- the Australian Tree Seed Centre at the CSIRO Division of Forestry, Canberra, Australia runs the Australian Tree Seed Centre (ATSC) which provides free research seedlots of Australian woody species under the `Seeds of Australian Trees' project, funded by the Australian Centre for International Agricultural Research (ACIAR). If necessary, assistance may include site-specific recommendations, the supply of literature and advisory visits to recipient countries by suitably qualified specialists. The focus is again on research, the services of the ATSC being made available to research projects and pilot plantations in selected countries of Asia, Africa, Latin America and the South Pacific.
  The Officer in Charge
  Australian Tree Seed Centre
  CSIRO Division of Forestry
  PO Box 4008, Queen Victoria Terrace
  Canberra ACT 2600
  Tel: (Aust 06)(Internat +616) 2818211
  Fax: (Aust 06) (Internat + 616) 2818266
  Website/searchable seed-list at: http://www.ffp.csiro.au/tigr/atscmain/index.htm

- The Centre Technique Forestier Tropical (CTFT) in France also supplies seed to certain (generally francophone) countries.
  J. Leroy-Deval
  Centre Technique Forestier Tropical
  B.P. 149, Libreville
  République du Gabon

- the Oxford Forestry Institute (OFI) in the UK provides research seedlots to selected projects and countries.
  Dr PS Savill
  Oxford Forestry Institute, Department of Plant Sciences
  University of Oxford, South Parks Road, Oxford OX1 3RB, UK
  Telephone: +44 1865 275000
  Fax: +44 1865 275074
  Email: ofi@plants.ox.ac.uk

Apart from these organizations, seed may occasionally be supplied through development groups and networking publications. Usually a single species is involved, and there is no link with scientific trials. Such offers are nevertheless worthwhile because they are based on practical evaluation, *in situ*, at the farm level.

## (8) Seed Storage and Supply

When seeds are collected they should be tested for viability and visually checked for weed seeds and infestation. The seeds are then split into smaller quantities, and sealed in labelled foil bags, and stored. Histoculture Drug Response Assay (HDRA) project supplies about 1,000 to 3,000 seeds upon request depending on the seed size and availability, area to be planted and the number of suitable species for the local climate. The seeds are accompanied by a phytosanitary certificate from the point of source.

Gilbert Leslie
51 Whitehall Road, Thornton Heath, Surrey
CR7 6AF
Tel: 0208 683 1451 mob: 077 325 45 223
E-mail: organicgilbert@talk21.co

## (9) Tree Planting Success Cases

*1. Kenya*

As part of a nutrition promotion programme in Kenya, seedlings of fruit, timber and firewood trees were distributed among local women. Species included *Psidium guajava, Punica granatum, Grevillea robusta* and *Tamarindus indica.* Forestry extension information and monitoring was provided by the local forestry department. The women meet weekly to discuss a number of issues including their tree planting work.

*2. Togo*

In a farm tree growing project run by an NGO in Togo, four out of the seven species supplied — *Gmelina arborea, Leucaena leucocephala, Cajanus cajan* and *Sesbania sesban* — have proven very successful and are being used for forestry/agro-forestry demonstrations at the project site and at a local school. At least 300 people participate in training courses at these sites annually.

## (10) Honey-Producing Trees Suitable for Multiple Uses

| TREE | OTHER USES AND CHARACTERISTICS |
|---|---|
| **A. Humid Areas** | |
| 1. *Calliandra calothyrsus* | Firewood, animal fodder. Fast-growing. |
| 2. *Gliricidia sepium* | Firewood, fencing, animal fodder. |
| 3. *Gmelina arborea* | Firewood, timber. |

| | | |
|---|---|---|
| 4. | *Guazuma ulmifolia* | Firewood, timber, animal fodder, edible fruit. |
| 5. | Mangroves: | |
| | *Avicennia nitida* | Excellent charcoal. |
| | *Laguncularia racemosa* | Resins, tannin, pulp. |
| 6. | *Syzygium cumini* | Firewood, shade. |

**B. Tropical Highlands**

| | | |
|---|---|---|
| 1. | *Eucalyptus flobulus* | Firewood, tools, poles, pulp. |
| 2. | *Grevillea robusta* | Firewood, cabinet wood, shade for coffee or tea. |
| 3. | *Inga vera* | Firewood, furniture, shade, food, seed pulp. |

**C. Arid Regions**

| | | |
|---|---|---|
| 1. | *Acacia senegal* | Charcoal, poles, implements, gum arabic, fodder, food: dried seeds. |
| 2. | *Acacia tortilis* | Firewood, fence posts, animal fodder. Fast growing. |
| 3. | *Albizia lebbek* | Firewood, furniture, animal fodder. Tolerates salt. |
| 4. | *Albizia citriodora* | Firewood, poles, railroad ties, citronella. |
| 5. | *Eucalyptus camaldulensis* | Firewood, excellent charcoal, termite-resistant wood, pulp. |
| 6. | *Eucalyptus citriodora* | Firewood, posts, general construction, fodder, food: pods. |
| 7. | *Pithecellobium dulce* | Firewood, posts, general construction, fodder, food: pods. |
| 8. | *Prosopis* spp. | Firewood, fence posts, fodder: leaves & seeds, food: seeds, erosion control. |
| | *pallida* | Fast growing, tolerates salt, arid conditions, up to 300 m. |
| | *juliflora* | Tolerates very arid regions up to 1500 m. May be weedy. |

**(11) Species Selection for Different Climates and Uses**

**i) Arid/Semi-arid Plants For Fuelwood/Charcoal.** *Acacia acuminata, A. aneura, A. aulocacarpa, A. farnesiana (*), A. nilotica (*), Casuarina cunninghamiana, C. equisetifolia, Haematoxylon brasiletto (*), Parkinsonia aculeata (*), Prosopis pallida (*).* **Ibid. for Animal Fodder.** *Acacia albida, A. acuminata, A. aulocacarpa, A. nilotica (*), Cajanus cajan.* **Ibid. for Green Manure.** *Cajanus cajan.*

**ii) Humid Lowland/Midland (0-1000 m) for Fuelwood/Charcoal.** *Acacia auriculiformis, A. mangium, Calliandra calothyrsus, Casuarina cunninghamiana, C. equisetifolia, Enterolobium cyclocarpum, Gliricidia sepium, Leucaena leucocephala, Mimosascabrella,Samaneasaman.* **Ibid.forFodder.** *Acaciaangustissima,Enterolobium cyclocarpum, Erythrina poeppigiana, Gliricidia sepium, Leucaena leucocephala, Sesbania grandiflora, S. sesban.* **Ibid. for Timber/Fuelwood.** *Acacia confusa, A. mangium, Albizia falcataria, Dalbergia retusa, Enterolobium cyclocarpum, Leucaena leucocephala, Samanea saman.* **Ibid. for Green Manure.** *Acacia angustissima, Albizia falcataria, Calliandra calothyrsus, Erythrina poeppigiana, Flemingia macrophylla, Gliricidia sepium, Leucaena leucocephala, Mimosa scabrella, Sesbania grandiflora, Sesbania sesban.*

**iii) Tropical Midland/Highlands for Fuelwood/Charcoal.** *Acacia mearnsii, Alnus acuminata, A. rubra, Leucaena diversifolia.* **Ibid. for Fodder.** *Acacia angustissima, Chamaecytisus palmensis, Leucaena diversifolia.* **Ibid. for Timber/Fuelwood.** *Artocarpus fraxinifolius, Alnus acuminata, A. rubra, Leucaena diversifolia.* **Ibid. for Green Manure.** *Acacia angustissima, Leucaena diversifolia.*

### (12) Sources of Information on Trees

The **Kenya Forestry Seed Centre** seed catalogue has the most complete listing. Nine pages of the catalogue give "Climate Zones and Species Suitability" based on humidity/rainfall, altitude, and mean annual temperature. These charts provide an important guide before you purchase seeds; for example, there are relatively few species suitable for over 2400 m altitude, but these lists give you a place to start.
Kenya Forestry Seed Centre,
P.O. Box 20412,
Nairobi, Kenya.

The **New Forests Project** provides packets of tree seeds, technical information, and training materials free of charge to groups interested in starting reforestation projects with fast-growing, nitrogen-fixing trees. Available for distribution are seeds of *Cajanus cajan* (pigeon pea), *Leucaena leucocephala, Gliricidia sepium, Robinia pseudoacacia* (black locust) and *Prosopis juliflora* (mesquite).
The New Forests Project,
731 8th St. SE, Washington, DC
20003, USA; phone 202/547-3800;
Fax 202/546-4784.

When applying to this or any forest seed centre, include an environmental description of your area, including elevation, rainfall, temperatures, soil type, and the purpose of the tree planting.

### *1) Acacia angustissima*

After 2.5 years Acacia anguistissima can grow to 5 meters height and about 6 cm thickness. In a trial that included *Acacia auriculaformis, A. melanoxylon, A. mearnsii, Calliandra calothyrsus, Casuarina cunninghamiana, Chamaecytisus palmensis, Leucaena diversifolia, Mimosa scabrella* and *Sesbania sesban* it was the best performer. Due to drought, weeds and termites, only the first 5 species survived two years. After planting, the trees received no special treatment, as would be the case when planted by the local farmers. Five weeks after a fire that swept through the trees and killed all of them above ground, *A. angustissima* re-sprouted from the base and already averaged 55 cm to 1 m height, a sign of its great coppicing ability.

Concerning the 'weediness' of *A. angustissima,* at a 1650 meter site naturally sown seeds have been observed not to germinate for a year or so, which indicates a dormant period. After this period seeds seem to germinate readily. It does not seem to set seed readily at sea level. For germination in the nursery, scarification (soaking in 90 degree C water for 30-60 seconds) is necessary. It can be germinated in a sawdust medium at sea level, but it does very poorly when sown directly in the field at low elevations; at higher altitudes it grows readily when field sown.

### *2) Calliandra calothyrsus*

*Calliandra houstoniana* is similar to the better known *C. calothyrsus,* but produces foliage even more profusely and naturally forms a more dense hedge. It looks like a good prospect for alley farming and erosion control barriers. *C. calothyrsus* is reported to have a high tannin content in the foliage, which makes it a problem for use as a fodder. It flowers profusely and butterflies love it, so it might be useful for bee keeping. Its glossy green foliage and relatively compact form (2.5-3 meters at sea level) make it a good ornamental.

### *3) Gliricidia sepium*

*Gliricidia* is a fast-growing leguminous tree for frost-free tropical regions with 450-3500 mm rainfall. It is used for fodder, living fences, green manure, contour plantings, fuelwood, etc. It is fairly termite resistant. This species is native to Central America and Mexico.

### *4) Leucaena leucocephala*

*Leucaena leucocephala* is a fast-growing, leguminous tree. It has been used for reforestation, for firewood, and as a forage crop that can equal alfalfa in nutritional value. Researchers have given it much attention in recent years.
There are three basic types of leucaena trees: Hawaiian, Salvador, and Peru. There are also crosses between these. You need to choose the type that best fills your needs. The **Hawaiian** type is short and bushy. Because its yield of wood and foliage is low compared to the other two types, this would probably be a poor choice. The **Salvador** type (Hawaiian giant) is tall and tree-like. The trees can grow 60 feet in height in 5 years. The best varieties of this type are K28 and K67. K67 is the best variety for projects that need high seed production. The **Peru** type is tall with extensive branching. The trees are good for forage; K6 is a good variety. An excellent forage-type leucaena is the Cunningham (K500) which was developed in Australia. It is a cross between the Salvador and Peru types.

Varieties K4 and K743 (hybrid) are low in mimosine, a chemical present in leucaena which can be toxic to animals when eaten in large quantities. *Leucaena diversifolia* is better for higher altitudes (500-2000 m) than *L. leucocephala.*

### *5) The Moringa Tree, Moringa oleifera*

In Africa this tree is known locally as:
BURKINA FASO: (Moré): Argentiga, Arzam tigha ("The tree of paradise"); (Fulfuldé): Guilgandani, Gigandjah.
GHANA: (Ewe): Yevu-ti.
KENYA: (Swahili): Mlonge, Mronge, Mrongo, Mlongo, Mzunze, Mzungu.
MALAWI: (Chichewa): Cham'mwanba, Kangaluni; (Yao): Kalokola; (Senna): Nsangoa.
NIGER: (Hausa): Zôgala gandi ; (Zarma): Windi-bundu.
NIGERIA: (Fulani): Gawara, Konamarade, Rini maka, Habiwal hausa; (Hausa): Zogall, Zogalla-gandi, Bagaruwar maka, Bagaruwar masar, Shipka hali, Shuka halinka, Barambo, Koraukin zaila, Rimin turawa, Rimin nacara; (Ibo): Ikwe oyibo; (Yoruba): Ewe ile, Ewe igbale, Idagbo monoye («The tree which grows crazily»).
SENEGAL: (Wolof): Neverday, Nébéday; (Serer): Nébéday.
SUDAN: (Arabic): Ruwag, Alim, Halim, Shagara al ruwag.
TOGO: (Dagomba): Baganlua, Bagaelean.
ZIMBABWE: (Tonga): Mupulanga, Zakalanda.

### i) Uses of moringa as a food

This tree is sometimes called 'mother's best friend' in the Philippines where the leaves of the malunggay, as they call it, are cooked and fed to babies. Other names for it include horseradish tree and drumstick tree (India) and benzolive (Haiti). Moringa tree leaves, pods, and roots are eaten; flowers are loved by bees; and seeds are powdered and used to purify water from murky rivers.

The leaflets can be stripped from the feathery, fern-like leaves and used in any spinach recipe. Small trees can be pulled up after a few months and the taproot ground, mixed with vinegar and salt and used in place of horseradish. Very young plants can be used as a tender vegetable. After about 8 months the tree begins to flower and continues year round. The flowers can be eaten or used to make a tea. They are also good for beekeepers. The young pods can be cooked and have a taste reminiscent of asparagus. The green peas and surrounding white material can be removed from larger pods and cooked in various ways. Seeds from mature pods (which can be 2 feet long) can be browned in a skillet, mashed and placed in boiling water, which causes an excellent cooking or lubricating oil to float to the surface. The oil reportedly does not become rancid and was once sold as "ben oil." The wood is very, very soft, though the tree is a good living fencepost. It makes acceptable firewood but poor charcoal.

The trees grow very rapidly and at three months can reach 8 feet. Prune trees frequently when they are young or they will become lanky and difficult to harvest. Where people begin breaking off tender tips to cook when trees are about 4 or 5 feet tall, the trees become bushier.

The tree has shown great resistance to dry weather when planted in Africa. It can be planted after the other crops, even near the end of the rains. In Nepal it is reported to have grown to between 6 and 12 feet tall at five months.

The edible parts are exceptionally nutritious! The leaves are outstanding as a source of vitamin A and, when raw, vitamin C. They are a good source of B vitamins and among the best plant sources of minerals. The calcium content is very high for a plant. Phosphorous is low, as it should be. The content of iron is very good (it is reportedly prescribed for anaemia in the Philippines). They are an excellent source of protein and a very low source of fat and carbohydrates. Thus the leaves are one of the best plant foods that can be found. The leaves are incomparable as a source of the sulfur-containing amino acids methionine and cystine, which are often in short supply in common foods.

It responds well to mulch, water and fertilizer. It is set back when the water table stays for long at an inch or two below the surface. It provides a light shade. The branches are much too brittle to support someone climbing the tree. It is not harmed by frost, but can be killed to the ground by freezes. It quickly sends out new growth from the trunk when cut, or from the ground when frozen. Living fences can be continually cut back to a few feet.

It seems to thrive in impossible places--even near the sea, in bad soil and dry areas. Seeds sprout readily in one or two weeks. Alternatively one can plant a branch and within a week or two it will have established itself. It is often cut back year after year in fence rows and is not killed. Because of this, in order to keep an abundant supply of leaves, flowers and pods within easy reach, "topping out" is useful. At least once a year one can cut the tree off 3 or 4 feet above the ground. It will readily sprout again and all the valuable products will remain within safe, easy reach.

When young, moringa tree pods are edible whole, with a delicate flavour like asparagus. They can be used from the time they emerge from the flower cluster until they become too woody to snap easily. The largest ones usable in this way will probably be 12 to 15 inches long and 1/4 inch in diameter. In this state they can be prepared in many ways:

a. Cut the pods into one inch lengths. Add onion, butter and salt. Boil for ten minutes or until tender.
b. Steam the pods without seasonings, then marinade in a mixture of oil, vinegar, salt, pepper, garlic and parsley.
c. An acceptable "mock asparagus" soup can be made by boiling the cut pods until tender, seasoned with onion. Add milk, thicken and season to taste.

Moringa seeds, or "peas," can be used from the time they begin to form until they begin to turn yellow and their shells begin to harden. Only experience can tell you at what stage to harvest the pods for their peas.

The dry seeds are not used for human food, perhaps because the bitter coating has hardened. They are used for their oil, which is about 28% by weight. The oil can be removed by an oil press. The residual cake is said not to be safe to feed to animals. If an oil press is not available, seeds can be roasted or browned on a frying pan, ground, then added to boiling water. The oil floats to the surface.

The flowers are eaten in the Pacific area. They are also used in Haiti for a cold remedy. Water is boiled, then a cluster of flowers is placed to steep in it for about 5 minutes. Add a little sugar and drink as needed. It is reported to be very effective.

To use moringa roots, the tree is uprooted and the roots grated like horseradish. To one cup grated root add 1/2 cup white vinegar and 1/4 spoon table salt. Chill for one hour. This sauce can be stored for a long time in the refrigerator. However, the root, best known in India and the Far East, is extremely pungent. When the plant is only 60 cm tall, it can be pulled up, its root scraped, ground up and vinegar and salt added to make a popular condiment much like true horseradish. The root bark must be completely removed since it contains harmful alkaloids.

**b. Use as an Antibiotic**

Herbal applications are commonly used to treat skin infections in developing countries, although few investigations are conducted to validate scientifically their popular use. A study has shown that moringa seeds are effective against skin infecting bacteria *Staphylococcus aureus* and *Pseudomonas aeruginosa in vitro* (i. e. in a test tube). This study has shown that mice infected with *S. aureus* recovered as quickly with a specially prepared aqueous (with added water) extract of moringa seed as with the antibiotic neomycin.

ECHO can provide trial-sized quantities of *Moringa oleifera* from the trees on their farm. Other potential sources are:

i) Christas Cactus, 529 W. Pima, Coolidge, AZ 85228, USA; phone 602/723-4185.
ii) Greenleaf Seeds, P.O. Box 98, Conway, MA 01341, USA; phone 413/628-4750 (No telephone orders).
iii) Of the Jungle, P.O. Box 1801, Sebastapol, CA 95473, USA.
iv) Peace Seeds, 2385 S.E. Thompson Street, Corvallis, OR 97333, USA; phone 503/752-0421.
v) Peter B. Dow & Co., P.O. Box 696, Gisborne 3800, NEW ZEALAND; fax (079) 78 844.
vi) Ilison Horticultural Ltd., P.O. Box 365, Nowra, N.S.W. 2541, AUSTRALIA; phone 6144-214255.
vii) Kumar International, Ajitmal 206121, Etawah, Uttar Pradesh, INDIA.
viii) Samuel Ratnam, Inland & Foreign Trading Co., Block 79A, Indus Road #04-418, SINGAPORE 169589; phone 2722711; fax 2716118.

If moringa does not already grow in your region, you may request a trial packet of the marble-sized seed. It grows wild in many places (such as Haiti and the Dominican Republic) where people do not know it is edible. The moringa is one of God's abundant resources for the struggle against world hunger.

### *c. Moringa stenopetala*

*M. stenopetala* has the lush green foliage and continues to grow during the exceptionally long dry seasons.

Freezes can damage *M. stenopetala,* forcing subsequent branching from low on the trunk. *M. stenopetala* develops into a round shrub-like tree. If it is not affected by freezing, the trunk is considerably thicker at the base, the tree seems more vigorous, and the leaves are larger and taste milder when raw.
It can be planted as a wind break – with seedlings placed at a spacing of 1 m. As soon as the upper branches of the tree grow broader, they are cut and the trees will respond by more profuse growth of their lower branches, thus thickening the hedge.

*M. stenopetala* has been grown as an ornamental in private gardens of Europeans in Kenya, reaching 10-12 meters and their trunk diameter is at least 2-3 times as thick as that of *M. oleifera* in Sudan. In Ethiopia it is cultivated as high as 1800 meters (5400 feet above sea level), where people use ash as the main fertilizer. By the end of a long dry season the trees may have lost their leaves.

Whereas it is the roots of *M. oleifera* that are used as a condiment similar to horseradish with *M. stenopetala* it is the bark that is so used.

Germination percentages for *M. stenopetala* and *M. oleifera* were only 54 and 40 percent in the open during the hot season in the Sudan, compared to 92 and 94 percent in half shade. During the cool dry season there was little difference. Both moringa species can be started from cuttings. However, trees grown from cuttings are known to have much shorter roots. Where longer roots are an advantage for stabilization or access to water, seedlings are clearly preferable.

### (13) The Neem Tree - *Azadirachta indica*

The Neem tree is good for reforestation as it grows very quickly and encourages the people that reforestation is possible. Its seeds contain an especially effective natural insecticide. The tree originated in India or Burma, where it is used widely for its insecticidal and medicinal properties. It is also grown in much of Africa, primarily for firewood. In East Africa it is called 'mwarobaini' in Kiswahili. That means the "forty tree," so called because it supposedly makes medicines to treat 40 different ailments. Seeds contain up to 40% oil which can be used for soap or lamp fuel. The residual neem cake is a good fertilizer with some nematicidal properties. It is the neem oil that is primarily used as an insecticide; water extracts of powdered kernels also can be used in this way.

Neem is fast-growing and drought resistant, excellent for reforestation of semiarid lands. It is an evergreen (except in extreme drought) and valued for its shade--especially in cities--and windbreak protection. It grows best in deep, well-drained sandy areas, but thrives even on acid soils. It may fail in silty or clay soils and in waterlogged sites. To plant, pick fully ripe seeds directly from the tree and plant immediately. The trees may be direct sown or transplanted, and they benefit greatly from tillage, weeding, irrigation, and some fertilization in the first few months of growth (or after transplanting). Neem has been established in many countries throughout the tropics; there is a good chance you may find seed in country if you make inquiries.

Seeds are only available on a seasonable basis, as they must be planted within 3-4 weeks of harvest. They can be obtained from:

a. Agricultural Research Service (ARS), US Department of Agriculture (USDA), 13601 Old Cutler Road, Miami, FL 33158, (305)238-9321.
b. The Kerr Center for Sustainable Agriculture, Vero Beach Research Station, 7055 Cherry Lane, Vero Beach, FL 32966, (407)562-3802.
c. Robert Barnum, Possum Trot Nursery, 14955 S.W. 214th Street, Miami, FL 33187, (305)251-5040.
d. FLAG Unit, International Livestock Centre for Africa(ILCA), P.O. Box 5689, Addis Ababa, Ethiopia.
e. The Tree Seed Program, Ministry of Energy and Regional Development, P.O. Box 21522, Nairobi, Kenya.

In SSA, seedlings can be obtained from:

a. Jean Hanson, ILCA, FLAG Unit, P. O. Box 5689, Addis Ababa, ETHIOPIA.
b. The Tree Seed Program, Ministry of Energy & Regional Development, P. O. Box 21552, Nairobi, KENYA.
c. Rene D. Haller, Baobab Farm Limited, P.O. Box 81995, Mombasa, KENYA; Telex 21265; phone 485729/754/501.
d. Roy B. McKenzie, McKenzie Agrisystems, Ltd., PO Box 95979, Mombasa, KENYA; phone 433460 Mombasa, 747131 Nairobi; fax 432309 Mombasa.
e. Tanzania, Forestry Research Institute, Silviculture Research Centre, P.O. Box 95, Lushoto, TANZANIA.
f. Forestry Research Institute of Malawi, P.O. Box 270, Zomba, MALAWI; phone 522866/522548.
g. Kenya Forestry Seed Centre, Kenya Forestry Research Institute, P.O. Box 20412, Nairobi, KENYA, phone: 0154-32541.
h. Regional Seed Centre, Forestry Commission, Forest Research Centre, P.O. Box H.G. 595 Highlands, Harare, ZIMBABWE; phone 47070/46878/9.

Nathanael Ariyo Olonire, P.O. Box 2674, Sokoto, NIGERIA, West Africa (bulk neem seed, leaves etc.).

### (14) *Sesbania aculeata*

It is also called *Sesbania bispinosa,* prickly sesban and dhaincha. In Vietnam it is grown in rice fields and its stems harvested for firewood before the rice crop is planted. It is a legume that nodulates vigorously. Its fibres are similar to birch, one of the best trees for paper. Stems can be processed into a jute-like fibre, used for making fishing nets, sacks and sails. Other uses include for windbreaks, erosion control, cover crop and green manure. The leaves reportedly make good cattle fodder. It is well adapted to difficult soils. It will grow on saline and alkaline wastelands and wet, almost waterlogged soils, even in areas that often remain barren for want of suitable crops. No seed treatment is required. It grows so well that it is excellent at suppressing vigorous weeds such as *Imperata cylindrica.* If the tree is unwanted, it might itself become a serious weed pest.

### (15) *Sesbania sesban*

Its common names are sesban, Egyptian rattle pod, suriminta, soriminta. It is a good alternative to leucaena for alley farming in highland areas (above 1800 meters). It is grown in hedgerows on broadbeds and ridges. The yields are 800 kg to 6 tonnes per hectare per year, depending on the cropping pattern. Under difficult highland conditions (frost, hail) in soils prone to erosion and waterlogging, this browse legume tree is a very promising tree. Sesban is adapted to arid and semi-arid regions up to about 1200 m and to acid soils.

### (16) *Sesbania grandiflora*

*Sesbania grandiflora* is strong in the winds, grows fast, produces edible beans and flowers and is an attractive fodder to goats and cows.

### (17) *Leucaena leucocephala*

*1) Description*

Leucaena leucocephala (6) ("koa haole"-Hawaii; ipil ipil - Phillipines) is a fast-growing, leguminous tree that can be used for reforestation, for firewood, and as a forage crop that can equal alfalfa in nutritional value. There are three basic types of leucaena trees: Hawaiian, Salvador, and Peru. These are described above.

Leucaena trees maintain uniform germination and good establishment. Like other trees, leucaena establishes slowly and a little tender, loving care is advisable. Leucaena does not establish well in acid soils, preferring a pH similar to maize of 5.5 or above. Phosphorus addition is suggested in P-depleted soils. Other elements that may be limiting to establishment include calcium, sulfur, zinc, boron and molybdenum. Seed pelleting with lime and P, or their addition at time of transplanting would be valuable in many tropical soils.

Seeds should be well dried, insect-free, fungus-free, and weed-free. "Giant" varieties have about 8000 seeds/pound (or 20,900 / kg) and common varieties about 12,000/pound. Seeds are often treated with the mild insecticide, Sevin.

Seeds do not germinate unless they are scarified (literally meaning "scratched") by scratching or cracking the tough, water-impervious seed coat. Of the following three ways, the first is worth the time:

a. Scratch or nick each seed with a triangular file, small scissors or knife. This method many result in 100% germination rate.

b. Acid etch; Concentrated sulfuric acid is poured over seeds for 15 minutes, then washed exhaustively.

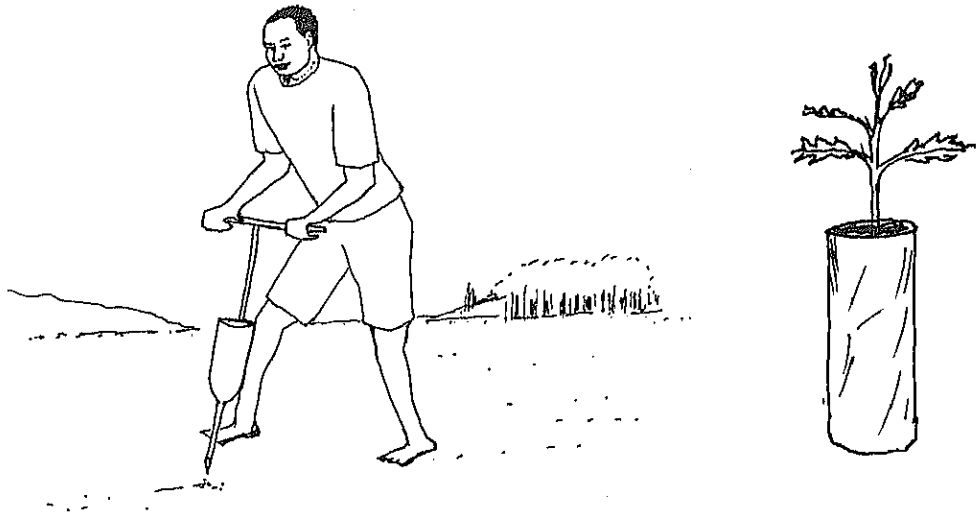
c. Hot water treatment: Vigorously boiling water is poured over seeds, about one gallon per pound of seeds, stirred gently and poured off in 3-5 minutes. Works about 70%. Alternatively, 80 degrees C. for 3 minutes.

Leucaena is a legume, and bacterial inoculation is necessary for good nodulation and growth. Many tropical soils contain appropriate bacteria, but preliminary tests are advised. Many countries manufacture inoculants for a number of crops. You may wish to contact your local agricultural extension agency or national department of agriculture to see if the inoculant you are looking for needs to be imported.

*2) Planting Leucaena*

Transplanting is preferred, but leucaena seeds can be drilled for direct planting on large acreages. Establishment is slow, with about 6 weeks in a small seedling stage (9 to 30 cm). Then growth is more rapid, reaching 2 m in about 8 more weeks. Weeds are the major problem.

***Figure 7.1:*** (a) Drilling leucaena seeds with a hand jabber (b) Leucaena seedling in extruded plastic tube



About 2,500 to 10,000 trees per hectare for wood, or 75,000 to 100,000 trees per hectare for forage management is the recommended density. Seeds can be drilled with a grain drill or dropped through a hand-jabber. Good land preparation and weed control are extremely important.

Excellent seedlings are obtained from extruded plastic tubes that are long (20 cm), narrow (3 cm diameter) and tapered at base (to 1 cm). Leucaena roots are deep and little-branched; plastic cups or used tin cans make poor containers. Seeds can be planted directly in the containers or soaked for two days to identify the viable seeds (those that enlarge about double in size). A mixture of peat and soil is suggested and a cracked rock layer on top will minimize fungus. Nodulation can generally be assured if soil is taken from leucaena-growing areas. Fungi causing damping-off are not serious on leucaena, but use of a fungicide in the first few weeks of growth may be advisable. Seedlings can be transplanted, but it is not recommended, since seedlings grown in deep beds root very rapidly and are damaged greatly on transplanting.

*3) Sources of Leucaena Seed*

ECHO has always distributed more than one variety of leucaena. Being a long-lived, self-pollinated, pure-line tree, farmers should avoid planting only one variety over large areas. ECHO distributes small packets of each for experimental purposes:

- K156 and K784 good for hedgerows, intercropping, alley cropping; K784 is psyllid resistant Peruvian K6 tall with extensive branching; good forage
- KX2 psyllid resistant; high production of leaf material
- K4 and K743 (hybrid) low in mimosine, which is toxic to animals in large quantities
- K636 psyllid resistant
- Cunningham K500 excellent forage
- K28 and K57 tall, tree like

Sources of seed in Africa include the following:

- ETHIOPIA: Forestry Research Center, P.O. Box 30708, Addis Ababa, Ethiopia.
- KENYA: Kenya Forestry Seed Centre, P.O. Box 20412, Nairobi, Kenya.
- MALAWI: Forestry Research Institute of Malawi, P.O. Box 270, Zomba, Malawi.
- MOZAMBIQUE: Centro de Experimentacao Florestal, Marracuene, Mozambique. antonia@ribeiro.uem.mz
- TANZANIA: Tanzania Forestry Research Institute, P.O. Box 95, Lushoto, Tanzania.
- ZIMBABWE: Forestry Commission, Forest Research Centre, Tree Seed Centre, P.O. Box HG, 595, Highlands, Harare, Zimbabwe. frchigh@harare.iafrica.com

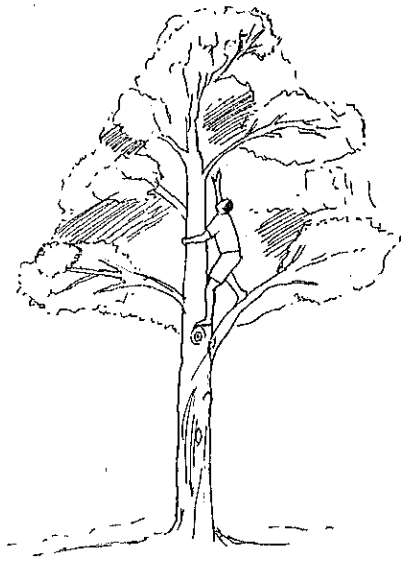
**(18) Training and Safety for Tree Seed Collection**

Seed collection, especially by climbing, is arduous work and it is essential that climbers are carefully selected and well trained before they commence collecting operations. They need to be physically and mentally fit, with a natural aptitude for climbing and a combination of self-confidence and common sense. Any sizable collection programme should have a nucleus of at least one skilled climber on the permanent staff, who may be employed on other duties outside the seeding season. It will be his responsibility to conduct short training courses for any temporary climbers before the start of each collection season. Good pictorial illustrations are an invaluable training aid, especially where climbers are illiterate.

Safety precautions will vary according to local conditions and particularly the species of tree and the equipment and methods of collection used. All staff taking part in collecting operations should be fully conversant with local safety rules. A selection of safety hints is reproduced below:

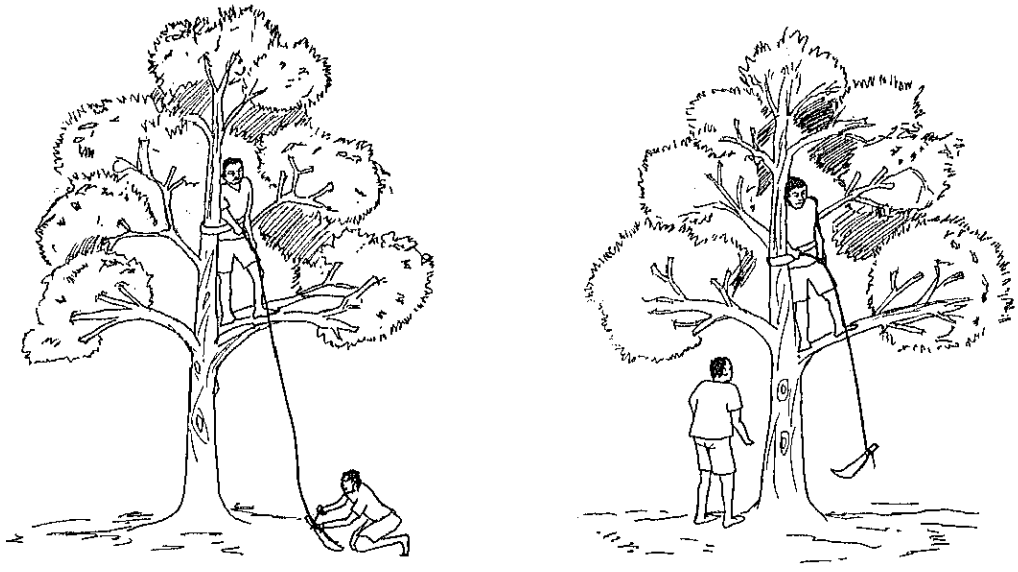
a. All equipment should be carefully stowed, both during transport in the field and while in store between collecting seasons.
b. Clothing should be strong, well fitting, and suited to the weather expected.
c. All equipment should be checked before it is used and, if there is doubt about its condition, it must not be used until repaired or replaced.
d. Do not climb in wet or very windy weather, nor in poor light as at dusk, nor when overtired.
e. Do not climb trees with obvious signs of stem rot, severe cankers or galls, split stems, double leaders, or other abnormalities indicative of mechanical weakness.
f. The safety line should be coiled on the ground before the climber ascends to avoid tangling or snagging the rope in the underbrush.
g. The anchorman should hold the safety line under one arm and over the other shoulder. It is wise to make a half turn around a neighbouring tree. This gives control and prevents the safety line from being pulled from his hands. Pull in and pay out the safety line by alternate hand grips. A sliding rope is difficult to control and can cause painful friction burns.
h. Never climb with anything tied or looped around the neck.
i. Safety helmets and goggles should be worn to prevent injury to the head and eyes in climbing rough, densely branched trees.
j. Stand on and grip branches close to the point of attachment to the main stem.
k. Watch for brittle branches; test doubtful branches before putting weight on them. Avoid branches with bark peeling from them - they are slippery. As far as possible, decide on the climbing route while still on the ground, especially for the branchy crown region.
l. The climber should have three points of support at all times (one hand and two feet or two hands and one foot), moving one limb at a time, except when attached to the tree by a safety strap or rope or when suspended on a safety line. Climb calmly with regular movements, taking short steps.

***Figure 7.2: Climber should have three-point support all the time***



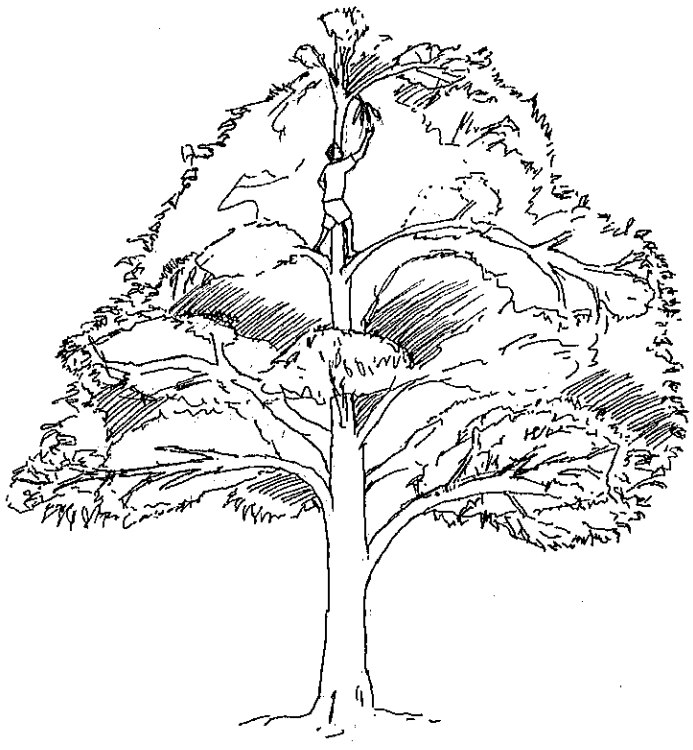
m. Do not carry tools while climbing the crown. If there is need for a pole pruner or cone rake etc., use a light tool line to hoist the equipment to the working level. Leave the tool line attached to large tools as a lanyard while working. Return tools to the ground on the line, do not drop them or throw them down.

***Figure 7.3: Use a light line to hoist any equipment***



n. Beware of sharp branch stubs: they can snag clothing and may cause painful cuts and bruises.
o. Climb spirally or in a zigzag manner, or fasten safety straps to the stem so that you cannot fall more than 2 m before your weight comes onto the safety line.
p. The diameter of the main stem should not be less than 8 cm at waist level during climbing. If in doubt concerning security, do not hesitate to tie a safety strap to the stem at a safe level before climbing within reach of the seed-bearing crown.
q. While attaching safety rope, keep one arm securely around tree until the rope is fastened to safety belt.
r. Before letting go of the tree with your hands, test your weight against the safety rope and footholds.
s. When picking near the top of a tree, keep your body close to the stem, so that your weight bears down, not outward.

***Figure 7.4: Picking pods from near top of the tree – keep body close to the stem***



t. The safety strap should always be attached around the tree stem except while you are climbing or changing position in the crown or are suspended on the safety line.
u. Before dropping bags of cones or other material, be sure that the personnel on the ground are notified and are well clear.
v. When collecting fruits from a ladder, make fast the top of the ladder to the tree with a nylon rope. The ladder must be further steadied with two guylines.
w. Have a well-stocked first aid kit handy at the climbing site at all times.

# CHAPTER 8:

# RICE CULTIVATION

## 8.1 Overview

The soils that cover most parts of SSA are ferrosols[1], arenosols[2] and gleysols[3] which are not favourable for crop production in terms of soil fertility. These soils do not hold nutrients capable of sustaining plant life including humus. Besides, total organic matter in these areas is little and decreases rapidly after cultivation if there are no additional inputs or sufficient fallow period. Together with the problems of erosion and desertification, the land productivity in this region is decreasing year after year.

Contrary to the difficulties of continuous cultivation in upland areas, lowland cultivation with irrigation may assure sequential cultivation for years with tolerable yield levels because irrigation water brings with it some micro-elements as well as some major elements depending on the water quality. It is for this reason that Asian rice fields have sustained production for hundreds of years.

Meanwhile, rice production as well as consumption in SSA has been steadily increasing in the last 30 years (Table 8.1). However, recorded increases in production have not met the demand and as a result imports have been increasing steadily. Particularly among those countries with a low self-reliance ratio (less than 30%), such as Sudan, Ethiopia, Eritrea, Kenya, Zimbabwe, Botswana, Namibia, Angola and South Africa, rice production should be promoted.

***Table 8.1: Rice in Sub-Saharan Africa***

| | | Yearly Average | | | Actual value* |
|---|---|---|---|---|---|
| | | 1971-1980 | 1981-1990 | 1991-2000 | |
| 1 | Rice, Paddy, Area harvested (ha) | 4,047,729 | 4,981,912 | 6,594,982 | 8,459,382 |
| 2 | Rice, Paddy, Production (t) | 5,494,771 | 7,553,793 | 10,724,421 | 12,713,948 |
| 3 | Rice, Imports Volume (ha) | 1,397,357 | 2,884,762 | 3,166,909 | 5,039,303 |
| 4 | Rice, Per capita consumption (kg per year) | 13.23 | 16.77 | 16.95 | 17.9 |
| 5 | Rice, Total Consumption (t) | 3,897,201 | 6,555,556 | 9,091,971 | 11,388,236 |

*Note: 1=2004, 2=2004, 3=2003, 4=2002, 5=2002

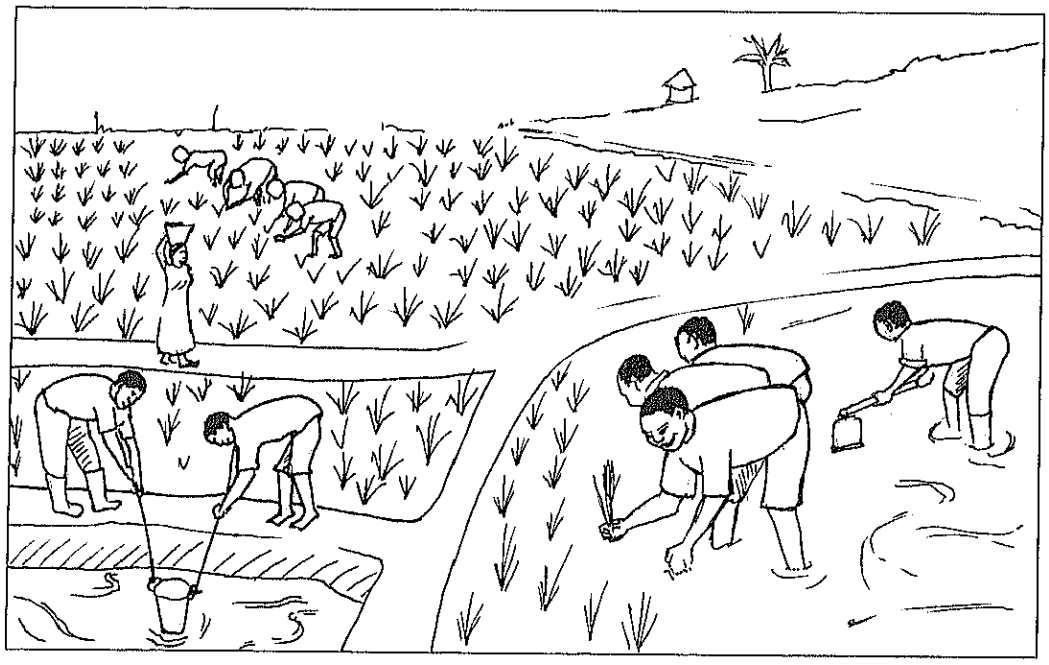
[1] Ferrosols are non texture contrast soils that have a high free iron content in the B horizon (subsoil). They are nearly always found only on basic volcanic material and are nearly always red coloured.
[2] Arenosols are sandy soils featuring very weak or no soil development.
[3] Gleysols are soils that develop under wet conditions, have a thin (<8 cm) or none at all, Ah horizon (topsoil) and are underlain by a mottle gray or brownish gleyed material. They are soils with permanent or temporary wetness near the surface. Moss peat that has identifiable plant remains may occur on the surface.

Rice is cultivated both under irrigation but also in upland and rain-fed conditions. The latter two cultivation methods depend heavily on rainfall amount and pattern which are not stable in most of SSA. Meanwhile, irrigated rice cultivation is free from dependence on rainfall provided that there is a reliable water source such as a stream/river or reservoir.

All in all irrigated rice cultivation could be an alternative for sustainable agriculture from the viewpoint of soil sustainability, low reliance on rainfall and marketability. The main constraints to starting irrigated rice cultivation are paddy field preparation and irrigation means. Each of these two requires relatively large amounts of capital and labour. Although production may become sustainable and stable afterwards, if one can't afford the initial capital and labour, then it is not possible to start irrigated paddy production.

This chapter tries to introduce low-cost and labour-saving methods for paddy rice production. It also introduces NERICA (New Rice for Africa), which is an upland rice that can be grown under rain-fed conditions.

***Figure 8.1: Land preparation, transplanting, fertilizer spreading and irrigating rice.***



## 8.2 Land Preparation of Paddy Field by "A" Frame

*(1) Description*

This technique is an easy way to prepare a paddy field with low cost. One can prepare a plot of land of a realistic size and increase according to the capacity of the family year by year. Necessary tools and equipment for the method are as follows:

1) "A" Frame
2) Hoes and/or shovels
3) Pegs (about 30 to 50cm long)
4) Strings (long enough to cover all the field)
5) Oxen and plough if possible
6) Rake

*(2) Procedure*

1) Select a lowland area where water is available from higher land by canal
2) Drive pegs one by one at the same height at one metre intervals using the "A" Frame
3) String a line between all the pegs lengthwise and also diagonally
4) Level the earth at the height of the lines by hoe or oxen-draw plough
5) Heap the earth up to form dykes around the levelled basin
6) Plant fertilizer trees at both lower and upper dykes if available
7) Water the field until it is fully submerged, pasting the dykes to stop any leakage
8) Puddle and level the field

*(3) Costs and Benefits*

An "A" Frame can be prepared free of charge if local materials are used (wood and string). If oxen and plough are used it takes one day to five days to prepare a paddy field of 5 a (are) according to the degree of slope. The costs could be studied by extension officer. Usually it takes five years for full harvest in Japan, though, one to two tons per hectare of paddy yields is not difficult from the first year. The farmer may attain three to six tons per hectare dependent upon the management skills of the farmer. The price of one kg of white rice, after husking and polishing may vary from US$0.1 to US$1.0 on the basis of milling quality and variety.

*(4) Risks*

This operation itself is low risk, but water supply may become critical after starting cultivation. Some rice pests and diseases are also a menace.

*Figure 8.2.1: Preparing a paddy basin*

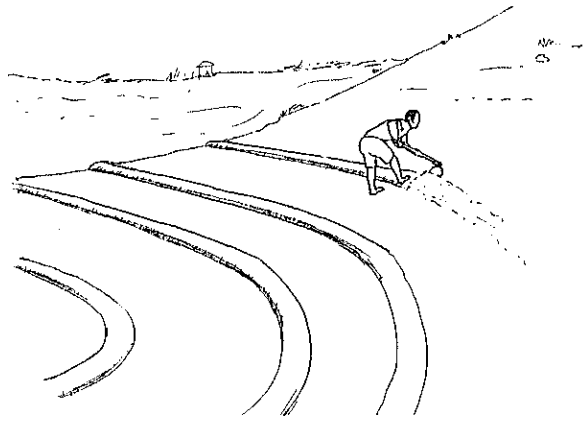


*Figure 8.2.2: Tools necessary for the preparation of paddy field*

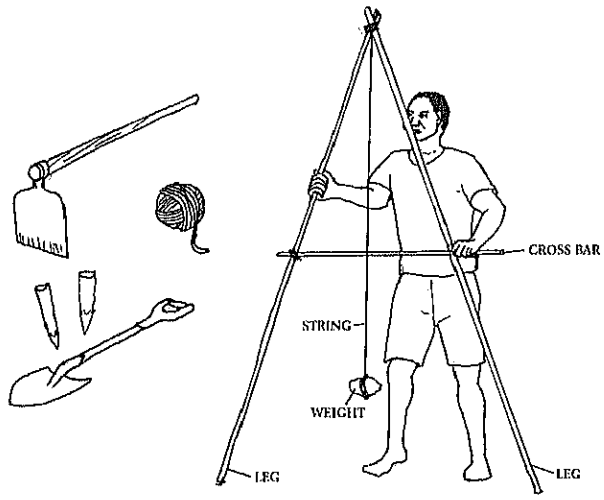
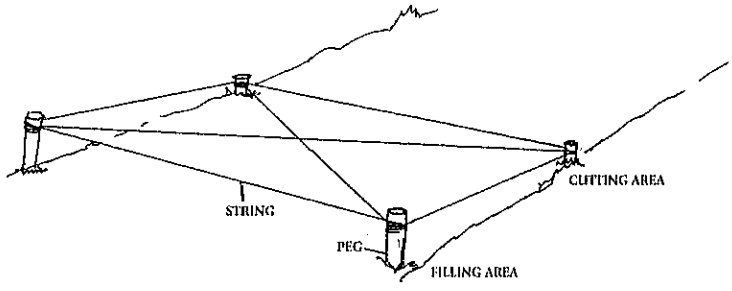



*Figure 8.2.3: Setting thread for leveling before preparation of paddy field*



## 8.3 Weeding tools used in growing rice by transplanting method

*1) Description*

Weeding is laborious work in rice cultivation as a result of which many types of implements have been developed to reduce drudgery in weeding paddy fields. The Japanese type weeders, illustrated in the drawings below, are quite favourable and efficient. Their structure is so simple that even a local blacksmith can fabricate them with basic materials.

*2) Procedure*

Paddy is transplanted in neat rows in the entire field and allowed to grow for a few weeks until weeds appear. Water is allowed in the paddy basin to a shallow or medium depth. The weeder is pushed by a person between paddy rows. Weeds are uprooted and left floating on the water surface. They are then collected and removed from field.

It is believed that the use of weeder stirs the soil to a shallow depth so that oxygen is supplied to the rice roots making them healthy. It is recommended that weeding should be done two or three times during the rice vegetative stage.

*3) Costs and Benefits*

Compared to hand weeding, weeding by this implement saves that farmer time and energy. Relative to hand weeding, use of this implement takes one third the time. However, it requires line transplanting and it may increase total labour inputs. About two to three times more time should be consumed for the line transplanting compared to random transplanting.

The price of the weeder depends on the place where it is manufactured, but may not exceed US$30 per unit.

*4) Risks*

Although damage by the apparatus is minimal, rough use of it in a paddy field may seriously injure rice plants. Careful use is required until one is well accustomed. If the water is too deep, the efficiency of the implement will decrease; therefore the water level should carefully controlled to secure smooth movement of the implement.

*Figure 8.3.1: Outlook of weeder*

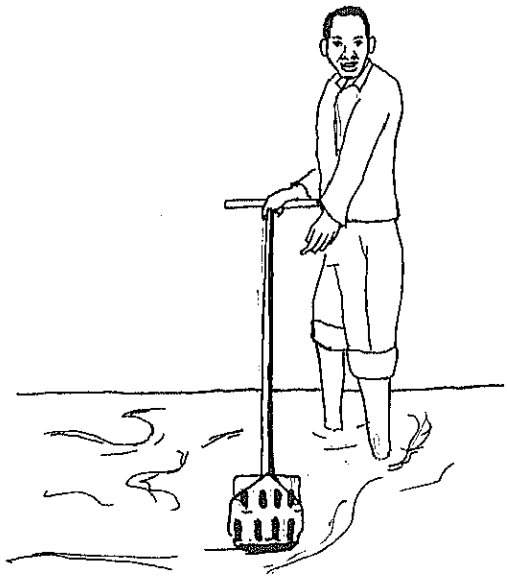


*Figure 8.3.2: Using weeder between rows*

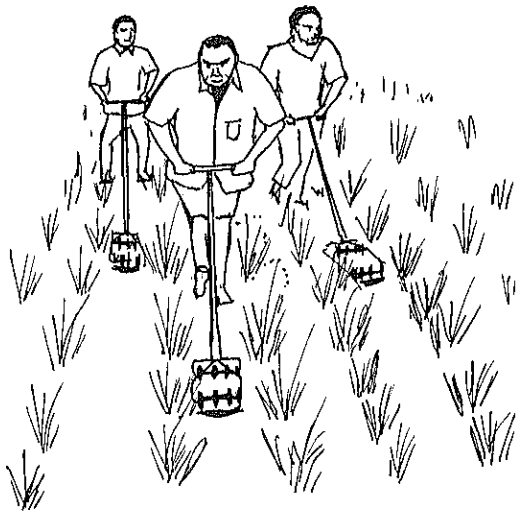
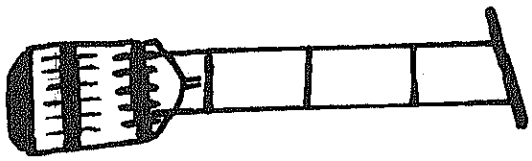


*Figure 8.3.3: Other design of weeder*



## 8.4 Dapog – Easy way to raise seedlings

*1) Description*

Raising rice seedlings in a nursery is a time-consuming activity and later involves laborious transplanting. Besides, seedbeds occupy part of the denuded field. The dapog system is a traditional method of raising seedlings used in the Philippines, which requires small seedbed areas, a short period of growing seedlings (10-12 days), and an easy method of uprooting them and carrying them to the field.

*2) Procedure*

Prepare normal seedbeds above water level; a concrete floor can be used instead. Lay banana leaves or plastic sheets on the seedbed (or concrete floor) and guard all the sides with banana stalk or wooden frame. Place rice seeds on the banana leaves or plastic sheet to an even depth of 1.5 – 2.5 cm. This layer of seeds should take 0.5 to 5 kg per $m^2$. Cover the seedbed with grass leaves to prevent bird damage and drought. Raise the level of water to cover all the seeds to just saturate them. Since no soil or other materials are used, the roots of the emerging seedlings start tangling against each other after a few days. Within 11 to 13 days the seedlings have exhausted the food from the seed and are ready to transplant at 10 to 12 cm height with two to three leaves. The seedlings mat is cut and rolled at an appropriate size that is easy to carry to the field, and seedlings are torn off one by one for transplanting.

*3) Costs and Benefits*

Using the dapog system, the labour requirements for raising and uprooting seedlings are about half of those for the ordinary seedbed. The amount of seed required is almost the same as for the ordinary method and varies from 20 to 40kg/ha.

*4) Risks*

Since seedling height is low at transplanting, there is a risk of transplanted seedlings getting submerged in water or to dislodge from the soil and float. It may therefore require careful planting taking relatively more time. Although recovering from planting damage is fast because of the abundant roots, the rate of missing hills may be about 20% more than that of the ordinary planting system. Thus, additional replanting labour may be required.

***Figure 8.4.1: Seedbed preparation before sowing***

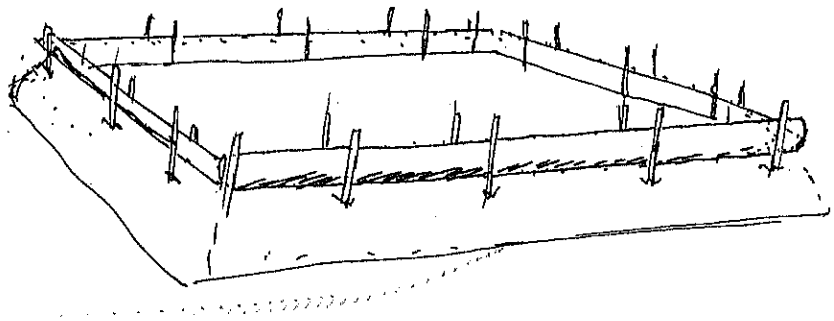


*Figure 8.4.2: Cross section of seedbed Just after sowing*

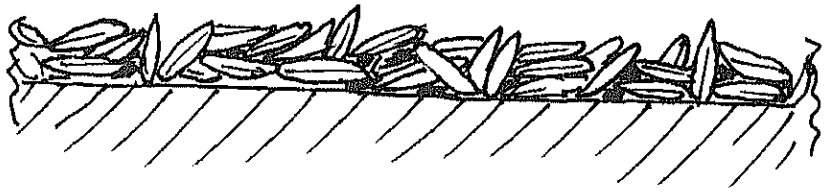
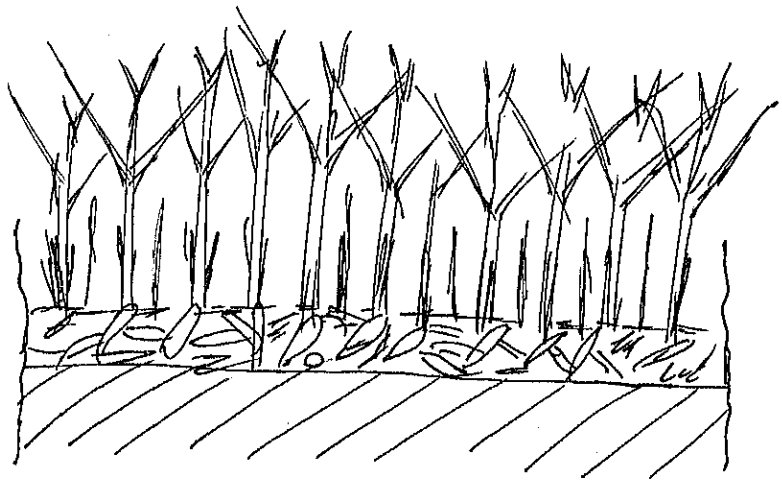


*Figure 8.4.3: Seedlings ready to transplant*



# CHAPTER 9:

# PREVENTION OF POST HARVEST FOOD LOSSES

## 9.1 Overview

Farmers produce crop products. Crop products become available during different short periods of the year, but people wish to consume the food steadily throughout the year. Therefore, some form of storage is required. Food losses can occur during storage. This chapter deals with storage of dry grains.

Households make choices on how much to store and how much to sell depending on the market price, their own consumption needs, storage facilities and their needs for immediate cash. If the local distribution and marketing system is efficient, they can rely on food being available for purchase all the year round, but if they are isolated for at least part of the year through bad roads and lack of transport, their food security will be more at risk and home storage is likely to receive higher priority.

Good storage is required for the following reasons:

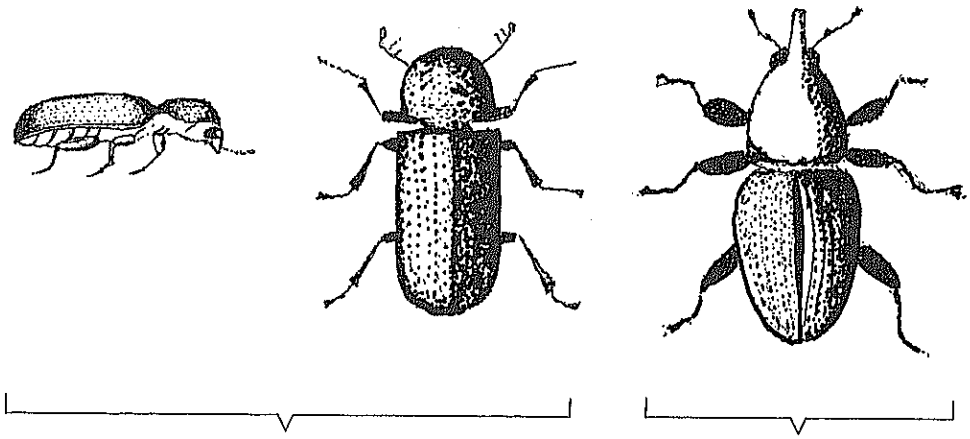
- to ensure that quality does not deteriorate during the storage period
- so that the quantity in storage is not unintentionally reduced
- the crop remains secure against pests, diseases and physical loss
- it is accessible at the time and in the quantity required

The main agents that cause deterioration of stored produce are:

- micro-organisms (fungi, bacteria and yeasts)
- insects and mites
- rodents
- birds
- metabolic activity

Fungi live on the bodies of plants as parasites or saprophytes. In both instances they cause damage on the body on which they live. Bacteria may not destroy dry stored grains but they may invade already damaged portions of the crop product during storage and multiply. Many types of insect pests are also found on stored grains. These include grain weevils such as the Lesser Grain Borer ***(Rhyzopertha dominica (Fabricus))*** and the rice weevil (Figure 9.1 (a) and (b), respectively).

***Figure 9.1: These and many other types of storage pests infest and destroy stored grain.***



*(a)* *(b)*

The following are the stages in the complete post-harvest system for cereals:

- harvesting;
- pre-drying in the field;
- threshing;
- winnowing;
- drying;
- storage of grain;
- primary processing: cleaning, grinding, hulling, pounding, milling, grinding, soaking, drying, sieving;
- secondary processing: baking, frying, cooking, extruding, blending, fermenting, roasting;
- packaging, marketing; and
- utilization by customers.

## 9.2 Detecting Insect Problems

*1) Description*

In order to manage stored grain effectively and avoid losses due to insect infestation, it is necessary to examine grain carefully before it is stored. After that regular inspections are carried out to see whether grain insects have infested the grain while in storage. To avoid insect infestation during storage, recommended dust chemicals may be used on the grain.

*2) Procedure*

If grain is already sealed in bags, use a grain auger (Figure 9.2) to sample and examine. The auger is inserted at several points and to various depths in a random sample of bags. The extracted grain is visually examined for insects and insect damage. Through this examination an experienced farmer can also detect any fungal growth on the grain.

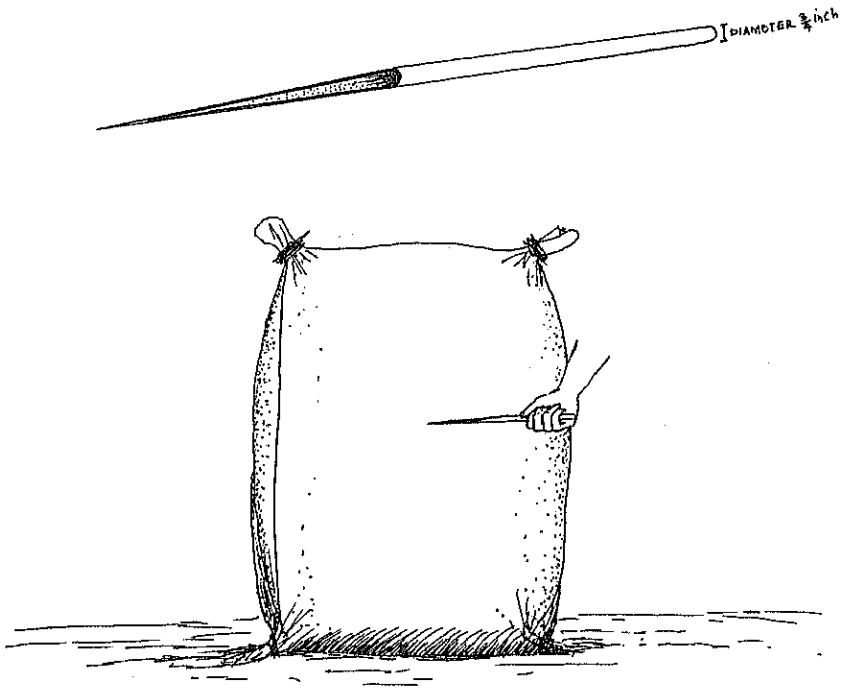
*3) Costs and benefits*

A grain auger can be made of a 30-cm length of a 2.5 cm light metal pipe or other light metal material at a minimal cost. Since much of the grain harvested may be stored in traditional cribs, inspection should be carried out while the grain is being dried and just before it is placed in the crib. With this method, no auger is needed. The farmer inspects the grain herself and takes appropriate measures.

*4) Risks*

The main risk associated with visual inspection of grain is that of not being able to tell whether insects have punctured grain and laid eggs inside while still in the field. This often happens with maize weevils. In order to minimize this risk, grain is examined under the sun so that any live insects are seen moving and detected.

***Figure 9.2: A grain auger***



## 9.3 Storage of roots, tubers, bananas and plantains

In terms of food energy, roots, tubers, bananas and plantains account for some 40 percent of total food supplies for about half of the population of SSA, where overall food supplies are at very low levels and declining. The decline has been associated with increased urbanization, which does not favour highly perishable and labour-intensive products.

### (1) Cassava

Fresh cassava tubers deteriorate rapidly; therefore cassava is sometimes left in the ground until the tubers are required for immediate consumption. This is an inexpensive and simple domestic storage strategy, but it imposes a constraint on the effective use of land for subsequent crops and reduces the processing quality of the tubers. Cassava should preferably be processed within 24 to 48 hours of harvesting.

If early processing is not possible, fresh, undamaged cassava roots may be stored for a short time by burying them in moist dust or sand. Cassava roots inter-layered in 10-kg lots with cassava leaves, maintain their quality for four weeks. The inter-layered cassava leaves provide an optimum temperature of 35° to 40°C and a humidity of 85 to 90 percent; and during drying, they also slowly liberate small amounts of hydrogen cyanide, which may help to reduce microbial deterioration of the tubers.

### (2) Sweet potatoes

In the tropics, sweet potatoes are harvested as required for consumption. Like other tuber crops, sweet potatoes exhibit a period of dormancy, which enables them to be stored for short periods. The storage life of many varieties can be greatly increased by curing. Favoured conditions for curing are relative humidity of 80 to 90 percent, at 30°C to 32°C, over a period of four to seven days. Curing promotes wound healing.

Damaged sweet potatoes may become infected with mould, and from time to time outbreaks of poisoning have been reported in livestock fed on the larger coarse-textured varieties. The toxins are believed to be produced by the growth of a mould on the tubers after superficial damage to the surface layers.

### (3) Storing other basic staples

Farmers may prepare their foodstuffs for storage by first drying them. In drying, the objective is to remove as much water from the food item as possible, thereby making it keep longer. The drying process may be conducted directly as in sun drying, where the sun's energy and the wind are utilized to evaporate water from the foodstuff, or indirectly, as in drying over a wood fire.

With the exception of maize, yams and rice, there are no specially designed structures for storage of most food crops. Staple crops such as cassava, cocoyams and some varieties of yams are kept either by delaying harvest until the crop is required or by storing underground in pits.

## 9.4 Post-harvest handling and storage of cereal and legume grains

Grain may rot in the fields if it is not harvested in time or if it is rained on before harvest. This problem can be overcome by ensuring timely harvest by hiring labour where this is found to be the main constraint or rescheduling the school holiday period to enable children to assist in timely grain harvesting.

Traditional grain cribs for maize and other grains, including legumes, are shown in Figure 9.3. In humid areas, traditional grain cribs are ventilated structures used for both drying and storing grain. For effective drying, the walls should comprise up to 40 to 50 percent open spaces, depending on the relative humidity in the drying area. The maximum width of the crib depends on the mean daily relative humidity; under exceptionally humid conditions the width of the structure should be reduced. The maximum moisture content for safe storage of selected cereals and legumes ranges from 7 percent for shelled groundnuts to 15 percent for beans, with an average of about 13 percent for cereals. It is often not possible to achieve these levels in humid areas. In ventilated cribs losses caused by mould, rats and insects range from 3 to 10 percent. Maximum moisture content of stored grains is presented in Table 9.1.

***Figure 9.3: Traditional grain cribs***

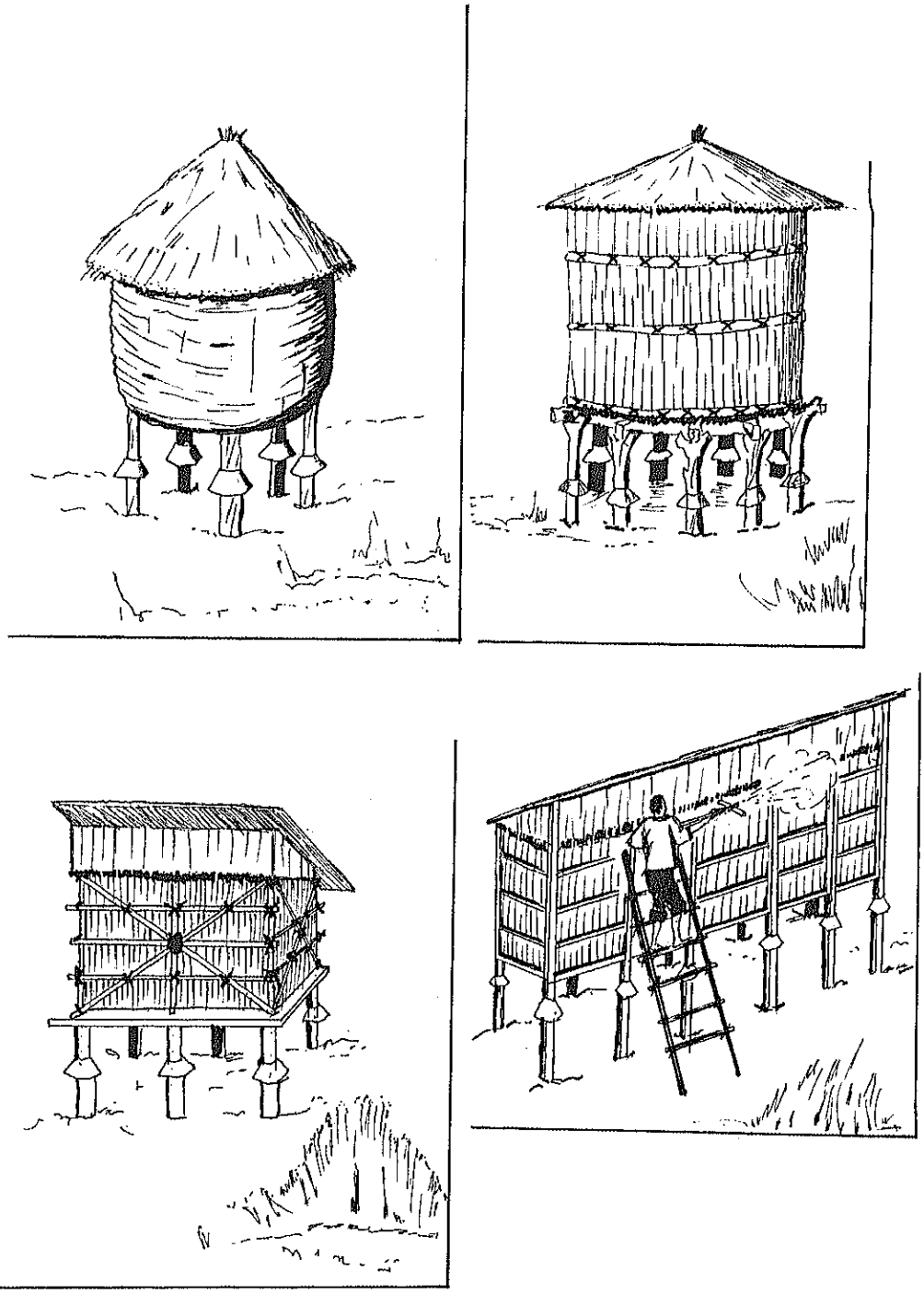


***Table 9.1: Maximum moisture content for safe storage of selected cereals and legumes***

| Commodity | Moisture content *(% wet basis)* |
|---|---|
| **Cereals** | |
| Maize (shelled) | 13.0 |
| Maize, white | 13.5 |
| Maize meal | 11.5 |
| Paddy | 14.0 |
| Milled rice | 12.0 |
| Millet | 15.0 |
| Sorghum | 1 3.5 |
| Wheat | 13.5 |
| Bulgur wheat | 13.5 |
| Wheat flour | 12.0 |

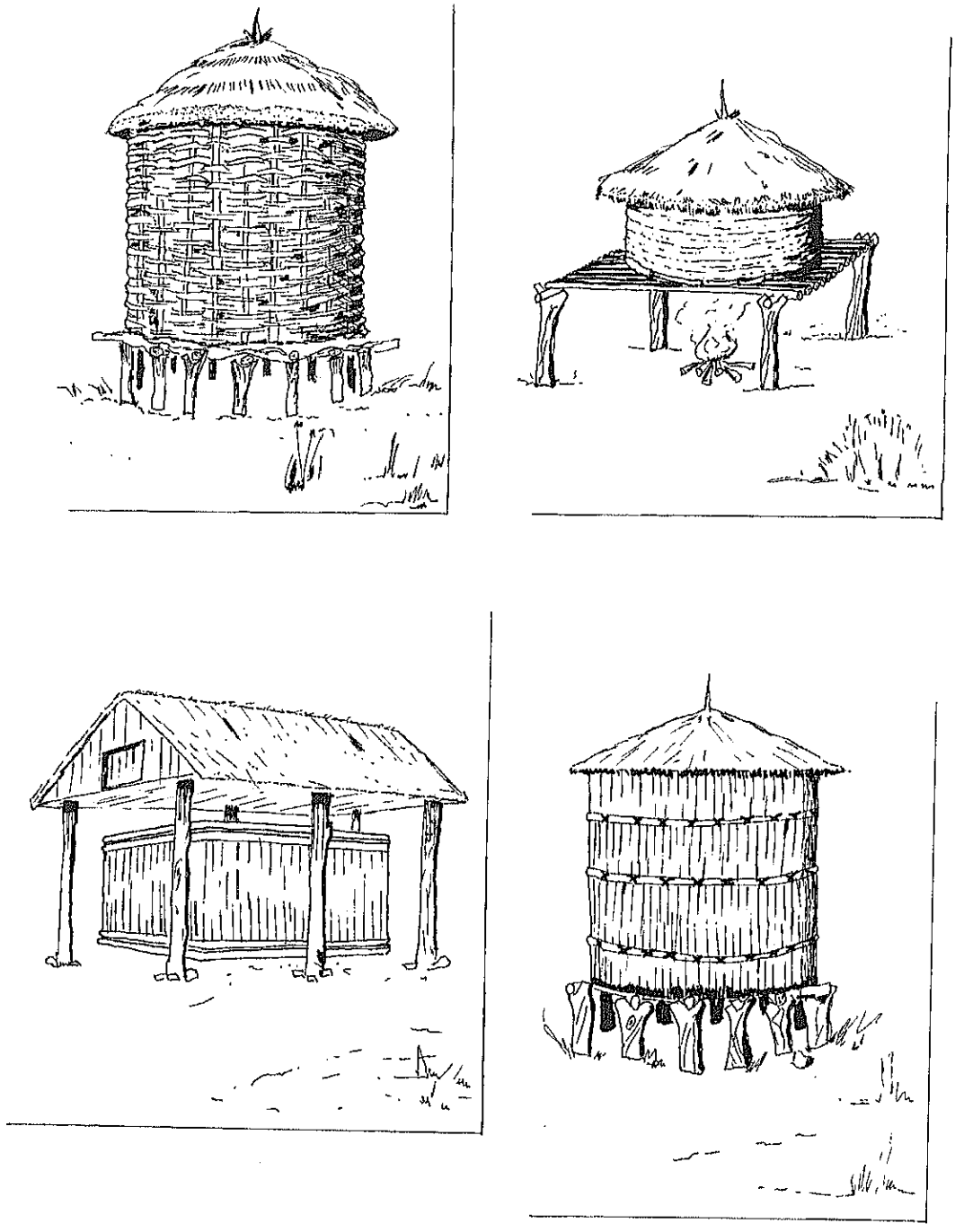
| Commodity | Moisture content *(% wet basis)* |
|---|---|
| **Legumes** | |
| Beans (haricot and horse) | 15.0 |
| Lentils | 14.0 |
| Cowpeas | 14.0 |
| Pigeon peas | 14.0 |
| Field peas | 14.0 |
| Green grams | 14.0 |
| Soybeans | 11.0 |
| Groundnuts (unshelled) | 9.0 |
| Groundnuts (shelled) | 7.0 |

*Source:* FAO, 1993.

Paddy rice is more resistant to pests than milled rice, and under village conditions, where fumigation or airtight storage is impractical, cowpeas are better stored unthreshed, as the intact, dry pods provide some protection against bruchids. Good husk cover can reduce field infestation in maize but only marginally reduces the rate of pest increase.

To keep out rats and improve aeration in the crib, improvements have been made to the traditional crib as shown in Figure 9.4.

***Figure 9.4: Improved traditional grain storage bins and cribs.***



*Source: FAO, 1985.*

Promotion of storage of cereals in solid-walled bins should also be accompanied by the introduction of improved shelling and threshing techniques, since in the bins cereals are stored in bulk. Hand shellers are too slow for the processing of large quantities of grain. Small-scale farmers prefer to use hired labour to shell by hand, which is known to be more cost effective.

## 9.5 Home- and village-based food preservation

Food spoilage may be reduced by controlling the availability of water to the organisms causing the spoilage and/or by lowering the pH of the food. The most common preservation technique practiced at household level in the tropics is sun drying; its importance for grain storage has already been emphasized. Drying is also often used to preserve meat and fish, fruits, roots and tubers and green leafy vegetables.
Fish and meat may be preserved by salting, smoking and drying. Some types of fish are also fermented. Milk may also be preserved by combinations of fermentation and drying.

## 9.6 Household processing of paddy rice in West Africa

In some countries paddy is parboiled before it is dehusked. Parboiling is partial cooking which causes the starch of the kernel to gelatinize, making it tougher. There is also a slight change in flavour which is preferred by some people. The toughening process makes the seed more resistant to insect attack, to shattering during husking and to the absorption of moisture from the air. Paddy that has been parboiled has a better nutritional quality owing to the migration of nutrients towards the centre of the grain during the process. The parboiling process involves three stages:

- soaking of the paddy in cold or hot water to increase its moisture content;
- treatment by steaming to gelatinize the starch in the kernel;
- drying.

## 9.7 The most important ways to keep domestic food safe and clean

- Eat meals as soon as possible after they are cooked, so that bacteria do not have time to breed.
- Use a safe water supply where possible. If not, boil drinking-water for babies for at least three minutes. Boil the drinking-water for the whole family if there is an epidemic of diarrhoea or cholera in the area or if the water quality is doubted.
- Wash your hands with soap and water.

# CHAPTER 10:

# APPROPRIATE FARM MACHINERY – ANIMAL DRAFT POWER

## 10.1 Overview

It is generally felt that it is too early to introduce sophisticated farm mechanization to smallholder farmers in SSA. However, utilization of machinery is an integral part of the use of other farm inputs such as good seeds, fertilizers and chemicals. It is also one of a mix of management tools with which a farmer can maximize production and profit. Further, machinery utilization, in most cases, reduces drudgery in farm work and saves time which can be used for off-farm work with attendant subsidiary effects.

These palpable benefits of mechanization put to doubt the stereotypical view that mechanization is not necessary for smallholder farming in developing countries. Modern and sophisticated technologies may be appropriate depending on the situation and needs[4]

Large-scale commercial mechanized farming is, of course, beyond the scope of this book. On the other hand, 'Appropriate Farm Machinery' is a key word for smallholder farming today and its adoption should result in labour saving practices and increases in labour productivity, leading to better profits. Table 10.1 illustrates the obvious advantage of engine-powered ploughing as compared to manual and animal ploughing.

***Table 10.1: Comparison of rate of work for ploughing one ha by different power sources***

| *Power source* | Tractor | Animals (3 men for a team of 2 oxen) | Manual labour |
|---|---|---|---|
| *Rate of work* | 5 hrs | 5 days | 40 to 60 man-days |

*Source: Adapted from FAO*

[4] p35, Participatory Approach to Sustainable Village Development (PASViD), The Ministry of Agriculture, Food and Fisheries, The Republic of Zambia, August 2000, Japan International Cooperation Agency (JICA)

Although savings in time and labour are positive results of utilization of machinery, investment in the assets is the farmer's most serious concern. In particular, initial (purchase price) and maintenance costs, are most critical because, often, the smallholder farmer cannot afford.

When considering introducing machinery, variable costs such as fuel, lubricants, labour (driver, loader etc.) and storage must also to be considered. It is an established fact that the production cost per unit area when using machinery decreases as farm size increases. However, most smallholders are not able to enlarge their farm size today due to traditional land tenure systems, lack of investment capacity, inaccessibility to farm credit, inaccessibility to inputs markets and so on.

Appropriate Farm Machinery users are smallholders whose preferences are easy operation, easy fabrication, maintenance-free, simplicity in structure, locally-available, safety in operation and so forth. In light of these points, Appropriate Farm Machinery presented in this chapter is animal powered, referred to as Animal Draft Power (ADP).

ADP can be recommended for the following reasons[5]:

- Animals have more power than man for timely and efficient farm operations.
- Animals cost less than engine-powered machinery such as tractors.
- Animals are easier to maintain and feed on crop residue.
- Animals have a high resale value.

But some negative views against ADP exist among researchers[6]:

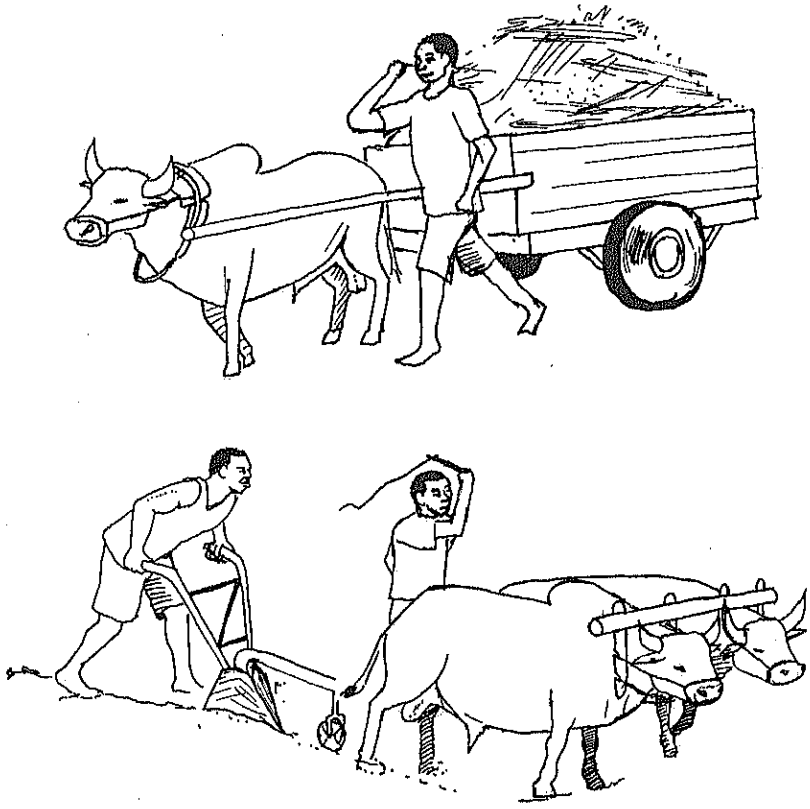
- Animal power does not reduce human effort appreciably.
- Draft animals require extra food and grazing land.
- Death rate can sometimes be high due to poor health management.

The practices presented here are intended to reduce drudgery particularly with activities such as land preparation, weeding and transportation. The main ADP sources are cattle and donkeys.

[5] Musa, H. L. and S. T. Bello, Research and Development of Draught Animal Power Utilization in West Africa, National Centre for Agricultural Mechanization, P. M. B. 1525, Ilorin, Nigeria

[6] Musa, H. L. and S. T. Bello op. cit.

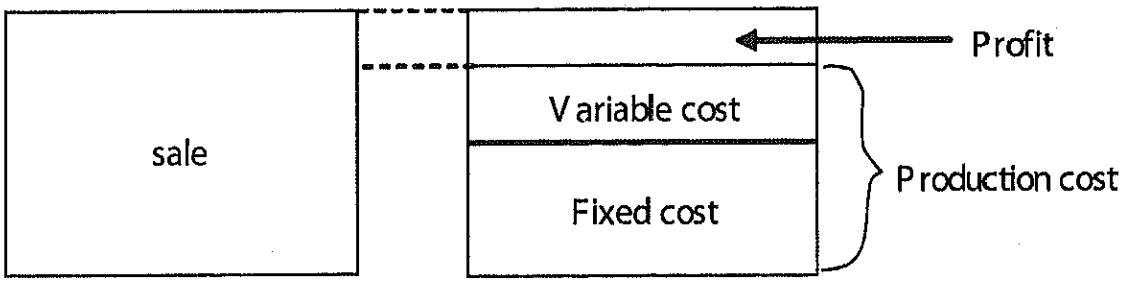
***Figure 10.1: Animal Draft Power***



## 10.2 Costing of ADP

Before introducing ADP, farmers should know how much animal power costs. The costs of utilization of ADP comprise fixed and variable costs (Figure 10.1) for animals and implements. Before adopting ADP it is important to determine these fixed and variable costs in order to estimate the final benefit to the farm economy.

***Figure 10.2: Composition of production cost***



### (1) Fixed costs

Fixed costs have a constant value throughout the year; therefore, the larger the farm, the lower the fixed cost per unit area. They comprise of depreciation of animals, implements and devices, interest for investments, shelters, insurance, veterinary and health care, feeding and so forth.

Depreciation cost is an unseen but vital cash flow as it represents the cost of replacement due to obsolescence and deteriorating usefulness of equipment, vehicles, buildings and infrastructure. Consequently, the cost should ultimately be borne for required replacements, repair to support essential operations and services. The straight-line method of calculating depreciation is simple and easy to apply.

Annual depreciation cost (ADC)[7] = (Initial Purchase Price (IPP) less Salvage Value (SV)) divided by Useful Life (UL) of an asset

In symbols ADC = (IPP – SV)/UL

Where,

- ★ Salvage value is the estimated value of an asset at the end of its useful life (e.g., 10% of the IPP)
- ★ Useful life of the asset is read out of tables provided by government

Table 10.2 shows useful information of prices and working life of implements and animals and Table 10.3 also presents some purchase prices of implements and animals in Zambia.

***Table 10.2: Prices and working life for animals and implements/devices***

| Implements / Devices / Animals | Illustrative prices (US$) | Working life (years) |
|---|---|---|
| Two oxen (2.5 years old) | 200 | 5 |
| Ox yoke and reins | 20 | 2 |
| Donkey (2.5 years old) | 100 | 7 |

[7] For example, a farmer buys an animal drawn plough at 200USD with 15-year expected durable life so that annual depreciation cost is figured out as 12USD by Straight-line method.

| | | |
|---|---|---|
| Donkey harness | 30 | 5 |
| Moldboard plough | 50 | 10 |
| Cultivator / Weeder | 60 | 7 |
| Seed planter | 120 | 7 |
| Harrow | 40 | 10 |
| Cart | 150 | 10 |

*(Source: FAO web site, http://www.fao.org/ag/aga/AGAP/FRG/Draught/contents.htm)*

***Table 10.3: Prices of implements and animals in Zambia (2006)***

| Implements / Devices / Animals | Illustrative prices (US$) |
|---|---|
| Cattle (Steer) | 420 |
| Cattle (Heifer) | 420 |
| Plough | 180 |
| Chain and Ropes | 52 |
| Ox cart | 570 |
| Harrow | 57 |
| Ripper | 42 |

*(Source: Project for Participatory Village Development in Isolated Areas, Zambia)*

**(2) Variable costs**

Variable costs cover all the additional costs the users have to meet once they use their animals and implements. Variable costs are labour cost if hired, fuel cost for engine powered machinery and so on. The total variable cost varies depending on hectarage of farm or operated hours. Consequently, it should be noted that to increase the net total profit margin means reducing production cost per unit weight of produce and vice-versa. This depends on how much fixed cost can be minimized and the volume of produce sold.

***Figure 10.3: Relationship among, profit, loss, sales and production cost***

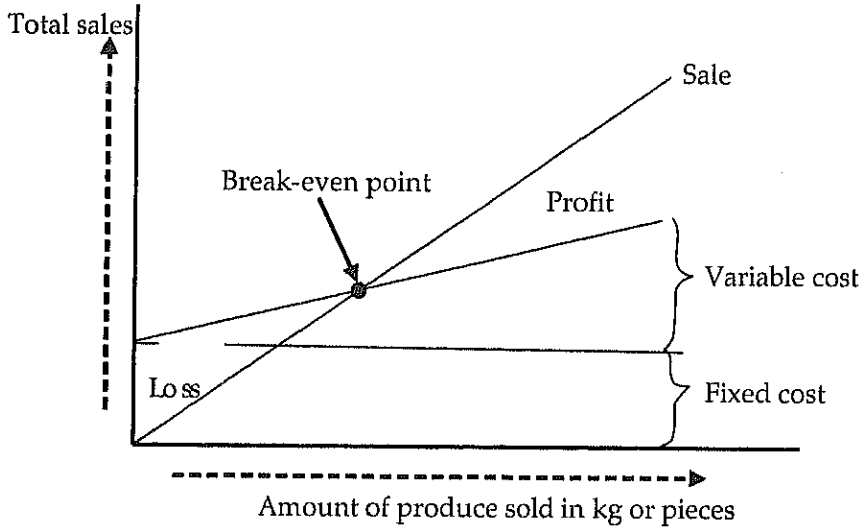



Table 10.4 shows an example of ADP cost calculation where a plough is used as an implement, two oxen as source of ADP with two skilled hired men to carry out the ploughing.

***Table 10.4: An example of ADP cost calculation for ploughing***

| Item | Illustration (US$) |
|---|---|
| Initial assumptions | |
| Animal purchase price (two oxen) | 200.0 |
| Animal working life (years) | 5 |
| Initial purchase price of mouldboard plough | 50.0 |
| Working life of mouldboard plough | 10 |
| Initial purchase price of yoke, chain, ropes, reins and shelter | 40.0 |
| Total of equipment (Mouldboard and yoke, etc.) | 90.0 |
| Annual equipment fixed cost calculation | |
| Annual depreciation cost of equipment (90 – 9) / 10 | 8.1 |
| Interest (10% interest on 50% of equipment IPP cost) | 4.5 |
| Repair and maintenance (10% of initial equipment cost) | 9.0 |

| | |
|---|---|
| *Total of annual equipment fixed cost* | *21.6* |
| Annual animals fixed cost calculation | |
| Animal depreciation cost (200 – 20) / 5 | 36.0 |
| Loan interest cost for purchase of animals (10% interest on 50% of animals cost) | 10.0 |
| Animal insurance cost (5% of initial cost) | 10.0 |
| Management and veterinary costs (20% of the initial cost) | 40.0 |
| Feed supplementation costs throughout year (20% of the initial cost) | 40.0 |
| *Total of annual animals fixed cost* | *126.0* |
| *Total of fixed cost of ADP (21.6 +126.0)* | *147.6* |
| Variable cost calculation (labour cost if hired) per day | |
| Cost of supervision of animals (hired skilled labour at 2 US$) | 2.0 |
| Cost of operation plough (hired skilled labour at 2 US$) | 2.0 |
| *Total daily variable cost for ploughing* | 4.0 |
| [Assumption]<br>Animal draft ploughing is used for 2ha at rate of work of 1ha/5days: therefore, 10days ploughing.<br>Total fixed cost per ha = 147.6 US$ / 2ha = 73.8 US$<br>Total variable cost per ha = 4.0 US$ x 10 / 2ha = 20.0 US$ | |
| *Total ADP ploughing cost per ha (73.8 + 20)* | *93.8* |

*Source: Adapted from FAO*

*Note: Animal sale price after working life is not considered as additional benefit.*

## 10.3 Ploughing by Oxen

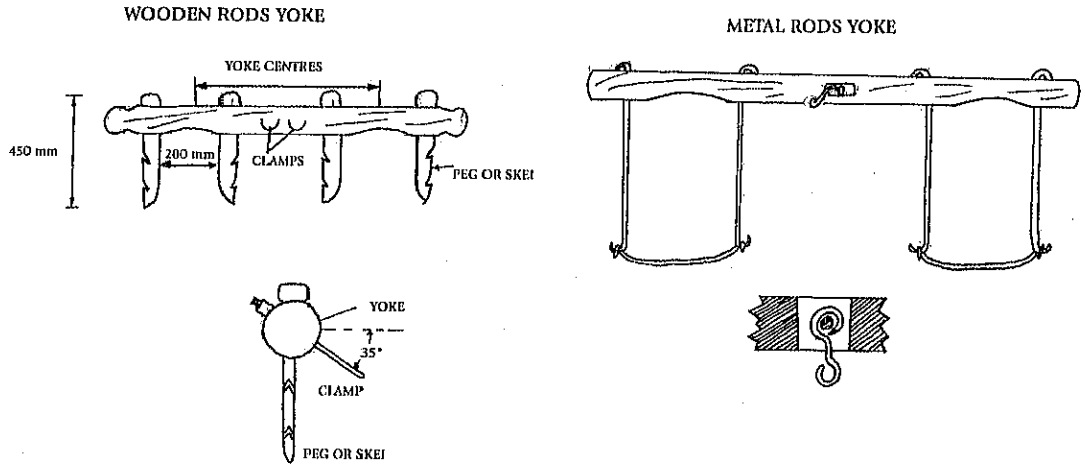
*1) Description*

Ploughing is a land preparation operation carried out before planting. To reduce drudgery in ploughing, the farmer should use an ox-drawn mouldboard plough operated by 2 to 3 persons. This is widely practiced in SSA. An ox's body weight ranges from 500 kg to 900 kg and its power output varies from 350 to 500kW[8], (Fraenkel, 1998) depending on the weight of the animal. Consequently, the heavier the ox the greater is its output. This is an easy way to turn over heavy soil within a shorter time. An ox team can work for 5 to 6 hours in a day (Fraenkel, 1998). The working speed is from 2 to 4 km/h; therefore, human operators can easily control the plough and the oxen.

*2) Procedure*

- Select breeds and number of oxen, depending on the farmer's investment capacity. Indigenous cattle breeds in Africa such as Zebu (*Bos indicus*, *Bos Taurus* and their crossbreeds) will be suitable because they are adapted to the environment and climate.
- Select implements - ploughs, yokes, and other devices. There are two types - wooden and with metal rods, (see Figure 10.4). The surface of the yoke should be smooth and cords should be loose enough to give maximum comfort to the animal. Yokes can be made by hand. The suggested yoke length is 90 cm.
- Observe the yoke carefully when in use and inspect the point of attachment of the trek chain to the beam.
- Make sure that when the animals are pulling, the yoke does not rotate across the shoulders.
- Training on how to adjust the yoke, set the depth of cut and control the ox-team should be conducted before the operation starts.

***Figure 10.4: Selecting farm implements***




*3) Costs and benefits*

Refer to 10.2 for cost calculation.

*4) Risks*

- Feeding management is necessary by adopting a grazing method.
- Tsetse control and regular spraying of animals with acaricides are necessary to minimise animal disease incidence.

## 10.3 Transportation by oxen power

*1) Description*

ADP helps farmers in transporting produce, agricultural inputs, implements, by-products and people. The components of this mode of transport are an ox or ox-team, harnesses and a cart. The power of pulling by this method is much greater than that of a similar number of humans. Its working speed at between 3 and 5km/h is rather slow but still faster than a human being. Animal haulage over short distances is economical. Load capacity varies from 400 to 2,000 kg (Howe 1983, Adeoti 1988) depending on animals' weight and scale of carts.

Another transportation device powered by an ox is a sledge. Use of sledges is more economical and structure is simpler than carts. Draft force ranges from 50 to 80 kg. A pair of oxen can pull a loaded sledge weighing from 200 to 300 kg[9].

*2) Risks*

Sledges are likely to cause damage to the surface of prepared roads. At least one country has banned the use of sledges because of soil erosion. Sledges are therefore suited mainly to short trips on or around farms. Sledges will have a harmful effect on vegetation; therefore, their use should be discouraged in areas where vegetation is needed to prevent soil erosion[10].

[9] Low-cost Load-Carrying Devices, The design and manufacture of some basic means of transport, Ron Dennis and Alan Smith, Intermediate Technology Publications, 1995

[10] Low-cost Load-Carrying Devices, The design and manufacture of some basic means of transport, Ron Dennis and Alan Smith, Intermediate Technology Publications, 1995

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