoculant powder is then added to the bag and the swirling repeated until the seeds are uniformly coated with the inoculant. Excess swirling will break down the coating and is not recommended.

6. Seeds can be further pelleted with lime or crushed rock phosphate if desired. The latter material is preferred for acid-producing rhizobia, like that for leucaena.

7. The coated seeds should then be emptied onto paper to air dry and then planted immediately or stored in the refrigerator for future planting. Caution should be taken not to expose the inoculant to direct sunlight or excessive heat or drying.

C. Planting the seeds and maintenance.

1. Plant the uninoculated and nitrogen control pots with 6-8 seeds first (depending on seed size). Then plant the inoculated seeds.

2. Plants are thinned to 2-4 per pot by snipping off the tops rather than pulling out the entire seedling.

3. Six replications of each of three treatments: inoculated, uninoculated and uninoculated plus nitrogen fertilizer are required.

4. Pots should be watered periodically to field capacity.

5. Precautions against contaminating the uninoculated pots with soil from the inoculated pots is essential. Contamination can be greatly reduced by: watering gently to avoid splashing, placing the pots on mesh benches so any drips

from the pots fall on the floor, assigning watering to a well-trained individual. In addition, pots should be set up in a randomized complete block design but not re-randomized thereafter to prevent contamination through handling.

D. Data collection and interpretation

1. Since biomass production is closely correlated with nitrogen availability, plant dry matter including root and nodule biomass are the most meaningful data to use in evaluating whether inoculation led to increased growth.

2. Six outcomes are theoretically possible:

	Uninoc.	Inoc.	+N	Significance
1	poor*	poor	poor	This indicated that nitrogen is not dominant factor limiting the production.
2	poor	poor	good	This result indicates that nitrogen is limiting plant growth but that inoculant strain was not able to effectively nodulate the host.
3	poor	mod	good	This indicates that the symbiosis was established but did not fix nitrogen optimally.
4	mod	mod	good	This indicates that nitrogen is limiting and that the inoculant strain is not optimal but is equal to the moderately effective native population.
5	mod	good	good	This indicates N is limiting and that the inoculant strain is better than the native population.
6	good	good	good	Inoculant strain and native population are equally and highly effective.

Inoculation would be advised in cases 3 and 5, unnecessary in case 6 and possibly worthwhile in cases 2 and 4 if better strains could be found.

*Relative growth.

	Learning Element	Code:
	Title: Nursery Management and Record Keeping **Occupational Area:** GROWING TREES	**Date of Issue:** Nairobi July 1984 **Page:** 8

11) When seeds are collected the following information should be recorded : date, amount collected, where collected, name of species and who collected it. If a germination test is done on the seeds this should also be recorded.

SEED COLLECTION RECORDS

Date	Species	Amount	Collector	Where collected	Germination
[illegible]	[illegible]	1 kg	[illegible]	[illegible]	30%
[illegible]	[illegible]	1/2 kg	[illegible]	[illegible]	90%
[illegible]	Eucalyptus	100 gr.	Jack	Tsavo	50%

12) When seeds are planted in the seed beds and then pricked out the following information should be recorded : species planted, amount planted, date planted, date of germination, germination remarks, date of pricking out, total number pricked out.

SEED BED RECORDS

Species	Amount	Date Planted	Date Germinated	Germination Remarks	Date Pricked Out	Number Pricked Out
Cedrela	1 kg	3-5-83	17-5-83	good	14-5-83	3000
Eucalyptus	0.1 kg	3-5-83	11-5-83	poor	11-5-83	15000
Grevillea	0.1 kg	1-5-83	17-5-83	good	20-5-83	2000

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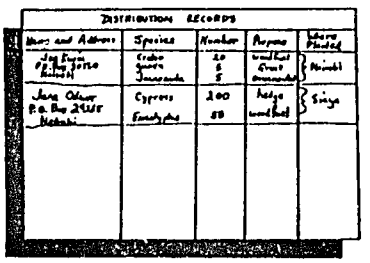
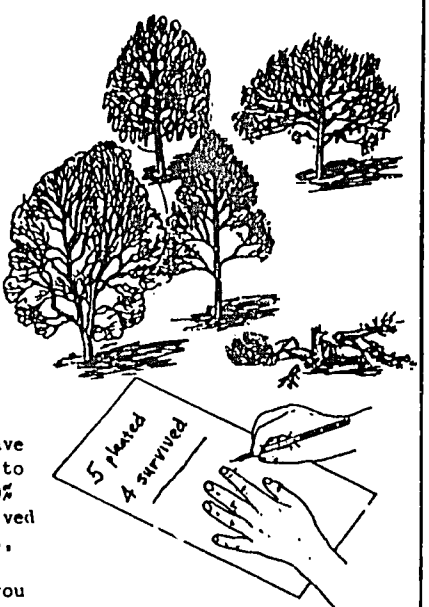
	Learning Element	Code:	
	Title: Nursery Management and Record Keeping		
	Occupational Area: GROWING TREES	**Date of Issue:** Nairobi July 1984	**Page:** 9

13) During the distribution period (rainy season), when people are taking the seedlings from the nursery, the following should be recorded : the name and address of the receiver, the species he takes and the number of each, the purpose for planting, the trees (fruits, ornamentals, hedge, woodfuel, etc.) and where they are to be planted.



DISTRIBUTION RECORDS

Name and Address	Species	Number	Purpose	Where Planted
Jog Eyre P.O. Box [illegible] Nairobi	Grevillea Quercus Jacaranda	20 5 5	woodfuel Great ornamental	Nairobi
Jane Oduor P.O. Box 2[illegible] Nairobi	Cypress Eucalyptus	100 50	hedge woodfuel	Siaya



14) Finally, as part of the evaluation of your nurseries success, you should try to determine the survival rate of the trees that have left the nursery. This would be done one year after the distribution period. For a small local nursery you can go to the people who received the trees and count the number that have lived. For a larger nursery, go back to the distribution records and pick a 20% (1 out of 5) sample of those who received trees. Contact these people by visits, letters or telephone and find out how many survived from as many people as you can contact. From the information you have collected, you can figure an estimate of the survival rate of the trees from your nursery.

$$\text{Percent survival} = \frac{\quad \times 100}{5} = \quad \%$$

$$\text{Percentage Survival} = \frac{\text{Number of trees still alive} \times 100}{\text{Number of trees originally planted}}$$

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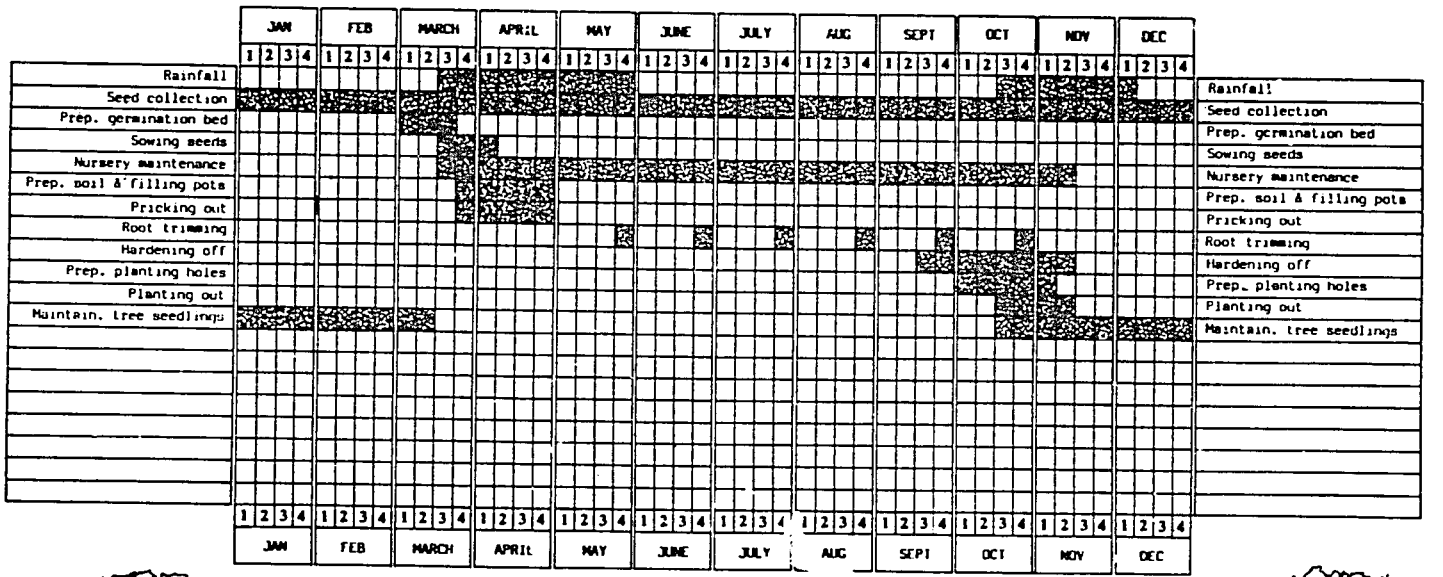
TREE HUSBANDRY CALENDAR

DRYLAND ZONE A



USEFUL INFORMATION SHEET

Code: AAK/GT/103a

Series: Trees

Title: **RECORD KEEPING**

Purpose: To provide guidelines on how to keep records for tree nurseries and planting projects and to explain why such records are important.

1. Why do we keep records for our tree projects?
   To provide us with information which will help us to develop and maintain good tree nurseries and maintain planted out seedlings in the field. Without these records the projects may not be successful for they help us to know our progress and to plan the work of keeping our home areas well planted with trees. The records we keep should also be useful to our friends and relatives who may want to start tree nurseries or tree projects in their homes.

2. What do we need to keep in our tree project records?
   A record will only be useful if it has all the information we want to remember or the information any visitor would like to know even in our absence. The more information the records contain the more useful they are. Below are some of the information that we must keep and how they will help us to improve, or monitor the progress of our projects.

What we need to know	Why we need to know
1. The variety or species of trees we plant.	- to determine which varieties/species are suited to our soils - to establish which time in a season is best for planting/sowing the seeds of each variety/species - to help us know which varieties/species are suited to the different climates e.g Berchemia discolora (Kisaya in Kikamba) prefers hot conditions whereas Ficus natalensis (Kiumo in Kikamba) prefers warm and wet conditions.
2. Source of seed	- to enable us collect more similar seed as and when necessary - to compare the performance of the plant at our homes and at its original environment - it makes it possible for us to know if what we have planted is from a good mother plant or not, which will in turn help us to decide whether to get more seed from there or not.

3. Collector of seed	- to be able to refer to the collector for some information which may not be in record e.g at what stage the seed was collected or whether the seed was collected from some part of the plant or from the ground.
4. Seed weight	- for future planting we can know approximately how many seeds we can obtain from a certain weight of seed. - if we know the average number of a particular seed per gram, we can find out about the moisture content i.e if we have very few seeds per gram it means the seed is still very wet and if we have a lot more seeds per gram the seed is dry.
5. *Seed viability	- if we know when the seed was collected, it will let us know whether seed can be kept for long or not. Some seeds such as Grevillea species, spathodea nilotica (Nandi flame tree) and markhamia species should not be kept for long while others such as croton megalocarpus can be stored for upto a year. - it may help us to know if the nursery bed was suitable or not. In a rough nursery bed where the right mixture is not used the viability will be low.
6. Whether the seeds were pre-treated before storage	- if seeds are to be stored for some time they should be treated with dawas so that they are not infested by pests. - if the seeds were not treated it may be wise to test with a few seeds before using a lot of labour on preparing a big nursery bed and sowing all the seeds which will not germinate due to insect damage.
7. Whether seeds were pre-treated before sowing	- for future planting we shall know if the seeds of a particular tree need pre-treatment or not. - we shall know which treatment is suitable for the various seeds we want to plant. (see Lesson I/5a - Germination bed preparation and sowing) - enables others to know whih seeds need pre-treatment and which method is appropriate for the particular seed.
8. Date of sowing	- it will help us to plan all other operations e.g pricking out, transplanting etc. - we are able to tell fast growing and slow growing trees. - enables any of our visitors to know the age of trees at any time of their (trees') lives. - if we know how long it takes the seeds to germinate, it will help us decide when to replant.

*Viability: The capability of the seeds to germinate. How much of the planted seed actually germinates in time.

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9.	Date of germination	- will help us determine early and late germinating seed varieties/species. - if seeds of a tree which usually germinate early germinate late in our nursery it may help us find out what management problems there were, it may also mean that something was wrong with our seed and therefore the plants will be weak or abnormal. - will enable us assess germination percentage.
10.	Date of pricking out	- for future nurseries it will help us plan when to prick out various varieties/species. - will remind us when to start root trimming. - if previous records are available it will help us plan when planting out should be done in various varieties/species.
11.	Weeding	- will help us know how frequently weeds occur, this will help us in future to plan for labour requirements for weeding. - if we are in business it will help us calculate how much is spent on weeding.
12.	Hardening off	- Lets any layman know how long each tree variety takes to harden off. - Enables us to have the tree seedlings planted out in time even in the absence of the nursery man.
13.	Root trimming	- Will let us know which varieties/species need their roots trimmed at what intervals as the roots develop at different rates. - enables us to know the number of times roots of each variety/species will need to be trimmed. - by counting and recording the number of seedlings trimmed we shall plan for the number of seedlings to be planted out.
14.	Date of planting out	- for future projects we shall know how long it takes from planting seed in a nursery bed to planting out for different tree varieties/species. - we shall always know the ages of all trees and can tell the fast or slow growing trees. - by recording the number of planted out seedlings we can find out the percentage of the trees that have taken off after some time. This will help us determine management or environmental problems in our projects and correct them in future.
15.	Nursery records	Nursery records will be able to: - indicate to you the seed species planted in a particular plot - Date planted - Plot size - Date when seeds germinated - The percentage germination

		- Who planted - Weight of seeds at planting - When you pricked out - When you weeded - when you started hardening off
16.	Location of planting out	- will enable us make follow ups and supervise the management of the trees - performance of the trees in various locations with same level of management will indicate the suitability or otherwise of the species/ variety to particular areas.
17.	Man power (labour) records	- helps us know whether there are enough people to do all the work that should be done when it should be done. This will help us reduce or increase the number of people working in our future tree projects. - since this is the biggest expenditure in a tree project, calculating what is paid to the workers will help us realise where our profits or losses are. This in turn will help us decide whether to increase wages for better performance or reduce them.

3. How should we keep our tree project records?
   For ease of reference four charts should be made to give as much detail as possible. These include seeds record chart, nursery record chart, manpower record chart and seedling distribution record chart. On the next page you will find a guideline on how to make these charts. More details may be found necessary in different areas.

NAME OF NURSERY/PROJECT: _____

1. SEED (SPECIES) RECORD CHART

SEED SPECIES	SOURCE & LOCATION	DATE COLLECTED	WHO COLLECTED	WEIGHT OF SEED	REMARKS

2. NURSERY RECORD CHART

SEED SPECIES	DATE COLLECTED	DATE PRETREATED	DATE PLANTED	PLOT		WHO PLANTED	WT SEED	GERMINATION DATE	PERCENTAGE GERMINATION	PRICKING OUT		ROOT TRIMMING	WEEDING	HARDENING OFF		REMARKS
				SIZE	NUMBER					FROM	TO			FROM	TO	

3. MAN POWER RECORDS

NAME OF WORKER	REPORTING TIME	DEPARTURE TIME	WORK DONE	REMARKS

4. SEEDLING DISTRIBUTION RECORDS

SEEDLING SPECIES	DATE SOWN IN GERMINATION BED	DATE PRICKED OUT	HEIGHT	TO WHOM	LOCATION	QUANTITY (AMOUNT)	REMARKS

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SOURCEBOOK SUPPORT MATERIALS - MODULE 10

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METHOD DEMONSTRATIONS

This follow-up often takes the form of a second type of demonstration the method demonstration. Method demonstrations allow farmers to learn by doing. The extension agent physically demonstrates a practice - how to determine a goat's age, for instance, by checking its teeth - and asks the farmer to try the same practice herself. The agent watches and corrects the farmer until she can do the practice properly, and then moves on to the next step of the demonstration.

Only one topic is covered at a time in a method demo. Checking a goat's teeth is one aspect of the topic: "Determining what livestock to buy at an auction." Goat buying and goat breeding are different topics. Each method demo is timed to coincide with the operations farmers are involved with in their individual farming cycles. Planting demonstrations are conducted a week or two before most farmers begin planting; weeding demonstrations are conducted just before the optimum time in a plant's growth cycle to do a complete weeding operation, In this way, a series of method demonstrations serve to span an entire growing season and keep the extension agent in close contact with his clients.

Being successful in conducting a method demo requires close attention to detail. The site and time of demonstration should be selected on the basis of audience comfort. Shade, heat, and sight lines are three important considerations. Materials for the demonstration should be locally available and arranged conveniently for use in the demonstration. The best way to make sure that nothing will be forgotten is to prepare a written plan (see ILLUSTRATIONS and TOOLS). This may include the step by step sequence of the demo itself as well as lists of materials needed and major points to be covered. Once the plan is written, the extension agent needs to rehearse the presentation in its entirety. Only by actually walking through a demonstration can the agent be sure that nothing has been left out.

When actually conducting the presentation, it is important to encourage as much farmer participation as possible. Points at which farmers can be directly involved should be indicated in the written plan. Other means of accomodating farmer learning styles are to continue to relate new material being presented to a farmer's previous experience and to carefully choose vocabulary with which the farmer is already familiar. Some technical terms may prove very difficult to translate without considerable thought beforehand. A good way to check to make sure that the audience is following a presentation is to pose questions to farmers at regular intervals. The demonstrator can also repeat steps where necessary. Finally, it is important for either the extension agent or one of the farmers to summarize the main points of a presentation at its conclusion.

The ILLUSTRATIONS and TOOLS sections which follow can be supplemented by a review of the adult learning principles and cross-cultural communication techniques contained in other sections of this chapter.

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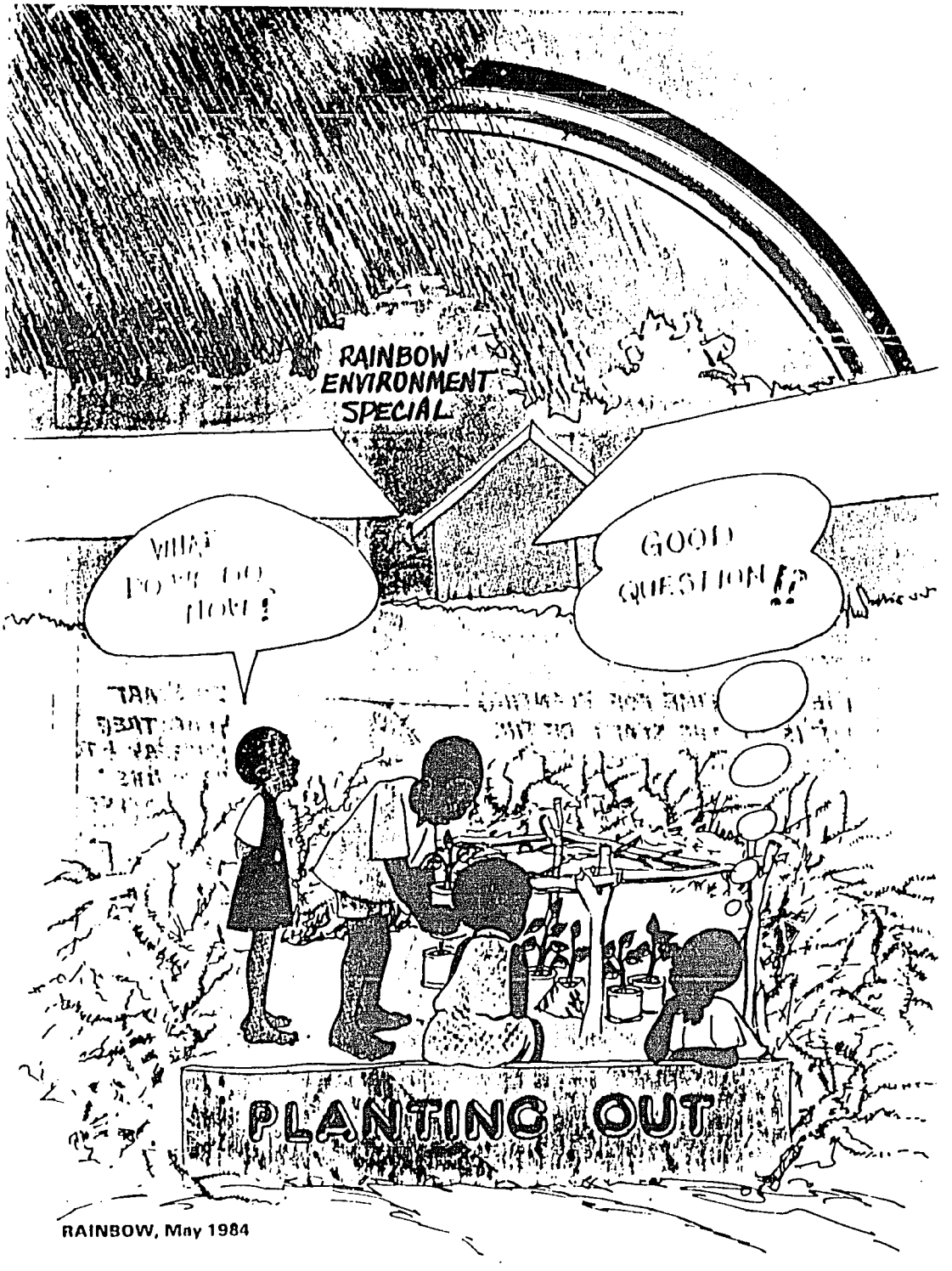

RAINBOW, May 1984

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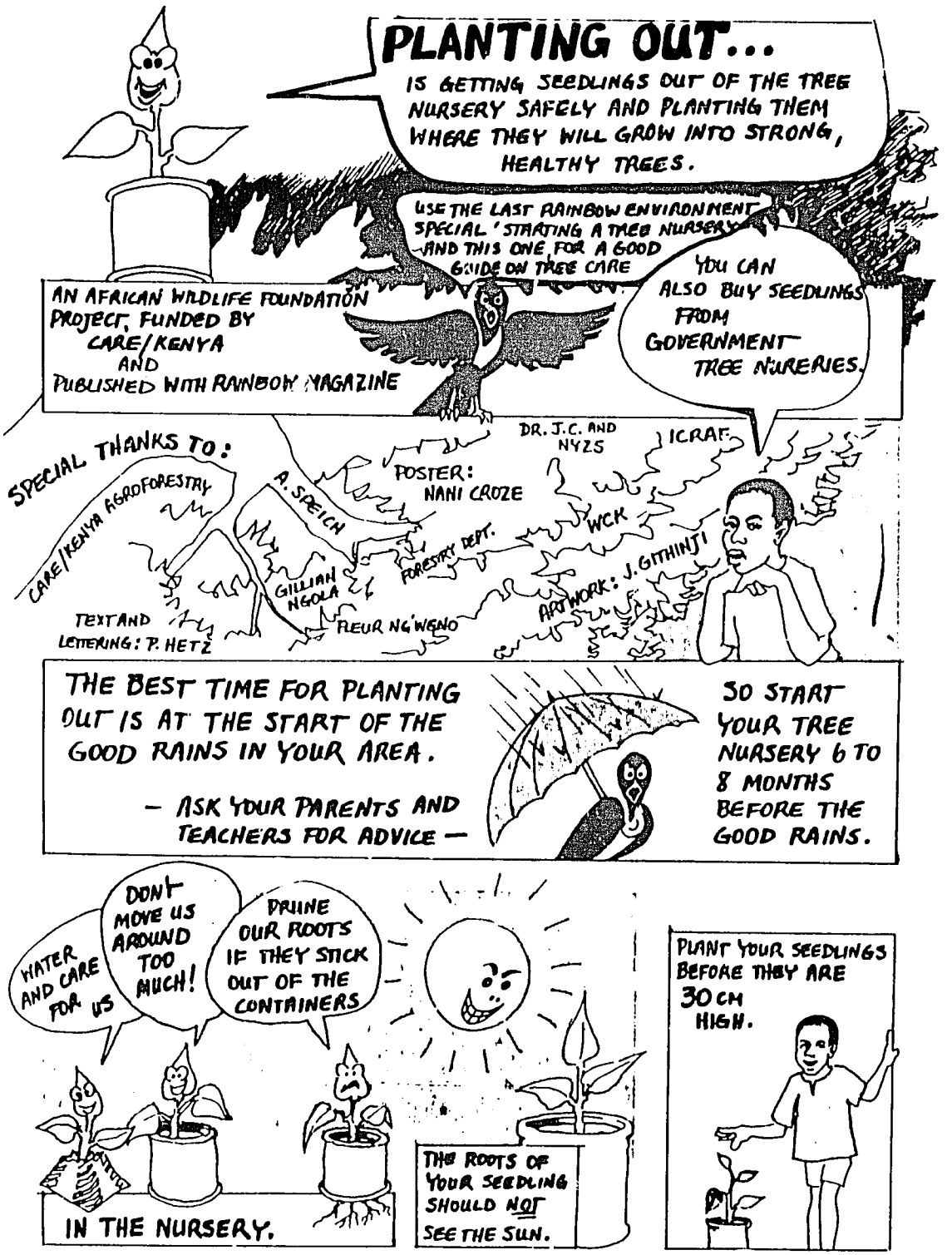
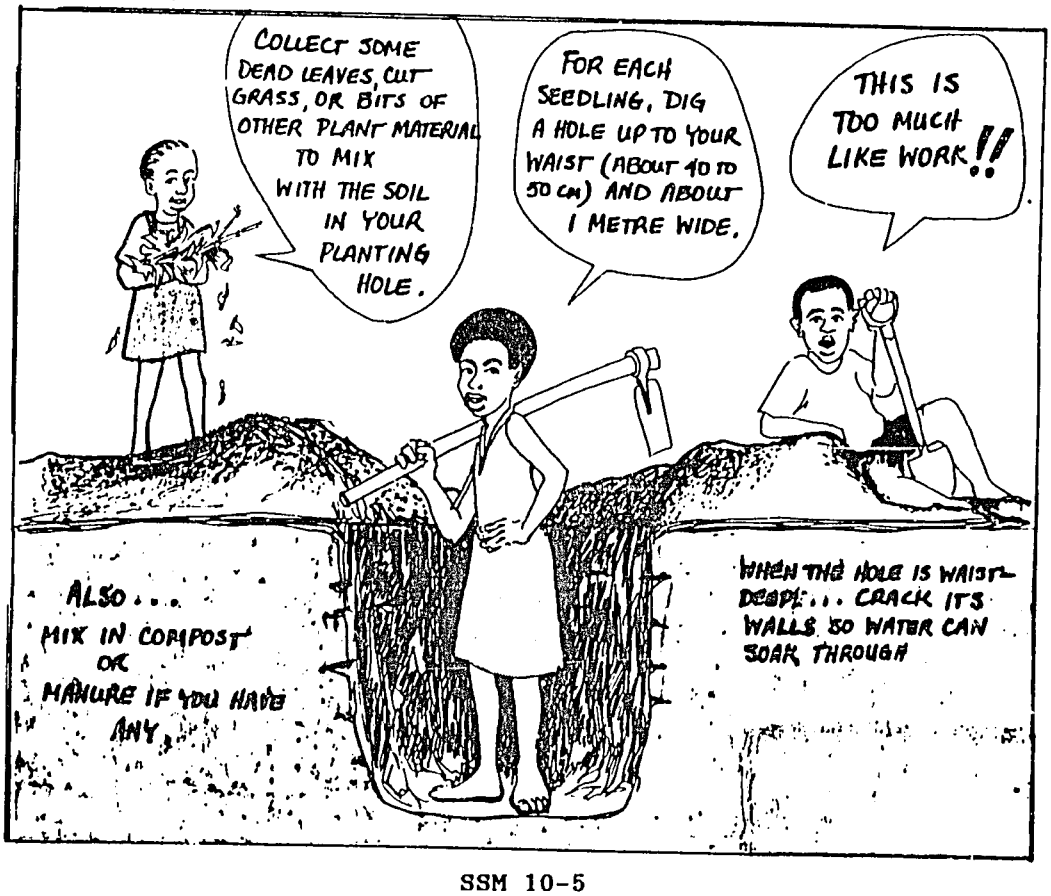

PLANTING OUT...
IS GETTING SEEDLINGS OUT OF THE TREE NURSERY SAFELY AND PLANTING THEM WHERE THEY WILL GROW INTO STRONG, HEALTHY TREES.
USE THE LAST RAINBOW ENVIRONMENT SPECIAL 'STARTING A TREE NURSERY' AND THIS ONE FOR A GOOD GUIDE ON TREE CARE
YOU CAN ALSO BUY SEEDLINGS FROM GOVERNMENT TREE NURSERIES.
AN AFRICAN WILDLIFE FOUNDATION PROJECT, FUNDED BY CARE/KENYA AND PUBLISHED WITH RAINBOW MAGAZINE
SPECIAL THANKS TO:
CARE/KENYA AGROFORESTRY
A. SPEICH
POSTER: NANI CROZE
DR. J.C. AND NYZS
ICRAF
WCK
FORESTRY DEPT.
GILLIAN NGOLA
FLEUR NG'WENO
ARTWORK: J. GITHINJI
TEXT AND LETTERING: P. HETZ
THE BEST TIME FOR PLANTING OUT IS AT THE START OF THE GOOD RAINS IN YOUR AREA.
— ASK YOUR PARENTS AND TEACHERS FOR ADVICE —
SO START YOUR TREE NURSERY 6 TO 8 MONTHS BEFORE THE GOOD RAINS.
WATER AND CARE FOR US
DONT MOVE US AROUND TOO MUCH!
PRUNE OUR ROOTS IF THEY STICK OUT OF THE CONTAINERS
IN THE NURSERY.
THE ROOTS OF YOUR SEEDLING SHOULD NOT SEE THE SUN.
PLANT YOUR SEEDLINGS BEFORE THEY ARE 30 CM HIGH.

BETTER TO PLANT ONLY A FEW TREES, AND CARE FOR THEM WELL. CHOOSE A PLANTING SITE.
FOR SPECTATORS AROUND THE EDGES OF PLAYING FIELDS.
SCHOOL DRIVE OR FOOTPATH
HERE!
NO, HERE
HERE
AROUND THE HOME.
CHOSEN THE SPOT? GOOD! NEXT, YOU MUST PREPARE YOUR LITTLE TREE'S NEW HOME, ABOUT 2 OR 3 WEEKS BEFORE THE RAINS START.
DON'T PLANT TREES UNDER ELECTRICITY LINES OR IN MARSHY GROUND.


COLLECT SOME DEAD LEAVES, CUT GRASS, OR BITS OF OTHER PLANT MATERIAL TO MIX WITH THE SOIL IN YOUR PLANTING HOLE.
FOR EACH SEEDLING, DIG A HOLE UP TO YOUR WAIST (ABOUT 40 TO 50 CM) AND ABOUT 1 METRE WIDE.
THIS IS TOO MUCH LIKE WORK!!
ALSO... MIX IN COMPOST OR MANURE IF YOU HAVE ANY.
WHEN THE HOLE IS WAIST DEEP!... CRACK ITS WALLS SO WATER CAN SOAK THROUGH

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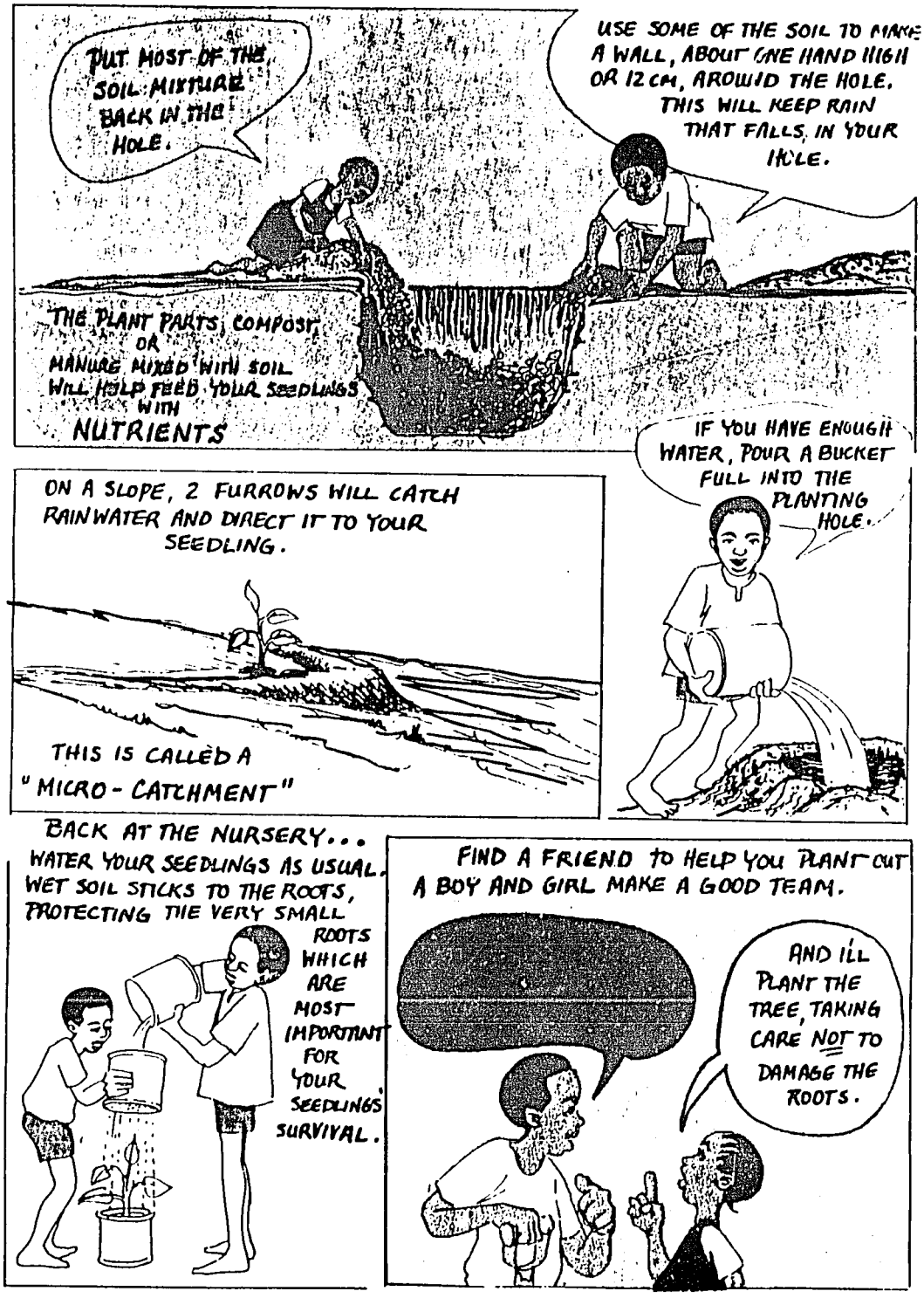
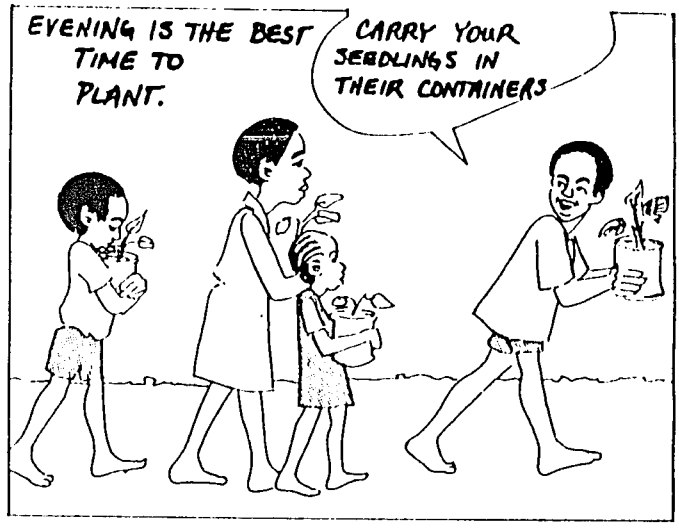
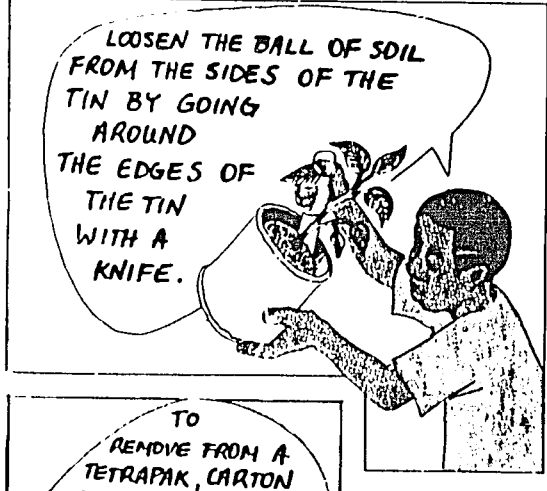
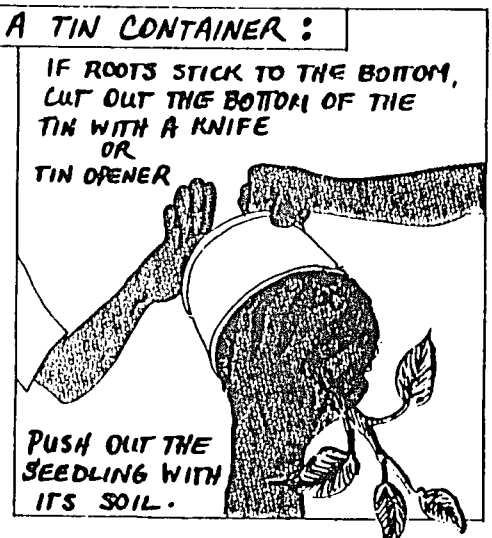
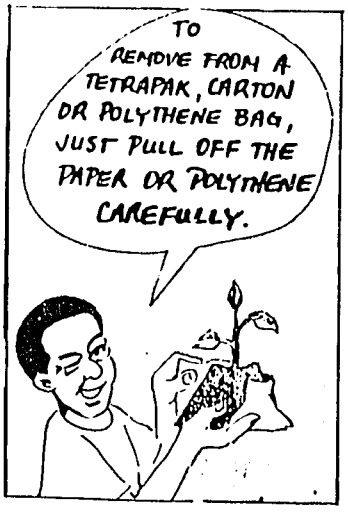

PUT MOST OF THE SOIL MIXTURE BACK IN THE HOLE.
USE SOME OF THE SOIL TO MAKE A WALL, ABOUT ONE HAND HIGH OR 12 CM, AROUND THE HOLE. THIS WILL KEEP RAIN THAT FALLS IN YOUR HOLE.
THE PLANT PARTS, COMPOST OR MANURE MIXED WITH SOIL WILL HELP FEED YOUR SEEDLINGS WITH NUTRIENTS
IF YOU HAVE ENOUGH WATER, POUR A BUCKET FULL INTO THE PLANTING HOLE.
ON A SLOPE, 2 FURROWS WILL CATCH RAINWATER AND DIRECT IT TO YOUR SEEDLING.
THIS IS CALLED A "MICRO-CATCHMENT"
BACK AT THE NURSERY... WATER YOUR SEEDLINGS AS USUAL. WET SOIL STICKS TO THE ROOTS, PROTECTING THE VERY SMALL ROOTS WHICH ARE MOST IMPORTANT FOR YOUR SEEDLINGS' SURVIVAL.
FIND A FRIEND TO HELP YOU PLANT OUT A BOY AND GIRL MAKE A GOOD TEAM.
AND I'LL PLANT THE TREE, TAKING CARE NOT TO DAMAGE THE ROOTS.

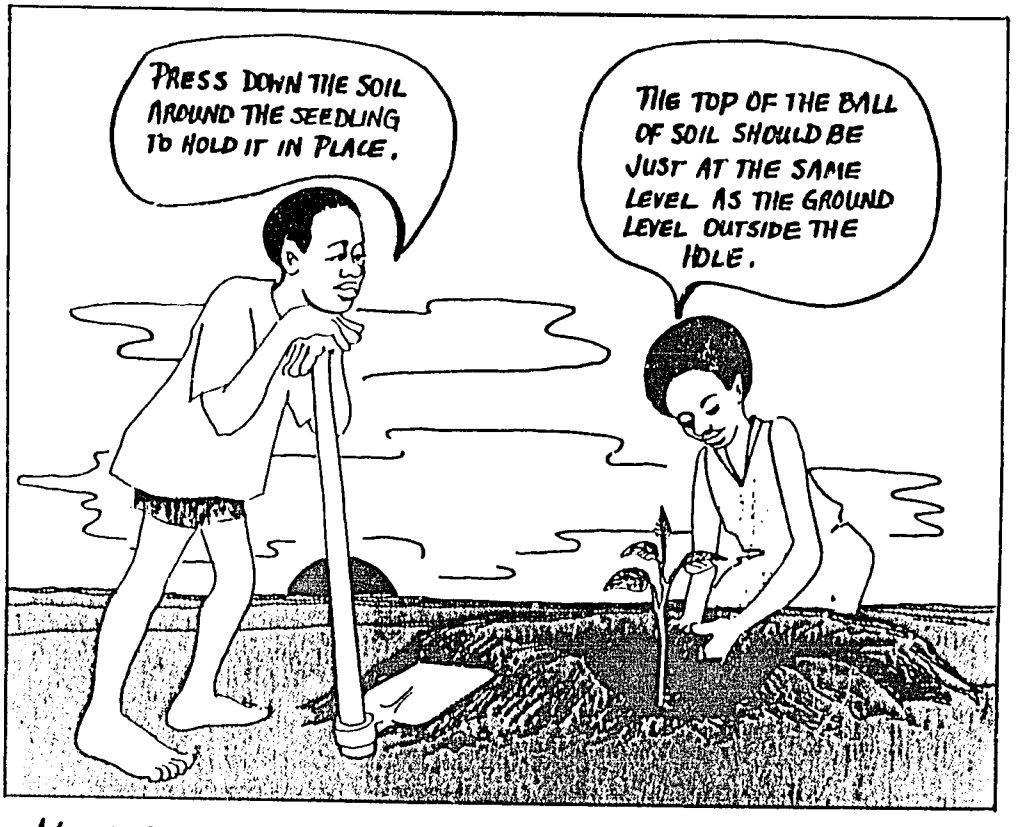


TO GET SEEDLINGS OUT OF A TIN CONTAINER:

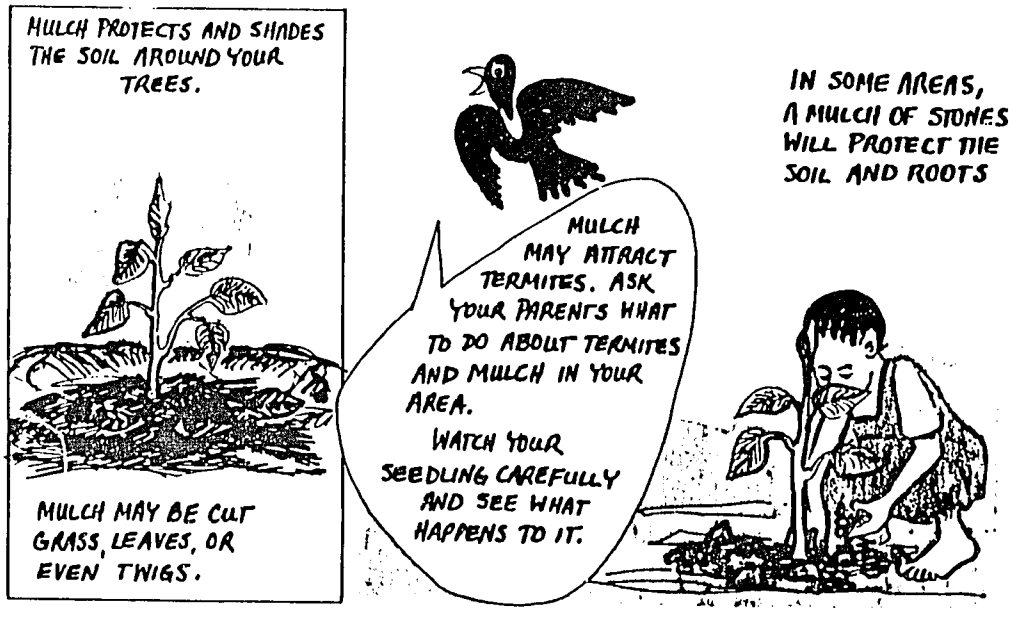


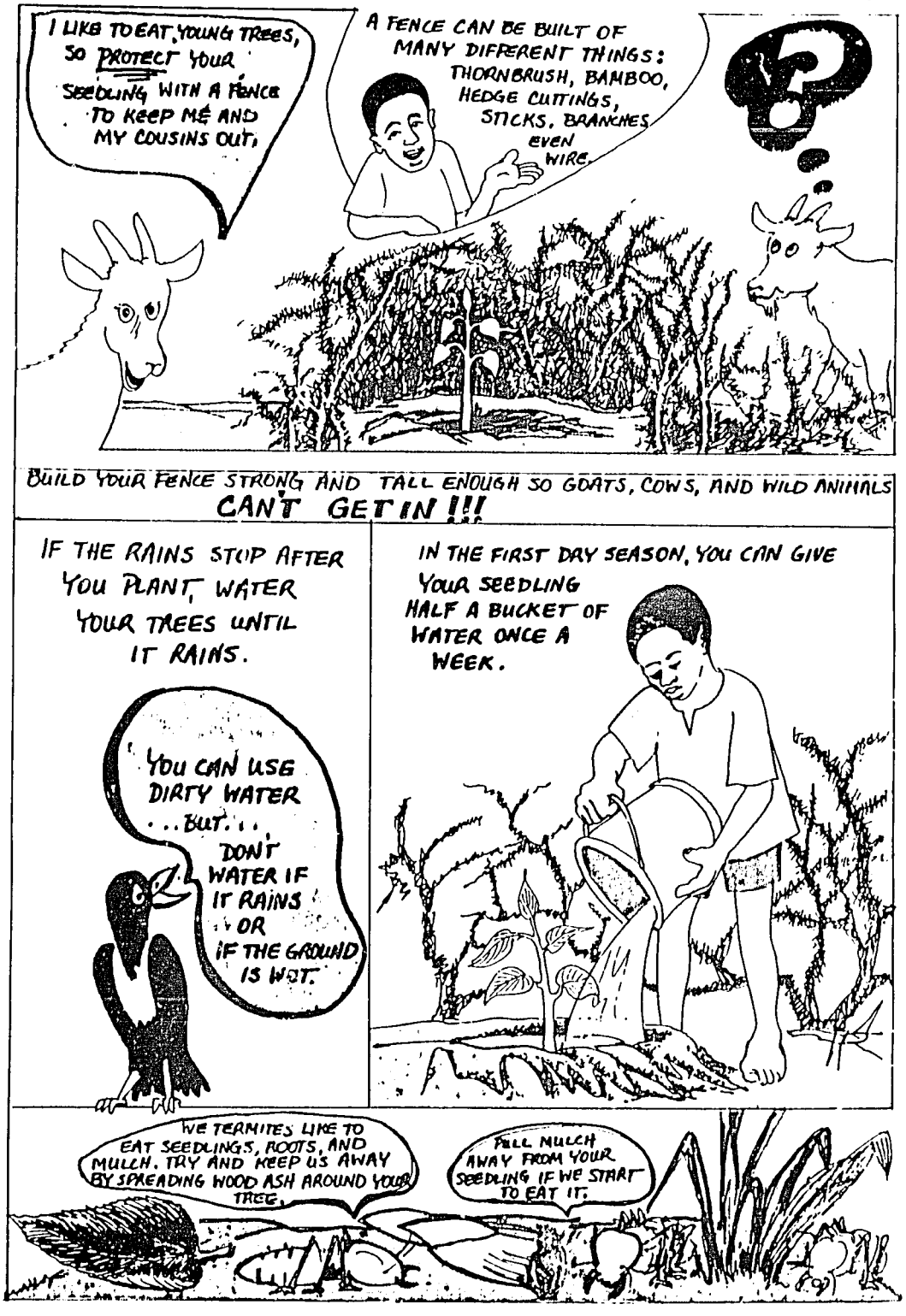


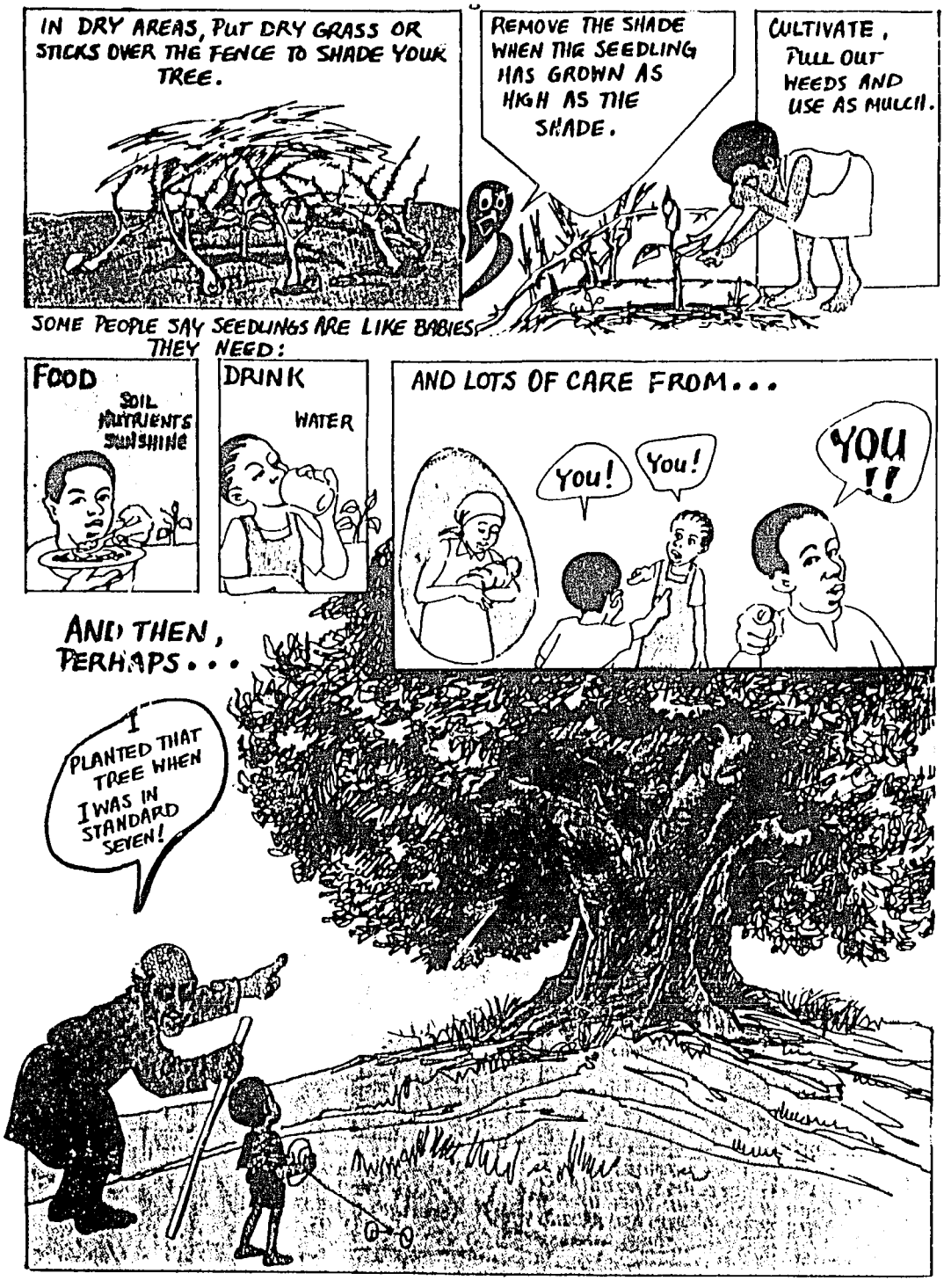




YOUR SEEDLINGS ARE PLANTED; NOW PROTECT THEM.




I LIKE TO EAT YOUNG TREES, SO PROTECT YOUR SEEDLING WITH A FENCE TO KEEP ME AND MY COUSINS OUT.
A FENCE CAN BE BUILT OF MANY DIFFERENT THINGS: THORNBRUSH, BAMBOO, HEDGE CUTTINGS, STICKS, BRANCHES EVEN WIRE.
?
BUILD YOUR FENCE STRONG AND TALL ENOUGH SO GOATS, COWS, AND WILD ANIMALS CAN'T GET IN !!!
IF THE RAINS STOP AFTER YOU PLANT, WATER YOUR TREES UNTIL IT RAINS.
YOU CAN USE DIRTY WATER ...BUT... DON'T WATER IF IT RAINS OR IF THE GROUND IS WET.
IN THE FIRST DRY SEASON, YOU CAN GIVE YOUR SEEDLING HALF A BUCKET OF WATER ONCE A WEEK.
WE TERMITES LIKE TO EAT SEEDLINGS, ROOTS, AND MULCH. TRY AND KEEP US AWAY BY SPREADING WOOD ASH AROUND YOUR TREE.
PILE MULCH AWAY FROM YOUR SEEDLING IF WE START TO EAT IT.


IN DRY AREAS, PUT DRY GRASS OR STICKS OVER THE FENCE TO SHADE YOUR TREE.
REMOVE THE SHADE WHEN THE SEEDLING HAS GROWN AS HIGH AS THE SHADE.
CULTIVATE, PULL OUT WEEDS AND USE AS MULCH.
SOME PEOPLE SAY SEEDLINGS ARE LIKE BABIES THEY NEED:
FOOD
SOIL NUTRIENTS SUNSHINE
DRINK
WATER
AND LOTS OF CARE FROM...
You!
You!
YOU!!
AND THEN, PERHAPS...
I PLANTED THAT TREE WHEN I WAS IN STANDARD SEVEN!

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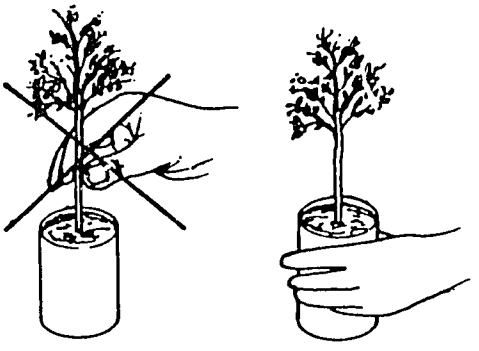
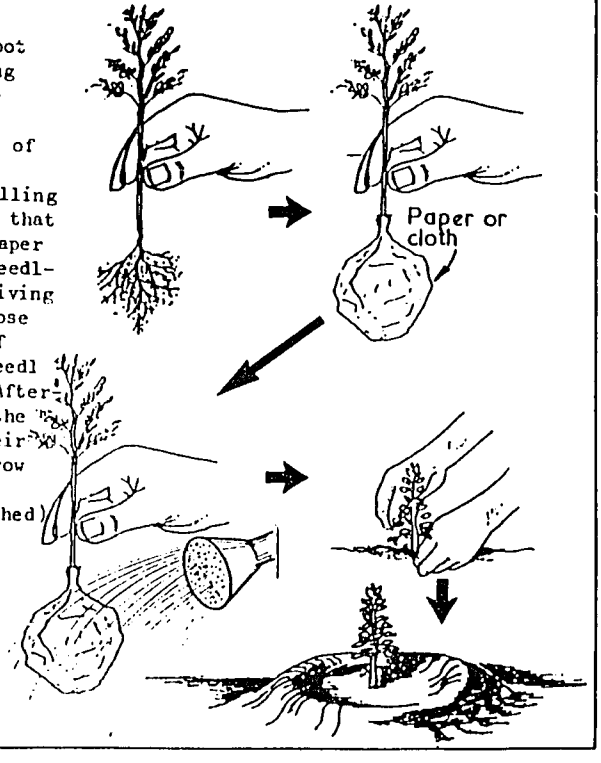
	Learning Element	Code:
	Title: Late Seedling Care	
	Occupational Area: GROWING TREES	**Date of Issue:** Nairobi May 1984 / **Page:**

6) The container seedlings must be carried carefully. If they are being hand carried, a box or basket should be used.

Never carry the seedlings by their stems. If a vehicle or cart is being used, then it is best for the seedlings to be packed upright like they were in the nursery. Pack them tightly so that they will not be damaged when they are being moved.



7) When transporting bare root stock, remove the seedling gently from the soil. Be careful not to damage the roots. Place a wet piece of paper or cloth around the roots. If you are travelling a long distance make sure that the protective cloth or paper is kept wet. Plant the seedlings immediately upon arriving at the site where you choose for planting. Use alot of water when watering the seedling for the first time. Afterwards, water daily until the trees start to grow on their own (when they start to grow again then their new root system has become established)



	Learning Element	Code:
	Title: Late Seedling Care	
	Occupational Area: GROWING TREES	**Date of Issue:** Nairobi May 1984 / **Page:**

8) Tell the people taking the seedlings how to plant the trees. If you have a handout on tree planting give it to them. It is important that the trees be planted the right way.

Lesson code: AAK/T/14a

Series: Trees.

Lesson title: **PREPARING PLANTING HOLES IN HIGH POTENTIAL AREAS.**

Aim: To enable trainees learn how and when to prepare planting holes for planting out tree seedlings and to understand why they are necessary.

What you will need for this lesson:

1. Site where the tree seedlings are to be planted out i.e - flat land
   - sloping land
2. 10 jembes
3. 10 pangas
4. 40 litres of water
5. 10 sticks each 30cm long.

What to brief your assistants about:

1. How the holes should be dug
2. How to prepare microcatchments on flat and sloping land
3. Why microcatchments are important.

The lesson.

There is no classroom session to this lesson. Begin the lesson at the site where holes are to be prepared and follow these steps:

1. Tell the trainees when we should start preparing planting holes.
   Explain why.

2. Tell the trainees why we should prepare planting holes for planting out our tree seedlings.
   Explain why they are necessary.

3. Move with the trainees to a selected spot where holes are to be dug.
   Tell them that the area should be cleared of all weeds.
   Let them clear the area.

4. Tell the trainees what the planting holes should be like and why.
   Show them a drawing of a planting hole.
   Tell them the dimensions of the hole.

5. Let one trainee dig the planting hole.
   Explain to them why the top soil should be separated from the sub-soil.
   Show them how to check the depth with the sticks.

6. Divide the trainees into pairs and provide each pair with a panga or jembe.
   Show each pair where they should dig their planting holes.
   Explain to the groups why the seedlings should be planted at least 4 metres away from each other.

7. Let the trainees dig the holes.

8. Tell the trainees what a microcatchment is.
   Show them a picture of a microcatchment on flat ground and tell them how big it should be.
   Explain why they are important.

9. Show them how to construct a microcatchment around a planting hole.

10. Let the trainees divide up into their teams and make a microcatchment around the holes they have dug.
    Check that they have done all of the work correctly.

11. Move with the trainees to a site where the ground is sloping.
    Ask the trainees how they can construct a microcatchment on sloping land.
    Discuss with them how the microcatchment should be made.

12. Show the trainees how to mark out a a microcatchment on sloping land.
    Explain why it is this shape.
    Show the trainees how to dig the embankment.

13. Let them practise constructing embankments on holes dug on sloping land.

14. Tell the trainees that the holes should be watered before the tree seedlings are planted out.
    Explain why they should be watered.

Tell them how much water should be poured into each hole and how often this should be done.

15. Let the trainees water the holes.
Tell them to include this job in the duty roster for the tree nursery.

16. Summarise the lesson by asking a number of questions including:
    a. Why do we need to prepare planting holes before the time for planting out?
    b. When should we start preparing planting holes?
    c. How deep should the holes be?
    d. Why should we construct basins (microcatchments) around the holes?
    e. Why should we water the holes.

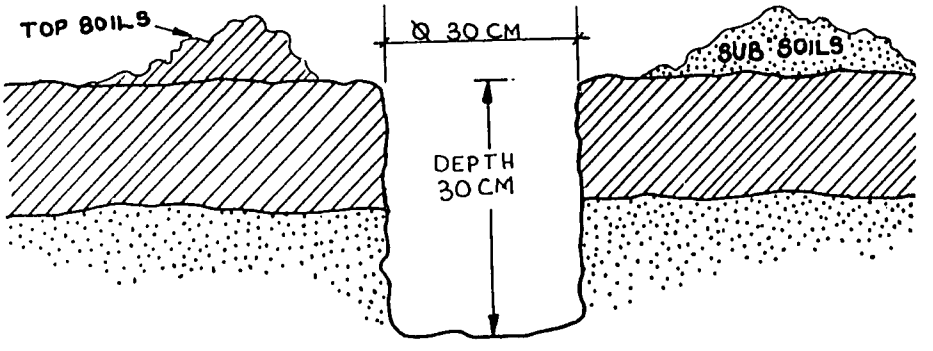
17. Tell the trainees their home assignments:
    a. To show their families how to make planting holes and basins (microcatchments) and to explain why they are necessary.
    b. To prepare their own planting holes at home.

Useful Information.

1. When should we begin preparing planting holes?
   2 weeks before planting out.

2. Why do we prepare planting holes before the time of planting out?
   So that the soil can be moistened and softened. This is necessary because hard dry soil will be bad for rapid root development. Seedlings which are planted out into soil which is hard and dry will not do well.

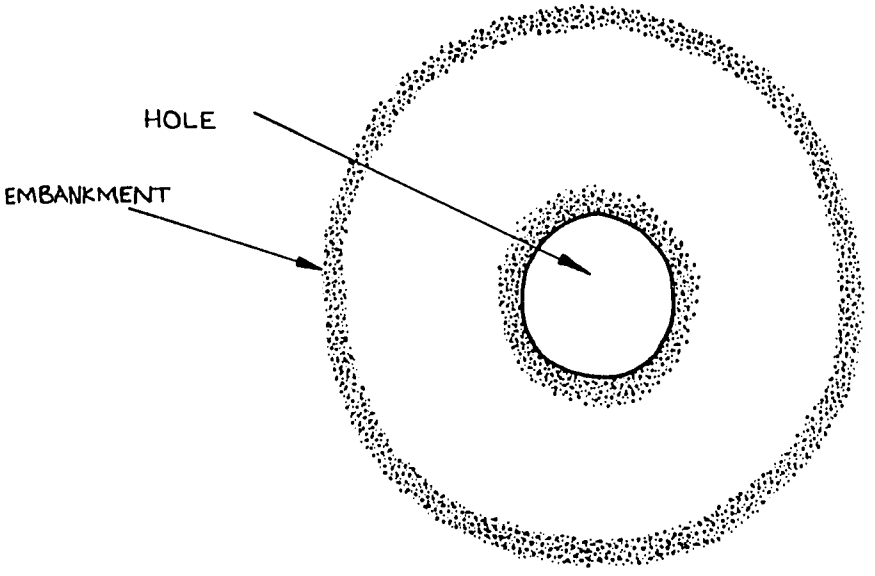
3. How do we prepare planting holes?
   - clear an area of 60cms diameter around the place where you will dig the hole.
   - dig a hole 30cm deep. This hole should be about 30cms in diameter. (Measure the depth with a 30cms stick).



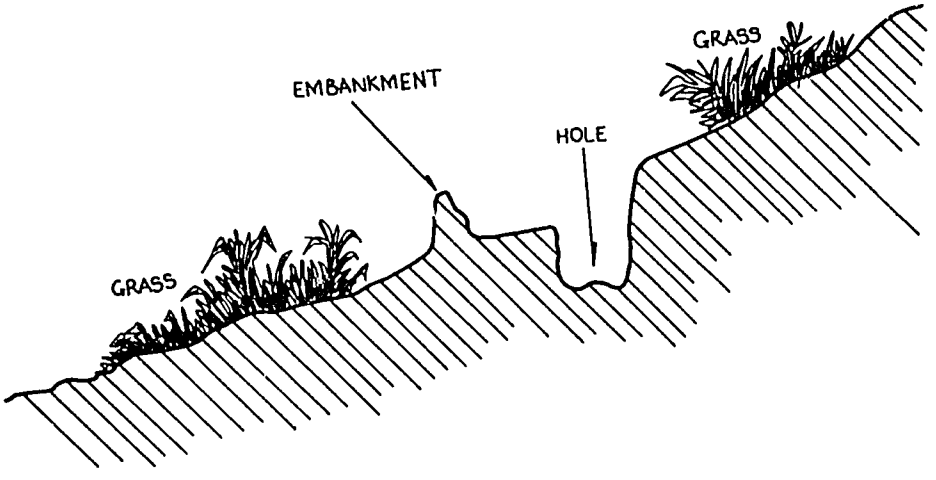
   - as you dig, separate the top soil into one heap and the sub-soil into another heap.

4. What is a microcatchment?
   It is sometimes referred to as a basin because its structure resembles a basin . It is a small embankment which is constructed around the planting hole. It is designed to hold enough rain or irrigated water for use by the seedling instead of just running off as surface water.

5. How do we make the microcatchments (basins)?
   It depends whether the ground is flat or sloping.
   a. on flat land.
      mark out a circle of 30cms radius with the middle of the hole as the centre.
      Build an embankment of soil about 15cm high.



b. on sloping land.
Clear an area of grass/weeds on the lower-side of the point where the hole has been dug. The area cleared should be about 45cms below the point where the hole has been dug. Using the grass and soil you have dug from the lower side of hole, build an embankment 15cms high. The embankment should be made in the shape of an arc. (see the diagram).



The embankment is 45cms away from the hole where the tree seedlings will be planted so that when it rains so much the seedling is not water-logged.

* * *

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RUSTIC TRANSIT

Plowing along the contour is an agricultural practice to aid in erosion control. By plowing with the contour, soil erosion can be reduced by as much as 50%. Contour lines are generally incorporated with other erosion control measures such as strip cropping, crop rotation, agroforestry, diversion ditches and diversion terracing.

Diversion terraces are widely used in Africa to catch surface run-off and allow its safe exit from the field. The terraces are constructed along the contour at intervals down the slope. The distance between terraces varies depending upon the slope of the land. The terrace is raised to a height of 50 - 70 cm with a width of 1 meter. The up slope side of the terrace has a channel 50cm wide and 30cm deep which catches surface run-off. This channel has a gradual slope of 0.25 - 0.50 percent off to one side of the field. The channel should be covered with a low growing grass to reduce erosion in the channel itself. The terraces should be vegetated with bunch grass, trees or naturally covered by weeds.

Contours can be laid out using rustic or modern instruments. Rustic instruments can be constructed easily and cheaply. Three people are generally needed to lay out the contour lines. Using rustic methods, about 4 - 6 ha/day can be marked as opposed to 15 - 20 ha/day with a tripod surveyor's level. These figures vary depending on the uniformity and slope of the land.

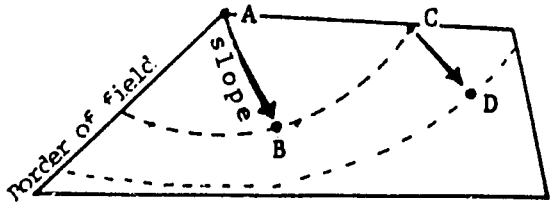
Laying out the Contours

The first step is to measure the slope of the field in degrees or percent. The steepness of the slope will determine the distance between terraces. The steeper the slope, the closer the terraces; the less the gradient, the farther apart the terraces. Slope can be measured using a protractor, abney level or surveyor's level. The protractor will give degree slope while the latter will be percent slope. Tables are available in most areas which indicate terrace spacing in relation to slope and soil type.

After determining the slope and the terrace spacing, the marking can be started. Start from the highest point in the field and measure down the slope your calculated terrace interval to your first point. It is important to always measure this distance directly down the slope. This direction may not coincide down the border of the field. If this distance is not measured directly down the slope, the terraces will not have uniform distances between them. This may mean starting from the middle of the field (fig. 8) from point "A" and measuring down slope towards point "B".

Point "B" is the starting point. From here you mark the contour towards the borders of the field.

When you arrive at point "C", you measure to your next terrace to point "D", directly down slope.



(Fig. 8) field

Using the rustic instruments, points can be marked every 10 or 15 meters. The points are marked by driving a stake into the ground. Using a surveyor's level, points can be placed every 20 - 25 meters. A helpful way to measure these distances is to tie a light weight rope between the sighting instrument and the sight rod.

Once all the contours are marked, you will see that some status may not be in line. It will be necessary to adjust some points in order to have a smooth plow line. For example, a sharp "V" in the contour will cause water to collect and leak through the terrace. It will also be harder for the farmer to plow his field.

The terraces can be constructed with a tractor, horse, oxen or by hand. The tractor is most efficient because it can throw more soil. When using animals, it is necessary to follow up with hoes to raise the terrace and also deepen the channel in front.

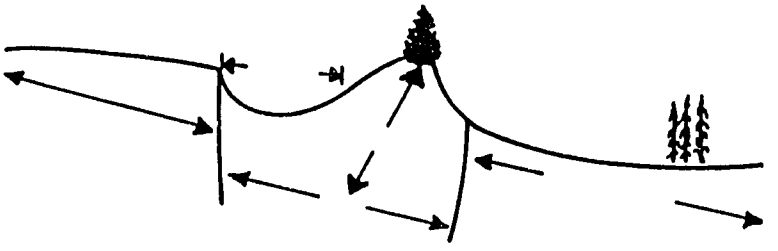
The actual plowing is done by throwing soil toward the stakes on both the uphill and downhill side. Two passes with a tractor on each side are usually sufficient. Three or four passes with animals on each side are recommended. The last pass with either method should be on the uphill side to clean out the diversion channel.

Vegetation should be established as soon as possible. Bunch grasses can be planted from cuttings or by seed. The grass in the diversion channel can be seeded or left to natural weed growth. Trees can also be planted on the terraces in conjunction with the bunch grasses.

SOME WAYS TO USE YOUR RUSTIC TRANSIT

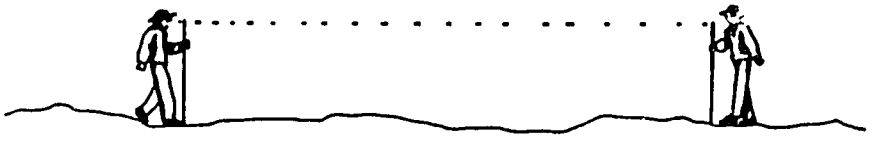
You will be using this level to aid you in making contour level terraces. These are for the protection of soil in crop fields. This method is not recommended for over 13% slope.

Example: This is a Contour line.



(Fig. 9)

You take the rustic transit and sight over the sight arm to the mark on the sight pole (which is ten meters away in this example)



(Fig. 10)

Some ways to use the rustic transit

You can also incorporate a drainage slope into the contour terraces. This would be to disperse water caught in the ditches of the contour terraces. For example, you decide on .5% slope for drainage. For every 1% slope at 10 meters distance from sight pole to rustic level, you move the mark on the sight pole up or down (depending which way the slope runs). In this case, with .5% slope drainage at 10 meters distance, you would move mark up or down 5 cm.

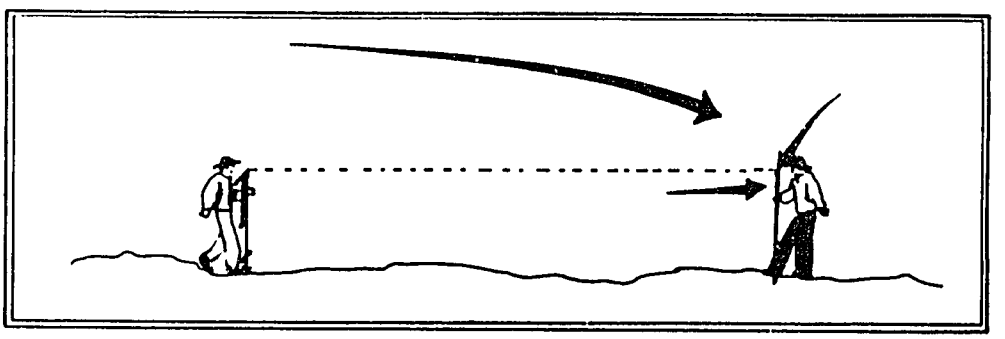


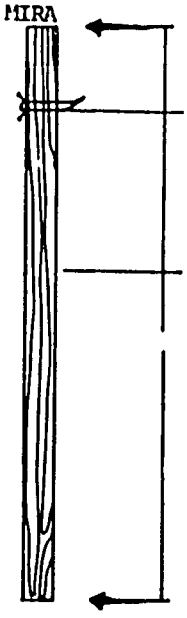
Fig. 11

For .5% slope, drain off channel, move sight line 5 cm every 10 meters between the two men (up or down depending on which way you want the water to run).

You can control 50% of your erosion by running your rows of crops along the contour line. The contour line does not need to be long.

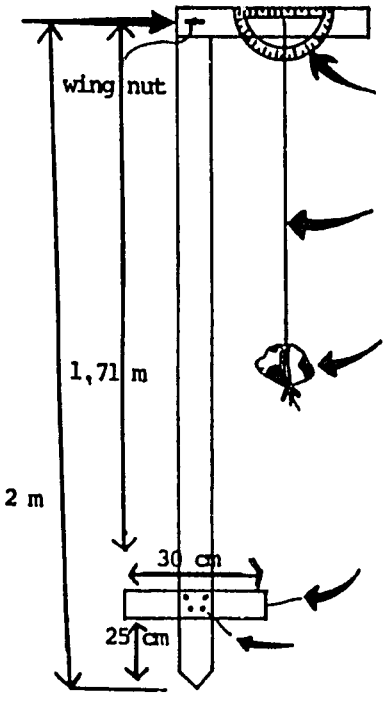
SIGHT POLE

(Fig. 12)



RUSTIC LEVEL

(Fig. 13)



Another Rustic Level that could be built.

Rustic Level: A-Frame

A rustic level is a tool that can be made of simple materials, easy to use and simple to construct. The materials can be anything that is readily available, such as lumber (1 X 2's or 2 X 2's) or poles cut from local vegetation.

The dimensions do not have to be exact. The cross arm should be placed about half-way up. The string with the end weight should be hung from a nail placed in the juncture where the two legs meet. Consideration should be given to bolting together all pieces to facilitate easy transportation.

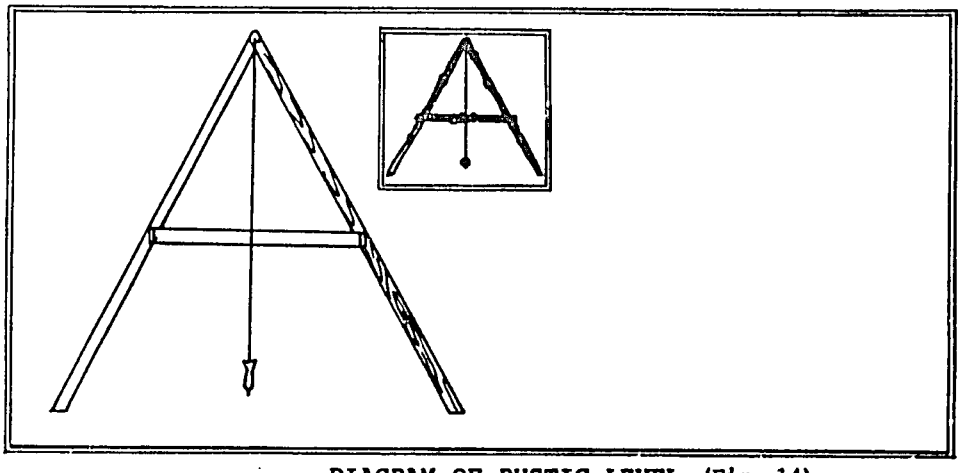


DIAGRAM OF RUSTIC LEVEL (Fig. 14)

To calibrate the level, choose a semi-level spot of ground and pound a couple of 6" - 8" stakes halfway into the soil at a distance equal to the spread of the level's legs. Place the level on the stakes and make a pencil mark where the plumb line comes to rest. Then reverse the level and make a second mark. The level mark is halfway between these marks.

To make contours along a hillside, simply put a stake at the starting point. Then place one of the legs of the level on the stake and the other in the direction you wish to travel. Then move the latter leg up or down hill until the plumb line comes to rest on the level line. Mark that spot and move on. Put one of the legs on the stake you just placed.

Some information contained here is extracted from Soils, Crops, and Fertilizer Use by David Leonard, Peace Corps Reprint R-8.

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HILLSIDE TERRACE

Definition:

A hillside terrace is a structure along the contour, where a strip of land is levelled for tree planting. Hillside terraces are up to 1 metre wide and constructed at about 2–5 m vertical intervals. Hillside terraces are only applied if there is a strong necessity justifying their construction.

Area of Applicability:

1. Agroclimatic Zones:

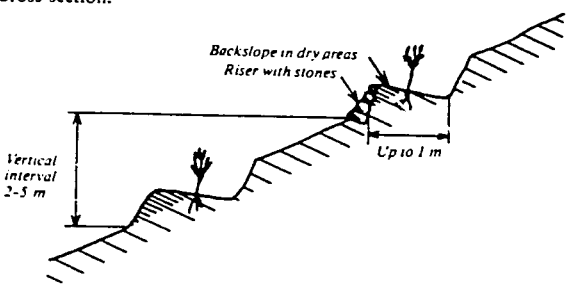
Moist Dega
Moist and Dry Weyna Dega
All Kolla

2. Local Situation:
a) Slope Range:
50 to 100%

b) Soil Range:
Only heavily degraded land

Specifications:

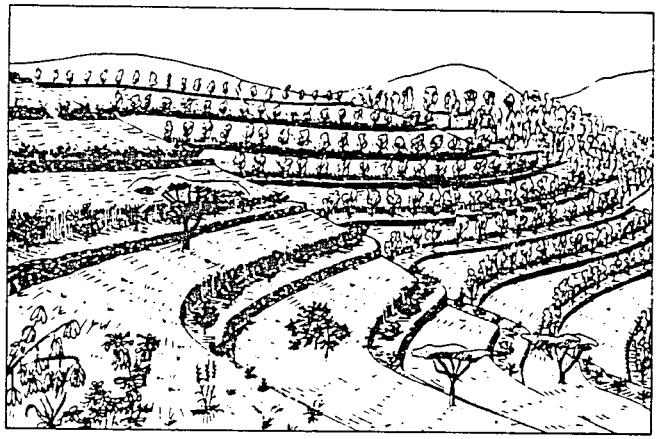
- Cross-section:



- Hillside terraces are mainly used to prevent damage of flood below steep slopes.
- They are lined out along the contour, the vertical interval between two terraces being 2–5 metres.

Effects:

Hillside terraces help to retain runoff and sediments on steep sloping land and to accommodate tree seedlings to be planted on them. They are also effective on badlands and in areas with low rainfall to conserve water.



On these heavily degraded slopes, hillside terraces were necessary. Trees were planted just recently, while terrace construction was done in the previous year to support soil formation around the pits. Spacing between trees is 2 m, and the vertical interval between terraces also 2 m. The area between two terraces is undisturbed and used for forage production.

Combinations:

Wherever AREA CLOSURE produces the same results, and if TREE PLANTING or MICROBASIN is sufficient, no hillside terraces shall be constructed. If degradation makes hillside terraces indispensable, combine with CUTOFF DRAIN and AREA CLOSURE, or mix with MICROBASIN. Add TREE PLANTING.

Materials:

Line levels, digging instruments, stones and as needed for combined measures.

Management and Maintenance:

Hillside terraces used for afforestation need little management except that TREE PLANTING has to be done carefully at the right location on the terrace (see figure on the left page) and at the right time. Regular weeding around the seedlings supports their stabilization and growth. The Peasant Association is responsible for hillside terraces on afforestation land. It also organises the use of the grassland between the terraces.

3.TREE PLANTING IN THE ARID AND SEMI-ARID LANDS BY USE OF MICRO-CATCHMENTS: GENERAL CONSIDERATIONS

As the name suggests a micro-catchment is a small catchment area. The catchment area is determined by the surrounding bunds and the run-off is concentrated in one corner of the micro-catchment (the lowest point) for use, primarily for tree planting, but can also be utilized for grass planting and even crops (eg. Sorghum and cow peas). Such micro-catchments vary greatly in size depending on local rainfall, slope and topographical conditions and can range from less than 25 sq.m. to 1,000 sq.m. (Evenari et. al.,1971).

In the Arid and semi-arid areas of Kenya (Kenya Eco-climatic zones IV-VI; Pratt and Gwynne, 1977) with high ambient temperatures a variable and sporadic rainfall (200mm to 600mm), establishment of trees using traditional forestry practises can be risky. Mortality is often high and soil erosion and run-off rates are often excessive. By using a system of micro-catchments it is possioble to optimize the use of the run-off for tree establishment and so reduce soil erosion.

Micro-catchments are used in different parts of the world to aid in tree establishment in areas where it would otherwise be very difficult. In Israel there are stands of trees established using 100 sq.m. microcatchments (or Negarim) in areas where rainfall is as low as 100mm per annum (Evenari et. al.1971).

Micro-catchments are one form of water harvesting that have a variable catchment to cultivated area which depends primarily on the rainfall (Pacey and Cullis, 1986). The basic principle of water harvesting is to collect and impound run-off water after rainfall events. For micro-catchments run-off is trapped within the catchment at the lowest point. Since micro-catchments are small structures, they are much more versatile in use than other forms of water harvesting and can be located anywhere provided the slope is less than 5% and the soil conditions are suitable. So since micro-catchments are so versatile in use and placement, they can be used where other forms of water harvesting are not applicable. This will include:-

1).Very small areas unsuited to other types of water harvesting (eg. around homes, schools, within settlements, areas which are not large enough to be suited to other forms of water harvesting and areas where extensive tree planting is being conducted).

2).Can be used on a large scale in the steeper areas (with a slope ranging from 3% to 5% . Such areas can be quite extensive, but it should be ensured that it is not going to compete with run-off for other forms of water harvesting.

Micro-catchments are cheaper to construct since only small terraces are made between the catchments. Further micro-catchments are not so topographically confined as compared to other forms of water harvesting. The relative water harvest is greater because less infilteration is lost to the catchment area (Evenari et al., undated). Low intensity rainfall can yield run-off in the micro-catchments where there would be none in larger water harvesting structures (Evenari et.al.,1971). Even saline soils can be used as such salinity with time is leached out in the micro-catchments (Evenari et. al.,1971)

The main use of micro-catchments for tree planting is to help in the critical stage of tree establishment (ie. from the time of planting to when the tree is well established, which is for the first one to two years). Two types of micro-catchments are discussed, the triangular micro-catchment for where trees are to be planted at a spacing greater than 10 metres and the box type micro-catchment for where the tree spacing is 10 metres. Both types of micro-catchment use the same construction techniques and work norms they only differ in their spacing.

The same construction principles can be used for different sized micro-catchments. In Turkana, Kenya the 10m x 10m micro-catchments have become the accepted norm, though they are considered overdesidnged to cope with the irregular and variable rainfalls (ranging from 200mm to about 400mm). In wetter areas, ie. 400mm to 600mm micro-catchments of 5m x 5m can be used.

4.VARIABLES THAT NEED TO BE TAKEN INTO ACCOUNT FOR MICRO-CATCHMENTS

4.1.Rainfall

Rainfall in the arid lands is very variable, from less than 200mm to over 400 mm. Run-off from rainfall is also very variable and will depend on soil type, soil cover and rainfall intensity. Generally the more intense the rainfall the greater the run-off.With increased rainfall the micro-catchments can be made smaller, since the catchments need not trap as much water after a rainfall event. If the micro-catchment is too large then the danger of localized water-logging and structure damage is increased.

Table 4.a. (adapted after Pacy and Cullis, 1986) below shows some examples of different micro-catchment sizes and other within field catchments related to rainfall and the catchment to cultivated ratio.

Table 4.a.

Area	Rainfall	Catchment to cultivated ratio	micro-catchment dimensions	micro-catchment dimensions	Source
Baringo	400-600mm	8:1	5 x 5 m	25 sq.m.	Barrow 1985
Turkana	150-400mm	8:1	5 x 5 m	25 sq.m.	
Turkana	150-400mm	11:1	10 x 10 m	100 sq.m.	
Israel	80-120mm	10:1	10 x 10 m 15 x 15 m	100 sq.m. 225 sq.m.	Shanon and Tadmor 1979
Arizona,USA	300-600mm	5:1			Fangmeier 1975
Arizona,USA	150-300mm	12:1			Morin and Matlock,1975

(Adapted from Pacey and Cullis,1986)

4.2.Soil Type

Since micro-catchments depend on localized rainfall run-off from the surrounding area, soil characteristics play a very important part. For instance sandy soils drain water very easily, so there will be less run-off after rain from such soils. While in other areas where the soils are heavy, and clay loams there will be an increased amount of run-off since the water can not easily drain into the soil.

The ideal soils for micro-catchments are those which cap easily (ie. the top layer of soil is very fine and caps over at the start of a rainfall event, so preventing any further infiltration and facilitating run-off) but with the lower layers being more free draining as this will allow for the run-off water to infilterate more quickly at the planting hole and so reduce the possibility of localized waterlogging. Such soils include loams, and sandy loams.

However in many areas the ideal soil type will not be realized. In some areas the soils are sandy but they cap and show reasonable run-off to occur which will allow micor-catchments to be used there. In other areas where the soils are more clayey in nature infiltration will be slow and so care should be taken concerning the possibility of waterlogging.

It is important that the soil be deep enough to store the run-off water and allow for proper root development. In this respect shallow soils should not be used. Some areas may have a superficial layer of stones (erosion pavement). These areas, provided the soil is deep enough, can easily be used for micro-catchments.

4.3.Siting

Micro-catchments should be used in areas where large scale tree plantings are to be undertaken or where the area is too small for any other form of water harvesting structure. Micro-catchments cannot be used in all conditions. Sands cannot be used because there is no run-off. While clayey soils do not allow for the water to soak in well and this can cause the young trees to die from water-logging. Also the water does not sink deep into the soil, instead it often spreads to the sides. So in the dry season it will dry up.

The Ideal soil type is a sandy loam where, when it rains, the water runs off the surface to the planting pit and then can soak into the soil well. The soils should also be deep so that they can store the water for the dry season. Shallow soils on top of rocks are not suitable. Generally micro-catchments should be constructed on fairly level land with a slope of no more than 5%. Though a slope of 2.5% is a better maximum.

5.CONSTRUCTION OF MICRO-CATCHMENTS FOR ESTABLISHMENT OF TREES

The following equipment is required to lay out micro-catchments:

a). Two pieces of wood at least 1.5m high. Both sticks should be of the same length and have a notch at the same place to tie the string.

b). One Masons line level (the longer the level the better).

c). One bit of fine strong string 14 metres long (for micro-catchments with a total area of 100 sq.m.). The String should be knotted in the middle as this will be the place where the line level should be during measurement.

d). One bit of string 20 metres long with a knot at the 10 metre mark. This bit of string will be used to lay out the micro-catchment on the ground in preparation for digging.

For 5m x 5m sized micro-catchments the measurements should be halved.

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b).Use of Line Level

If a field of micro-catchments is to be laid out then lay out should start at the highest part of the field working down towards the lowest part.

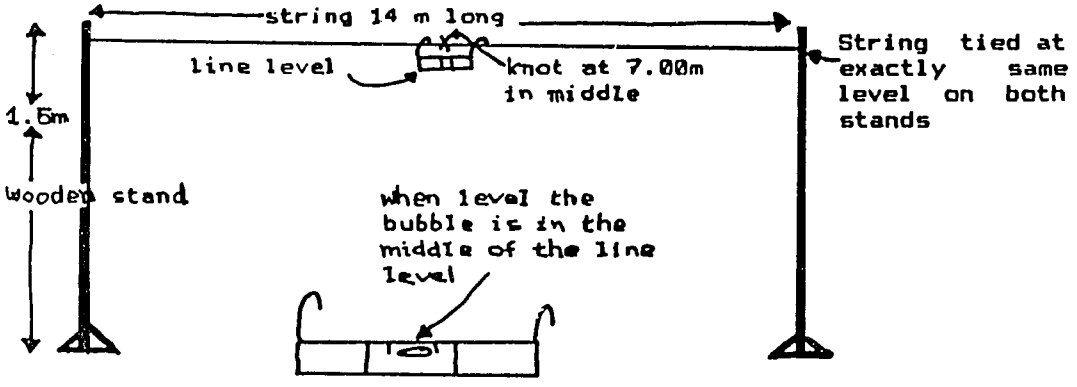
a). The string 14m long should be tied to the notches of the two wooden stands. The two wooden stands should be stood roughly on the contour with the string tight (this will mean that the wooden stands are 14 metres apart). The Line level should be placed so that the knot in the string lies directly above the mid point of the line level. This will help make the readings more accurate.

b). To check whether the two stands are level on the contour the bubble should be in the middle of the line level. If it is not then one or other stand should be moved up or down until the bubble is in the middle of the contour.

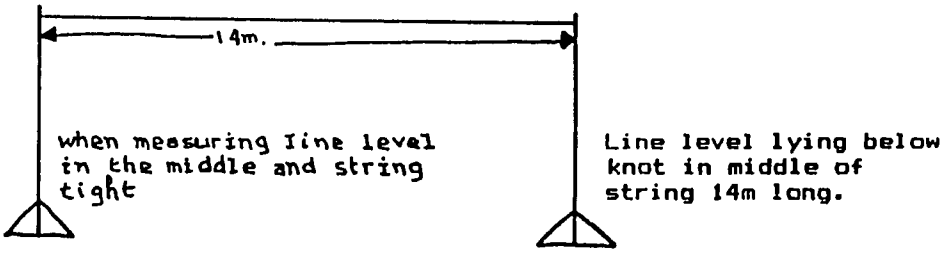
c). Once the bubble is in the middle of the line level then the two stands form two corners of the micro-catchment, and are on the same level.

Diagram 1:Layout of a Micro-catchment use a Line Level

a). Line Level and Stand



b) Means of Measuring



c). How to Move stand up and down

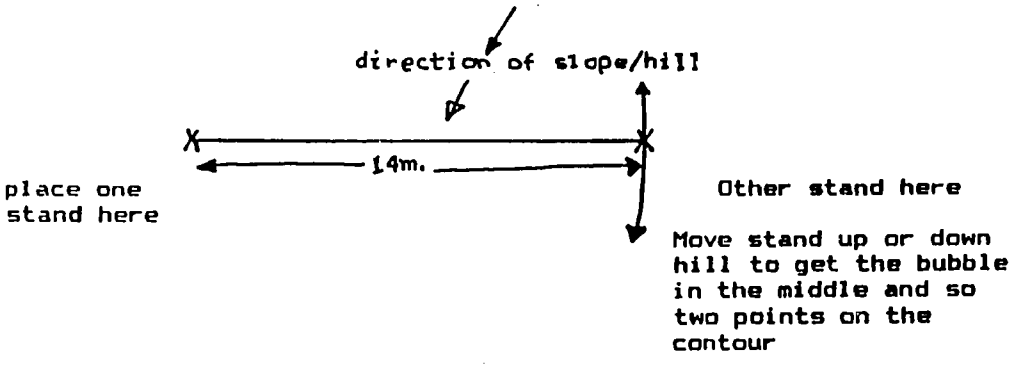


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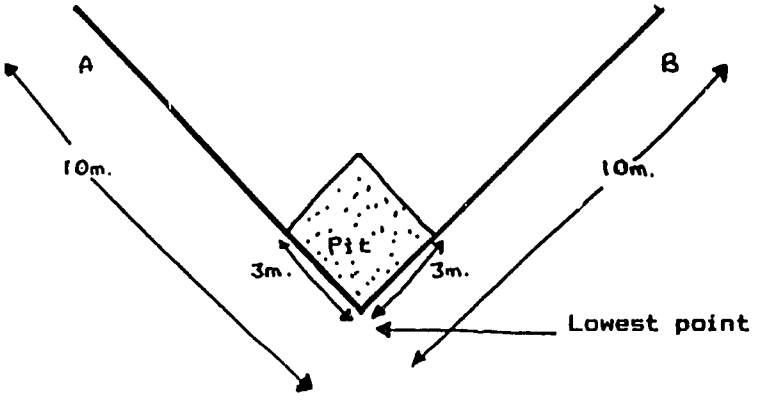
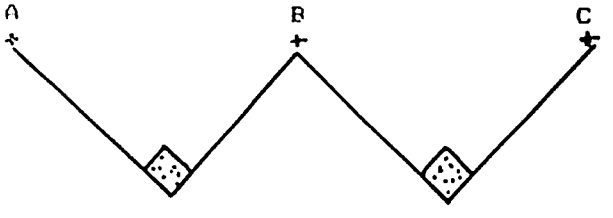
Diagram 2: Layout of Micro-catchment



d). The lower corner can be identified by using the 20 metre bit of string with a knot at the 10 metre point. A person should hold one end of the string to one post(A). Another person should hold the other end to the other post(B) while a third person takes the mid point where the knot is and walks down hill from the two posts until the string becomes tight. This will give you two sides of the micro-catchment (which can be marked with a stick) as well as the lowest point of the micro-catchment where the pit will be dug.

e).This can form a single 'V' Shaped mirco-catchment and is now ready to be constructed. However if more micro-catchments are to be constructed then:-

Diagram No.3:Layout of More microcatchments
a).Second Micro-catchment

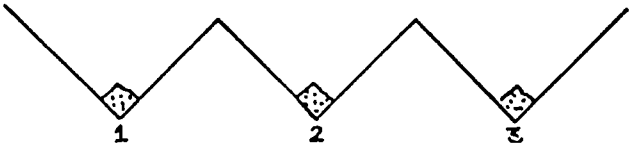


move up & down until bubble in the middle

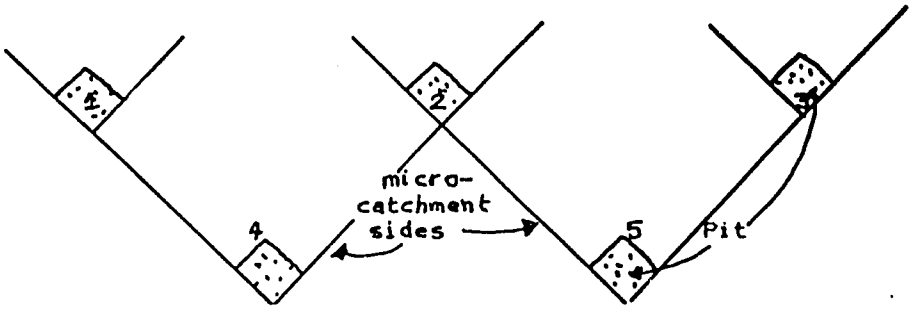
With Micro-catchment at Point A and B laid out, the person at point A moves to Point B, and the Person at point B moves to point C. At point C the stand should be moved up and down until the bubble is in the middle. Then Mark that point and lay the micro-catchment out. Then Move on and mark out the next micro-catchment and so on. In this way the first line of Micro-catchaments will be laid out. In order to prevent breakage from run-off coming in either a terrace can be built on the outer edge to take any run-off away or the first line of micro-catchments can be built bigger (to a height of 40cm well compacted soil.

Diagram No.4 Second and Sub-sequent lines of Micro-catchments

If the first line of micro-catchments have been laid out properly then the next line is relatively easy.



Since points 1,2 and 3 should be on the contour(as they are th. lowest points of the micro-catchment), section (d) above should be repeated to lay out the second line of micro-catchments.



However this may not be totally accurate as the distances between 1, 2 and 3 may not be the same. So place the stands and move them up or down the sides of the micro-catchment at point 1,2 or 2,3 until the string is tight and the bubble of the line level is in the middle. Then lay out the micro-catchment. In this way a field of micro-catchments can be quickly laid out.

c). Micro-catchment construction

The planting pit acts as a borrow pit supplying soil for construction of the bunds on either side of the pit in the micro-catchment.

Diagram No.5:Construction of Micro-catchment

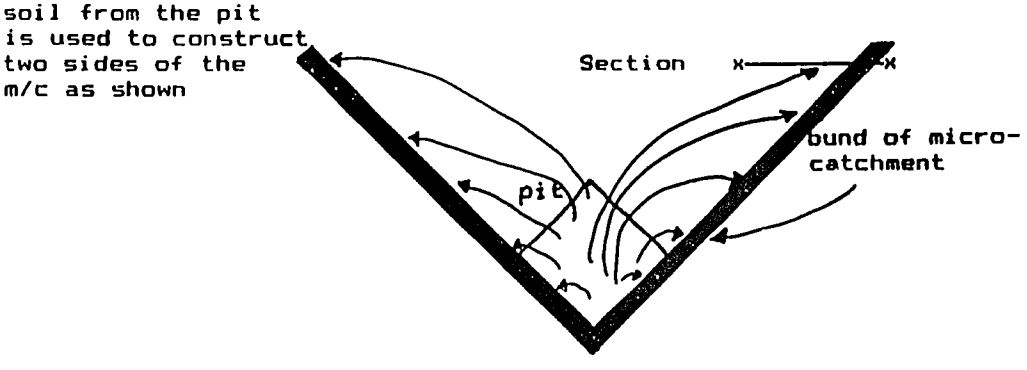
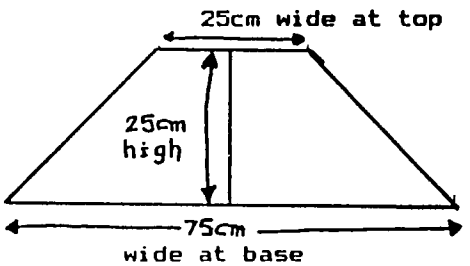


Diagram 6.a:Section of Micro-catchment bund(Section XX of Diagram 5)



Dimensions	10m x 10m	5m x 5m micro-catchment
dimensions of pit	2.5m x 2.5m x 0.4m deep	1.0m x 1.0m x 0.4m deep
Volume of pit	2.5 cubic metres	0.4 cubic metres
Length of two bunds	10 metres x 2 bunds	5 metres by two bunds
Bund height	25 cm	15 cm
base width of bund	75 cm	50 cm
Top width of bund	25 cm	15cm
Volume of bund	2.49 cubic metres	0.36 cubic metres

Note:
a).Ensure that the bunds are well compacted by stamping on it.
b).Only take the soil from the planting pit.
c).The bund should be the same height all round (ie. 25cm)

Approximate Capacity of 10m x 10m micro-catchment to hold water
a).Capacity of pit...2.5 cubic metres or 2,500 litres.
b).Capacity of the micro-catchment assuming that it is roughly flat will be.....25 cubic metres or 25,000 litres.
c). This gives a total capacity of 27.5 cubic metres or 27,500 litres.

Capacity of micro-catchment to hold water

Rainfall in mm	Amount collected in micro-catchment
10 mm	1,000 litres
20 mm	2,000 litres
30 mm	3,000 litres
40 mm	4,000 litres
50 mm	5,000 litres
60 mm	6,000 litres
100 mm	10,000 litres

Thus there is very little chance that the micro-catchments will ever be totally be filled with water even accounting for cumulative rainfall over a period of a week. The micro-catchments are over designed for the following reasons:
a).Great differences in soil types in different places
b).So that different designs do not have to be made for different slopes and rainfall conditions. In future when micro-catchments have proved themselves then changes may be made to the basic structure to allow for differences in soil types, rainfall etc.
c). This design allows for rainfall over a number of days to be stored in the catchment

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d).Where in the micro-catchment should the tree seedling be planted?

Diagram No.7:Where to Plant in the micro-Catchment
Diagram No.7a:Surface view of Micro-catchment

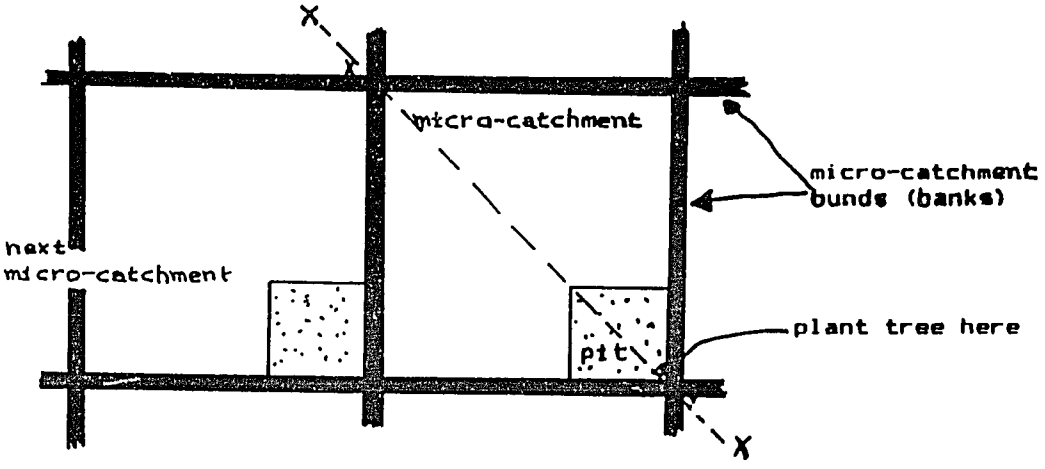
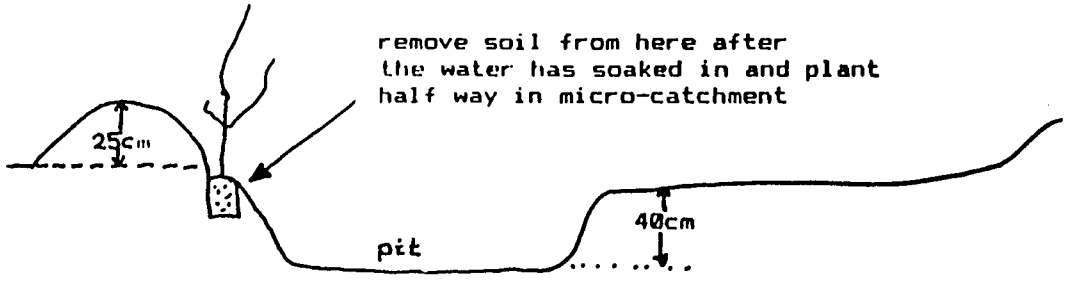


Diagram No.7b:Section view of micro-catchment (ie side view) from Point XX



a).Do not plant the tree seedling in the pit of the micro-catchment as the young seedling may get water-logged and die.
b).Do not plant on top of the terrace as the young seedling may not get enough water.
c). Plant the seedlings when they are a good height. The seedlings should be at least 20cm high before they are planted.
d).The seedling should be planted at the base of the bund in the corner above the pit.
e).If for any reason no seedlings are available then lightly dig in or throw in 1 to 2 gallons of goat manure. When it rains a lot of seedlings will germinate which can then be thinned out later on.

6. SMALL SEMI-CIRUCLAR BUNDS TO ENCOURAGE GROWTH OF YOUNG NATURALLY OCCURING TREES.

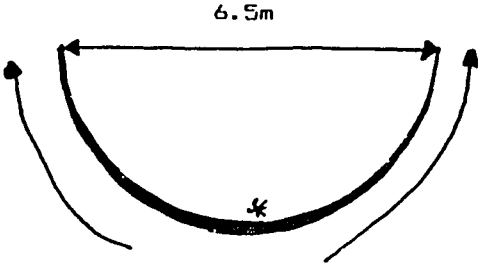
In Turkana there are certain areas with very many young *Acacia tortilis* trees which are often kept small by goats browsing on the branches. There may be other young trees as well. If the amount of water available to the young trees during the rains can be increased then such trees will grow more quickly and so escape browsing.

This is quite simple to do. In this case it involves making a small semi-circular contour bund around the young tree. The tips of the bund should be on the contour. The semi-circular bund should have a radius of about 3.25m (see diagrams below). The soil for the bund should be scraped from the area within the semi-circular bund to a depth of about 10cm. But care should be taken not to take soil from around the base of the young tree. This soil will then form the bund which should be 0.50 metres wide, and about 30 cm high remembering to compact the soil (see diagram).

Such a system will provide a lot of extra water during the rainfall times and allow a greater quantitiy of water to be stored in the soil which will then encourage the tree to grow quickly and establish itself out of goat reach. Excess water can drain away from the tips of the bund which are built on the contour.

Each young tree will have to be laid out seperately as follows:
a).Site the young tree so as to be in the lowest point of the semi-circular bund.
b).With two pieces of wood (as for micro-catchments) with a length of string 6.5metres long, knotted in the middle (at 3.25m) and using the line level find the the tips of the semi-circular bund so that they are on the contour and the radius is 3.25. To measure the radius use the middle of the string (at 3.25m) and the point 1 metre behind the tree and use that as the place to lay-out the semi-circle.
c).Lay out the semi-circluar bund and construct.

Diagram:Surface view of Semi-circular bund around an young tree.



approx. 10m around the sides

Diagram:Section view of Bund of Semi-circular bund

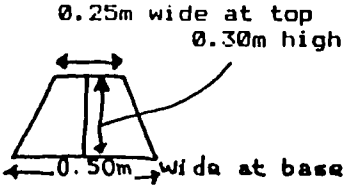
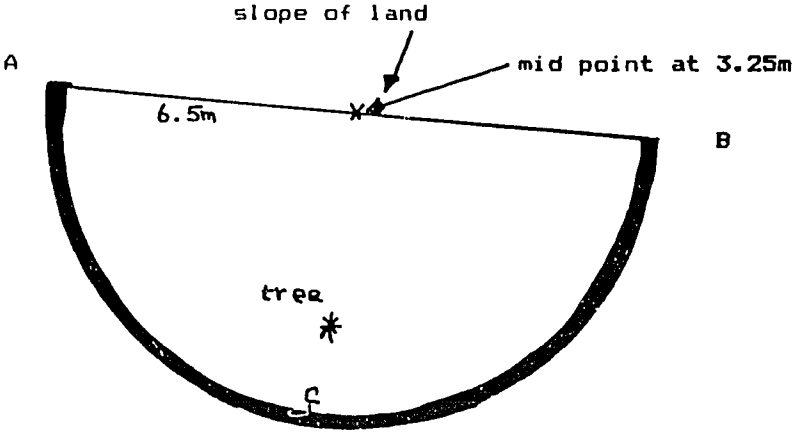


Diagram:Layout of Semi-circular Bund



Find the slope of the land and then get the two stands on the contour so that the point C is 3.25m from the centre of the string between A and B. Use a piece of string and stick and draw a line connecting points A,B and C. This will form the semi-circular bund.

This section can be linked to watering(if necessary) and protection of naturally growing young trees since in many parts of Turkana naturally growing young trees occur that may be prevented from growing for one reason or other, usually because they are being continually browsed by goats. This is particularly so for Acacia tortilis, which occurs frequently as a small apparently stunted very thorny small bush. Such trees are not naturally small rather it is a reaction to:-

a). Lack of rainfall to allow for good growth
b). Continued browsing by goats, the thorns prevent the goats from totally destroying the plant since they can only nibble at the tips.
c).Under favourable conditions, ie. in years of very good rainfall, such trees can grow very quickly and grow out of goat reach so they are no longer liable to destruction by browsing. This is because the trees have a very well established root system which allows the tree to grow very rapidly after good rains.

Thus the young trees (for ex. Acacia tortilis, Acacia albida, Cordia sinensis and Salavadora persica) are potentially very usefull trees that with a little care could grow much more quickly.

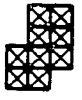
TREE PLANTING

Definition:

Tree planting for conservation is an activity to improve the vegetative cover of the ground, thereby reducing runoff and soil erosion and producing wood. Tree planting supports many other conservation activities if combined with them. Tree planting by itself is a soil conservation measure because the tree roots stabilize the soil and the tree protects the ground from raindrop impact.

Area of Applicability:

1. Agroclimatic Zones:



All Wurch
All Dega
All Weyna Dega
All Kolla

2. Local Situation:
a) Slope Range:
All

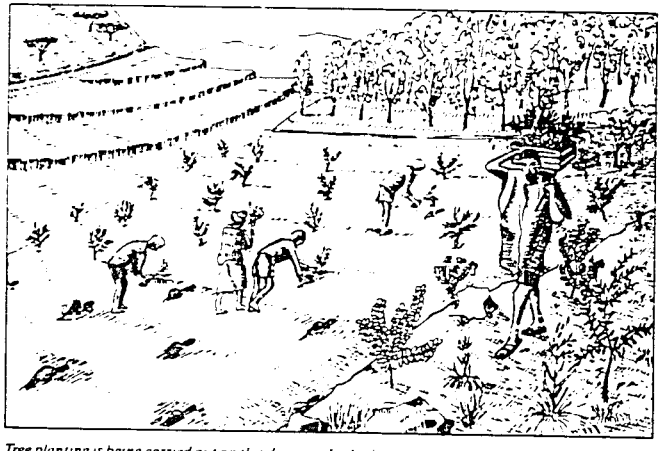
b) Soil Range:
All except highly degraded land

Specifications:

- Select planting site after consultation with the Peasant Association. Prepare pits for planting, either on physical structures or simply along the contour (page 85): Each pit has a width of 25 cm, and a depth of 40 cm. Generally, they are spaced at 2 m and for eucalyptus trees at 5 m.
- In highly degraded areas, apply AREA CLOSURE for 1-2 years before planting.
- Pits are kept open for 3-12 months before trees are planted in order to support soil formation around them.
- In areas with two cropping seasons per year, plant trees during the first rains. Plant drought-resistant species as early in the rainy season as possible.
- For nursery development, collect direct information from existing nurseries as well as specific manuals (page 89).
- Suitable tree species for different agroclimatic zones see page 90.
- Transport of tree seedlings must be very careful. Put enough soil around roots. Check that the soil has sufficient moisture. Seedlings must be transported in boxes, tins or other containers.

Effects:

Tree planting by itself is conserving soil and water. Through pitting, only a minimum of soil is moved. Thus, the slope remains stable and resistent against erosion. Especially in wet agroclimatic zones, tree planting does not need any additional conservation measures. Trees provide close canopy, improve infiltration of moisture in the soil, provide mulch and organic matter, recycle nutrients and provide high protein manure or animal feed. Besides, they produce wood and other products for various uses.



Tree planting is being carried out on this drawing. In the foreground to the right, a man carries a box with well protected seedlings. Trees on the slope are planted in rows. Pits have been excavated months earlier. After removing the plastic sack, tree seedlings are planted by putting soft earth around each. A cutoff drain protects the field from runoff coming from the grown-up forest above.

Combinations:

AREA CLOSURE is always combined with tree planting. HILLSIDE TERRACE is applied mainly on steep slopes of moist and dry areas. MICROBASIN mainly on gentle to medium slopes in moist and dry areas. CUT AND CARRY for undergrowth vegetation.

Materials:

Seeds or seedlings of tree species are selected according to the requirements of the farmers. A small nursery can be established nearby if knowledge about seed preparation and raising of seedlings exists. Line level, digging instruments.

Management and Maintenance:

Tree planting has to be organised through the Peasant Association, which also has the responsibility for community forests. Growing plants are observed for weed competition and insect damage. Fodder trees are allowed to grow for two years without pruning. Maintain planted trees for at least 5 years until survival is ensured. Irrigate during short drought periods. Completely exclude cattle from planting site. Supervision of the growth of planted trees is organised by the Peasant Association.

MICROBASIN

Definition:

A microbasin is a small structure with the shape of half or a full circle, excavated to obtain a small basin for planting a tree. Microbasins have sizes according to their designation to conserve water, being small in moist and large in dry agroclimatic zones.

Area of Applicability:

1. Agroclimatic Zones:

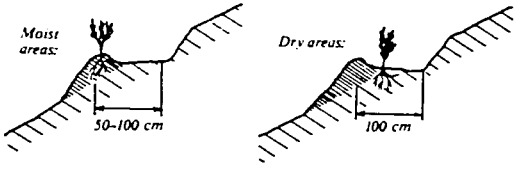
Moist Wurch
Moist Dega
Moist and Dry Weyna Dega
All Kolla

2. Local Situation:
a) Slope Range:
All

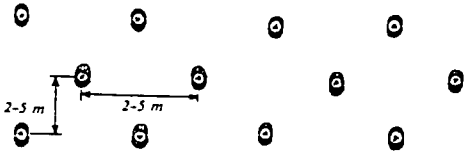
b) Soil Range:
All except highly degraded land

Specifications:

- Cross-section:



- Spacing/Placement:



Effects:

Microbasins have multiple effects: In moist areas, they provide a small platform for TREE PLANTING. In dry areas, they are used to harvest water from a larger area (2-3 m diameter) on gentle slopes, sometimes with additional water collection ditches. Microbasins support soil formation through the movement of soil for construction.

Microbasins are used for tree planting in this dry area. Pits were dug in the centre of the basin for optimum use of stored water. The farmer plants a tree after removing the plastic sack around the roots of the seedling. Soft earth was prepared beside the pit to accommodate the seedling in the pit. The microbasins were prepared in rows, always one microbasin in the lower row between the two microbasins of the higher row.

Combinations:

AREA CLOSURE is combined with microbasins, as is CUTOFF DRAIN below or within degraded forest land. Mixed with HILLSIDE TERRACE, they are used as an economic means of water conservation.

Materials:

Digging instruments, line level, tree seedlings and as needed for combined measures.

Management and Maintenance:

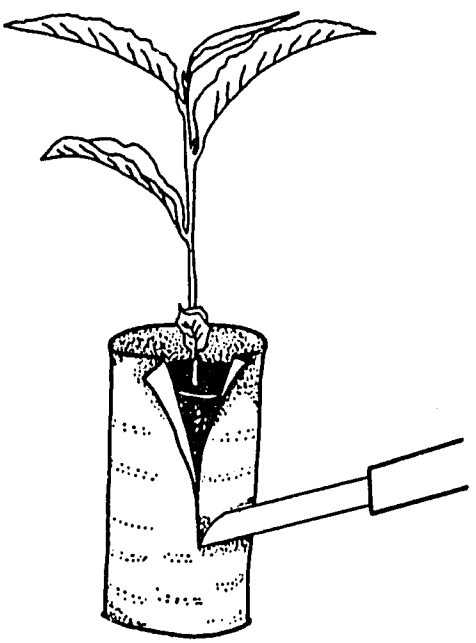
Microbasins have to be carefully lined out on the slope with intermittent placements for runoff control and proper spacing. Their size should be small in moist (1 m diameter), and large in dry areas (2 m). After tree planting, microbasins need little maintenance. AREA CLOSURE must be organised by the Peasant Association.

Useful information: PLANTING OUT

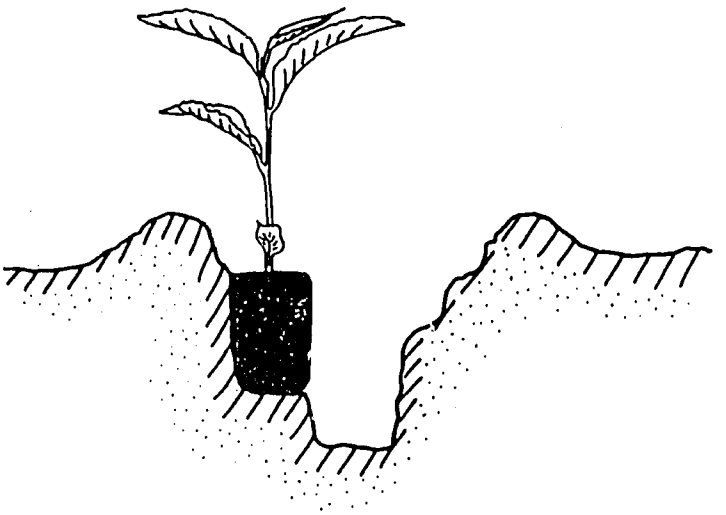
1. What do we mean by 'planting out!
   It is the transferring of seedlings from the tree nursery to the field.

2. When do we plant out?
   At the beginning of the rains. The seedlings should be about 5 months old.

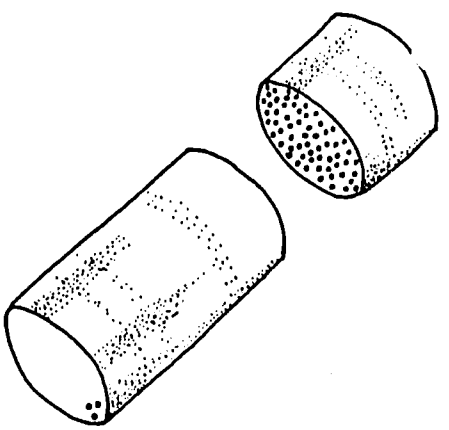
3. How do we plant out?
   - about one hour before planting out you should pour water into the holes upto one quarter of their depth
   - cut and remove the pots of the tree seedlings to expose the blocks of soil. Never plant tree seedlings with their pots because this will prevent the roots expanding sideways.



   - trim the long roots in necessary
   - if the seedlings are overgrown you should pluck off a few leaves. This will reduce the stress caused to the seedlings by excessive evaporation of water from the leaves
   - place the seedlings into the raised side of the holes which you have previously dug. The top of the block of soil in which the seedling has been growing should be level with the ground level. If the block is lower, then place some soil back in the bottom of the hole to lift the seedling to the correct height. If the block is too high you should dig the hole a little deeper. (see the illustration).



- take 2 tins which are of the same diameter. Using a nail make several holes in the base of the top tin. Then make 3 small holes on the edge of the bottom surface of the lower tin. (The tops of the tin should be removed completely).



- place the two tins into the deeper side of the hole with the 3 holes of the bottom tin nearest to the seedling. The bottom of the lower tin will be below the block of soil in which the seedling is growing. This will encourage the tap root to penetrate deep into the soil.

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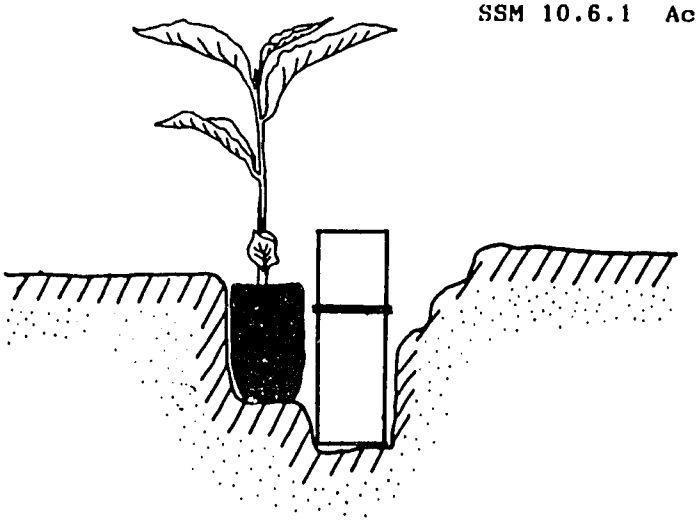
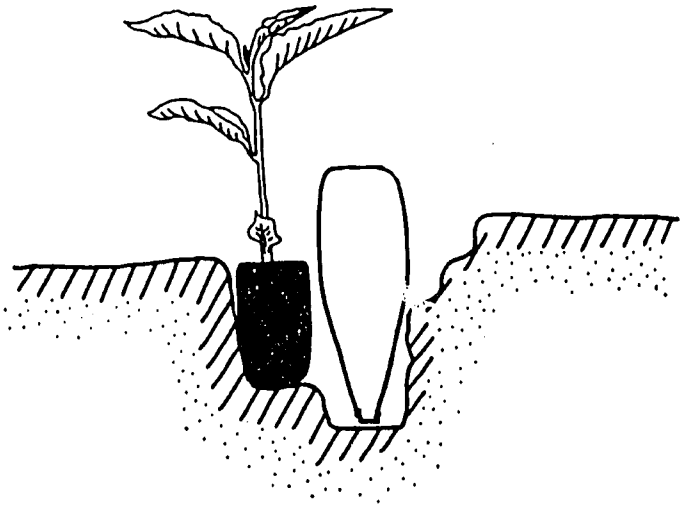


- make sure that the upper tin is about 5cms above ground level. Fill in the hole with top soil and then pour water into the tin.
  (The tin should be raised above ground level to prevent soil and other materials falling into the tin and blocking the holes)
- cover the tin with a stone or lid to reduce loss of water by evaporation.

4. Why should we mulch?
   By spreading dry grass or stones around the planted out seedlings we can reduce the evaporation of water from the surface of the soil.

5. How often should we water the planted out seedling?
   Each seedling should be watered everyday by topping up the tins.

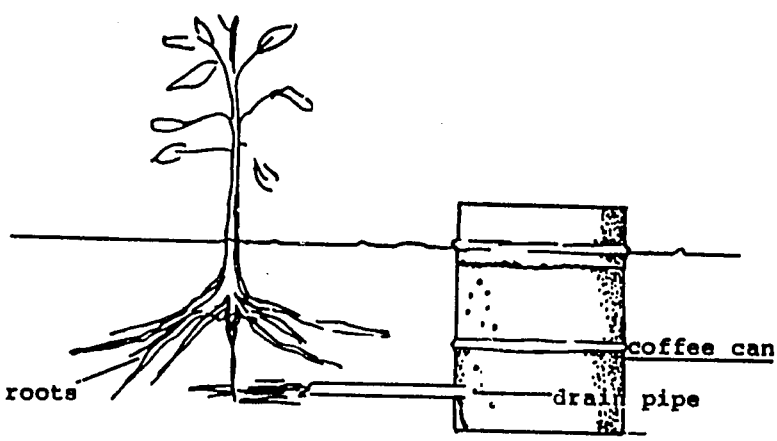
6. How else can we water?
   By using a bottle.
   The bottle should be buried into the soil so that only a quarter of it remains about the surface.



7. Why should the tins and bottles be so deep in the soil?
   To ensure that the water is supplied deep in the soil. If the water is deep the roots will go deep. If the water is poured on the soil surface the roots will not penetrate deep down but grow near the surface. When this happens the seedlings will not be able to resist drought during a dry season because they have not developed roots down to the lower levels in the soil where there is water.

8. Why should we make a small fence around each seedling?
   - to prevent animals eating them and destroying them
   - to prevent people and animals from treading on them
   - to protect them from intense sunlight and to reduce evaporation of water.

   Twigs, thorns and other materials should be used to construct a protective barrier around each tree seedling.



(Fig. 23) Can Collection

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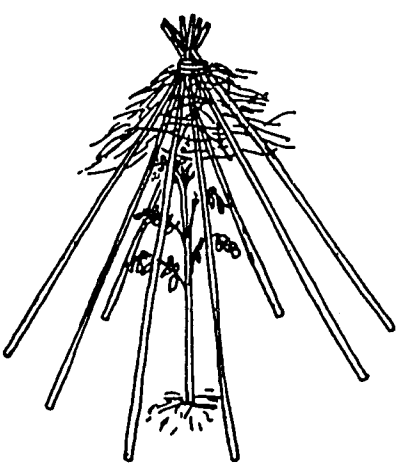
	Learning Element	Code:
	Title: Maintenance and Protection of Young Trees **Occupational Area:** GROWING TREES	**Date of Issue:** Nairobi May 1984 **Page:**

3) In arid and semi-arid areas, build a shade to protect the tree from the sun burning the leaves. Using the structure you made for protecting the tree, place grass or leaves through the sticks near the top of the structure. Another method is to place 4 poles in a square around the tree. Connect all sides of the square with sticks. Once this is done place grass or leaves on top of the sticks tying down the ends.

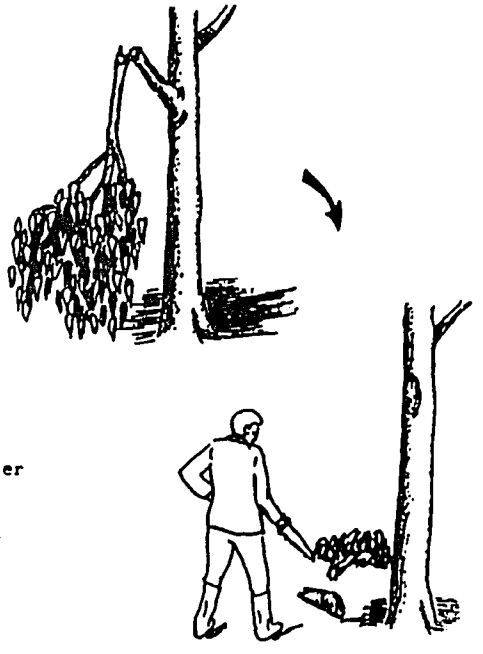


	Learning Element	Code:
	Title: Maintenance and Protection of Young Trees **Occupational Area:** GROWING TREES	**Date of Issue:** Nairobi May 1984 / **Page:**

8) Until the tree becomes strong enough, you will have to weed around the tree. Otherwise the weeds will take water and food that the tree needs to survive.

9) In time of drought you will have to water the tree until it becomes established. You do not need to use fresh drinking water. You can use dirty water, such as water used after washing dishes and hands. Do not use water with chemicals in it or salt water.

10) Sometimes people will damage trees. If you see someone damaging a tree, report him to the local forest officer, Chief or Police. If the damage is a broken branch or an open wound you can fix it, if it is not serious. With a broken branch, cut the branch as close to the tree trunk or larger branch, as possible. Use a pruning saw. Do not use a panga. The closer you cut the trunk or branch the better the wound will heal. With an open wound try and fill the wound with gum resin, a tar substance or just paint over the wound.



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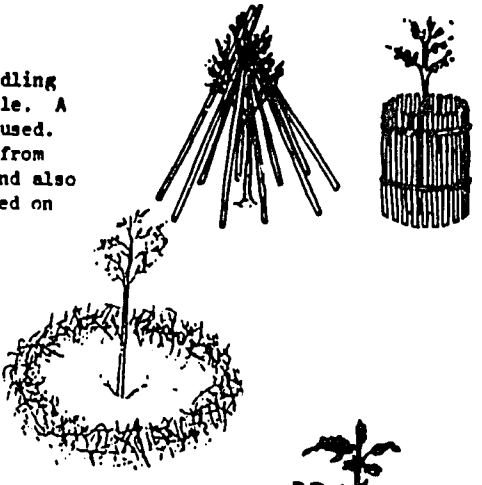
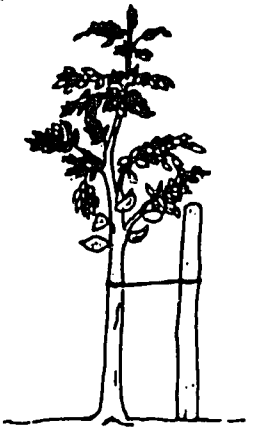
	Learning Element	Code
	Title: How and When to Plant a Tree	**Date of Issue:** Nairobi May 1984 / **Page:**
	Occupational Area: GROWING TREES	

6) Water the seedling by filling the well you made with water.

7) Place sticks around the seedling forming a pyramid or a circle. A ring of thorns can also be used. This will protect the tree from animals eating the leaves and also protect it from being stepped on and trampled.



8) When the tree is 3 feet tall or larger, place a stick in the ground near the tree. Tie a string or rope around the stick and connect it to the stem of the tree. This will support the tree while it is growing.



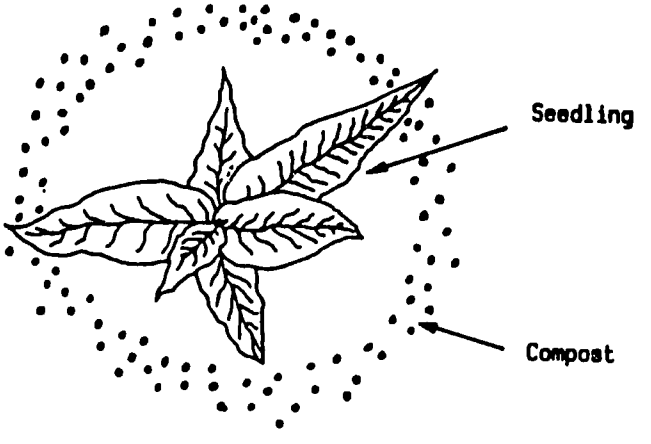
Useful information: CARING FOR PLANTED OUT SEEDLINGS

1. Why do we need to care for the seedlings we have planted out?
   Because they are still young and vulnerable to:
   - drought
   - competition from weeds
   - goats looking for something to eat.

2. Weeding.
   You must begin weeding as soon as the weeds appear.
   As you weed you should loosen the soil around the plants to a depth of about 5cms. (This is particularly necessary if a hard crust or pan of soil has formed over the soil surface). Loosening the soil will allow the water to soak into the soil instead of running over the surface.
   Do not dig too deep or you will cut or damage the smaller roots of the seedlings.

3. Microcatchments.
   Unless the microcatchment is kept in good condition it will not be effective in catching the water for the tree seedlings.
   Make sure that the embankments are high enough and that any breaks in it are repaired.

4. Compost.
   Only apply compost after you have weeded and loosened the top soil around a seedling. The compost must be well rotted. Apply 2 big handfuls (this will be 3 or 4 handfuls for children) around each seedling. Place it in a ring around the tree seedling so that it is about 5 or 6cms away from the stem, and then mix it into the soil.
   (If the compost is in contact with the stem it may cause burning or rotting).
   (See the illustration).



5. Maintaining the individual protective fences.
   The fence is needed until the tree seedlings are too tall for goats to be able to reach the leaves.
   Ensure that the sticks have not been removed.
   Ensure that the sticks are taller than the seedlings.

6. Watering.
   Continue watering once a day for the first one month.
   After this water every other day and continue until the beginning of the next rain season (in March).

TREE MANAGEMENT GUIDELINES FOR SIAYA AGROFORESTRY INTERVENTIONS: CARE-KENYA AGROFORESTRY EXTENSION PROJECT

Introduction

The following are general management guidelines for agroforestry interventions currently being implemented in Siaya through CARE's Agroforestry Extension Project. Tree management aspects of agroforestry system development and improvement remain primarily in the experimental realm, as there has not yet been time to generate substantial experience. The following basic principles, therefore, need to be applied to the use of these guidelines: 1. flexibility, and 2. farmer determinism.

In other words, the project extension team should use the guidelines as material for generating, together with the farmer, ideas for developing the most opportune management strategy for a particular set of circumstances. In deciding upon specific management strategies, the farmer should be allowed to take the lead, if he or she chooses to, and also to have the "last say" in how a system will be developed and managed. Rely on farmer know-how. (In Siaya, for example, farmers generally are quite familiar with managing trees for poles, and about coppicing.) But provide the farmer food for thought and initiate the management dialogue with the aid of the following material.

The Guidelines were developed as follows: Project Consultant, L. Buck, developed list of proposed/tried interventions and grouped them according to major feature and product components (August, 1985). Several project Field Officers then were interviewed for their ideas and understanding about management strategies to be applied with respect to the various interventions. The concensus of opinion on management was written down, and the Project Manager interviewed by the Consultant for substantiation and/or modification thereto. The Guidelines represent the product of these inputs. It is suggested that as ideas change and/or become more specific, the Management Guidelines be modified accordingly so they remain up to date with project experience.

Tree Management Guidelines for Respective Intervention Classifications

I. Nitrogen-fixing trees in Alleys (densely planted tree rows between rows of cereal crops) for Soil Fertility Improvement and Firewood.

A. Design Objectives

1. To produce nitrogen-rich leaf litter as fertility improving mulch.

2. To produce stickwood for woodfuel.

B. Management Strategies

1. Leucaena leucocephala

When Leucaena trees one year old, prune branches prior to onset of rains. Lay branches between crop rows. (Rain will decompse leaf litter, so nitrogen reaches soil and is available to maize/sorghum when needed early in the growing cycle.)

The next season, cut Leucaena stem at height convenient to farmer (between hip and breast height). Used coppiced material as above.

About two months into growing season, when the cereal crop begins flowering, may cut back coppiced material (regrowth) from Leucaena for additional biomass. (Feasibility of second cutting per season depends on soil and rainfall conditions, ie; how fast the Leucaena regenerates. In high potential areas four Leucaena cuttings per year is potentially feasible; in dryer areas fewer cuttings are possible.)

2. Sesbania sesban

During second season after planting, prune lower branches about two weeks before the onset of the rains. Lay cuttings between maize rows, and collect sticks for firewood after leaves have decomposed. Repeat for 2 to 4 seasons before tree expires, depending on growing conditions and tree performance. After two to three years cut stem to the ground for firewood.

3. Sesbania grandiflora

Manage generally as in No. 2. above. This Sesbania species, however, grows in higher potential areas than sesban, and has a longer life span. Manage, therefore, with consideration to growth rate and longevity factors.

4. Calliandra calothyrsus

After first season cut tree stem for coppicing and use cuttings as suggested above. Continue harvesting and using coppiced material each season. Multiple cuttings per season may be possible as in No. 1, above.

5. Markhamia platycalyx

Markhamia is a relatively slow grower, and its leaves require longer to decompose than the relatively fast growing species listed above. No management is applied until the second or third year. Then, have farmer experiment with pruning and laying-in branches at various intervals after harvesting of cereal crop.

II. Dry Season Fodder Production With Woodfuel by-Product in Border Plantings (inside existing fence), or Woodlots

A. Design Objectives

1. To produce livestock fodder supplement during dry season; plant between 50cm and 2m spacing

2. To produce stickwood for woodfuel.

B. Management Strategies

1. Leucaena leucocephala

After two to three seasons, depending on growth rate, cut tree stem and use cuttings as fodder. Allow to coppice and harvest coppiced material when necessary throughout dry seasons. Use browsed branches as woodfuel.

III. Pole and Firewood Production from Windbreaks

A. Design Objectives

1. To establish a single or double row windbreak to protect cropland or homestead.

2. To obtain poles for domestic use and/or sale.

B. Management Strategies

1. Cassia siamea.

Plant trees 50cms to 1m apart. After two years thin trees to 1-1.5m, using thinnings as poles and firewood. Allow remaining trees to grow as windbreak.

IV. Pole, Firewood Production and Shade

A. Design Objectives

1. To provide shade for the homestead.

2. To provide poles and/or firewood.

B. Management Strategies

1. Cassia spectabilis

Plant trees at about 2m espacement. Prune lower branches each season for firewood, and to encourage upward growth for poles. As upper canopy develops trim for desired level of shade production. If additional poles desired, cut tree stem and use straight coppiceed material for poles. (On fertile soils, poles from coppicing likely to be straight, on infertile soils they are likely to be crooked.)

V. Border Plantings for Poles and Firewood

A. Design Objectives

1. To produce poles for home building and/or cash.

2. To produce firewood for domestic use.

B. Management Strategies

1. Cassia siamea

Trees planted at 2m spacing on border. After first season, before rains, prune lower branches to encourage good upward growth for poles. Continue each season, usings trimmings as firewood, until pole height has been achieved. Then harvest poles. If farmer wants to maintain live fence along border, encourage dense hedgerow plantings and thin the straight trees for poles. Cut less straight trees each season at fence height, and use coppiced material for firewood. (Where soil fertility is poor, more substantial thinning required to obtain straight poles.)

2. Calliandra calothyrsus

During second season, or when root system has been firmly established, begin pruning lower branches for firewood, and continue each season until desired height for poles is reached.

VI. Border Plantings for Timber, Poles and Firewood

A. Design Objectives

1. To produce timber and/or poles for household use and/or cash.

2. To produce firewood for domestic use.

3. To establish or maintain productive farm or field borders for demarcation.

B. Management strategies

1. Grevillea robusta

Plant at about 2m spacing along the border. Prune lower branches when tree is about 1m high to encourage upward growth for poles; do not cut branches that develop above 2m. Cut trees for poles as required, or allow to develop into timber trees.

2. Markhamia platycalyx

Plant at about 2m spacing along the border. Begin pruning lower branches when trees 1m to encourage upward growth. May experiment with cutting stem to coppice, using small coppiced material for firewood, and allowing one or two shoots to grow as poles. Leave for timber trees unsuitable for poles.

3. Maesopsis emenii

This species is self-pruning to large extent. Plant relatively densely; about 1m. Thin out poles, leaving large tree every 10m for timber.

4. Terminalia brownii

When tree about a meter high prune lower branches for good upward growth, using cuttings for firewood. Thin out good oples and replant. Use remaining trees for timber.

5. Casuarina equisetifolia

This species is essentially self-pruning. Thin poles at desired hieght and replant. Trees that appear inferior for poles may be cut for firewood.

VII. Cropland Plantings for Timber, Poles, Firewood and Mulch

A. Design Objectives

1. To produce timber and/or poles for cash and/or domestic use.
2. To produce firewood for domestic use.
3. To improve soil fertility and structure, and therefore crop yields, from nutrient-rich tree litter.

B. Management Strategies

1. All of the trees listed in VI., above, may be planted at wide spacings throughout the cropland (3-10m or more, depending on the species, soil and rainfall conditions, and farmer preference. Pruning of lower branches to be done as indicated above for respective species, to encourage upward growth, and to obtain firewood. Shade effects of these species should be minimal, but additional crown managment may be desired, particularly if closely spaced. Leaf litter may be allowed to decompose where it falls, or may be collected and redistributed if desired.

VIII. Hedgerows for Fences, Fodder, Firewood, Poles and/or Fruit

A. Design Objectives

1. To establish multi-purpose living fences to demarcate and/or protect crop fields, grazing areas and/or homesteads.
2. To produce fodder and firewood for domestic use; poles and fruit for domestic use and/or sale.

B. Management Strategies

1. Parkinsonia aculeata

Plant in double rows at 30cm spacing, alternating between rows. May also plant as single row. Just before planting, while seedlings still in nursery, cut off the growing tip to encourage lateral growth. After one season, weave branches together to from dense natural fence. After two years cut branches for firewood. Allow goats to browse for pods. (Protective outer fence not necessary as livestock do not like leaves except under severe circumstances.) If poles desired, allow a tree to grow up every 2-4 meters. Maintain remaining trees at hedge height of farmer convenience, using trimmings for firewood.

2. Trevetia peruviana

Plant and manage as for Parkinsonia, above, except does not provide fodder. Produces excellent, strong poles so allow pole development every 2-3 meters.

3. Prosopis chilensis

Plant and manage as for Parkinsonia, above.

4. Acberia caffra

Plant and manage as for all species above, except does not provide fodder or poles. Does produce fruit, so harvest when ready.

IX. Soil Conservation and Fertility Improvement

A. Design Objectives

1. To establish fast-growing, lateral rooting systems on terraces or cut-off drains to hold exposed soil.

2. To provide nitrogen-rich mulching material.

B. Management strategy

1. Erythrina excelsa

Plant cuttings along terraces or in the ditch of cut-off drain at 1 to 2m spacing. One year after planting cut back to 30cms to encourage lateral branching. Allow to grow to 1.5m, and prune to that height every season. Use trimmings to produce more cuttings, or leave on soil to decompose for beneficial nitrogen effect. Collect remaining sticks for firewood. If poles desired, allow one to grow up every 2m.

X. Improved Fodder Production from Existing Trees in Degraded Grazing Land.

A. Design Objective

To improve production of forage/browsing material from existing trees and shrubs.

B. Management strategy

Discuss with farmer which trees are valuable for fodder. For identified trees, construct micro-catchments to improve water penetration and retention capability, and thus to promote faster growth. While trees young, protect from browsing livestock with thorn fences. Prune lower branches to keep out of livestock reach, and encourage upward growth.

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XI. Fruit Production

A. Design Objective

To produce fruit for household nutritional value and/or cash sale.

B. Management Strategy

1. Passiflora edulis (Passion fruit)

Plant seedlings about 1m from existing live or artificial fence. During first season after planting encourage passion vines to climb along fence.

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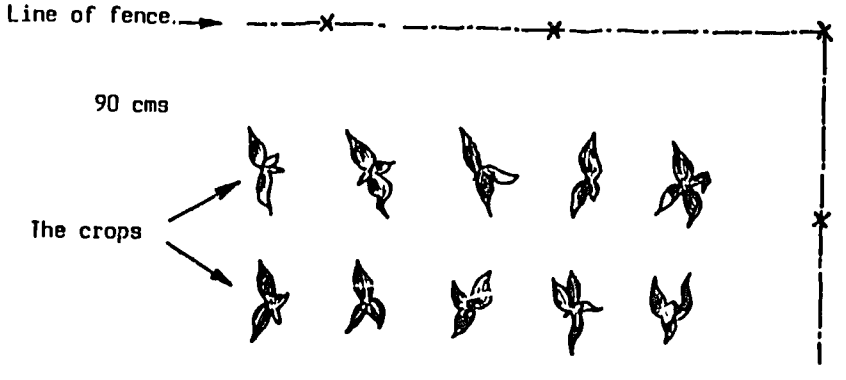
Useful information: MAKING A LIVING FENCE

1. Why should we make a living fence?
   - it is cheap because all of the materials which are used can probably be found locally.
   - a living fence will last for a very long time if it is maintained properly. (It does not cost any money to maintain it).
   - it is stronger and will deter most of the domestic birds and animals which destroy crops in the shamba.

2. How do we mark out and plant the fence?
   - The fence should run all around the shamba.
     It should be a minimum of 90cms away from the edge of the crops you are or will be growing. This space will allow enough room to:
     - reduce the shading effect i.e the crops will have enough sunlight.
     - prevent the roots of the fence competing for plant food and water with the crops.

     Remember when you mark out, to leave a gap for a gateway. This gap should be about 90cms or 1 metre wide.
     To do the marking out:
     - place pegs in the 4 corners of the shamba so that the line of the fence will be at least 90cms away from the edge of the crops. (see diagram).
       (If you have a wire fence around your shamba you should mark out so that the living fence is outside of this by 90cms).
     - place a series of sticks along each side of the shamba so that they are in a straight line between the corner pegs.
     - dig the soil along the line of these sticks. The soil should be dug to the depth of the jembe head and should be dug 15cms each side of the line of sticks.



     - tip one debe of boma manure along every 4 metres of the cultivated strip. Then dig in boma manure.
     - plant the sisal suckers every 60cms. You may find it easier to break some sticks to 60cms length to use for spacing.

3. What material do we plant?
   Sisal is probably one of the best plants we can use to make an effective living fence because it makes a thick barrier at ground level and the blades grow tall and are sharp.

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Also the roots of sisal plants do not spread sideways but grow downwards. Therefore the roots will not interfere with the crops which will be growing in the shamba.
Other plants can be used. You should discuss the other plants you could use with the farmers in your area, and experiment to see which will do well as a living fence.

Useful information: MAINTAINING A LIVING FENCE

1. What do we mean by maintaining a living fence?
   Maintaining a living fence means reducing the growing parts of the plant used to make the fence so that it remains effective but does not compete with the crops. This includes, cutting the leaves, branches or roots which are growing sideways. It also involves replacing the dead plants.

2. Why is it important to maintain a living fence?
   - To reduce the competition between the living fence and the enclosed crop for air, light, food and water.
   - To block all the spaces which would allow creatures like chicken, goats, sheep, cattle and man to enter the plot and damage the crop.
   - A regularly maintained fence will be easier to control than one which becomes overgrown. It reduces the amount of labour needed in the long term.

3. When should we maintain the fence?
   At least every 6 months, or when the leaves/blades/branches grow more than 45cms away from the main stem. If they are more than 45cms long they may begin to interfere with the crop.
   If any gaps are noticed they should be filled as soon as possible because gaps will allow animals in.

4. How do we maintain the fence?
   - by cutting the blades/leaves/branches which have grown longer than 30cms from the stem, especially those on the inside (crop side) of the fence.
   - by uprooting suckers which are growing on the inside of the fence.
   - by replanting suckers where there are gaps.
   - by digging to the depth of the jembe head on the crop side of the fence. Dig about 30cms away from the stem. This will cut the roots which would grow into the crop and interfere with the crop yields.

   Note: Place the trimmed blades/branches in the fence to make the fence stronger.

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4.6 TREE MANAGEMENT

Watering and weeding

In humid regions, if tree planting is done at the onset of the long rains after the rooting zone has been thoroughly wetted, no supplementary watering should be required. Young trees will, of course, benefit from any extra water they receive, especially during the first dry season after planting. This extra water, either from irrigation or hand-watering, should be regarded as a luxury. In agroforestry, it should not be planned as a necessity.

In the dry regions, on the other hand, watering is often required to get the seedlings established; especially during the first dry season after planting. Watering should always be regarded, however, as a temporary measure to help seedlings get established. If watering is done, it is important to do it only once in a while with a good amount of water, rather than a small amount of water every day. This will help the tree to grow its' roots deep into the soil. If small amounts of water are given every day, the tree roots will stay near the surface. This si not good for the long term survival of the tree.

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Weeding of planted seedlings is absolutely essential until the seedlings can no longer be overtopped by competing grasses and weeds. Failure to weed can also result in seriously stunted seedlings as the latter must compete with fast-growing weeds over soil moisture and nutrients. Unweeded seedlings are also vulnerable to indiscriminate grazing and grass cutting.

Pruning and thinning

Pruning is used primarily to produce knot-free wood and to reduce the growth of branches, especially if they overhang crops. Kenyan farmers commonly prune cypress to about two-thirds its height. Pruning is essential with pines if useless knotty timber is to be avoided. In general, pruning cuts should be clean and 2-3 cm from the trunk to minimise the risk of infection and decay. The branch should be cut from below first, then from the top to avoid collapse of the branch and stripping of the trunk's bark.

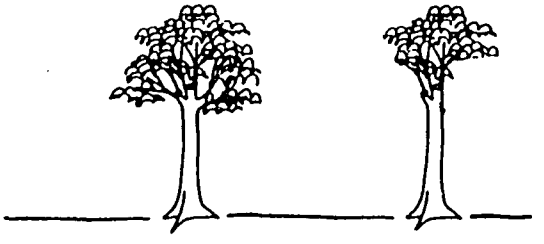

Fig. 9. Pruning of trees is cutting the lower branches. (Source: (7))

Thinning is designed to remove weak or poorly formed trees and shoots, and to give fewer remaining trees more space and other resources to grow. Thinning of woodlots is often used to generate interim income (say, with poles), while the remaining trees go on to a longer rotation (say, to timber size).

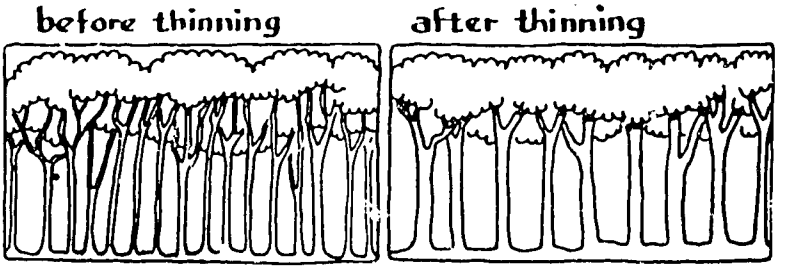

Fig. 10. The importance of thinning. (Source (1))

The trees or coppice shoots that need thinning in order to avoid gross inefficiencies will usually be fairly obvious to the small tree farmer. They will be dead, dying, deformed or

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substantially thinner stems next to same-aged stems. On the farm, thinnings can always be used as firewood. Diseased trees should always be removed to prevent the spread of disease. Thinning is often used in agroforestry to reduce shade and root competition.

4.7 COPPICING

Coppicing is vegetative regrowth from stumps of tree trunks that have been cut back close to the ground. Man has long since taken advantage of the coppicing ability of many tree species for the main reason that it saves having to plant a new tree after harvest. In the temperate zone, some trees have apparently been harvested innumerable times over centuries, always from the same stump (the so-called stool). In the tropics, the long-term coppicing behaviour of trees is not so well known.

To begin with, agroforesters must be aware that not all species coppice. Among common species that do not copice are pines, cypress, infact most conifers coppice poorly. Also the black wattle (Acacia mearnsii) coppices poorly. Others, such as Eucalypts, Cassia siamea, Leucaena, Calliandra, neem, and many indigenous Acacia spp. coppice very well. Grevillea coppices poorly.

Trees are normally coppiced for the first time when they are still young and vigourous. An old, weakened tree, especially one with damaged bark, do not coppice well. Trees grown industrially on a coppice basis, for example eucalypts grown for poles and firewood, are usually cut for the first time under the age of 10.

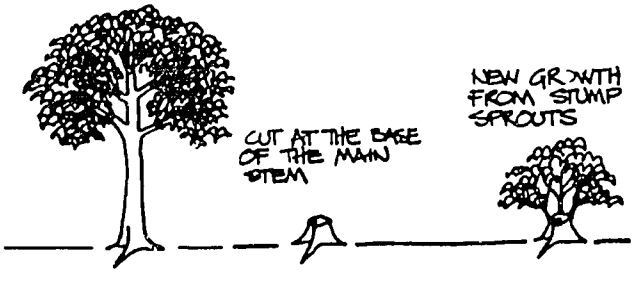

Fig.11. Coppicing of trees. (Source (7))

Two basic considerations with coppicing are (1) stool height and (2) how many coppice shoots should be retained.

Advice on stool height varies. In general, however, optimum stool

heights seem to be in the range of 10-30 cm above ground level. Cutting the trunk flush with the ground is to be avoided because of the high risk of fungal and other decay of the stumps. Cutting the stool too high, say above 50 cm, is also inadvisable not only because it wastes wood but also because, for some physiological reason, coppicing vigour tends to decrease with height. High shoots are also prone to windthrow. Eucalypts coppiced above 50 cm are a common sight on Kenyan farms, and they often have a low productivity because they have been cut too high.

The basic rule with the stool cut is that it must be clean and angled that the cut surface can drain freely and the points of entry of decay organisms minimised (same as with branch pruning). The cut is best done with a chainsaw or crosscut saw, but most farmers don't have such tools.

Coppice rotations for poles and firewood, notably with eucalypts, are generally in the 7-12 year range. In the early days of firewood production in Kenya, primarily for the railway, E globulus and E. saligna used to be coppiced three times, 10 years each rotation; stools apparently deteriorated at about age 30.

With some fast-growing species, firewood for household use can be produced on rotations as short as 6-12 months. This applies to such species as Leucaena, Calliandra and Sesbania. They have been known to produce coppice shoots 3-5 m high and up to 7 cm in diameter in one year. The small poles used in this case are sometimes called "fuelsticks". They are of a small size and therefore of the right size for the kitchen.

When the time comes to replace a coppice stand, the stumps can be killed by debarking them completely. They can also be killed by cutting them back flush with the ground, and painting them with diesel oil.

A variation on the straight coppice stand is the coppice-with-standards. The standards are those trees that are allowed to continue growing through the various rotations. This is done to produce some timber while most of the coppice growth is used for poles or firewood; it is also used to retain some seed trees.

4.8. POLLARDING

Pollarding is the cutting branches in the top of a tree in order to harvest the branches and leaves, and in order to stimulate the regrowth of a new, often better-formed and more productive crown. Pollarding is often used with ornamental trees so at to promote the growth of dense, vigorous and well-shaped crown. Pollarding differs from ordinary pruning in that the latter is designed to remove unwanted branches (and thus prevent knot formation in trunk wood) below the crown. The idea with pollarding is also

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to make the tree lose its leading shoot (so-called apical dominance), and thus to promote multiple-stem growth at the top of the main trunk.

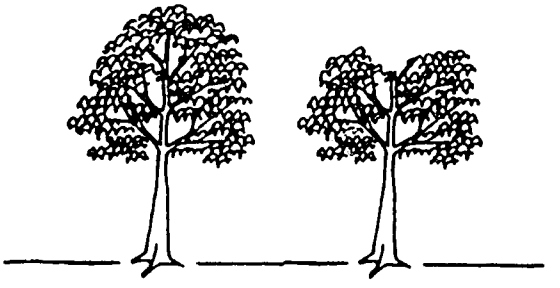

Fig. 12. Pollarding trees means cutting the top branches.
(Source (7))

In agroforestry, pollarding is usually used to produce more or more nutritious fodder, to harvest the branches, to produce poles and to reduce shade.

From a forestry point of view, the main concern with pollarding is to retain a proportion of the crown so that the tree will not only survive, but also avoid being seriously weakened. The crown with its leaves is, of course, the "food factory" of the tree, and as such it must not be disrupted or reduced to the point where the rest of the tree is "starved".

Photo 5. An example of pollarding in Eucalyptus (Source (12))

Good examples in Taita/Taveta of pollarding are cypress in the highlands and Melia volkensii (kirumbutu) in the lowlands. In the Mt. Kenya region, pollarding of Grevillea works very well. The tree is cut back when it produces too much shade, and when it demands too much moisture and nutrients in competition with crops nearby. The farmer gets to harvest a good part of the tree. The cycle is repeated every few years and perhaps continued over several decades. The main trunk continues to grow, so at some point the farmer cuts it for use or sale as timber. In the meantime the farmer will have harvested firewood, poles and mulch without the expense and bother of replanting trees. In the Taita Hills this is not (yet) done.

PEST AND DISEASE CONTROL

Trees are attacked by insects and by viral and other disease, just like any other plants. In small-scale farm forestry, serious losses of trees to pests and diseases are fortunately rare, particularly if indigenous species or a mix of species are used. Diseases tend to affect mainly seedlings in nurseries or older, weaker trees. In Taita/Taveta farmers like to plant trees of the higher altitudes in the drier areas. Such trees are also weak and are easily attacked.

Even where trees are planted in the right ecological environment, and where they are healthy and vigourous, they can easily be attacked in the juvenile stage by termites - termites are the major pest for trees throughout Kenya. The use of chemical pesticides is often not recommendable: they are too costly and they are dangerous. If termites persistently attack a tree nursery, it is recommended to protect the seedlings with woodash. Woodash repels the termites. The recipe is as follows:

-establish a layer of woodash, some centimeters thick, where the seedbed will be located.
-cover with a sheet of plastic if heavy rains are expected in the area; this will protect the ash against washing out.

Ash may be also used to protect seedlings after planting out, in which case it is put in the hole at the moment of planting.

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