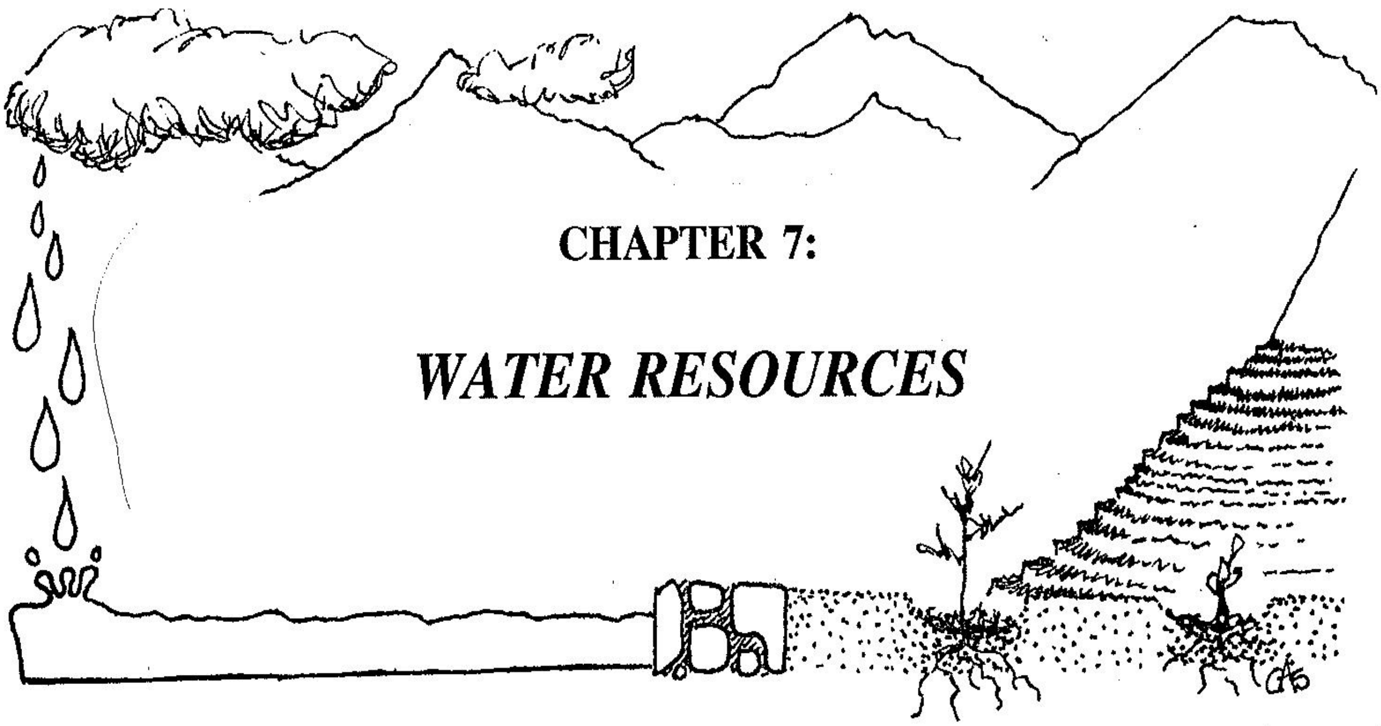
CHAPTER 7:

WATER RESOURCES



Life and agriculture are dependent on water. One of the most frequent questions ECHO receives from the field reflects the need for strategies to produce food in dryland areas or in the dry season. The erratic and unpredictable rainfall in much of the tropics makes food production difficult; months of drought bake and harden the soils, so the torrential rains which follow lead to erosion. People without sufficient water for cooking and personal use are not able to irrigate crops during the dry season. This chapter gives some ideas on soil and water conservation in times of water shortage and seasonal abundance.

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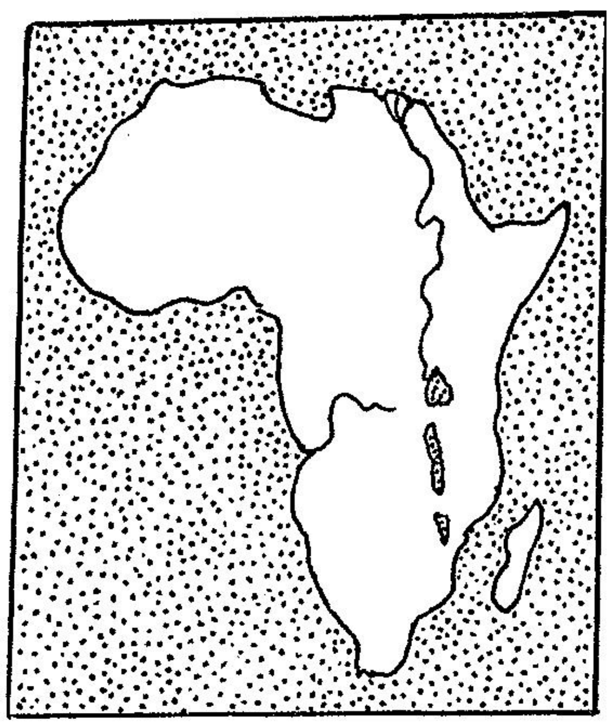


ARID REGION FARMING PRIMER by Dr. Frank W. Martin

INTRODUCTION. In every region of the world it is necessary to find or develop appropriate techniques for agriculture. A large part of the surface of the world is arid, characterized as too dry for conventional rain fed agriculture. Yet, millions of people live in such regions, and if current trends in population increase continue, there will soon be millions more. These people must eat, and the wisest course for them is to produce their own food. Yet, the techniques are so varied that only a very large volume would cover the entire subject. This publication is only a primer, an introduction to appropriate techniques. More extensive treatments are mentioned in the bibliography. In many cases the most suitable techniques for a particular region may be those already developed by the local inhabitants. In some cases it will be difficult to improve on local techniques, but at times even simple and inexpensive innovations may be almost revolutionary. This bulletin suggests that one must begin to improve local agriculture in arid zones by learning what is already there. Then both techniques and plants that may be useful in specific situations are suggested.

<u>Definitions and degrees of aridity.</u> "Arid" implies prolonged dryness, and is used with respect to the climate and the land below it. In such regions the ability to produce agricultural crops is restricted. Usually on arid lands the potential evaporation of water from the land exceeds the rainfall. The land may be characterized according to the degree of aridity as dry forest, chaparral or brushland, grassland or savannah, or desert. "Arid" does not adequately characterize the soils, however, for they may vary in many ways. Often they are alkaline or saline.

Several degrees of dryness must be recognized. The first is where the dry climate is modified by seasonal rainy seasons. In such a region it might be possible to produce a wide range of annual crops during the short rainy season, enough to sustain animals and feed mankind, although few food or feed trees might be feasible without special techniques. The second situation is a year round aridity, sometimes modified by light or irregular rains, which might make production of crops impossible. The third situation is where water is brought in by wells, canals, or other means so that normal agriculture can exist, in spite of the aridity of the climate. This primer concerns the first two situations, but not the third. There are techniques suitable for all arid regions.

<u>Principal arid regions of the world.</u> Arid regions are often extensive, but in the tropics it is common, even on a small island, to find arid regions near regions of abundant rainfall. The large arid regions are:

North America
- Much of Western USA
- The Sonoran Desert

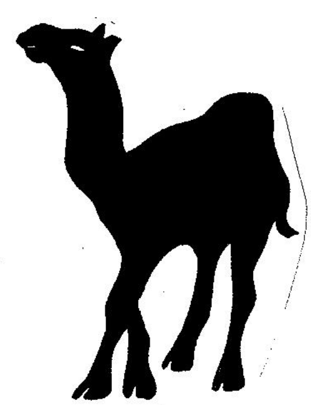
Central America
- The Pacific Coast

South America
- The Atacama Desert
- The Serrano of Brazil

Australia
- The Central Deserts

Africa
- The Sahara Desert
- The Sahel
- The Kalahari Desert
- East Africa

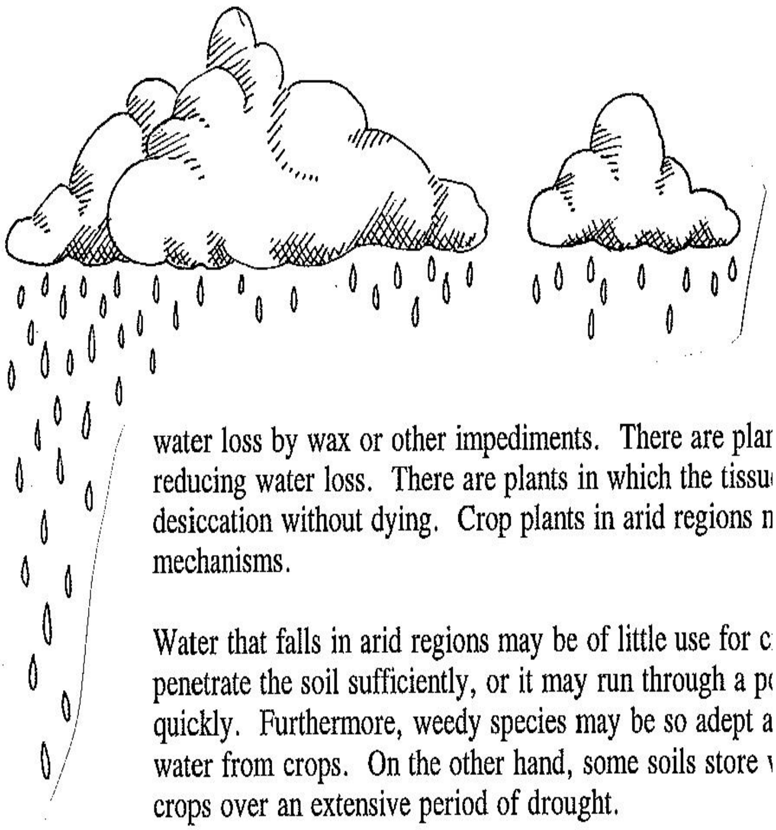
Asia
- The Middle East
- The Indian or Thar Desert
- The Namub Desert
- The Karakum Desert
- The Gobi Desert



However, while the above mentioned regions may constitute the most arid regions, nevertheless, there are many more areas, large and small, where aridity is a problem.

PRINCIPAL PROBLEMS OF AGRICULTURE IN ARID REGIONS

<u>Water.</u> Water is absolutely necessary for all plant and animal life. Plants have evolved that are capable of living and reproducing in semi-arid, arid, and even desert regions. However, as aridity increases, fewer and fewer species are adapted, and the potential biomass is reduced.



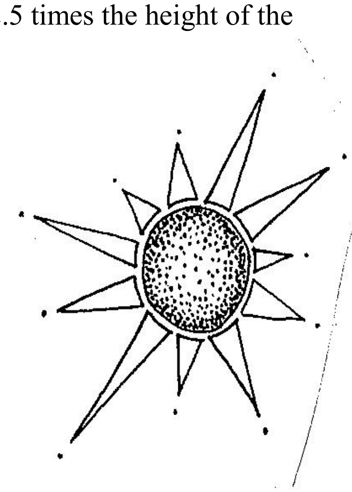
Plants are adapted to aridity by several mechanisms. There are plants with a short life cycle that can germinate, grow, and produce during a very short period of available moisture. There are plants with deep or extensive root systems which have the ability to gather water over a wide area. There are plants which store up water in their tissues and release it very slowly. There are plants that are protected from water loss by wax or other impediments. There are plants with very small or narrow leaves, thus reducing water loss. There are plants in which the tissues themselves can withstand much desiccation without dying. Crop plants in arid regions may have any or a combination of such mechanisms.

Water that falls in arid regions may be of little use for crop plants because the amount is too small to penetrate the soil sufficiently, or it may run through a porous soil too quickly, or it may run off too quickly. Furthermore, weedy species may be so adept at utilizing scarce water that they rob the water from crops. On the other hand, some soils store water so efficiently that it is possible to grow crops over an extensive period of drought.

Water from rivers, lakes and wells in arid regions may have problems of quality, especially the presence of excess minerals. The use of irrigation water might lead to the accumulation of salts in the soil resulting in alkalinity or salinity, which might then limit crop production. The removal of salt from the soil is very difficult.

In all arid regions a major challenge is to manage water appropriately. The purpose of such management is to obtain water, to conserve it, to use it efficiently, and to avoid damage to the soil.

<u>Heat and Wind.</u> The major effects of heat and wind are to increase the rate of evaporation, and thus to increase the effects of aridity. Wind may also cause mechanical damage to crops. Both are combatted by changing the microclimate. The effects of winds can be reduced by windbreaks (lines of trees perpendicular to the direction of prevailing winds). Some useful tall species are tamarisk, casuarina, and eucalyptus. A windbreak can consist of trees and other plants of varying height. As a general rule, a windbreak is effective over an area 2.5 times the height of the tree. One must remember, however, that a windbreak may also rob crops of light, water and nutrients. Thus, the advantages of a windbreak must be weighed against the disadvantages in any particular environment. Windbreaks can also be constructed of non-living materials, which are likely to be expensive.



Heat is received principally from the sun and can be reduced by shading. But, shading also reduces the yields of plants. A light shade such as that below a coconut planting or a protective screen or lathwork can be useful in reducing heat and retaining moisture, with only a minimum loss of yield.

<u>Soils.</u> Soils of the arid tropics are highly variable, as they are in any climate. Nevertheless, it is possible to make some generalizations about such soils. Because of the low rainfall and consequently reduced plant growth, organic material is produced slowly. Yet, again because of low rainfall, it may be broken down slowly as well. The amount of organic material in the soil, and thus the potential fertility, is likely to be high in semi-arid zones, low in deserts.

Because of low rainfall in desert soils, minerals derived from breakdown of rocks are not leached from the soil. In some cases where the soil is periodically flooded or irrigated the soil might be saline as well. Such soils support few crops. Soils of the semi-arid and arid zones might support few plants on the surface, but a good part of the biomass might be in the soil itself as roots. Shrubby desert plants often have very hard woody roots that may be a physical barrier to agriculture.

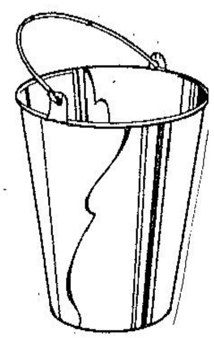
<u>Disease and Pest Problems.</u> Arid regions have their fair share of disease and pest problems. However, these may often be quite different from those of wetter regions. Nematodes are often a severe problem in sandy soils. No general rules are useful, and indeed, agriculture anticipates diseases and pests, and their parasites as well.

AGRICULTURAL TECHNIQUES FOR ARID LANDS

Many of the techniques for agriculture in arid lands are not very different from those in other climatic zones. The unique problems of arid lands are almost entirely related to water or its effects over long or short times. Therefore, the discussion here revolves around two questions: "How to capture existing water," and "How to use water wisely."

<u>How to Capture Existing Water.</u> Much of the water that falls on arid lands is lost by runoff, deep penetration into sands, or by evaporation. Runoff can be captured for later use in natural or nature-like ways, or in manmade structures. These include the following:

1. Furrows, and diking of furrows, ditches, and pits following contours to slow the runoff of water and permit deeper penetration.
2. Similar structures reinforced by bench terraces, vegetative strips, or trees for alley cropping.
3. Crescent-shaped basins arranged to gather water for one or more trees.
4. Reservoirs of water, such as natural or constructed shallow basins along roads which capture runoff, earth structures that lead water into aquifers (underground streams), rock or clay-lined underground basins.
5. Other man-made structures. These include cisterns (household or community sized clay, stone, or concrete tanks, check dams (small structures that impede water movement in a stream), and conventional dams.



<u>How to Obtain New Water.</u> In many arid regions water can be obtained from wells. The depth of the well necessary to obtain water may vary a few to thousands of feet. Water in wells is either fossil (stored over impermeable layers for thousands of years), or from water that has entered the soil from rain, and is therefore stored rainwater. Both sources of water are limited and can be exhausted.

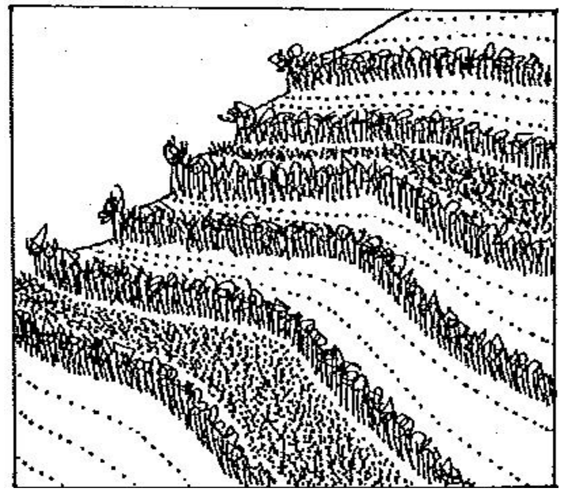
New water is also obtained by condensation from the air, either onto metal screens or plastic (the principle of the solar still) or onto foliage. Ingenious systems can be developed to capture this condensation. This source of water depends on nighttime temperatures that lower to the point of condensation.

<u>How to Conserve Existing Water.</u> Water that is conserved is just as valuable as water that is obtained, and conservation is one of the best strategies for arid zones. There are many techniques, here presented only as lists.

At the level of the home: Reduce water use in the home. Capture gray water (from kitchen and bath) for later use in the garden. Use overflow from septic tanks to irrigate trees.

On the farm or garden: Reduce evaporation with windbreaks and light shade. Plant in the best soil, and lead runoff water to it. Plant in furrows, pits, or swales. Establish plants in a nursery in pots, when feasible, for later transplanting. Keep the soil rich in organic material. Use drought resistant crops or varieties, when possible. Maximize use of trees that produce food in arid regions. Plant during appropriate seasons. Use mulch, but not in excess. Irrigate efficiently (usually the most efficient system is drip irrigation). Keep weeds down. Eliminate crop plants as soon as they finish producing.

Other techniques: **Hillside farming.** The special aspect of hillside farming that merits attention here is that water rapidly runs off and often causes erosion. Thus, hillsides can be arid even in an otherwise wetter climate. The techniques required for successful hillside farming are those that capture water, minimize runoff and erosion, and help build soil fertility. Some techniques are very simple, such as plowing along the contour and leaving vegetative strips between planting. Some are more complex and expensive, and may require engineering, such as building bench terraces, correcting gullies, and building ponds and dams.



The most elegant techniques and probably the most satisfactory are associated with the use of multiple purpose legumes in systems of alley cropping. Trees along the contours are used to gradually develop terraces and meanwhile enrich soil by capturing nitrogen and bringing up deeply buried nutrients, making them available in foliage, used as fertilizer. In addition, such trees may furnish firewood, feed, or occasionally food.

The crops for hillsides should be those with very deep roots or that can take advantage of short times of availability of water.

Use of trees. Trees will often be the most useful crop plants in arid regions, for with deep roots they can make maximum use of water. Trees will need special protection when they are planted, including irrigation in time of need. A good tree crop ought to fill many purposes.

Residual moisture. In some soils in arid regions with short rainy seasons, crops are planted near the end of the rainy season and even after rains have ceased in order to take advantage of moisture stored in the soil. Tepary beans are produced using this principle. Melons are often used as such crops in Central America.

Alternate years. A common practice in arid regions is to plant only every other year. During the year when the ground is left fallow, weeds, which use up the water in the soil, are controlled. This type of planting is suitable only for soils with a large capacity to store water. This will be evident when the crops or weeds on a soil remain green for a long period after rains have ceased.

Feeding of animals. Crop residues, both harvested and those left in the fields, may be used as feed during dry seasons. Animals such as cattle, goats, sheep, hogs, chickens, and ducks clean up the field and can help eliminate weed seeds, and, of course, they also leave their manure.

CROP PLANTS FOR TROPICAL ARID REGIONS

Crop plants for arid regions are those that survive and produce in spite of aridity. However, in almost all of these crops, seeds must be germinated or cuttings must be rooted under conditions of almost normal water availability. Therefore, when one speaks of tolerance of dry conditions one is talking mostly about the drought tolerance of the growing or mature plant. In the following tables, plants that are useful in arid regions are considered. These plants vary in ability to tolerate aridity and in yields under arid conditions. Choosing the right crops for arid regions might involve considerable experimentation in a particular region, and, in fact, the development of suitable production systems might require years. This should come as no surprise. Native systems, as crude as they may appear, usually represent the accumulated wisdom of centuries of experimentation. If this is so, how can one hope to make an improvement? The answer is often in the introduction of species or varieties unknown in the region. In other cases it is the introduction of technologies developed in other regions (see page 185 for resources).

TABLE 1. FOOD PLANTS FOR DRY REGIONS OF THE TROPICS

Scientific name	Common name	Degree of Tolerance (0=none to 3=high)
CEREAL GRAINS		
Zea mays	Corn	1
Sorghum bicolor	Sorghum	1.5
Pennisetum americanum	Pearl Millet	2.5
GRAIN LEGUMES		
Phaseolus vulgaris	Common Bean	1
Vigna unguiculata	Cowpea	1.5
Cajanus cajan	Pigeon Pea	2
Dolichos lablab	Lablab Bean	2
Vigna radiata	Mung Bean	2
Phaseolus acutifolius	Tepary Bean	2.5
Vigna aconitifolia	Mat Bean	2.5
Tylosema esculentum	Marama Bean	3
LEAFY VEGETABLES		
Symphytum officinale	Comfrey	1
Manihot esculenta	Cassava	1
Cnidoscolus chayamansa	Chaya	2
Moringa oleifera	Moringa	2
Leucaena leucocephala	Leucaena	2.5
ROOT CROPS		
Dioscorea rotundata	White Yam	1
Manihot esculenta	Cassava	2
Sphenostylis stenocarpa	African Yam Bean	2
VEGETABLES		
Citrullus lanatus	Watermelon	1
Cucurbita mixta	Mixta Squash	1.5
Cynara scolymus	Globe Artichoke	1
Abelmoschus esculentus	Okra	1.5

FRUIT TREES

Carica papaya	Papaya	1
Pouteria campechiana	Canistel	1
Psidium guajava	Guava	1
Spondias cytherea	Golden Apple	1
Olea europaea	Olive	1.5
Tamarindus indica	Tamarind	1.5
Zizyphus jujuba	Jujube	1.5
Carissa carandus	Karanda	2
Dovyalis abyssinica	Dove Plum	2
Punica granatum	Pomegranate	2
Anacardium occidentale	Cashew	2.5
Opuntia spp.	Prickly Pear Cactus	2.5
Phoenix dactylifera	Date	3

OIL PLANTS

Pentaclethra macrophylla	Owala Oil	1
Helianthus annuus	Sunflower	1
Butyrospermum paradoxum	Shea Butter	2

MISCELLANEOUS

Catha edulis	Khat	2

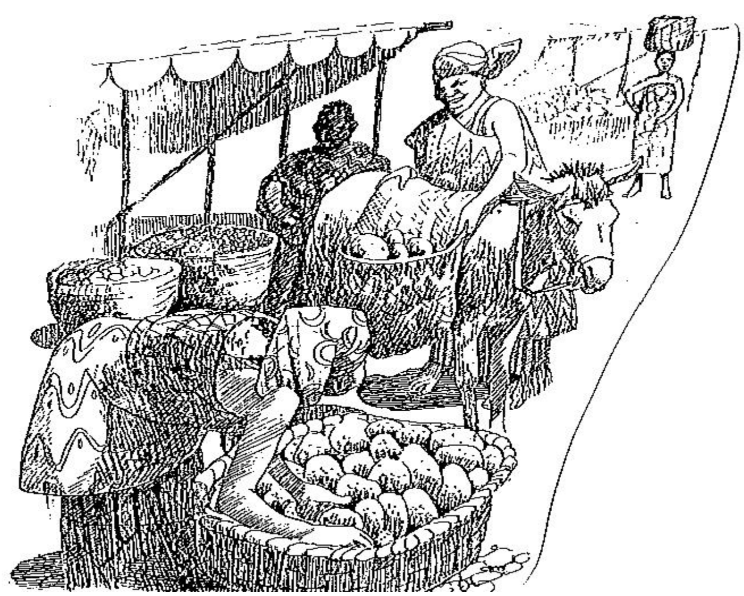
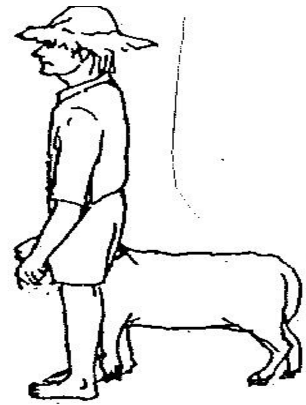


TABLE 2. NON-FOOD PLANTS FOR ARID REGIONS

Scientific Name	Common Name	Degree of Tolerance (0=none to 3=high)
FEED LEGUMES		
Gliricidia sepium	Mother of Cacao	1.5
Ceratonia siliqua	St. John's Bread	1.5
Prosopis spp.	Mesquite	2
Leucaena leucocephala	Leucaena	2.5
Acacia albida	Apple Ring Acacia	2.5
Acacia tortilis	Umbrella thorn	2.5
Parkinsonia aculeata	Jerusalem Thorn	3
FEED GRASSES		
Cynodon dactylon	Bermuda Grass	1
Digitaria decumbens	Pangola Grass	1
Sorghum sudanense	Sudan	1
FIBER PLANTS		
Gossypium barbadense	Sea Island Cotton	1
Agave fourcroydes	Henequen	2
Agave sisalana	Sisal	2.5
TIMBER PLANTS		
Swietenia mahogoni	Mahogany	1
Acacia tortilis	Umbrella Thorn	2.5
PLANTS FOR ALLEY CROPPING		
Gliricidia sepium	Mother of Cacao	1.5
Cajanus cajan	Pigeon Pea	2
Leucaena leucocephala	Leucaena	2.5
GROUND COVER		
Dolichos lablab	Lablab Bean	2
Canavalia ensiformis	Jack Bean	1.5
WINDBREAK		
Casuarina spp.	Casuarina	2
Eucalyptus spp.	Eucalyptus	1.5
Tamarisk spp.	Tamarisk	2.5
LIVING FENCE		
Gliricidia sepium	Mother of Cacao	1.5
Bursera simaruba	Gumbo Limbo	1.5
Acacia nilotica	Babul Acacia	2.5
Euphorbia tirucali	Pencil Euphorbia	3

ANIMALS FOR DRY REGIONS OF THE TROPICS



Why Animals? In dry regions of the tropics where agriculture is always difficult, animals are frequently more capable of utilizing the often abundant plants that are available, and many times can be fed with crop residues. While some feed crops are given in Table 2, the most important feeds in many regions will be those which grow by themselves, naturally and untended. Sometimes improvement of this natural fodder by fertilizing, watering, or selected weeding may be the best solution to increasing the yield of animal feed. In addition, appropriate care of animals is necessary, and even poor herdsmen are often very skilled in raising animals.

Animals on the farm can be used for a wide variety of purposes. In addition to excellent food in the form of eggs, milk and meat, animals serve as beasts of burden, and can be trained to handle difficult jobs on the farm. The dung is a useful resource for crop production but is also used in plastering walls and floors, and when dry, as fuel. Animal wool, hair, or fur can be used in bedding and clothing.

Principal Animals and Their Characteristics. **Cattle.** In many arid regions the production of cattle might be the best way to make use of land. Cattle feed principally on grasses, but also benefit from legumes. They are much less apt to graze or browse on shrubs than goats. They are very adept at finding something useful to eat on grasslands, even during the dry season. Cattle may be used for milk, for meat, for farm labor, and for their hides and other by-products. There are many breeds of cattle, often used for a single purpose, or at times serving for two or more main purposes, and some of these will be much more adapted to a given situation than others. Choosing the appropriate breed or strain of cattle will always be important.

The carrying capacity of land, the number of cattle (or, other animals that can be raised on it), will vary widely, and can determine the success or failure of a given venture. Cattle may graze in open range or fenced pastures, but in either case, rotation is necessary in order to not destroy the future potential of the grazing area. Improvement of the grazing area can be achieved by the introduction of new grasses or legumes, by fertilization, occasionally by fire (a risky process), by killing poisonous plants, and by eliminating brush and some trees. Some breeds will gain more on a given pasture than others.

Since cattle raising is a capital-intensive effort (even the cattle represent considerable capital), a great deal of investigation and local knowledge is desirable before embarking on such an enterprise. On the other hand, raising the family cow is possible almost everywhere and can be the foundation of success on the small farm.

Goats. Goats may be produced for about the same purposes as cattle, and their smaller size makes them suitable for many situations. They are often grazed on open range in arid regions. They are browsers (nibble at a variety of plants), and sometimes are better adapted to production of useful meat than cattle, especially in heavy shrubland. While goats may be raised for milk, the really fine milk varieties are not well adapted in the tropics.

Sheep. In addition to the wool-bearing sheep of the temperate zone, there exist hair sheep which are much better adapted to the tropics. In addition to their value in producing meat, such sheep are often used to control weeds in orchards, and thus constitute a profit-producing biological control.

Burros. The small donkey of the drylands of the world is supremely adapted to living off the browse and meager feed often available, and for its size is surprisingly strong and a magnificent beast of burden. Not to be laughed at, the burro can easily be adapted to useful roles on the farm, including basic transportation and pulling carts.

Camels. This species is best adapted to very dry areas where agriculture is very limited.

The choice of animals for the farm in the arid tropics, and the techniques used to raise such animals are very important, and vary considerably from one region to another.

Feed Crops. After adaptation, no element in the production of animals is more important than feed. Farmers may be quite conscious of acceptable treatments in care and breeding of their animals. They may not be aware of the progress that could be made by improvement of feeds, even though such advice may be available through local agricultural experiment stations, extension services, or the department of agriculture. A first step in improving animal production should be to learn how farmers are feeding animals, and the second step is to learn what feeding practices are recommended. A third possible step, much more difficult, is to learn the feeding practices in areas of similar soils and climates.

A major problem in the production of animals is what to feed them during the dry season. An efficient production system includes solving this problem in advance. Some of the potential solutions include: dry season irrigation of pastures; restricted grazing of pastures during wet seasons so that feed will remain for the dry season; harvest and storage of wet feed as silage; harvest and storage of dry feed as hay, or as seed, in the case of grain crops; cultivation of feed crops adapted to arid zones; and migration to more productive areas.

One of the most useful possibilities for increasing dry season feed is the use of crop residues. The value of such residues as feed varies, and sometimes other substances are added to enhance palatability or nutritive value. In a well-managed agricultural enterprise of any kind, it will be useful to look for such potential uses of residues.

Another solution to the problem of dry season feed shortage is to reduce the size of the herd as the dry season approaches. The frequent practice of letting animals go hungry cannot be recommended as good husbandry.

USEFUL PUBLICATIONS AND ADDITIONAL RESOURCES (prepared by ECHO staff).

Agroforestry Technology Information Kit by The International Institute of Rural Reconstruction (475 Riverside Drive, Room 1035, New York, NY 10115, USA) cost: $27. Kits are also available as well from their headquarters in the Philippines: IIRR, Silang, Cavite 4118, PHILIPPINES.

Agroforestry in Dryland Africa by Rockeleau, D., Weber, F. and Field-Juma, A. 1988, ICRAF (International Centre for Research in Agroforestry, P.O. Box 30677, Nairobi, KENYA). 311 pp. cost: $31.00.

Crops of the Drier Regions of the Tropics by D. Gibbon and A. Pain, available from Longman Scientific & Technical, Longman Group UK Ltd., Longman House, Burnt Mill, Harlow, Essex CM20 2JE, UK.

ECHO's Technical Note on Dry Farming by Randy Creswell, cost $3.00.

Haloph: A Data Base of Salt-Tolerant Plants of the World by James A. Aronson, 1989, Office of Arid Lands Studies (The University of Arizona, 845 North Park Ave., Tucson, AZ 85719, USA).

Lost Crops of Africa, Volume 1: Grains (NAS), limited supply available from ECHO.

More Water for Arid Lands: Promising Technologies and Research Opportunities and Saline Agriculture: Salt-Tolerant Plants for Developing Countries, both by National Academy of Science (National Research Council, Office of International Affairs, 2101 Constitution Avenue, Washington, D.C. 20418, USA). Order from AgAccess, P.O. Box 2008, Davis, CA 95617, USA; phone 916/756-7177.

The Challenge of the Negev by Dr. Evenari (Ben-Gurion University of the Negev, P.O. Box 1025, Beer-Sheva 84110 ISRAEL).

Food from Dryland Gardens by David A. Cleveland and Daniela Soleri (Center for People, Food and Environment, 344 South Third Ave., Tucson, AZ 85701, USA). A comprehensive handbook.

Practical Guide to Dryland Farming Series: Introduction to Soil and Water Conservation Practices; Contour Farming with Living Barriers; Integrated Farm Management; and Planting Tree Crops by World Neighbors in Indonesia (Studio Driya Media; Jl. Tubagus Ismail Raya No. 15; Bandung, West Java 40143; Indonesia) available at $4 per booklet from World Neighbors, 4127 NW 122 St., Oklahoma City, OK 73120-8869, USA; phone 405/752-9700.

Seed Sources for Arid Land Gardeners: see the chapter on Seeds and Germplasm.

Information Sources for Arid Land Gardeners:

Office of Arid Land Studies (The University of Arizona, 845 North Park Ave., Tucson, AZ 85719, USA).
The Center for People, Food and Environment (344 South Third Ave., Tucson, AZ 85701, USA).
Maricopa Agricultural Center (37860 W. Smith-Enke Rd., Maricopa, AZ 85239, USA).
Int'l Crops Research Institute for the Semi-Arid Tropics (Patancheru, P.O. Andhra Pradesh 502-324, INDIA).
International Center for Agricultural Research in the Dry Areas (P.O. Box 5466, Aleppo, SYRIA).
Drought Defenders Project (Henry Doubleday Research Assn., Ryton-on-Dunsmore, Coventry, CV8 3LG, UK).
Arid Lands Information Network (174 Banbury Road, Oxford, OX2 7DZ, UK). Publish "Baobab," a networking

publication for those working in arid lands.

International Institute for Environment and Development (3 Endsleigh St., London, WC1H ODD, UK; phone +44 71-388-2117; fax +44 71-388-2826; e-mail iieddrylands@gn.apc.org). Publish the quarterly "HARAMATA, Bulletin of the Drylands."

SEPASAL (Survey of Economic Plants for Arid and Semiarid Lands, Centre for Economic Botany, Royal Botanic Gardens, Kew, Richmond, Surrey TW9 3AE, UK; fax +44 81-332-5278). Plant information database.

Video:

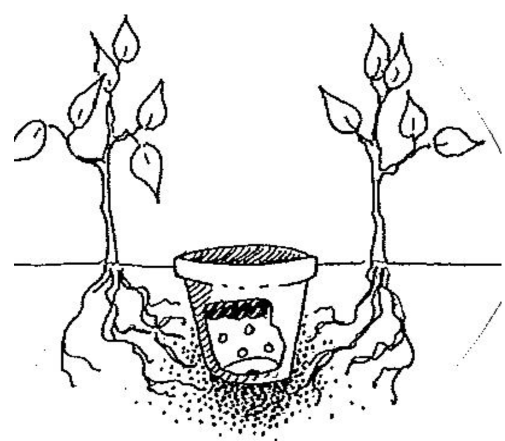
Looking After our Land: Soil and Water Conservation in Dryland Africa. (Oxfam Publications, c/o BEBC, P.O. Box 1496, Parkstone, Poole, Dorset BH12 3YD, UK; phone 01202 715555; fax 01202 715556.) A two-hour tape (£14.95) and an illustrated 88-page book (£8.95); specify whether you want the English or French version and whether your video equipment uses the PAL, SECAM or NTSC system.

DRYLAND TECHNIQUES AND WATER RESOURCES

A TECHNICAL NOTE ON DRY FARMING by Randy Creswell in Mali, West Africa, is available from ECHO. This 18-page note gives specific technical guidelines for growing plants in arid regions. Randy defines dry farming as "the profitable production of crops, without irrigation, on land with a low average or highly variable rainfall." The document gives practical steps for increasing water absorption, reducing the loss of soil moisture, suitable cropping systems, mulching, plowing and tillage, planting, and a series of tables on requirements of drought-resistant crops. Available from ECHO for US$3 (free to development workers).

You may know of special techniques or plants for arid regions that may also help other readers. The quality of EDN is greatly increased as our readers share their best ideas with us. Please write!

PARTIALLY BURIED FLOWER POTS OR TIN CANS SAVE IN WATERING. Like many of you, we have a very long dry season at ECHO. Many plants are beyond the reach of our irrigation system. Even though we have the luxury of reaching them with a garden hose, it can still be quite a task (and waste of water) to get the soil sufficiently wet in the root zone of a fairly recent planting. Often I have had the water flowing for five minutes only to find that the soil is dry an inch below the surface. Forming a shallow basin around the tree can help, but it must be reconstructed and much of the water remains near the surface and quickly evaporates.



Now when we transplant a tree we bury an old flower pot with drainage holes just outside the rootball. The size is not too important; we use about a 15 cm (6 inch) diameter pot. When watering we quickly fill the pot once or twice and we are done. All the water is channeled directly into the soil near the rootball. Sometimes we throw a pinch of fertilizer into the pot.

This is a takeoff on a technique you may have read about. In some arid regions farmers grow plants next to a buried porous clay pot. That would no doubt provide a slower more controlled release of water, but it has two disadvantages. First, it sounds expensive (if such pots are even available). Secondly, the very slow release of water would encourage roots to concentrate only around the pot. The water rather quickly leaks out of the regular flower pot (no doubt some is lost to the plant when it is young) but forms a "ball" of moist soil into which a large quantity of roots can grow.

In parts of my own garden I have started using this technique for vegetables and flowers also. I place the bottom of the pot about 3 inches deep and cluster plants around it, the number and spacing depending on the size of the mature plant. A benefit I had not anticipated is that small weed seeds near the surface of the soil are less likely to germinate because the surface remains dry.

I was pleased to read in the July-September 1991 issue of *Agroforestry Today* that a farmer in Kenya has devised and used a very similar approach. George Nti'Gitonga "realized that the normal period for planting--during the rainy season--was not the best time to establish seedlings. There were two reasons: a labor bottleneck due to work [with other crops]... and difficulties in working the heavy clay soils when they were wet." Also he knew the rains might not come.

"So Mr. Nti'Gitonga plants his trees during the dry season, when the soil is powdery and he and his family have more time.... He buries an old tin can next to each tree seedling with a small hole punched near the bottom on the side facing the tree. The farmer fills the can with water, which runs out quickly into the dry soil. He then fills the can again and covers it with a stone (to prevent evaporation).... Using this method he needs to water his seedlings only once a week. In fact, they can survive 2-3 weeks without additional watering." Using this method, he has established 25,000 trees on his farm. Recently he won first prize in a national contest to reward farmers for outstanding contributions to rural tree planting.

Dr. Carl Campbell at the University of Florida responded to this article: "I was especially interested to read about the use of pots or cans sunken into the ground for watering plants. I have been doing that in a limited way for a long time too, and have seen and read about many cases in which the method is used. For me a useful variation is to leave the container above ground, on the surface, so it can be moved to water more than one plant. I like to use large plastic jugs with a very tiny hole when I am going to be gone for a few days and have some tender, newly planted trees."

CAPTURING WATER FROM FOG for household or agricultural use is a promising technology. It is not a new idea: African nomads and Andean people have long taken advantage of trees' natural water-catching properties by collecting morning dew or using the water trapped by forests. But now scientists around the world are working to enable more dryland communities to harvest the fog water in their regions.

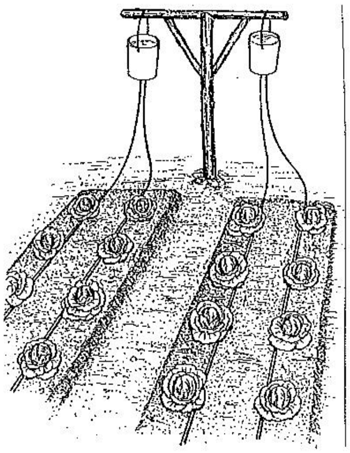
The technology is simple: polypropylene meshes are set up vertically in areas with dense fog and light winds. As the fog passes through the mesh, the suspended water droplets are caught by the net and drip down into a collection trough and are channeled into a storage tank. Water captured by the nets is of excellent quality--fog is a long-term sustainable resource much more reliable in both availability and safety than groundwater in many areas. This technology is best suited to upland areas with persistent fogs that limit visibility to 100 m or less and light winds (about 10 km/h) needed to carry the fog through the mesh. The knitted polypropylene meshes known to be effective are inexpensive (about US$0.25 per m^2), durable, and available from many sources worldwide.

In 1995, three ECHO staff visited one site just north of Quito, Ecuador, in which the water-catching nets have been successfully installed. The area near the Mitad del Mundo ("Middle of the World") equatorial monument is a dry, eroded zone plagued by dust storms. Nearby is a fertile volcanic crater called Pululahua, an ecological reserve known for its unique vegetation. The people above the crater can see the near-constant fog from distant humid valleys which blows across the crater and over their dry land. A few years ago, trial fog collectors of 1 m^2 were erected on the ridge above the crater (at 2830 m elevation) to catch water droplets in the fog that passes through the nets. The trial collectors harvested up to 20 liters of water a day, with a daily annual average of 12 liters. Based on these results, sixty-three 4.5 m x 6 m mesh panels were set up on the ridge and are now capturing water for the nearby arid community.

Fog collection is one of the most hopeful water-harvesting technologies for certain zones. It is not suited to every area, however, and trial nets are a wise investment if you believe fog collection has promise in your area. Some limitations include very strong winds which can damage the collectors, not enough wind, insufficiently dense fog, and inaccessible sites. A collector (two vertical posts mounted in well-packed holes and anchored with strong cables, mesh secured with cables, and a plastic collection trough) with a 50 m^2 surface area could cost US$300-500, which could cost significantly less than buying water from trucks, for example.

Dr. Robert Schemenauer of Environment Canada is a cloud physicist and one of the primary researcher-promoters of fog collection. He sent ECHO some excellent publications on site evaluation for fog harvesting, details on setting up a trial net, sources of mesh, and more. Write to ECHO for this introductory information if you see a potential for your area. Address more specific correspondence to Dr. Schemenauer at Atmospheric Environment Service, 4905 Dufferin St., Downsview, Ontario M3H 5T4 CANADA; fax: 416/739-4211. There will be a July 1998 conference on fog collection in Vancouver, BC, Canada; write Dr. Schemenauer for more details.

DRIP IRRIGATION was demonstrated at ECHO's 1995 conference by Dick Chapin and former ECHO intern Beth Adams, who taught vegetable production in Malawi. Chapin Watermatics produces "bucket kits" of gravity-run drip irrigation used in vegetable garden projects in developing countries. These kits enable people to produce vegetables with the same efficient use of water that commercial drip systems provide.

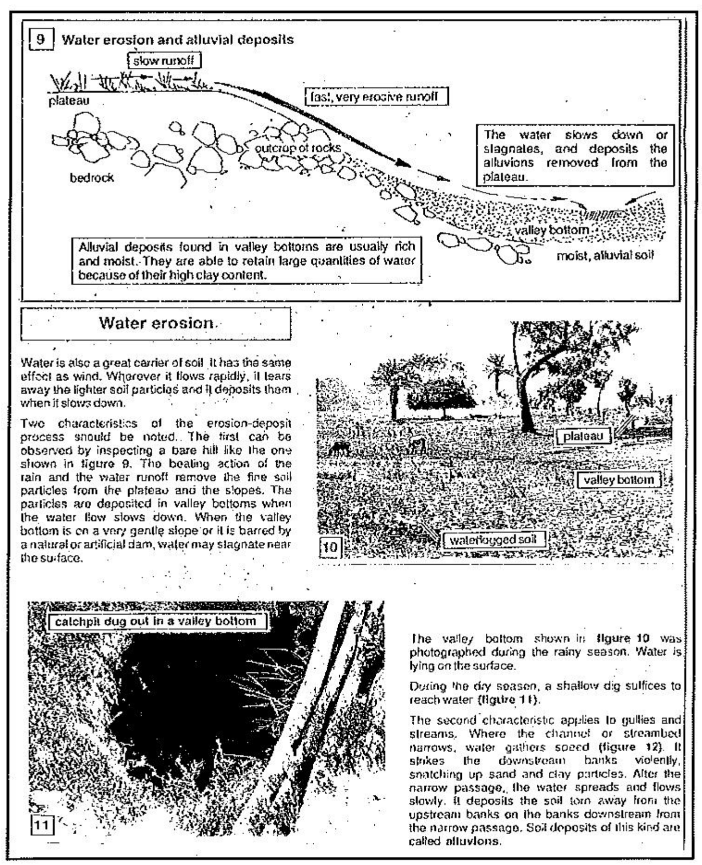


The system consists of a 5-gallon bucket mounted 1 m above soil level, a filter-stopper fitted into a hole in the bottom of the bucket, two connecting tubes, and two 50-foot (15m) lines of 15-mil drip tape with outlets 12" (30cm) apart. (Buckets are not provided with the kits.) Prepare the garden beds 15 m x 1 m for two rows of plants. Lay one drip line along each side on the surface of the bed. Fill the buckets and transplant alongside the drip tapes near the holes. The buckets need to be filled twice daily with water; soluble fertilizer or manure tea can be used as needed. Mulch placed over the tape reduces surface evaporation. The kits can produce vegetables for up to 5 years if carefully maintained.

ECHO is evaluating this drip system in some of our garden beds. The plants are growing very well. We anticipate that foliar diseases, sometimes spread by overhead irrigation, should be reduced. The kits are suitable for vegetable production in our dry season.

Dick Chapin offers a free demonstration kit, literature, and video for agricultural missionaries in developing countries. Further kits can be purchased for a small fee. Contact Dick Chapin at 368 N. Colorado Ave., Watertown, NY 13601, USA; phone 315/786-8120 or 788-0891; fax 315/782-1490.

WAYS OF WATER: RUN-OFF, IRRIGATION AND DRAINAGE (382 pp.) by Hugues Dupriez and Philippe De Leener is an *excellent* handbook on water management, full of clear diagrams and photos (both close-ups and aerial). Topics are grouped into bite-sized lessons several pages long. Section headings include water and soil, water in plants, water in the air, surface water, watering crops, irrigation methods and efficiency, and lifting water. This is a comprehensive resource, readable with well-illustrated details on every topic. ***VANISHING LAND AND WATER: SOIL AND WATER CONSERVATION IN DRY LANDS*** (117 pp.) by J.L. Chleq and H. Dupriez is another book in the same series. This one covers erosion causes and control, wells, and water lifting. It is also illustrated in the same style; see 'page' at right. Available in French and English. African, Caribbean, and Pacific nationals may contact CTA, Postbus 380, 6700 AJ Wageningen, NETHERLANDS; also available (£13.99 and £5.95, respectively) from IT Publications; see below under "Waterlines."



9 Water erosion and alluvial deposits

slow runoff

plateau

fast, very erosive runoff

outcrop of rocks

bedrock

The water slows down or stagnates, and deposits the alluvions removed from the plateau.

valley bottom

moist, alluvial soil

Alluvial deposits found in valley bottoms are usually rich and moist. They are able to retain large quantities of water because of their high clay content.

Water erosion

Water is also a great carrier of soil. It has the same effect as wind. Wherever it flows rapidly, it tears away the lighter soil particles and it deposits them when it slows down.

Two characteristics of the erosion-deposit process should be noted. The first can be observed by inspecting a bare hill like the one shown in figure 9. The beating action of the rain and the water runoff remove the fine soil particles from the plateau and the slopes. The particles are deposited in valley bottoms when the water flow slows down. When the valley bottom is on a very gentle slope or it is barred by a natural or artificial dam, water may stagnate near the surface.

plateau

valley bottom

waterlogged soil

10

catchpit dug out in a valley bottom

11

The valley bottom shown in figure 10 was photographed during the rainy season. Water is lying on the surface.

During the dry season, a shallow dig suffices to reach water (figure 11).

The second characteristic applies to gullies and streams. Where the channel or streambed narrows, water gathers speed (figure 12). It strikes the downstream banks violently, snatching up sand and clay particles. After the narrow passage, the water spreads and flows slowly. It deposits the soil torn away from the upstream banks on the banks downstream from the narrow passage. Soil deposits of this kind are called alluvions.

LOOKING AFTER OUR LAND: SOIL AND WATER CONSERVATION IN DRYLAND AFRICA. Oxfam and the arid lands unit of the International Institute for Environment and Development have teamed up to make a video and book duo that is a welcome addition to our video library. The book contains many excellent pictures and illustrations, and the tape is informative with a lot of content at a modest price.

Oxfam writes, "The book and video have been produced expressly for development workers in arid and semi-arid Africa, but will also be of general interest to a wider audience... It is suitable for use in workshops and discussion groups and the material is reinforced by the book. [Ed: I would go further than that. The book gives a lot of technical details that either are not in the video or were not obvious, but which you are going to need when time comes to try the methods.]

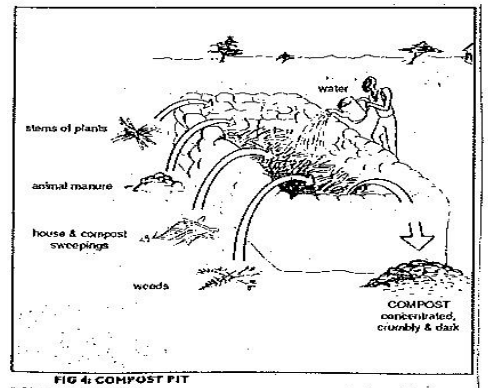


FIG 4: COMPOST PIT

"The video and book are about the main lessons to be learned from new approaches to soil and water conservation in sub-Saharan Africa. Six case studies, two each from Burkina Faso, Kenya and Mali, show how, in the wake of many failures, some success has been achieved in projects where the participation of local people has been recognized as the crucial issue." The authors/producers deal with both the social and technical side of the work.

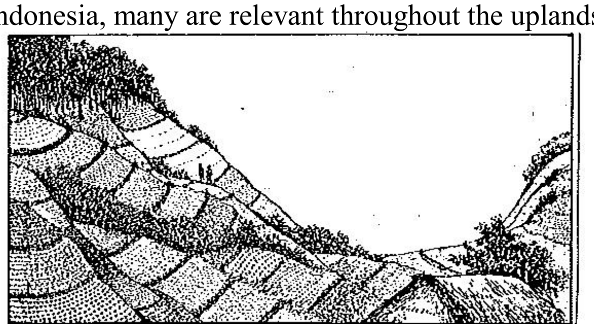
The 2-hour tape costs £14.95 and the very well illustrated 88-page book £8.95. Order from Oxfam Publications, c/o BEBC, PO Box 1496, Parkstone, Poole, Dorset BH12 3YD, UK; phone 01202 715555; fax 01202 715556. BE SURE TO SPECIFY whether you want the English or French version AND whether your video equipment uses the PAL, SECAM or NTSC system. Add for postage: 20% in the UK, 35% Far East and 25% elsewhere. (The book *only* is available for US$14.95 from Humanities Press, 165 First Ave., Atlantic Highlands, NJ 07716, USA; phone 908/872-1441.)

***PRACTICAL GUIDE TO DRYLAND FARMING* SERIES.** Lucy Fisher with World Neighbors in Indonesia sent us a copy of this wonderful set. I am excited about it for several reasons. It is unbelievably well illustrated with detailed drawings. It deals with subjects that are of great interest to many development workers. It describes in detail several of the techniques that have been the basis for some dramatically effective projects by many groups in various countries. Finally, at $4 per booklet, it is a good price.

Titles of the four units are: Introduction to soil and water conservation practices, Contour farming with living barriers, Integrated farm management, and Planting tree crops.

Lucy wrote, "We have been reading EDN for several years, and have found much that has been relevant to the agricultural programs we assist in Southeast Asia. Perhaps some of your readers would be interested in the agricultural extension booklets used in the programs we support here in Indonesia and the Philippines." Originally published in Indonesian, they are now available in English.

"While the methodologies discussed are specifically applicable to the conditions found in the semi-arid regions of SE Indonesia, many are relevant throughout the uplands in the tropics.



"The first book, 44 pages, discusses the basic principles of soil and water conservation on sloping land. Design, construction, use and maintenance of contour-based systems (hedgerows, rock barriers and bench terraces) to reduce erosion and increase rain water absorption are described.

"The second book, 40 pages, considers the reasons for contour farming with terraces as well as methodology. Details include finding the contour lines of the slope, dike/ditch preparation, hedgerow species selection and planting, maintenance of terraces, and alternative uses for the living barriers (which include a variety of leguminous shrubs and grasses).

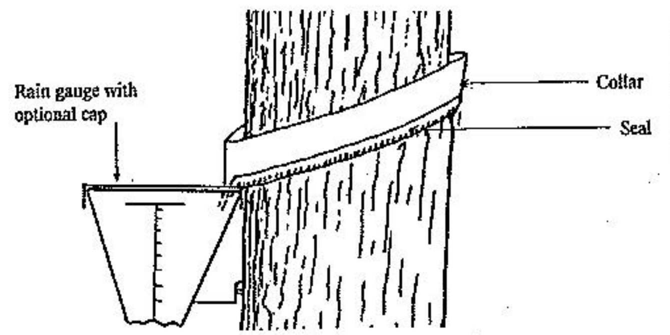
"The third book, 36 pages, covers integration and diversification of upland farming activities to reduce risk and increase farm productivity. Soil and water conservation is promoted as the basis for integrated farming. Topics include soil fertility, cropping practices and patterns, livestock, tree crops, cover crops, wood production and environmental conservation.

"The fourth book, 38 pages, covers integration of tree crops into the farming system, uses of tree crops, propagation methods (seed, stakes, grafting, air-layering), nursery construction and maintenance, planting out/transplanting, and subsequent care of trees. It also includes a planning worksheet and tables of suggested tree species according to use."

Booklets are $4 each plus postage, English only. Order from World Neighbors, 4127 NW 122 St., Oklahoma City, OK 73120-8869, USA; phone 800/242-6387 or 405/752-9700; fax 405/752-9393. For the Bahasa Indonesian version, write to Studio Driya Media, Jl. Makmur, 16 Bandung, West Java, INDONESIA.

HANDBOOK FOR AGROHYDROLOGY (281 pp.) provides details on the practical aspects of hydrological research in agriculture. If you are evaluating the need for runoff water or rainwater collection and soil erosion control, learning about soil moisture, designing a water harvesting plan, or processing water statistics, this book will be extremely useful to you. The book is written for agricultural staff without hydrological expertise who work in developing countries, where proper use of limited resources is critical but extensive data is usually not available. Some mathematical/chemical background is necessary in using this book, although the text is clear enough to be very informative for even the beginner in this field.

Agrohydrology uses an understanding of water processes to increase crop production, largely by optimizing soil moisture. The three main sections of the book are: Runoff and its measurement, Water harvesting and field structures, and Data analysis. The equipment used in data collection is also covered in depth.



Stemflow Measurement on trees

The chapter "Water Harvesting and Field Structures" covers three scales of systems. Micro systems concentrate water over an area of less than 1 meter, such as tied ridges and furrows (construction details and examples from Botswana and Zimbabwe). Meso techniques gather runoff from within a few meters, such as zai holes, contour bunds or ridges, diamond-shaped basins, and strip tillage. Macro systems, including broad flat catchments over large areas, are described with details on their feasibility and design.

The book is available for £30 including surface mail from Publications Distribution Office, Natural Resources Institute, Central Avenue, Chatham Maritime, Kent ME4 4TB, UK. No charge is made for single copies sent to governmental, educational, research, and non-profit organizations in countries eligible for British Government Aid. Use your official title and write on letterhead when requesting a free copy.

"WATERLINES" FROM IT PUBLICATIONS is "the world's only magazine devoted entirely to low-cost water supply and sanitation. It is written for professionals--administrators or engineers, project managers or policymakers, trainers or workers in the field." It is quarterly, and the cost for individuals is £15/$28 per year (£21/$40 airmail). ECHO has not seen this magazine, but coming from IT, we expect that it would be very useful. Write to subscribe and request a catalog: IT Publications, 103-105 Southampton Row, London WC1B 4HH, UK; phone +44 171 436 9761; fax +44 171 436 2013. The IT catalog lists over 60 of the best books on water conservation, supply, sanitation, scarcity, irrigation, pumps, filtration, and harvesting.

THE ARID LANDS INFORMATION NETWORK (ALIN) in Senegal is an organization primarily for field workers to share their practical knowledge of development work in arid and semi-arid areas of Africa. They offer networking opportunities with other people doing similar work in your area, helpful booklets on development topics, and the fine publication *Baobob*. *Baobob* is written three times a year (English and French) by ALIN members who exchange ideas and experiences in community development in Africa. Members receive all ALIN publications free of charge. Membership is free to all individuals working in dryland areas of Africa; paid subscriptions are available for other organizations and individuals. Write ALIN at Casier Postal 3, Dakar-Fann, SENEGAL; phone 221 25 18 08; fax 221 25 45 21. Direct all subscription enquiries for *Baobob* to Sally Lane, ALIN, 274 Banbury Road, Oxford OX2 7DZ, UK; tel 44 865 312402; fax 44 865 312600.

TRAINING IN INFRASTRUCTURE FOR DEVELOPING COUNTRIES. Water, Engineering and Development

Centre (WEDC) sent us information about their unique courses. WEDC is a unit within Loughborough University of Technology devoted to training, research and consulting related to the planning, provision, operation and maintenance of water supplies, sanitation and physical infrastructure in developing countries. They offer an interesting variety of short courses (3-12 weeks) and Masters-level courses.

Examples of 12-week diploma programs include "Irrigation and Water Resources," "Community Technology for Rural Development," "Groundwater Development," Infrastructure for Low-income Urban Housing," "Management of Municipal Services," Project Preparation for Environmental Engineering," "Solid Waste and Environmental Management," "Urban Water Supply," "Wastewater and Irrigation," et. al. Shorter courses are offered on related topics. Special individual study programs, in-country training, and Masters or Doctorate research is also possible.

Twelve-month MSc courses which focus on developing countries include "Water and Waste Engineering," "Water and Environmental Management," "Urban Engineering," "Urban Water Supply," "Technology and Management for Rural Development," and "Planning and Management of Urban Services." These programs cost £9,250 in 1996-97 for continuous study.

Request fliers giving details and costs for any of the above from the Admissions Secretary, WEDC, Loughborough University of Technology, Leicestershire, LE11 3TU, ENGLAND; phone 0(44)1509 222885; fax 0(44)1509 211079; e-mail wedc@lut.ac.uk.

THE URBAN AGRICULTURE NETWORK has been active since 1993, and now has 3000 members in 40 (primarily developing) countries.