MANAGING DRYLAND RESOURCES
A MANUAL FOR EASTERN AND SOUTHERN AFRICA

This manual is intended for use as a field guide by development workers of community-based and non-government organizations, churches, government agencies and research institutions engaged in agricultural development. Further it will serve as reference material for schools, vocational institutions and universities. It builds on the *Sustainable Agriculture Extension Manual,* which was published by IIRR in 1998 and focuses on experiences from wetter, higher potential areas.

This manual provides an overview of selected problems and issues in dryland agriculture in eastern and southern Africa, and the various attempts by individuals , communities and development organizations to overcome these problems. It provides specific examples of technologies and approaches, as well as selected experiences of individual farmers, organizations and communities.

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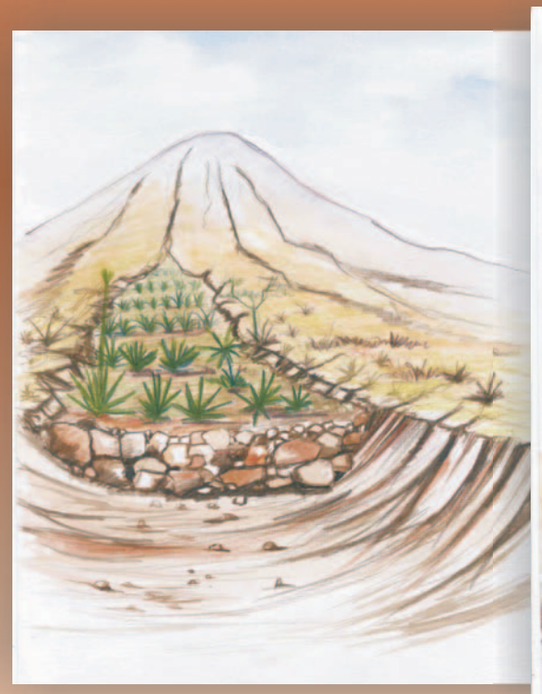

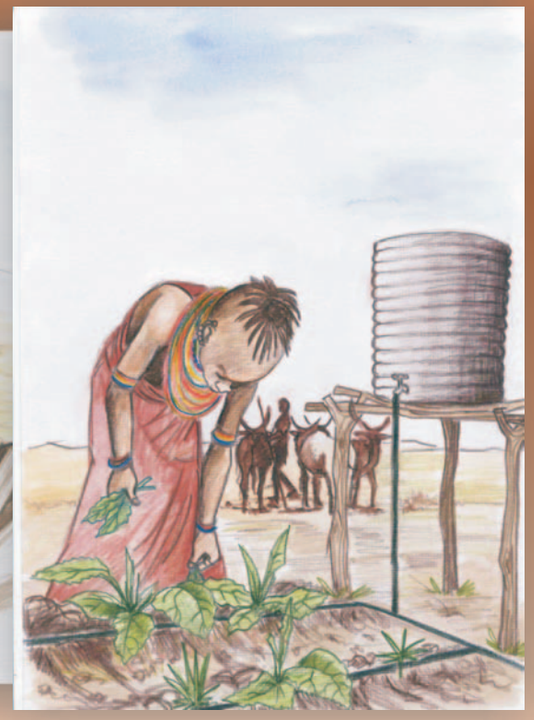

IIRR

MANAGING DRYLAND RESOURCES

MANAGING DRYLAND RESOURCES

AN EXTENSION MANUAL

FOR EASTERN AND SOUTHERN AFRICA

IIRR International Institute of Rural Reconstruction

International Institute of Rural Reconstruction

Africa Regional Office, PO Box 66873, Nairobi, Kenya, www.iirr.org

The International Institute of Rural Reconstruction is a non-profit, non-governmental organization that aims to improve the quality of life of the rural poor in developing countries through rural reconstruction: a sustainable, integrated, people-centred development strategy generated through practical field experiences. Based in the Philippines, IIRR has regional offices in Africa (located in Nairobi), Latin America (Quito) and Asia (Silang, the Philippines). IIRR's Africa office is committed to strengthening the institutional capacity of partner organizations through knowledge generation, acquisition and sharing.

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Contents

Foreword

The devastating effects of the recent drought in the Horn of Africa have again called attention to the need for a longer-term response to the problems of food security and rural development in the region. Recurring drought and conflict are the main factors that have exacerbated these problems. They will continue to do so until more sustainable responses are in place. Solving these problems will require an integrated approach that encompasses the main themes of this volume. These include managing productive resources throughout the drought cycle, understanding ways to promote change, and managing conflict. There is considerable accumulated experience on options to help tackle these problems. This experience forms the core of the book's chapters on dryland characteristics, policies, crops, soils and water, livestock, and ways to stimulate people to make the most of the strengths of individuals, their communities and organizations.

The main objective of this volume is to make these dryland options available for application on a wider scale. Equally noteworthy, however, is the process that led to its development. Each of the sections builds on contributions from individuals who have successful experience in that area. This participatory process acknowledges the wealth of often localized experience that may be applied, while adding an appropriate framework to help understand the dynamics of the problems and possible solutions. Taking advantage of local experience to address more generalized problems of food security, resource management and conflict resolution is a common objective but often a very daunting challenge. This manual and the work that went into it provide an outstanding example of how that process can work effectively.

Daniel Gustafson

FAO Representative in Kenya

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ICCO
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Sincere thanks also to:

- The workshop participants and staff (see *List of participants* and *Participants' profiles*).
- The staff of IIRR's Africa Regional Office.
- The many other unnamed farmers, extension workers, NGO staff and researchers whose knowledge and experiences are reflected in this book.
- The management and staff of the Kenya College of Communication Technology, where the workshop was held.

Introduction

This manual is intended for use as a field guide by development workers of community-based and non-government organizations, churches, government agencies and research institutions engaged in agricultural development. Further, it will serve as reference material for schools, vocational institutions and universities. It builds on the *Sustainable Agriculture Extension Manual*, which was published by IIRR in 1998 and focuses on experiences from wetter, higher potential areas.

The manual provides an overview of selected problems and issues in dryland agriculture in eastern and southern Africa, and the various attempts by individuals, communities and development organizations to overcome these problems. It provides specific examples of technologies and approaches, as well as selected experiences of individual farmers, organizations and communities.

The book draws on experiences from dry areas of mainly eastern Africa but also has experiences from the southern part of the continent. The experiences selected are those that have worked. However, what may have worked in one place may not be appropriate in another. The reader should not see the experiences and techniques in this book as prescriptions. The book offers a range of options and ideas to be selected and adapted. It is hoped that these will stimulate researchers and field practitioners to test and adapt these options to local conditions, and to generate and share new approaches and technologies.

Every possible effort has been made to cover both cropping and pastoralist systems, as well as the transition between the two. Resource management in drylands is too vast a topic for a single manual. This book attempts to cover the subject as broadly as possible, but the emphasis is on what is not already covered in existing publications.

Many organizations are involved in sustainable use of resources in Africa's drylands. A good number are represented in this publication. However, it is impossible to bring together all these organizations, and many more with a wealth of experiences are not included. For this reason, this book should not be seen as exhaustive. Instead, it provides a step to further exploration of the subject.

This manual is a reflection of the collective experience of the contributors. In the approach used in putting together the book, a sampling of practical experiences is used to demonstrate principles. This means there are bound to be gaps. The reader may send requests for more information or questions directly to the authors using the addresses listed in the *Participants' profiles* (see Part 7, page 197).

Parts of the manual

The manual is divided into seven parts.

Part 1 describes the drylands and their crop and pastoral production systems.

Part 2 focuses on government policies as they affect people in the drylands, an approach to managing the cycle of drought that all such areas experience, environmental management, the roles of women and men, and conflict management.

Part 3 describes crop farming: the selection of crops, ways to control pests and grow trees, and techniques for drying surplus food and marketing horticultural crops.

Part 4 discusses ways to conserve the soil and improve soil fertility, and how to conserve water and use it efficiently.

Part 5 covers livestock: rangeland management, animal nutrition, marketing and restocking.

Part 6 deals with how to strengthen institutions and communities to promote the sustainable use of resources. It covers community organizing, extension approaches, land-use plannign and land titling, savings and credit, participatory research, and wildlife management.

Part 7 gives the profiles of the people who contributed to this manual and lists resource organizations and useful publications.

Manual production

The manual is a product of more than a year of intensive consultations with experts from various institutions. The final product was compiled through an intensive, participatory production writeshop. The overall administration and technical management was guided by a steering committee. IIRR served as the secretariat of the steering committee and organized the writeshop itself.

In-country consultations

Consultations were held in several countries to identify organizations with strong project experience in managing resources in the drylands. The individual steering committees came up with possible topics for inclusion in the book. They also identified potential resource persons and authors.

Preparatory workshop

The scope of the manual, the range of topics to be included, and the institutions and individuals with the relevant experience and expertise, were determined in a two-day preparatory workshop. Participants included representatives of the in-country groups, NGOs, government departments, farmers, universities, research institutions and private individuals with relevant expertise.

The participants in this preparatory workshop agreed on a common understanding of what constitutes drylands and the critical issues in those areas. They also drew up a list of institutions with relevant experience and contact people within each institution. They invited these individuals to draft manuscripts on their allocated topics, and provided them with detailed guidelines on how to do this.

Writeshop

The manual itself was the product of a two-week, intensive writeshop, which involved some 60 farmers, researchers, extension experts, field practitioners, artists, editors and desktop-publishing specialists. During the writeshop, each participant presented his or her draft manuscript using overhead transparencies of each page. Copies of each draft were given to the other participants, who critiqued it and suggested revisions. After each presentation, an editor helped the author revise and edit the manuscript and incorporate the audience's comments. An artist drew illustrations to accompany the text. The edited manuscript and artwork were then desktop-published to produce a second draft. Meanwhile, other participants were also presenting their manuscripts to the group. Each author worked in turn with the team of editors and artists to revise and illustrate the text.

Early in the writeshop, the participants generated ideas for new topics. These were drafted by individuals who had relevant experience and knowledge. The editorial team also assisted the farmers present to write about their experiences; the farmers then presented these to the larger group.

Each participant presented his or her revised draft to the group a second time, also using transparencies. Again, the audience critiqued it and suggested revisions. After the presentation, the editor, artist and desktop-publishing specialist further revised the manuscript and developed a third draft. Towards the end of the writeshop, this third draft was made available to participants for final comments and revisions. After this, relatively minor editing and adjustments were necessary before the finished manual could be printed.

This writeshop approach has several advantages over conventioanl methods of producing a manual. It speeds up the production of information materials, taking full advantage of expertise of writeshop participants. The process of writing, getting comments, revising and illustrating the manual takes place at the same time, considerably shortening the often-difficult process of writing, editing and publishing. A large number of writeshop participants contribute to each topic: in effect, the writeshop provides an opportunity for technical peer review by a large number of reviewers, as well as pre-testing for understandability and field relevance by a group of the intended readers.

In addition, the writeshop brings together a large number of people from various institutions and walks of life, each with different perspectives and expertise in sustainable agriculture. It is hoped that the relationships and networks forged during the writeshop will continue long into the future.

List of participants

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1

Dryland characteristics

What are drylands?

Different people define drylands in different ways.

- In terms of the **absolute amount of rainfall.** For example, the Convention to Combat Desertification defines drylands as areas with between 0 and 600 mm of rainfall per year, depending on altitude and latitude.
- In terms of the **length of the wet season and the temperature.** For example, areas with less that three months of enough moisture to support plant growth, and with an average temperature of at least 80° Fahrenheit (27°C).
- By comparing the **annual rainfall with the amount of 'potential evapotranspiration'** (roughly, the amount of water that evaporates from a pond or a well-irrigated field in one year). One definition is those areas where the rainfall is less than 40% of the potential evapotranspiration.
- In terms of **vegetation.** Drylands are areas where conditions favour perennial grasses rather than annual cereals. Rainfed cropping therefore has an inherent risk of failure.
- In terms of **land use.** Some farming systems are more sensitive to drought than others: for example, cattle in wetter areas may not eat dry grass during a drought. Pastoralists may regard grazing areas as drylands, in contrast to the wetter areas, usually highlands, where crops are grown.

The definition of dryland varies from country to country. For example, most of Uganda has relatively high rainfall. If the maize crops fail once in five years, people regard the area as dryland. Such a definition is of little use in countries such as lowland Kenya or Ethiopia, where rainfall levels are generally much lower. Some 80% of Kenya is classified as dryland.

Some areas normally regarded as wet may in fact be dryland. For example, not all the East African highlands are wet. Certain areas on the shores of Lake Victoria lie in a rain shadow and receive only 600 mm of rain a year.

There is no firm boundary between dryland and wetter areas. One grades into the other, and the boundary changes from year to year. Prolonged drought, unseasonal rains and other climate changes may mean the area expands or contracts.

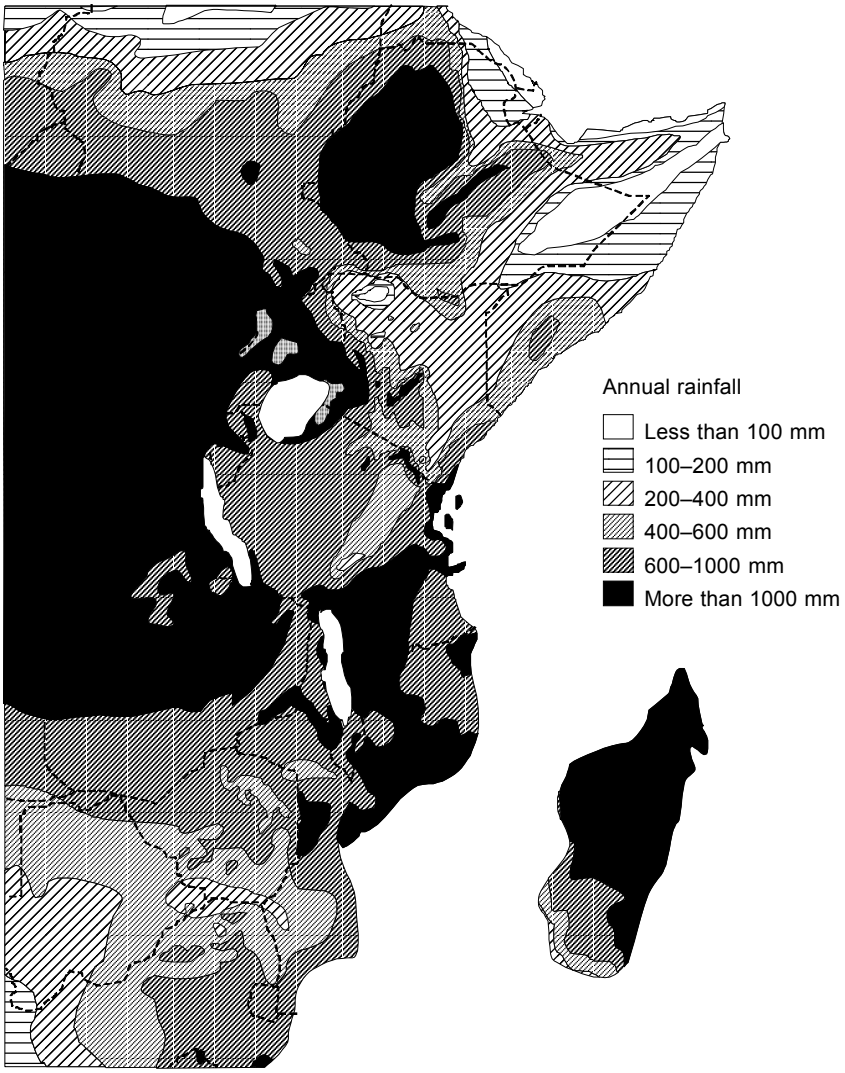
Categories of drylands

Drylands are not homogeneous: different categories exist. Understanding this is important to identify whether opportunities exist to change or develop the dominant pastoral production system.

Two broad types of dryland can be distinguished: arid and semi-arid; and sub-humid, wetter drylands. The dividing line is often put at 600 mm of rain per year (see map on next page).

Arid and semi-arid drylands

In these areas rainfall is the limiting factor for the condition of the vegetation. The number of cattle grazing has no lasting negative effect on the vegetation. Overgrazing is not a problem. Droughts, when they occur, cause the cattle to die, keeping numbers down. The vegetation is very resilient; even after a serious drought, it is able to restore itself. The concept of 'carrying capacity' does not apply. In these areas, pastoralists and their livestock dominate. It is not advisable to replace the pastoral production system as it already uses all available resources to a maximum.



Rainfall in East Africa (adapted from FAO/Agrohymet Network and ESRI)

Wetter drylands

In these areas the condition of the vegetation depends on the number of cattle. Overgrazing may occur when their numbers exceed the so-called carrying capacity. This damages the vegetation, which is not able to regrow after a serious drought. Despite the high risks, the wetter drylands are increasingly used to grow crops. It may be possible to develop new land-use systems that combine various uses. The aim should be to develop a system that is more productive than the pastoral system it replaces.

Characteristics of drylands

Natural capital

Rainfall The rainfall is low, erratic and scattered, and is concentrated in a few heavy storms. The rains may be delayed, and droughts are frequent. Rains may occur at times when they do not benefit crops in the field.

Soils The soils are thin and easily eroded. They are low in organic matter (less than 2%) and dry out quickly. Some soil types occur only in dryland areas. Within the drylands there are scattered patches with better soils or a wetter climate.

Vegetation The vegetation is sparse, leaving a large proportion of the soil surface exposed. This allows rain to compact the surface, forming a crust which stops water from seeping into the soil. The water runs off instead, causing erosion and flash floods.

Physical capital

Infrastructure There are few roads, and permanent settlements are sparse. Markets, abattoirs and food storage and transport facilities are poorly developed. Irrigation from groundwater or dams has converted some otherwise dry areas to more productive cropland – while preventing pastoralists from grazing their animals on this land.

Farming systems The major dryland crops are sorghum, pearl millet, finger millet, short-season maize, cowpeas and haricot beans. In wetter areas or land with irrigation, farmers also grow cassava and pigeonpeas for local consumption, and beans and Asian vegetables for export. Livestock herders keep cattle, sheep, goats, camels and donkeys; sedentary farmers may also keep chickens. Camels, goats and donkeys are hardier than cattle and sheep.

Human capital

Indigenous knowledge Pastoralists have a rich store of indigenous knowledge about their environment and animals, how to predict drought, where to find pastures and water, and how to prevent and treat livestock diseases. Indigenous sedentary farmers have equivalent knowledge about their crops and soils. How-

ever, new settlers may not be as familiar with the problems and opportunities in the drylands.

Education Most people in the drylands are poorly educated. Illiteracy rates are high, especially among women. Children often attend boarding schools in the towns, and may be reluctant to return to their original lifestyles after graduating. Dropout rates are high.

Social capital

Lifestyles The majority of people depend directly on the land. There are two broad groups: nomadic or semi-nomadic pastoralists, and sedentary farmers who grow crops. Pastoralists and sedentary farmers may belong to different ethnic groups, each with its own culture. However, pastoralists and crop farmers are not necessarily distinct: 'agropastoralists' may also grow crops in addition to keeping livestock, and crop farmers also keep livestock and may move with them if required.

Mobility Pastoralists, in particular, are highly mobile. They move with their herds in search of grazing and water. They take advantage of the scattered rainfall in a way that no other production system does. They pay little attention to government, and often cross district and international boundaries.

Social groups People are organized into extended families and clans, which provide important support during times of hardship. The difficult environment forces people to rely on each other. They tend to be less individualistic and more willing to help their relatives and friends than in high-potential areas.

Conflict. The drylands are particularly prone to conflict. Pastoralists may invade cultivated fields during the driest periods to save their livestock. Settlers erect fences that block the pastoralists' migration routes. Conflicts also arise between pastoralist groups (for example, cattle-rustling raids) and between groups of crop farmers (for example, over irrigation water) (see *Managing conflicts*, page 45).

Services and industry. The government provides limited services such as policing, health clinics, and local governance. Extension and veterinary services have recently been privatized in several countries; this has led to their collapse because most users cannot afford to pay the fees required. The private sector is confined to transport and trading; there is little manufacturing industry.

Financial capital

Poverty The vast majority of both pastoralists and sedentary farmers are poor. They have limited cash. Pastoralists tend to have more capital (in the form of animals) than do sedentary farmers. A few people are wealthier: they own larger herds or more (or more fertile) land.

Income sources Pastoralists are commercially oriented: they sell animals in order to buy food (grains, sugar, tea) and things they cannot make themselves (cooking utensils, clothes), to pay school, veterinary and medical fees, and to buy

food in an emergency. However, pastoralists often lack a market for their animals. Crop farmers are more subsistence-oriented: they grow most of their own food. Many men seek employment in the cities for at least part of the year.

Credit There are few banks or other sources of formal credit. People rely on informal sources such as friends and relatives, and by loaning out livestock (see *Restocking livestock*, page 144, and *Savings and credit*, page 170).

Changes in the drylands

Population The human population is rising, both by natural increase and by in-migration from more densely populated high-potential areas. This puts extra pressure on the limited resources. Intensive cultivation degrades the soils, and overgrazing depletes the ground cover.

Climate In recent years, the climate has been in a state of flux. Droughts have become more frequent, and rains fall at unusual times of the year. These changes may be caused by global warming.

Land use and ownership Settlers erect fences and encroach on traditional grazing lands. Irrigation schemes are built in areas with better soils, which are often the same areas used by pastoralists as dry-season grazing. Common land is increasingly claimed as private property, encouraging a change from pastoralism to crop farming, and removing the best land from the pastoralists. Powerful, city-based individuals have grabbed large tracts of land (see *Land-use planning and titling*, page 165).

War Civil war and cross-border conflicts have increased political instability and insecurity. The proliferation of automatic weapons has fueled more deadly raids between different groups. This has cut off pastoralists from large areas of grazing (see *Managing conflicts*, page 45).

Lifestyles Pastoralists are shifting to agropastoralism and cropping – often with government encouragement. Children who go to school often abandon the pastoral life and stay in the towns. They have not learned how to manage livestock, so have few appropriate skills to contribute to the local community. The social fabric is weakening. Diets are changing too, as sedentary pastoralists switch from their traditional milk-and-blood-based diet to maize meal (see *Crop production systems*, page 9, and *Pastoral production systems*, page 13).

Policies Governments try to control pastoralists by disarming them, and combating cattle rustling and banning burning of the bush (a traditional way of maintaining grasslands). A major focus of policies has been to sedentarize pastoralists. Many policies are influenced by a poor understanding and low opinion of pastoralists' production systems and their mobile lifestyle (see *Government policies*, page 21).

Markets The government-run market infrasructure for livestock has seriously deteriorated in recent decades (see *Livestock marketing*, page 135). Similarly, few market facilities are available for small crop farmers.

Gender Increasingly, many men work at least part of the year in the cities. The women stay at home and must take on new tasks and responsibilities, such as herding cattle and selling produce (see *Roles of women and men*, page 39).

Relief and recovery programmes Outside assistance has often destabilized pastoral production systems, undermining people's ability to deal with problems and increasing their vulnerability to droughts. Some people have come to expect such assistance and have become dependent on it. There is an increasing disparity between wealthier herders and those who have lost everything due to war or drought (see *Managing the drought cycle*, page 26).

Based on manuscripts by Sora Adi and Ahmed Jemal

Crop production systems

Drylands pose great constraints on crop production. Yields vary enormously from year to year, and crops frequently fail. The rainfall, soils, weed infestation and pest incidence vary greatly from place to place. For the farmer it is extremely difficult to plan ahead, and cropping is very risky. Although in most areas crops have to be grown under rainfed conditions, different traditional forms of water harvesting and flood irrigation are used, as are modern irrigation techniques. The risks of environmental damage are generally larger under crop farming than under pastoral conditions. The biomass is low, which lowers the applicability of practices such as mulching and composting.

Water

Water is the principal limiting factor. The low, unreliable rainfall means that often very little moisture is available for plant growth. The rains may start on time but then stop again, killing seedlings. Or the rains may be late, making the season too short for sustainable growth during the crucial phase of flowering. Recurrent droughts cause frequent crop failures. Farmers respond by using various ways to conserve rainfall and store it in the root zone.

Soils

Soils show great variations in fertility, depth, texture and structure. Most are infertile and low in organic matter and available nutrients. High evapotranspiration and low rainfall raise the risks of salinization and soditization. The soil structure is weak, making it vulnerable when rain falls. Because annual plants dominate, and most vegetation dies off during the dry season, soils are mostly bare and are particularly exposed during the first rains. The raindrops hit the poorly protected soil, crusting and sealing the surface. Little water can percolate into the soil to be stored in the root zone; most runs off, causing erosion. The soil's poor structure and shallow depth further limit its capacity to store water.

Black cotton soils occur mostly in flat plains. They are deep, have good moisture-retention capacity, and are fertile. But they are extremely difficult to cultivate: when dry, they are too hard; when wet, they are too sticky.

Ploughing poses extra risks, as it easily destroys the weak soil structure. A shallow hard pan may form, reducing the effective depth of the soil for water storage, and making it hard for roots to penetrate. Inappropriate ploughing also increases water loss by evaporation. Soil preparation is usually done by hand and with animal traction.

Crops

Food grains and legumes are the basic crops grown by small crop farmers. They include maize, sorghum, millets, cowpeas and pigeonpea. In the higher areas, the grains include wheat, barley and teff. Crop farmers also grow small quantities of oilseeds (sunflower, sesame, groundnuts), root crops (cassava, sweet potatoes), fibres (cotton), fruit and vegetables. Generally, they select varieties that mature quickly under rainfed conditions. Cropping patterns are adapted to local conditions. Crops are often grown in rotation or as intercrops to minimize the risks of drought and to manage soil fertility. Most crops are annuals; permanent crops and trees are rare. However, crop farmers increasingly grow trees on their farms, around the houses and fields.

Under rainfed conditions pests are a serious problem. Poor soil fertility induces high rates of infestation. Striga is a typical example of a parasitic weed of sorghum; control is very difficult. Locusts and armyworms are major crop pests.

Livestock

Most crop farmers also have a few cattle, goats, sheep and chickens. Herds are small, as available grazing areas are limited. Only more successful crop farmers have bigger herds. The livestock are usually fed on crop residues or are allowed to graze nearby. If the crop fails, the animals can graze on it. Special fodder crops are not grown. Small livestock are a source of ready cash and a safeguard in times of distress. Livestock provide manure for the fields, either by grazing on the stubble after the harvest, or through composting.

Farm management

The farms are small – only a few hectares – and most are privately owned. They may be divided into many, scattered fields, spreading risks and allowing the farmer to make use of different conditions in each field.

Most work is done manually. Animals can be used for ploughing and to transport water. Because they relieve the farmers' workload, they enable the cropped area to be expanded. A limiting factor is the availability of fodder. Camels and donkeys may also be used for draught. They are hardier and need less fodder than oxen, and are usually in better condition at the start of the ploughing season. The many, scattered fields makes ploughing more troublesome. Not all families have their own plough or draught animals, so they may exchange or share labour and equipment.

Weeding is essential to reduce competition for moisture. It is often poorly done, as it takes a lot of work.

Relatively few external inputs such as inorganic fertilizers and pesticides are used because of their high prices. The unreliable rains make the use of inorganic fertilizers risky, as without enough rain the fertilizer may damage the crop roots.

The little capital invested is used mainly to buy seasonal inputs, tools, ploughs and draught animals. Using credit to pay for seasonal inputs may be very risky.

Social characteristics

There are great variations among crop farmers, depending on the different biophysical conditions, the farmers' skills, the availability of labour, and access to resources outside the farm. These factors also determine whether farmers are ready to invest in their farms. Their ability to adapt their farming practices from their wetter home areas to the new dryland conditions is an important factor for success.

Most are marginal subsistence farmers, cultivating basic food crops. But the production of such crops is low, not enough to meet requirements in most years. Farmers have few assets and capital, so have to look for other opportunities to earn money, often outside the farm. Migration in various forms has always been one of the pillars of income for small crop farmers in the drylands. Their diversification strategies include (see also *Economic diversification*, page 178):

- Using other natural resources: charcoal burning, brickmaking.
- Diversifying their cropping system: beekeeping, private woodlots.
- Migrating in search of work.
- Working on other farms.
- Establishing small businesses.
- Acquiring additional skills: masonry, bicycle repair, carpentry.

History

Crop farmers have occupied the better parts of the drylands. Both small and large farmers can be found in these areas. Some smallholders settled here generations ago, pushed out of the wetter highlands by high population pressure. They have gradually invaded drier areas, displacing the pastoralists, or have settled in isolated wet spots in the drylands, often the mountainous parts. This settlement took place during colonial times. White settlers also established large farms and ranches in the pastoral rangelands.

This process of land encroachment by both smallholders and large commercial enterprises still continues. Some older commercial farms have been subdivided, and settlers have acquired their own title deeds. Recently, rich businesspeople and entrepreneurs have begun producing high-value export crops such as vegetables and flowers. Although this is economically attractive, it reduces the availability of water for other users downstream. Smallholders are also venturing into these crops.

Pastoralists who have lost all their animals in a disastrous drought are also increasingly taking up crop farming.

Where crop farmers have recently settled in drylands, their relations with pastoralists may be strained, as the access to natural resources is changing. Private land titling and enclosures of wetter areas conflict with traditional communal ownership and access. But in general, small farmers in the highlands and pastoralists in the lowlands have developed good relationships. They trade various goods; bartering grain for meat, buying manure, and buying bulls for fattening, breeding and animal traction are long-standing practices (see *Pastoral production systems*, page 13).

Services and institutions

Government policies have stimulated private land titling. The subdivision of former ranches or farms has enabled settlers to develop their own farms. However, support to their farm operations is very limited. Infrastructure and markets often are lacking.

Research and extension services have focused mainly on high-potential and highland areas, and have not been geared towards the needs of the drylands. The knowledge and experience from these more favoured areas cannot be applied in the drylands, and few appropriate extension messages have been developed.

Banking facilities are not geared towards the needs of smallholders. Banks hesitate to give credit to small crop farmers because of the high risks.

Possible improvements

Various ways to improve crop farming can be suggested:

- Soil and water management: conservation tillage (minimum tillage, tied ridges, ripping, etc.).
- Water harvesting and storage: tanks, reservoirs.
- Fertility management: manuring, composting, mulching.
- Drought-tolerant and early maturing crop varieties (both local and exotic varieties).
- Integration of trees on farms: as boundary markers, woodlots, mixed with crops, agroforestry.
- Use of animals for traction and for more farm operations.
- Production of high-value crops under irrigation: vegetables, fruit and flowers – often close to urban centres and where good infrastructure exists.

Some of these methods are described in more detail in the sections on *Crops* (page 53) and *Soils and water* (page 81).

Farmers will, however, choose between investing their time and energy on the farm or outside. Cropping is bound to remain risky, and if they can find attractive income opportunities outside, they are likely to invest little on the farm.

Based on a manuscript by Ben Haagsma

Pastoral production systems

'Crops cannot walk'

Whereas crop farming is dominant in the wetter highlands of eastern Africa, pastoralism is the dominant production system in the dry lowlands. Pastoralists use dryland natural resources sustainably where other land-use systems cannot thrive. Modern rotational-grazing systems offer no alternative, as experience has shown. Key elements of this production system are **opportunistic management** of the rangelands and **mobility** of the herds. This enables pastoralists to make use of natural resources, water and fodder, the availability of which varies so widely in time and space. The pastoralists migrate huge distances, often crossing international borders. Their movements follow strict rules between different ethnic groups and clans. The pastoralists' systems drought-proof. They have developed over centuries as the people have adapted themselves to their hostile environment.

Pastoralists' herds consist of different species, each with its own feeding and water requirements. Cattle, sheep and donkeys graze; camels and goats browse. The herd composition differs according to the climate, vegetation and soil type of the range. The composition can also be adjusted when range conditions change or new areas with different vegetation are occupied. There are major differences among pastoralist groups: some are very mobile (in the driest areas); others are more sedentary (in the wetter drylands). A central strategy of pastoralists is **herd maximization**. This is their best mechanism to deal with unreliable, varying availability of natural resources.

The diet of the pastoralists has changed. There are hardly any pure pastoralists; most eat grain as well as meat and milk products. They also grow crops, using many different practices. In the driest areas, they harvest water for sorghum gardens, practise flood-recession agriculture along major rivers, and use small-scale irrigation. But for most pastoralists, crop farming is a minor activity. Herds are a better guarantee against droughts. As they say, 'cattle can walk; crops cannot walk'. Pastoralists' crop growing is also opportunistic. If the harvest is good, the family benefits and may not need to sell an animal to buy grain. A good harvest also provides additional fodder. If there is any surplus, it will be invested in the herd. In case of drought, the fields are simply abandoned.

Agro-pastoralists

Agro-pastoralists are more settled pastoralists with permanent crop fields close to their homesteads. But the difference between pastoralists and agro-pastoralists is not clear-cut. Agro-pastoralists keep large herds. Crop failures are regular, and the herds enable them to survive. Growing crops is mainly the women's task. Men

move away with their herds in search of water. They may return each night, or spend several months away during the dry season when pastures are far away. Any surplus from cropping is invested in livestock.

Usually, agro-pastoralists cultivate those drylands with better moisture conditions, often the valley bottoms, which are the dry-season grazing areas for pastoralists. This may create conflicts with the pure pastoralists, unless rules have been established. Agro-pastoralists may also use cropping as a conscious strategy to prevent small farmers from encroaching into pastoral territory.

Pastorliasts and crop farmers

The economic contribution of the livestock system to the national economy is considerable, even though perhaps difficult to quantify. Pastoralists actively trade their livestock, often over large distances. They also maintain close contact with small crop farmers, who buy young steers for fattening and draught. Animals are bartered for grain. So pastoralists and crop farmers have established relations over a long period. Each has their own roles and strengths, and they help each other.

Seen over a longer period, pastoralists have even switched back between less and more mobile systems. Some pastoralist groups long ago were crop farmers, and vice-versa. Differentiation also takes place within each group: the Maasai includes both herders and crop farmers, and a Kikuyu farmer may become a herder. Climatic changes, political pressure, market opportunities may cause these shifts. So it is not easy to make a clear-cut distinction between pastoralists and crop farmers.

Pastoralism vs rotational grazing

Block-grazing and rotational-grazing systems on ranches are often advocated as a replacement for pastoralism. Such systems restrict grazing to blocks, and adjust the herd size to the carrying capacity of the range. This means that in average years there is a good use of the available fodder. In bad years, there is still a shortage of fodder and the herd size has to be adjusted. In wet years, however, there are too few livestock to graze the abundant range, so the range is under-utilized.

Mobile, opportunistic pastoralists can make better use of the available resources. All the major range-development schemes in the 1960s and 1970s have failed.

Marginalization

In the past decades pastoralists have been affected by a number of processes that have seriously reduced their capacity and responsibility to manage their own grazing and water resources.

- Outsiders have invaded their land, always taking the best areas. They have introduced individual title deeds, thinking them superior to the traditional,

communal land ownership. They have established national parks, game reserves, wheat farms and big irrigation schemes.

- Pastoral areas have been the scene of civil wars and cross-border conflicts. This has cut pastoralists off from large areas of grazing. Sophisticated weapons are now available everywhere, leading to high insecurity.
- Big rangeland-management programmes have tried to introduce other livestock practices, ignoring the value and high productivity of the pastoralists' existing production systems. All these attempts have failed.
- Demographic pressure forces small-scale crop farmers to encroach upon the pastoral lands, again taking the most valuable pieces.
- Many relief and reconstruction programmes have neglected local methods to cope with droughts. This has led to a loss of independence, self-esteem and pride among pastoralists.
- In an example of the interaction between highlands and lowlands, extracting water upstream harms the downstream pastoral production system by decreasing the availability of water for grazing land and flood-recession agriculture.

These processes of marginalization have undermined the production base of the pastoralists. Now much less land, of lower quality, is in their hands. This has also increased the difference between rich and poor pastoralists. Nowadays many more herdless pastoralists can be seen, tending the flocks of the rich people in their communities or clans. Destitute pastoralists gather in relief centres or small towns. They have fallen out of the pastoral production system. In view of the shrinking size of the pastoral lands, these people cannot be expected to become herders again. They have to look for other income opportunities, but they generally lack the skills needed, so are restricted to low-grade jobs.

At the same time, the land uses that replace pastoralism are often not successful. Dryland cropping is very risky, and irrigation schemes have a very poor economic record, even without factoring in their negative effects on the pastoralists they replace (see *Irrigation*, page 100).

Pastoral development policies

Most policies have been strongly steered by the view that the pastoralists are bad, irrational users of their lands. Pastoralists have been blamed for degradation of the drylands, for a backward, primitive way of life, and for escaping from administrative control. Pastoral lands were also seen as 'empty' lands.

Sedentarization has been the central strategy of governments – and often still is. In their view this was necessary to make pastoralists into modern citizens: 'moving people cannot be developed; nomadic people should become settled people'. Banning bushfires, controlling cross-border trade, banning cattle rustling – all have impacted negatively on the range condition, trade practices and the movement of herds. More recently, the breakdown of market infrastructure, abattoirs

and the meat-processing industry, notably in Kenya, has hit the pastoralists seriously, making the sale of livestock more difficult. As a result, pastoralists have lost much confidence in state institutions.

Crop farmers, especially large, commercial farmers and companies, increasingly grow cereals in the drylands, even though the area may be too dry for grain production. Soil degradation sets in. As this grain farming often takes place on the better pastoral lands, the livestock production of the pastoralists declines.

Pastoralists have their own distinct way of life, strongly linked with their production system. Because policies frequently fail to take this into account, they can unintentionally destroy a viable production system, one that is important for the national economy. Pastoralists' culture is not static: they have always been subject to change and adapt to new conditions. Pastoralists themselves do not want to live in a museum, fenced in and looked at. Preserving their culture as it is today

The Maasai of Narok

Over the last decades, the Maasai living in the semi-arid district of Narok, Kenya, have experienced drastic changes in their land-use system. From pure nomadic pastoralism, they have shifted to settled pastoralism, to agro-pastoral production and crop cultivation. The driving factor behind this decline has been the invasion of big commercial wheat, barley and maize farms in their area. This has reduced the land available for the Maasai and their livestock, restricting them to less-fertile land. A spiral of degradation has followed: too many animals on a smaller area, led to overgrazing; crop fields in more vulnerable areas led to soil erosion; damage to crops by wildlife increased because of the nearby Maasai-Mara park. Livestock productivity (both meat and milk) has suffered. Livestock diseases have increased as more animals are crowded together. The change from communal land-use to private plots has further harmed production conditions. Marketing possibilities have fallen as the state livestock marketing system has collapsed and the road infrastructure deteriorated. There are very few stimuli for the pastoralists to improve their system.

Ilkerin Loita Maasai

This case of Maasai-Mara is typical for a situation where outsiders have encroached upon good pastoral land. It has led to separate land-use systems in the same area, managed by different groups, competing against one another.

South of Narok, the neighbouring Ilkerin Loita Maasai are a different case. They have shown that crop farming can be integrated into the dominant system, and that pastoralists can increase their cropping activities – without harming livestock productivity – if they maintain the say over their whole area. No outsiders have intruded upon their area, although the pressure has been great. The Loita Maasai have increased their cultivation of maize, which was introduced 25 years ago. Small maize plots close to each homestead are now common. The manure from nearby *bomas* fertilizes these fields. Crucial dry season grazing areas are still available. The land-tenure system is still communal; no individualization has taken place, and livestock numbers have not declined. The pastoralists appreciate maize farming, as it reduces the need to sell livestock to buy grains, and makes them more independent. However, also the Loita Maasai are confronted with the same failing marketing system and the poor roads to Narok, which impede further development of livestock production.

—Dickson Nyariki and Geoffrey Kironchi

is not relevant. Rather, policies are needed that protect the pastoral production system and to allow it to change in ways pastoralists themselves choose. A joint search for development options is therefore necessary.

Basic services

Pastoralists need the outside world – without it they cannot survive. Small towns in pastoral areas provide essential products and services: consumer goods, veterinary services, traders and markets. The provision of basic services such as education, health and drinking water can help pastoralists to cope with difficult living conditions. But the way these services are provided must be made to fit better with the pastoralists' circumstances. Services limited to centres are not enough; as far as possible, there should be a mobile component. There are good examples of mobile clinics and schools, which pastoralists appreciate greatly.

Education is a special case. It may alienate pastoralist children from their way of life. But pastoralists are also quick to grasp the opportunity that educated people may offer to their livelihood: lobbying for better policies, contacting businesspeople, exploring other markets, accessing information, etc. A more pastoral-friendly curriculum is often advocated to stimulate widespread appreciation for the pastoral production system. Unfortunately, mobile services are often more expensive than sedentary services.

Many pastoralists move outside the pastoral production system itself to work in the towns; they do not necessarily see this as a big problem.

Land tenure

Pastoralists need an area where they can find dry- and wet-season grazing lands, watering points and salt licks. Water and grazing areas are widely scattered, and the rainfall is highly variable, meaning that such an area must be very large. Pastoralists move flexibly within this area in search for the best grazing areas. Their movements vary from year to year, following the rain. Such a large grazing area can be exploited only by putting all individual herds together.

This has implications for the tenure system. If the total pastoral area were divided into individual blocks, a single pastoralist would not be able to find all the necessary components (dry/wet season grazing, water, salt lick) in one block. In a good year the herd would grow, but in a bad year the animals would suffer and all might die. This would lead to the range being under-utilized.

For this reason, communal land-tenure systems are more appropriate. Communal tenure offers a better use of all available resources. Boundaries should be based on terrain conditions, in such a way that the area will provide all the herds' needs. The boundaries of this 'grazing unit' should guarantee the best conditions for the herds, and their size would vary according to the rainfall patterns. Pastoralists often set out their own boundaries between different clans, which are normally strictly recognized.

Moving from the real drylands to the slightly wetter drylands, pastoralists meet other land users: crop farmers. These have individual plots, often in areas essential to pastoralists, or on a cattle path towards a watering point. The demarcation of farming plots needs to recognize the rights of other users.

Defending pastoralists rights

Every pastoral area includes pieces of land attractive for others. This can be a swampy area, which farmers would like to drain and cultivate. Or it might be a forest, where a tourist company could build a camp or hotel. The Ilkerin Loita Maasai (see box on page 16) in Narok District, Kenya, have successfully fought a claim by outside authorities on their forest. They consider this area essential for the survival of their herds in times of drought because it provides them with water and fodder. They wanted to have the forest included in their area and the boundaries formally recognized. They won their court case.

Which system is best?

Under what conditions can another land-use system (or a combination of systems) replace pastoralism, manage the resources better and raise yields sustainably? And when will replacing pastoralism make the resource use less efficient, lower yields, and even degrade the land?

At one extreme, in the driest parts of the drylands, the case is clear. Pastoral production systems cannot successfully be replaced. Even modern ranching cannot compete with them. Hardly any competitors venture in with other land uses. The risk in such areas is that outsiders would try to occupy the few wet spots – the dry-season grazing areas – as happened when Kikuyu farmers occupied Mount Marsabit a few decades ago.

At the other extreme, in the wetter parts of the drylands, the situation may be different. More sedentary land use may be possible, either by the pastoralists themselves also growing crops, or by other people farming separate holdings. In the latter case, good rules and regulations are needed to safeguard the interests of both groups.

Based on a manuscript by Ben Haagsma

2
Policies

Government policies

Central and local government policies are a major influence on people in the drylands. The farming system and the environment are affected by what people do. Good policies can promote sustainable livelihoods, stimulate the economy and help people survive during a drought. Bad policies can discourage local initiative and result in resource degradation, poverty and conflict.

Here are some of the policies that affect the drylands.

Land ownership and tenure Countries have different policies towards land ownership and tenure. In Ethiopia, the government owns all land, and allocates user rights to individuals or groups. In Kenya, private ownership of cropland is common, but the state owns most pastureland. Granting land titles to individuals or groups may restrict the freedom of pastoralists to seek the best grazing land.

Land use and modification Policies may promote the conversion of land from pasture to cropland. Granting ownership titles is one such policy (see *Land-use planning and titling*, page 165). Irrigating land in river valleys may prevent pastoralists from using what used to be their grazing reserve during drought. Bans on burning may turn valuable grazing land into less valuable bush.

Water There may be controls on the use of groundwater and surface water. Building a dam may lower the water table downstream, changing the vegetation and destroying valuable dry-season grazing land.

Infrastructure The building of roads and irrigation schemes, the provision of electricity and telecommunications, the establishment of markets and other facilities may bring in large numbers of outsiders and change the nature of the local economy.

Good policy making involves dialogue with local people.

Education Pastoralists have mixed feelings about education. They are negative about school curricula, which are often strongly biased against pastoralists. But they also know that their children need education to develop other skills. Well-educated children are able to help their parents, linking them with markets and providing valuable information and contacts. However, schooling removes children from the rural environment. They do not learn herding skills from their parents, and they may be reluctant to return to the pastoral way of life.

Privatization Many government services have recently been privatized through 'structural adjustment' programmes. Newly privatized extension and veterinary services have collapsed in many areas, as farmers are unwilling or unable to pay for them. For example, the Kenya Meat Commission used to run marketing facilities and a large abattoir, but these have closed.

Land tenure in Tigray, Ethiopia

During the Mengistu regime in Ethiopia, the state owned the land and allocated parcels to groups of villagers for a period of only seven years. Seeing that the land they farmed might be reallocated to someone else in the group, farmers were understandably reluctant to invest in improvements such as soil- and water-conservation measures.

The regional government in the northern province of Tigray has recognized this problem. It now allots cropland to individuals rather than to groups. Farmers are allowed to rent land out, and children can inherit user rights from their parents. However, the farmer is not allowed to sell the land.

The Tigray government hopes that this policy will encourage farmers to manage their land for the long term.

—Melaku Gebremichael

Decentralization Policies made locally in the drylands are more likely to be relevant than those set by the national government, which may be more attuned to the high-potential areas. Several countries have recently passed decentralization laws giving local governments and local people considerable decision-making power. Uganda, in particular, promotes the involvement of local people in making decisions. Local governments may have the power to raise revenues locally, or may be required to do so. This has its disadvantages, too: poorer districts will be able to raise less money and will therefore be able to provide fewer services than richer districts.

Research and extension Universities and government research and extension agencies have tended to focus on high-potential areas, and on high-value crops and exotic livestock breeds, rather than on the problems and opportunities of drylands. Research may be inadequately funded, and extension agents are usually poorly equipped, poorly paid, unmotivated, or simply unable to reach remote regions.

Food quality and marketing Quarantine restrictions, transport controls and health inspections aim to prevent the spread of livestock diseases and ensure the quality of meat and other foodstuffs. Governments may encourage the transport of livestock to market on lorries rather than on foot, and require that animals be slaughtered in approved abattoirs.

Response to disasters Many governments have established specialized agencies to predict drought and to coordinate relief efforts (see *Managing the drought cycle*, page 26). How well these agencies function affects the severity of an emergency and how quickly local people can recover afterwards.

Borders Restricting movements across international boundaries may help prevent smuggling and the spread of livestock diseases. But it may also strangle trade and deprive pastoralists of access to their traditional grazing grounds.

Security Recent wars in the region have led to a proliferation of sophisticated firearms. Inter-ethnic clashes are common, and they are particularly difficult to deal with if they occur across international borders. Attempts to disarm pastoral groups, prevent cattle raids, and halt clashes may be successful, or may further exacerbate the problem (see *Managing conflicts*, page 45).

Basongora councils in Kasese District, Uganda

In 1995, Uganda decentralized wide-ranging powers to local councils. In Kasese District in the western part of the country, the district council sent officials into every village to help the local Basongora pastoralists get organized. Community-based organizations, women's groups, youth councils and elders' forums were formed. Both men and women representatives were elected to the local council.

These various organizations took up their work enthusiastically. The local councils compiled information and sent it to higher levels of government. They called on the government to construct roads, boreholes, dams, schools and markets. Effective lobbying ensured that the national government responded to these demands. For example, the councils have successfully negotiated rights to use land in the nearby Queen Elizabeth National Park.

—Tumwine Yasin

Gender Laws may restrict or promote the rights of women: for example, their right to own or inherit land and assets, their representation in local councils and parliament, and the services they receive. Research and extension services may ignore women by design or default, even though women do most crop farming and care for calves, sheep and goats (see *Roles of women and men*, page 39)

Conservation Laws that protect wildlife and national parks have many consequences. They prevent pastoralists from using valuable grazing land. They stop people from cutting fuelwood and making charcoal and harvesting plants. Bans on poaching prevents them from exploiting an important source of food during drought (see *Environmental management*, page 36, and *Wildlife management*, page 190).

Common features

Relevance Many policies affecting the drylands are inherited from previous governments or even from the colonial era. They may no longer be relevant for today's needs.

Fragmentation Some governments have a coherent policy on drylands in general, or on pastoralists in particular. Other governments have piecemeal policies, some of which may contradict one another. Different agencies may be responsible for implementing and enforcing policies. For example, the Ministry of Agriculture may be responsible for controlling livestock diseases, the police may regulate transport, while the Ministry of Health handles meat inspection. Coordination among these agencies may be poor.

Translation into action Governments may lack the capacity to provide services in all areas, collect taxes, or enforce laws. Some policies are enforced strictly, others haphazardly. Individual officials may interpret policies in different ways.

Unintended consequences Even the best-formulated policy may have unforeseen consequences. For example, the state may own land to ensure that it is used for the common good; but this means that individual farmers have no interest in conserving soil or controlling erosion. Policies that are designed for the high-potential areas may be totally inappropriate for the drylands. For example, credit schemes that require regular payments may be unsuited for areas where the risk of drought is high.

Corruption Officials often supplement their salaries with bribes, and may treat well-connected or powerful people favourably.

Information Local people may not know about policies that affect them. For example, someone who sells an animal may not know he or she is breaking the quarantine law. Governments impose bans but seldom offer alternatives, giving people no choice but to break the law.

Lobbying Governments may be more or less open to lobbying for policy change. Well-organized groups with good connections (men, ranchers, farmers on irrigated land, large organizations, the private sector) are more likely to be treated favourably than those that are less articulate (women, pastoralists, small organizations).

Change The situation changes, technologies change, governments change. A policy that works today may not be appropriate tomorrow. Policies must be revised periodically if it becomes obvious that they are not working as intended. Members of parliament and elected council representatives are couriers of local people's opinions. Lobbying, research and the use of the media are also important ways of convincing policy makers of the need for change.

Stakeholders in policy making

Various groups have an interest in farming in the drylands. Policy decisions should ensure that their views are taken into account. The types of stakeholders will depend on the situation, and it is likely that their interests will conflict. Here is a short list:

- **Community members** Men, women, children, the elderly, disabled (especially in war-torn areas), of different ethnic groups.

Soil and water conservation policies in Machakos, Kenya

Soil erosion has been a constant problem in the hilly drylands around Machakos, in Eastern Province. In the 1930s, the colonial government started a soil conservation service to promote practices such as trash lines, stone terraces and vegetation strips across slopes. As the numbers of people and livestock increased, the government discouraged ploughing on steep slopes, prohibited cultivation along watercourses, reduced livestock numbers, and promoted tree planting, pasture reclamation, and gully control. Since these measures were implemented by coercion, farmers were reluctant to adopt them.

After independence in 1963, conservation efforts were slow to restart. In the 1970s, extension efforts focused on introducing simple, cheap and effective conservation measures, using visits to individual farmers to advise them. In the 1980s, this was replaced by the training-and-visit approach, where extension staff visited groups of farmers. This was more effective than the individual approach, but overloaded the extension staff. It was in turn replaced by the 'catchment' approach, where groups of farmers diagnose their farming problems, plan solutions, and implement them.

These changes in extension approaches have been accompanied by shifts in the types of soil fertility management recommendations. The colonial government emphasized mixed farming by smallholders, and the use of manure, compost, crop rotations and fallow. After independence, policy shifted to subsidizing the prices of fertilizer and other inputs, and making them available when they were needed.

In the early 1990s, Kenya began liberalizing its economy. In 1993, fertilizer prices were deregulated. Import quotas, licenses and subsidies have been removed, and controls over cereal marketing have been lifted. In addition, the exchange rate of the Kenyan shilling has fallen by over 30%, making imported fertilizer more expensive.

These changes are generally unpopular with farmers in Machakos. Fertilizer prices are too high, they say, so they now use more organic manure. They would like to see the subsidies restored, and want the government to help with credit and marketing. Traders have suffered because of the drop in demand for fertilizer, so have started selling it in smaller quantities. Extension workers point out that fertilizers are now more widely available than before. All agree that liberalization has not brought the benefits that many had hoped for.

—Harrie Kinyanjui

- **Farmers** Pastoralists, agropastoralists, crop farmers, farmer associations.
- **Private sector** Importers, input suppliers, produce marketers, agro-industries, exporters, credit providers, industry associations.
- **Support services** Researchers, extension staff, veterinarians, non-government and community-based organizations.
- **Government** Central and local government, traditional chiefs.
- **Donors** Multilateral, bilateral, non-governmental.

Based on manuscripts by Tumwine Yasin and Harrie Kinyanjui

Managing the drought cycle

Droughts are inevitable in dryland areas. They may occur frequently or less frequently, depending on the location, and rainfall patterns and trends – but they are bound to occur.

Local people – both pastoralists and crop farmers – recognize this. They deal with drought in different ways. They have developed many kinds of coping strategies to manage droughts.

Many organizations working in dryland areas see drought as a risk or problem that interferes with normal activities. They fail to see that the design of their programme needs to consider the occurrence of droughts, just like pastoralists and farmers have 'designed' their coping strategies.

Droughts are not the only disasters that hit people in the drylands. Warfare, killer diseases and floods also create havoc. Disasters can be natural or induced by people. Nevertheless, all these disasters can be managed, as the drought-cycle model shows.

Four stages

A drought cycle consists of four stages (see the diagram on the next page):

1 **Normal stage** Rainfall is adequate, and there are no major problems. The danger of drought, though, is always present, and one should prepare for it.

2 **Alert or alarm stage** The rains fail, and the early signs of drought appear. During this time, efforts focus on mitigating the effects of drought.

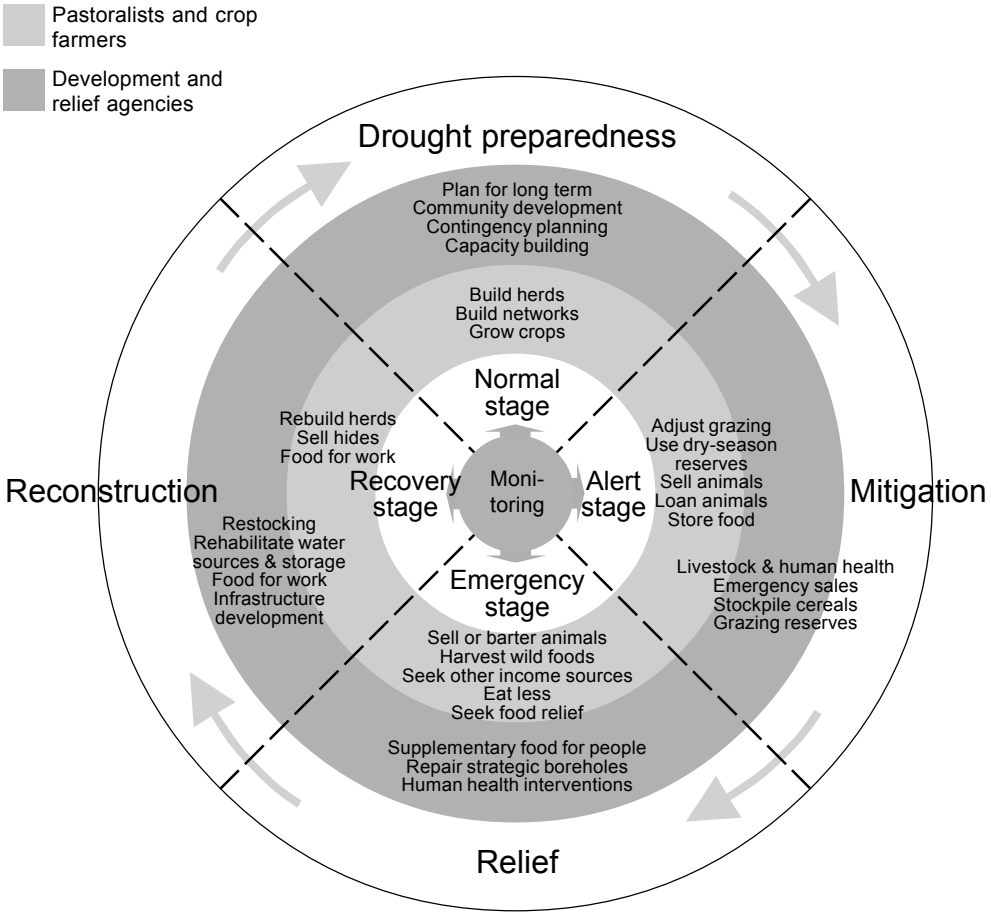
3 **Emergency stage** Food and water run short, causing severe malnutrition and a high death toll of people and livestock. Efforts shift to relief measures.

4 **Recovery stage** The rains return, and people and animals can begin to recover. Reconstruction activities can now be set in motion.

There is overlap between the stages. Some particularly vulnerable people and areas feel the effects of drought sooner than others.

Not all droughts go through all four stages. Adequate preparations during the normal and alert stages may prevent the worst effects of drought, avoiding the emergency stage. And of course, it may rain.

Clearly, these droughts also affect the natural resources. The amount of fodder available decreases rapidly, and water points dry up. But in most of the drylands the vegetation shows a remarkable capacity for regeneration once the rains return. Also herds can build up rapidly again by grazing on the fresh grass. In contrast, in the wetter areas the vegetation might have suffered during a serious drought and it often takes longer to regrow.



The drought management cycle

Local responses to the drought cycle

Pastoralists and crop farmers do different things at each stage in the cycle and in different places. What they do depends on the availability of other sources of food and income, local traditions, and the skills and resources of individuals and households.

In general, pastoralists can respond more easily and quickly to drought than can crop farmers. They can buy or sell animals or move to new areas in search of water and grazing. Crop farmers are tied to their land and must wait for several months before a crop is ready for harvesting.

Below are some are examples of how pastoralists and crop farmers deal with the various stages in the drought cycle. The boundaries between these stages are not absolute, and the stages may overlap. The location of an activity in a particular stage means that it is most intensively practised at that time, and less so during other stages.

Normal stage

During the normal stage, pastoralists:

- Try to build up their herds so they take maximum advantage of the available grazing land and as an insurance policy against drought.
- Vary the composition of their herds – camels, cattle, sheep and goats – to use all the grazing resources available.
- Build up their social networks. Strong ties mean they can rely on others to help them during times of trouble.
- Grow crops to supplement their diet and to avoid selling animals to buy food.

Crop farmers may:

- Plant a range of crops to take advantage of the available soil moisture and to bridge gaps between harvests. They plant different crops at different times – perhaps intercropped in the same field – to make sure that at least some of the crops can benefit from any rain that does fall.
- Invest in irrigation.
- Store seeds in case the rains fail. Some farmers store seeds with wealthy relatives who are less likely to be tempted to eat them.

To raise their income, both crop farmers and pastoralists may may:

- Tap trees and sell the resins (gum arabic, *oppoponex* and myrrh).
- Make and sell handicrafts such as ropes and mats.

A century of droughts in southeastern Ethiopia

Period	Local name of drought	Features
1889–93	*Bero*	Many dead livestock. People reduced to eating hides; not even any roots to eat. Drought attributed to the wrath of God. At the end of the drought, there was plenty of grass but no animals to graze on it
1936	*Ber isregnan gele* ("when prisoners were released")	Several thousand livestock perished, but people did not die
1945–46	*Bona dera* ("long drought")	A two-year drought, but no people died as a result. Heavy rain at the end resulted in the death of several animals. People sold hides to buy animals
1972–74	*Bashe*	Many dead animals, but people did not die because of the advent of food relief
1984–85	*Kolkul*	Many dead animals, especially cattle and sheep
1991–92	*?*	Some livestock died, but no people
1998–99	*?*	Grazing was depleted and water was scarce. Weak animals, lactating cows and calves died

Alert stage

During the alert stage, pastoralists:

- Adjust their grazing practices, for example by grazing in the early morning or late evening when the grass is fresher and there may be some dew.
- Move their herds to more distant, dry-season grazing reserves. These reserves may be in the highlands or around water sources. (Some groups agree not to use certain grazing areas during periods of normal rainfall, so they can be used during a drought.)
- If they can get a reasonable price, sell extra animals so they can buy grains.
- Try to acquire and store extra fodder for sick and lactating animals that stay at home; reserve water for these animals.
- Loan cattle to relatives or friends who have access to water and grazing. The caretakers can consume the milk and keep any calves born, but must return the animals to the owner later.
- Store surplus milk. Camel milk can be stored for up to 40 days.
- Lower the watering rate of their herds so they can search for pastures that are more distant from the watering point.
- Prepare dried meat, which can last for 6 months.
- Look for temporary jobs to supplement their income and diet.
- Look for fruits, plants and roots that contain moisture.

Crop farmers may:

- Switch to more drought-tolerant or early maturing crop varieties or species (such as teff, cassava, sorghum and millet).
- Store their crops after the harvest instead of selling them immediately. Farmers in dryland areas can never be sure of the next crop.
- Dry and store cassava, sweet potatoes and vegetables.
- Sell sheep, goats and chickens.
- Provide irrigation at critical stages in the crop's growth.
- Dry food such as fruits and cassava.

Emergency stage

In this stage both pastoralists and crop farmers may deal with the emergency in similar ways. They:

- Skip meals, and reduce the amount of food in each meal.
- Harvest wild foods and fruits.
- Hunt wild animals for their meat and skins. (Many wild animals are able to survive drought much better than livestock.)
- Sell fuelwood and charcoal.
- Appeal to the government and to donors for help.

Additionally, pastoralists may:

- Sell animals that are in good condition. Weak, emaciated animals are hard to sell, and may fetch very low prices.
- Exchange livestock and other items for food and water.
- Migrate to relief centres and towns. Pastoralists may see relief food as a new economic activity. This food means they do not have to sell as many livestock, enabling them to recover more quickly after the drought is over.
- Rely on assistance from friends and clan members. Neighbouring ethnic groups may also help: they know that sometime they may themselves need help in return. People working in the cities or in other countries may send money to their relatives back home.

Wild foods used by Arsi and Somali pastoralists in southeastern Ethiopia

Fruits and berries

- *Flacourtia indica*
- Wild plum/olive (*Ximenia americana*)
- Sycomore fig (*Ficus sycomorus*)
- *Damak* (Somali) (*Grewia bicolor*)
- *Mimusops kummel*
- Desert date (*Balanites aegyptiaca*)
- *Mpuka, mswahi* (Kiswahili) (*Dobera glabra*)
- *Combretum aculeatum*

Roots

- *Albizia gummifera*

Leafy plants and seeds

- *Ziziphus spina*
- *Lannea malifolia*
- *Mtwansiku* (Kiswahili) (*Erythrina abyssinica*)
- Acacia pods (*A. tortilis*, *A. ethbaica* and *A. busei*)

Crop farmers may:

- Sell their assets and equipment.
- Migrate to other, wetter areas, to relatives or to towns.
- Buy extra maize (only rich farmers can do this).
- Reduce the size of their gardens to minimize water use.

Recovery stage

During the recovery stage, pastoralists:

- Rebuild their herds with the support of relatives and friends, or with the help of other pastoralist groups who have been affected less badly by the drought. They avoid selling animals so they can rebuild their herds.
- Build up their herds of sheep and goats so they can consume the milk and sell additional animals to buy heifers and immature bulls. If famine relief is available, fewer animals have to be slaughtered for food, so their numbers recover to their original level more quickly (see *Restocking livestock*, page 144).
- Skin dead animals and sell the hides immediately after drought. They can use this money to buy new stock.
- Work for people in other areas in exchange for food.

How the Waso Borana deal with drought

The Waso Borana, a pastoralist group in northern Kenya, divide their animals into two herds: milking and dry. The milking herds normally graze near the settlement, while the dry herds graze further away. The group keeps cattle, sheep, goats and camels, each of which respond to drought in a different way, and eat different things.

The pastoralists have three grazing strategies: wet season, dry season, and drought fall-back. During the wet season, they graze their livestock in areas without permanent water sources, fed only by rainwater. In the dry season, they move to areas with permanent water sources, which they have kept free of cattle during the wet season.

The drought fall-back areas are critical for the Waso Borana's survival. These areas are grazed only during a drought, about once every 4–5 years. There are five boreholes in the area, managed by a community organization. The water manager prepares a water-use schedule for all herd owners. Apart from the boreholes, the community organization also manages livestock diseases and marketing.

Immediately the rains begin again, the organization removes the generators that run the pumps. The herders must move away, preserving the grazing area until the next drought.

Guyo Godana and his family are Waso Borana who live in an *olla* of five households in the Sericho area. They dealt with a drought in one year in the following way. The pastures were in bad shape because the rains had not fallen for more than a year. With water becoming scarce, an urgent decision had to be made. All the male adults in the *olla* met to discuss the situation. They made the following decisions:

- Each household would slaughter the biggest bulls and preserve the meat for the next three months.
- The households would move to Sericho to get access to relief and medical services.
- They would sell ten steers to help the families settling in Sericho and to assist the trekking of the livestock to the Yamicha borehole.
- Every herd owner would pay money to help maintain the borehole.

After 3 gruelling months the rains started falling. The herd was reduced to half its size. The families in Sericho had lost two babies due to malnutrition. But at least they could now start building up their herds again.

—Abdullahi Shandey

Crop farmers may:

- Plant early maturing crops.
- Borrow seed, or sell animals to buy seed.
- Look for oxen or other animals for ploughing.
- Exchange labour with other farmers.
- Obtain credit from the bank or moneylender.
- Receive help from relatives, especially those working in the towns.
- Invest in land preparation.
- Apply extra manure to their fields.
- Concentrate their efforts at first on the more fertile plots.

How three Ethiopian pastoral households coped with drought

During the 1984–85 drought in Ethiopia, **Olad Hule** sold two camels for US$ 362 and US$ 241. He used this money to buy maize at US$ 0.48 per kilogramme, which he sent to his family. He also had three milking cows. After the end of the drought Olad had few animals left. With cash from his lineage group, he bought a few sheep and goats and started rebuilding his herd.

During the same drought, **Ibrahim Wako** sold five cows for US$ 220 to buy maize. He also bought some meat and shared it with his relatives. He also received handouts and worked in exchange for food. He lost five cattle during the drought, but was able to support his three wives and eight other family members. During the 1979–80 drought, he lost two calves and sold two oxen. He and his family survived by picking and selling wild coffee beans. After the end of the drought he bought hides from fellow pastoralists and sold them at attractive prices in the neighboring markets, using the money to buy sheep and goats. With the money from the coffee beans, he was able to buy a zebu cow from the Bale highlands.

Suleiman Ibrahim and his family survived the 1984–85 drought by drinking camel milk. He sold three young camels and a cow, and he slaughtered a barren camel for meat. A disease killed his cattle, and he dried the meat to eat later. During the 1945–46 drought, his father lost 100 cattle, 25 camels and 100 sheep and goats.

Not all people are affected in the same way during a drought. Women, children and the elderly are the most vulnerable. As a result of previous droughts there is an increasing number of 'destitute pastoralists' who have lost all their cattle and are very vulnerable when a new drought hits.

Tensions between men and women may rise during the alert stage. When the men and boys move further away with the herds, the women are left alone in the settlement, and may be attacked by raiders.

Different crop and livestock species are affected in different ways. Crops such as millet and sorghum are hardier than maize and beans. Camels and goats resist drought better than sheep and cattle. Sheep and goats breed more rapidly than cattle and camels, so their numbers can recover more quickly. In fact, people may give sheep and goats to their relatives and friends to help them survive a severe drought.

Responses by outside agencies

Outside agencies (government and non-government) should base their plans and activities on the drought cycle. The agencies should also critically look at their own programmes to see whether any of their activities might trigger droughts.

Normal stage

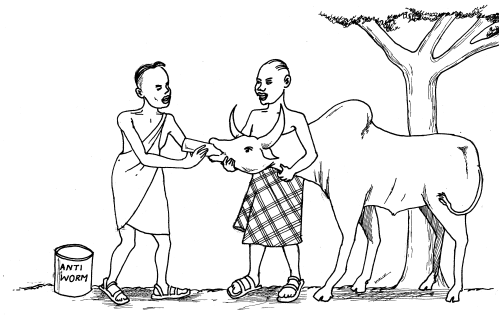
During the normal stage, agencies should focus on drought preparedness. The aim is to make local people stronger so they can cope with future droughts. Activities include:

- Community development.
- Analysing community capacity and vulnerability to drought.
- Planning together with the communities on how to respond quickly to disasters and have the necessary resources available.
- Building the capacity of communities and local government structures, and integrating the drought plans into the district development plans.
- Providing information on markets for crops and livestock.

Alert stage

During the alert stage, agencies should contribute to mitigating the effects of the coming drought. Efforts include:

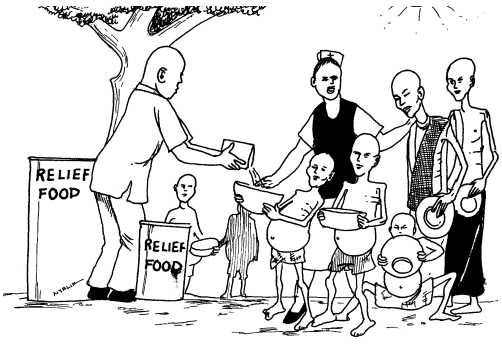
- Animal health activities such as deworming.
- Assisting pastoralists to sell animals, for example by arranging transport or identifying buyers.
- Stockpiling cereals in remote areas to facilitate quick distribution during relief operations.
- Human health interventions, such as vaccinations.



Emergency stage

During the emergency stage, agencies focus on providing relief to the affected communities. Consulting with the affected communities is an essential step in deciding what are the appropriate actions. Agencies cannot provide all the services needed. Their efforts focus on:

- Providing supplementary food for vulnerable groups such as children and the elderly.
- In severe emergencies, distributing food and water to all affected people.

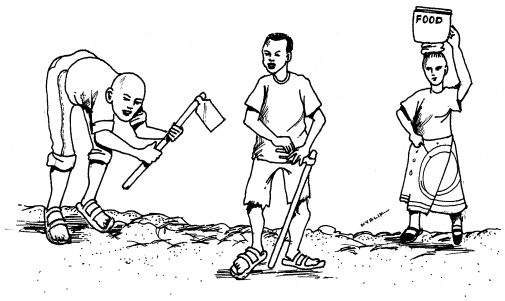


- Repairing strategic boreholes, and making sure that spare parts for pumps are available.
- Providing health services.
- Buying weak animals, slaughtering them and returning the meat to the community.

Recovery stage

During the recovery stage, agencies can focus on helping local people rebuild their lives. These efforts include:

- Providing animals to rebuild the depleted herds.
- Rehabilitating dams and boreholes.
- Providing food to local people in exchange for work.
- Developing the local infrastructure.
- Supplying seeds to farmers.



Providing assistance

Development agencies often provide most assistance during the emergency stage, and relatively little during the other stages. However, adequate investment during the normal and alert stages could prevent a full-scale emergency. Relief measures are very costly: prevention is better than a cure.

During the emergency stage, relief efforts are often poorly targeted: food distribution may be poor, and the supplies may not match the needs. A lack of water may be a bigger problem than the lack of food, yet relief efforts provide food that requires a lot of water to cook. As finding water is often the women's task, women suffer especially. And if food is made available in only a few areas, weak and ill people may have to trek long distances to reach it.

During the recovery stage the plans already jointly worked out in the normal stage will be executed. This will help them to decrease their vulnerability in the next drought. In this way they can get out of the vicious circle of becoming weaker and weaker with each drought and less able to cope with the next one.

However, if food for work and food aid are provided for a long time and are not based on proper plans, 'dependency syndrome' may result, where local people come to expect handouts rather than fending for themselves. Ill-targeted interventions have often undermined local responses and increased the people's vulnerability to droughts. Each drought creates more havoc, and it seems as if people are constantly fighting the drought.

Policy makers often suggest inappropriate ways to respond to a drought. For example, officials with experience in wetter areas may suggest trucking in fodder for herds in drought-stricken areas. This is not advisable for two reasons:

- Huge amounts of fodder would be needed; the limited amount of transport available would be better used to provide food and other relief for the people.
- It is more efficient in terms of labour to move the cattle in search of better grazing than to harvest and transport fodder.

Monitoring and early warning

Local people know when it is going to rain and have their own drought early warning systems and indicators. For example, if people in Ethiopia see a certain type of black fly, they know a drought is on its way.

An adequate drought-monitoring system is vital for aid agencies to be able to plan and respond to the drought cycle. Governments must have efficient early warning systems at district, provincial and national levels. Such systems have sometimes been misused for political ends. They must be accurate and autonomous to ensure donors' trust.

After the serious droughts in the 1980s, early warning systems were established in several districts in Kenya. As such systems need to be constantly operational during all stages of the drought cycle, funding for these systems is the biggest constraint.

Both Kenya and Uganda have established high-level drought-management agencies to coordinate responses by government and non-government organizations.

Based on manuscripts by Ben Haagsma, Abdullahi Shandey, Ayele Gebre Mariam and Mbauta Reuben

Environmental management

Natural resources in drylands are scarce, and it is vital that they are used prudently. Concern about the overexploitation and degradation of these resources is growing among both direct users and professional environmentalists. The natural resources in drylands are at risk because of overgrazing, deforestation, bush fires and soil erosion. On the other hand, research shows that drylands are surprisingly resilient. Degraded, overgrazed land still has a good capacity to recover.

Understanding the environment

Environmental problems are complex and hard to understand, and often harder to solve. They may occur in one place but not elsewhere. Technical, economic, social and political factors all contribute, and many different interest groups are involved. Some problems have a strong political dimension: for example, insecurity and forced sedentarization may cause overgrazing. Many problems are the subject of fierce debates among policy makers and environmentalists.

For every problem, many solutions have been tried. Some have been successful; others not. Degradation cannot be resolved merely by simple technical measures or by passing new laws. A proper assessment is essential to define solutions, and it must be shared with the groups concerned to ensure that corrective measures are followed. While consultation and awareness campaigns are important, they are not enough: they must be accompanied by viable, acceptable alternatives. People generally damage the environment because they have no other options: for example, cutting trees for firewood or charcoal to earn much-needed cash. Alternative income opportunites can decrease the pressure on natural resources.

Problems and possible solutions

In East Africa, rangelands are being carved up, fenced and settled by crop farmers from the crowded highlands. The Barabaig pastoralists of Tanzania, for example, have been forced to make way for large-scale wheat farms. The same is true for the Samburu in northern Kenya, who have lost important grazing areas to parks and game reserves as well. Meanwhile, insecurity in remote areas confines pastoralists close to habitation. Overgrazing and trampling allow the soil to blow away in dust storms, leaving the land bare.

Farmers use slash-and-burn to open up bushland, and their cropping practices are not always environment-friendly. Environmental degradation is caused by many interrelated factors, both man-made and natural. The more widespread causes are reviewed below.

Overgrazing

Large herds grazing within limited areas deplete the vegetation. Inter-community actions and government assistance can allow pastoralists to secure access to unused grazing areas. Conflicts can be resolved by traditional methods or other acceptable ways. Water points must be maintained and strategically allocated (see *Managing conflicts*, page 45).

Deforestation

Pastoralists usually protect forests as their last resort during serious droughts. However, crop farmers may clear forests to plant crops. Charcoal-making is an important source of income for both groups, with traders often also involved. Deforestation may be confined to certain areas. Rangelands temporarily abandoned due to insecurity quickly revert to bush.

Governments can help secure tenure rights for communities and rally locals to conserve and manage forested areas jointly. Some crop farmers and agropastoralists plant trees on their homesteads to check soil degradation.

Bush fires

Pastoralists have used fire to manage rangelands for centuries. Fire stimulates the growth of fresh grass and kills ticks and unwanted bush species. It has also been used in tsetse-control schemes to clear fly-infested bush. If controlled, fires do not necessarily degrade the productivity of the range, and uncontrolled fires are the exception rather than the rule. However, outsiders have seen fires as a bad practice and have banned them. This is the topic of a fierce debate amongst environmentalists.

Because of serious damage caused by uncontrolled bush fires, the regional government in Boranaland in southern Ethiopia has banned any form of vegetation burning. Good rangelands have quickly been invaded by hardy tree species that are very difficult to control.

Soil erosion

Soil erosion is more prevalent on cultivated fields, as they are exposed to the elements for a greater part of the year. It is less a problem on rangelands, except in overgrazed places where herds crowd around settlements and water points.

Possible solutions are described in the sections on *Land-use planning and titling* (page 165) and *Soil and water conservation* (page 83).

Deterioration of water supply

Water supplies are deteriorating in terms of both quantity and quality. Springs, wells and rivers dry up because of deforestation and soil erosion. Water is polluted by excessive or improper use of pesticides and chemical fertilizers, usually

in large-scale irrigation schemes. Cotton – a popular dryland cash crop – requires heavy use of pesticides.

Measures to improve water supplies include protecting the soil by planting trees and banning bush fires, providing information and training on better cropping practices, promoting integrated pest and soil-fertility management, and ensuring effective regulation at the community level.

Salinization

The build-up of soil salinity is the biggest risk in irrigation projects. Improper water management and inadequate drainage cause salts to accumulate in the soil. This harms the soil structure, often irreversibly. Crop yields fall, and cultivation may be abandoned.

Salinization could be reduced by improved irrigation practices and more water-efficient methods such as drip irrigation (see *Drip irrigation*, page 104).

Waste handling

In most towns waste management is a matter of burning heaps of rubbish on vacant plots. The wind scatters garbage, and carelessly dumped waste pollutes groundwater.

Solutions may be found through proper policies such as urban planning, establishing sanitary dumping sites, and creating opportunities for collection, sorting, transport and recycling of refuse.

Roles of women and men

Women and men play different roles in dryland communities. What they do varies between pastoralists and sedentary farmers, and also from group to group and from family to family. As in most countries, the women are generally in charge of the household: they cook, wash, fetch water, and take care of the children. They are also often responsible for crops: they plant, weed and harvest. Some crops, especially potatoes, leaf vegetables, flax and spices, are commonly regarded as 'women's crops'. Milking animals, calves and poultry are kept near the house, and it is the women's task to care for them.

The men are commonly responsible for other livestock, often spending months away at distant pastures. In some areas, maize and sorghum are seen as 'men's

Typical roles of women and men

	Women	Men	Both
Pastoral communities	Care of calves and milk animals Milking Making ghee Selling milk and ghee Searching for herbs Cleaning the compound	Seeking pasture Watering cattle	House construction
Cropping communities	Weeding Harvesting Storing and selling produce Women's crops	Grazing animals Working outside the home Men's crops Land preparation	Constructing community centres
Both	Child-bearing, child care Caring for the old and sick Storing and preparing food Washing Fetching water Collecting firewood Cleaning the house Cooking and cleaning for social events	Herding cattle, sheep and goats Fencing, maintenance Guarding Making major decisions Attending school and training Attending social events Managing money Community politics Maintaining relationships with outsiders	Voluntary community work

Education gives women control over their lives

Education is slowly changing attitudes and opportunities for girls and women. In Boro, Kenya, for example, some women attended skills training from the Ministry of Agriculture and Rural Development. They saw that many of the men seemed to waste their time and spend all their money on drink. The women decided to take charge of their own lives. They started small businesses like basket weaving, making clay pots for flowers and home use, and making snacks to sell. They use their earnings to pay school expenses and buy food and clothes for the family.

—Philigona Ooko

crops'. The men also do tasks such as heavy construction work, and they guard against raids by enemies. Men also handle relationships and negotiations with other groups.

Although women have the responsibility for many tasks, it is the men who control these activities. For example, women produce many of the things that families sell, such as crops, dairy products and handicrafts, while the men may handle the selling and control the money. The women may control only the chickens or other minor sources of income. Men also make most major decisions affecting the family, such as moving camp or buying and selling land or livestock. Women and children may have little say in these decisions.

Many men have more than one wife. The wives are regarded as assistants to their husband – the head of the family.

More men than women are killed or injured by violence. However, women are increasingly the victims of raids, during which they may be raped or killed. As in many societies, some wives are beaten by their husbands.

In pastoral societies, women take care of children and the household, as well as milking cattle and tending calves. Men herd the other animals at distant grazing grounds.

The right to be consulted

Ugandan law now gives a woman the right to be consulted on important decisions. One man in Kasese discovered this to his cost. He sold his land without discussing beforehand with his wife or children. When she found out about the sale, she told the children. Together, they explained the law to the buyer, who realized he had to return the land. He did so, and sued the owner to return his money.

This case received a lot of publicity, and men in the area have become much more careful about selling land. Buyers now refuse to pay unless the wife and at least one child have also signed the sale agreement.

Children and the elderly

Children and the elderly also play important roles. Young boys often help their fathers and uncles, or herd small stock. Boys are more likely than girls to finish school, getting qualifications that might lead to taking jobs in the towns. Girls help around the house and learn from their mother and older sisters. Some girls go to school but most drop out early. More women than men are illiterate as a result of unfinished education. Older people have rich indigenous knowledge about crops, animals, the environment and traditions. Individuals may specialize in midwifery or treating livestock diseases.

Older men are responsible for governing the community and for religious affairs. Traditionally, their decisions are accepted without question. They manage social events and projects such as building schools and roads or managing irrigation, even though it is the women who do much of the work.

In pastoral communities, many traditional leaders have lost control over young people. The social fabric has weakened. Boys and youths have easy access to weapons, and often create havoc by conducting bloody raids.

When the husband leaves to work in the city, the wife must take on new tasks and responsibilities on the farm.

A borehole run by women in northeastern Somalia

Many different clans wanted to use the borehole in Buran village, in the Sanaag region, because it was the only one in the area.

Users were supposed to pay a fee for water. But the fee was not consistently charged, and the committee (of men) who ran the borehole mismanaged the money.

Horn Relief, a Somali NGO, discussed the problem with both men and women in the community. The villagers identified two problems: there was not enough water to go round, and the funds were poorly managed. Horn Relief deepened the borehole, so increasing the supply of water.

A group of women who had attended training in community resource management decided to take over management of the borehole. They formed a committee to oversee operations and standardized the charge for water. They used the money to maintain the equipment and to buy fuel, and set aside some funds for emergencies.

Water disputes have disappeared, and everyone in the community is happy with this arrangement.

—Bilal Mohamed Yussuf and Alusala Nelson

Changing roles

If the family needs cash, it is typically the younger men who go to the towns to look for a job. Their wages help support families who might not be able to survive from farming or herding alone. The women, children and the elderly are left at home and have to do extra work and take on additional responsibilities because the men are away.

Wars have similarly disrupted the traditional division of labour. The widows of fallen soldiers face special hardships. They either have to do the work and take on the responsibilities of the menfolk, or are deprived of their land and livestock because of traditional inheritance rules. However, their new responsibilities also open up new opportunities for women. Some have become leaders, and their example inspires others.

Improving technology and changes in prices also affect what men and women do. For example, in some ethnic groups, women used to control the maize crop. Men have now taken on this responsibility because maize fetches high prices when sold.

Government policies and traditional values often favour men over women. Women may be unable to inherit, and their voice may be ignored in decision making. Women may be reluctant to meet extension agents (most of whom are men), or may be prohibited by tradition from doing so. It is mostly men who attend training on improved farming practices – even for those tasks usually done by women.

Some governments have begun implementing policies that try to correct this imbalance. Uganda, for example, has laws requiring that husbands and wives make major decisions jointly, and allocating a minimum quota of seats in local councils to women. Favouring women for university places has opened up educational

Irresponsible men, sensible women

Maasai men in Tanzania are normally the heads of their families. They manage the family's livestock for the benefit of all family members.

If a Maasai woman sees her husband mismanaging the property and wasting money on drink, she can summon a clan meeting with a local government official. If the participants agree with her complaints, they can relieve the husband of his duty as guardian of the family's property and give this responsibility to his wife. It is then illegal for anyone to buy livestock from the man, and this fact is publicized widely.

—Lembulung Ole Kosyando

opportunities for them. Women were key to bringing Somalia's warring factions together and forming a government after 10 years without one.

Non-government organizations are also important agents of change. They use various strategies to promote the role of women. Some of these are described below.

Nevertheless, attitudes of both men and women are hard to change. Protective of their own status, many husbands prevent their wives from taking advantage of training and other opportunities. They complain of a threat to traditional values and culture. Women, on the other hand, find it hard to overcome their own feelings of inferiority and ignorance, quite apart from their husband's attitude. They may expect their husbands to make decisions for them. If they join a community organization, they may find themselves taking on the extra work involved, without reducing their workload around the farm and in the home.

Ways to promote change

Organizations can use various approaches to promote the involvement of women in development activities, and to ensure that women benefit. Here are some methods that have proved useful in drylands:

Men decide, women do the work

Village men were heavily involved in planning a conservation-tillage project in Arusha, Tanzania. They said that a hardpan was preventing water from seeping into the soil, stopping crops from getting the moisture they needed. They suggested using a soil ripper to break up the hardpan.

When time came to clear the land, however, the men were nowhere to be seen. Instead, it was the village women who did the hard work: ploughing, planting, weeding, applying fertilizer and harvesting.

If the women had been consulted earlier, they might have suggested other ways to solve the problem, or even identified other, more important, problems to solve.

—Joseph Mwalley

Fighting malnutrition in Zimbabwe

A project in Binga, Zimbabwe, is unusual because it involves men in what is traditionally a women's task: child care. Both fathers and mothers are trained how to weigh their children and plot the weights on a chart. The parents also learn how to recognize problems such as malnutrition, and what to do if they recognize them.

The men and women have developed an interest in monitoring their children's growth, and in providing them with enough nutritious food. The major problem has not been a lack of interest among the fathers, but inconsistent attendance by nursing mothers.

—Likani Lebani

- **Involve women** Many development projects are designed by men, are run by male project staff, and involve male community members. Inevitably, they become biased towards men. Involving women at all stages in project design and implementation can help overcome this problem.
- **Education and training** Ensure that women are invited to training, and cover topics that are relevant to them. Make sure that the courses are held at a convenient time and place for women. It may be necessary to hold separate training courses for women and men to make sure that both are comfortable and that men do not dominate.
- **Research** Develop and promote technologies that solve women's problems. Examples are food storage and processing, health, water, and 'women's livestock' such as goats and chickens.
- **Extension** Ensure that extension agencies serve both men and women. Increase the number of women extension agents and field workers, and ensure that they cover a broader range of topics instead of just home economics.
- **Development projects** Certain types of activities (such as building roads) may benefit men, while others (digging wells for drinking water, constructing clinics, planting trees for fuelwood) may benefit women.
- **Grants and loans** Provide grants and loans to individual women or womens' groups.
- **Awareness raising** Special activities can raise the awareness of both men and women about their status and role in the community. Once men become aware of the role and needs of women, many change what they think and do. The same goes for women: those who have attended such activities become bolder, can take more initiative to help themselves, and may assume leadership positions.
- **Advocacy** Promote leadership roles for women, and advocate for changes in laws or procedures to reflect women's interests.

Based on manuscripts by Joseph Mwalley and Busingye Schola

Managing conflicts

Conflicts are common in dryland areas. There are various reasons for this. There are limited resources to share among an increasing population. The marginal environment and unpredictable weather mean that pastoralists move in search of grazing, and may come into conflict with other people wanting to use the same resources. Migrants from the highlands settle as crop farmers in areas (often on the best land) previously used for grazing. Periodic drought pushes people into more confined areas, forcing them to compete for decreasing amounts of fodder and water. Desperation may drive them to violence. Development activities introduce change, and change means that some groups may lose out. Many pastoral groups have a tradition of raiding the cattle of rival communities.

Types of conflicts

Various sources of conflict affect people in dryland areas. Here are some common ones.

Land Ownership of land, granting of titles for common land, granting of titles to outsiders, land grabbing, location of boundaries, conversion of land to cropping.

Access to and control over natural resources Access to grazing during drought, access to water points, rights to harvest fuelwood and make charcoal, rights to extract minerals.

Damage by one group that affects another Livestock damaging crops, envi-

Cattle raids are frequent in some dryland areas.

ronmental damage, irrigation schemes leaving pastoralists without water or dry-season pasture.

Culture and relationships Lack of cooperation, cultural and language differences between different groups (especially between pastoral and sedentary people), clan disputes.

Income Disputes over water-user fees or produce prices, competition for jobs and income from enterprises, jealousy due to wealth disparities.

Development projects Disputes over project management, misunderstandings and lack of information about objectives; decision making without consulting those affected, competition over scarce resources, poor policy and programme implementation.

Policies and politics Sedentarization, restrictions on use of nature reserves, contradictions or lack of clarity in laws and policies, heavy-handed enforcement of laws, political interference (national, provincial or local) favouring one group over another (see *Government policies*, page 21).

Crime Banditry, cattle raids, crop theft, corruption by political, business or community leaders.

Conflicts transferred from outside Conflict may arise in new places because the groups involved are mobile; political manipulation, proliferation of small arms.

These sources of conflict may overlap. For example, a dispute over grazing rights may also involve land titling, cultural differences and political interference.

Magic and superstition

Traditional beliefs and taboos are important in controlling criminals and ensuring that people comply with social norms. People's fear of magic and superstition is more important than whether the practices actually work.

Guarding crops in Zambia…

People in a new settlement scheme were suffering losses because of theft at night from their maize fields. One farmer decided to use magic to protect his crop. A thief harvested cobs from the field one night, but found his way out blocked by a large snake. He tried to go out another way, but found another snake there. Whichever way he went, there was a snake in the way. He stayed in the middle of the field until the following day, when passers-by heard his cry for help. The owner arrived and took him to the police. Since then, there has been no more maize stealing in the area.

…and in Ethiopia

In Kadida Gamela District in southern Ethiopia, a certain clan known as Shamana is thought to have magical powers. Farmers in the area ask for their help to protect their crops against theft. They hang handfuls of grass thatch taken from a house around their field boundaries to show that the field has been protected.

—Mwangala Sitali and Desalegn Desta

Land disputes in Kenya

Land disputes are common in the drylands. Here are two examples, both of which were resolved by force.

School land in Nakuru

In 1988, a teachers' cooperative in Nakuru, Kenya, bought 5 ha of land to build a school. But someone else obtained a title deed for the same land and started building. Members of the cooperative chased him out, and the community put up a temporary school and started admitting pupils. The owner returned with workers and chased the children and teachers away. But the community members persisted: through public pressure, they managed to have the owner's title deed cancelled and re-established the school.

Farming along the Tana River

In the 1980s, the Kenyan government encouraged Somali pastoralists to start growing crops on irrigated land along the Tana River. The settlers were given loans by the Kenya Agricultural Finance Corporation, with the land as collateral. Unfortunately, no land titles were issued to the settlers, so the arrangement was based on trust.

Many of the settlers did not use their loans for the purpose intended, and failed to repay them. When KAFC tried to reclaim the land, it encountered armed resistance from the settlers. The loans were never recovered.

—John Mbugua and David Njoroge

Characteristics of conflicts

Some ethnic groups have traditional allies and rivals. Otherwise, alliances are surprisingly fluid: in one area, community members may collaborate, while nearby members of the same groups are fighting.

Newspaper, television and radio coverage of conflicts cause outsiders to think of the drylands as lawless, dangerous places. This perception may affect policy decisions and the willingness of outsiders to invest in the area.

The conflict cycle

Conflicts tend to follow a cycle. At first, a disagreement may be minor and may not be expressed. This may be followed by a period of rising tensions, escalating into open disputes, and then into violence. The violence may continue through a cycle of revenge and counter-revenge. Memories are long: a dispute may smoulder for some time, and then re-ignite. Eventually, the conflict may subside as conditions change or if the parties come to an agreement.

Scale

Conflicts may occur at different scales. At the micro end, conflicts may occur within a household (between husband and wife, or between parents and children), between households or clans, among different groups in the community

(e.g., between sedentary farmers and pastoralists), or between community groups and external organizations (such as government, NGOs or firms). The largest-scale conflicts involve disputes between different ethnic groups and countries.

Conflicts are easier to manage if they are in their early stages and at a relatively small scale. They are much harder to manage if they have turned violent or if they involve large groups of people. The best approaches to use will depend on the nature of the conflict.

Dealing with conflicts

Force

The stronger party may force its will on the other. For example, pastoralists traditionally raid the cattle of rival groups to increase the size and quality of their own herds, and to reduce the level of competition for water and grazing. Women and children were sometimes taken hostage during these raids. Automatic weapons have made these raids particularly deadly.

Elders resolving disputes

Elders are well respected in many communities, and they are often involved in solving disputes. Here are three examples.

Guraghe, Ethiopia

Elders in the Guraghe community in southern Ethiopia study disputes carefully before giving judgment. They apply traditional laws known as *kitcha*, which specify various types of penalties and remedies for different problems. If one of the parties does not comply with the judgment, they have the option of using a curse known as *gurda*. People believe that the relatives of the party subject to this curse will die. Understandably, the relatives usually apply enough pressure to convince the offending person to comply with the judgment.

Tigray, Ethiopia

When grazing and water runs short in Tigray, elders from communities in the drought-hit areas visit better-watered land to ask local people for permission to graze their cattle on their land. The local people usually agree to allow a certain number of animals in to graze. The elders then discuss with members of their own community to avoid overcrowding of livestock in any one area.

Somalia

Clans in Somalia often compete for access to water points. These conflicts are usually resolved when each group appoints a number of elders to meet and discuss the issue. However, the arrangement usually works for one season only, so the problem recurs in the next year. Women are not involved in this.

Horn Relief, an NGO, is helping overcome the underlying problem – the lack of water – by drilling more boreholes in the area.

—Tenkir Gebresenbet and Alusala Nelson

Asking outsiders for help

It may be necessary to bring in outsiders such as the government or an NGO to help solve a problem. This was the case in a conflict in 1993 over boundaries between Lesoit and Lengatei, two villages in Kiteto District, Tanzania. Lengatei is a village of sedentary farmers, which contains the water source used by the two villages. Lesoit is inhabited mainly by pastoralists, but the soil is good, most of the farmers of Lengatei cultivate land there, and there is much potential for expanding crop production.

Some farmers feared that they would lose their farms through the land titling process; others feared they would lose their access to water.

After extended discussions between the elders of the two villages, facilitated by an NGO and the government, the two villages eventually agreed to allow each other access to the current resources. This agreement made it possible to demarcate agreed boundaries (see also *Land-use planning and titling*, page 165).

—Lembulung Ole Kosyando

A disturbing recent trend is for politically instigated raiding of other groups deliberately to weaken them – stealing cattle to sell, and killing women and children. Fortunately these tactics are still exceptional.

Force does not have to be violent. One example is the use of economic power. A wealthy individual may buy out his opponents; he may hire guards to prevent others from using land, and may bribe officials to ensure that decisions are favourable to him.

Other types of force include peer pressure, gossip, ostracism, curses by elders, and witchcraft. While force is frequently used, it may store up trouble for the future. The losing party may resent the defeat and seek an opportunity for revenge.

Withdrawal

Withdrawal is the opposite of force. One party may be defeated outright, or it may decide that the desire to avoid confrontation outweighs its goals. A pastoral group that has lost its cattle in a raid may have no option but to turn to other means of survival; a grower may be forced to accept the price offered by a trader for her produce.

Withdrawal is a common tactic to avoid confrontation. One group may avoid problems by moving to another area, opting out of a project or boycotting negotiations. It may use delaying tactics or may postpone a decision.

Compromise

Compromise involves going part way to meet an opponent, and expecting that they do the same. It means one or both of the parties must give up its maximum demands. Traditional approaches to this include direct negotiation between the parties, deliberations by councils of elders, and mediation by a neutral third party.

Representatives of traditional enemies may meet and decide that the fighting has harmed both, and that both would benefit from peace. They may decide to settle their dispute there and then.

Legal approaches

National laws, the police and the courts provide an official way of resolving disputes. Some national systems take account of local customs and religious rules. They may recognize the ethnic group and its elders' councils as legal entities. Using these channels may be easier for the parties involved, and it avoids burdening the official system. In order to have recourse to the courts, an organization must be properly registered with the relevant authorities.

Using legal approaches can be expensive and time-consuming. Too often, the richer and more powerful party can win by bribing officials, intimidating oppo-

Resolving a conflict in Karusandara, Uganda

A serious conflict erupted in Karusandara village in Kasese District, Uganda, when the Bakonjo ethnic group wanted to plant cotton, maize and other dryland crops. This would prevent the Busongora from grazing their animals on the land and using the water from the River Sebwe. Several people died in the fighting that resulted.

The government and elders tried to settle the dispute, but without success. Most of the government officials belonged to one of the groups, so the other group thought they would be biased.

The Centre for Environment Technology and Rural Development (Cetrud) was already involved in a project in the area. The government asked Cetrud to act as a neutral third party, and the two groups agreed. Cetrud used alternative conflict-management techniques to help the two groups analyse the problem and find a solution that was to the advantage of both.

Cetrud first met separately with representatives of the two sides. These meetings involved a cross-section of elders, women and youths. Cetrud explored their willingness to meet with the other side.

Cetrud then organized a series of three short workshops. The two parties presented their points of view, both blaming the other for causing the problem. Both agreed that they wanted to find a solution. The Cetrud staff then led the participants through a series of conflict-resolution games and showed videos of disputes in other places and how they were resolved. This helped the participants realize that they could share the land and water to their mutual benefit.

They agreed that the resource belonged to both. They clearly demarcated pastoral and crop land, and decided to reserve two broad avenues so the animals could reach the river for water. They set up a committee to oversee the implementation of the agreement, and requested Cetrud to continue monitoring the situation and to assist if required.

Cetrud and the government agreed to start a development programme to assist people in the area, and designed this together with representatives of both groups. The government agreed to expand an existing livestock restocking programme and a loan scheme for cotton growing into the area.

—Godfrey Kasozi

Songs of praise, words of scorn

Among Gabbra pastoralists in northern Kenya, the women traditionally sang songs in praise of young warriors after a successful raid. If the raid was a failure, they would mock them.

After long discussions between ITDG (a Kenyan NGO) and community elders, the elders agreed that this practice should stop as part of efforts to change attitudes towards raiding.

—Swaibu Balaba and Ben Haagsma

nents so they drop the case, or by hiring clever lawyers. Aggrieved parties may be reluctant to take their case to the police because they fear damage to their reputation or they suspect the police may be corrupt or heavy-handed. In many areas, policing is inadequate and poorly funded.

In addition, the government may offer adjudication and arbitration services outside the court system. Various approaches to land titling and land-use planning help overcome conflicts over land (see *Land-use planning and titling*, page 165).

Alternative conflict management

Non-government organizations promote alternative ways to manage conflicts over natural resources. These involve joint decision making by the various parties, rather than the more common adversarial style.

Alternative conflict management uses methods such as negotiation and mediation to help the parties reach agreement. The goal is to find a 'win–win' solution where all parties gain (i.e., consensus), rather than one where one or more must give something up (compromise).

The mediator is key to this process. This person may be a respected person from the community or a representative of an NGO or community-based organization. He or she must be seen as neutral by all parties.

Various methods are used in conflict resolution. They include training the various parties in consensus-building techniques, brainstorming, group discussions, role-plays, simulations, music, dance and drama, case studies, and study of the Bible or the Koran.

Based on a manuscript by Godfrey Kasozi

3
Crops

Crop selection

Successful crop production in dry areas requires varieties that are well adapted to these areas. Many crops, such as maize, cannot withstand the high temperatures, low soil moisture and lack of reliable rainfall that characterize arid and semi-arid areas. Other crops, such as sorghum, are naturally adapted to dry conditions and can produce stable or even high yields if properly managed.

Crops selected for the drylands should be quick maturing to take advantage of the short growing periods. They should grow with limited moisture and tolerate pests and diseases. Farmers prefer crops that are multi-purpose – those that provide food, fodder, fuel for cooking and other by-products. Local varieties are often the best adapted for dry areas, but scientifically developed crops should also be considered.

Farmers must find out what kind of crops their soils can support. For example, shallow-rooted crops are needed if the soil is thin. But even the most appropriate variety cannot guarantee a good harvest. And the best varieties from an agronomic point of view do not necessarily taste the best or fetch the best prices.

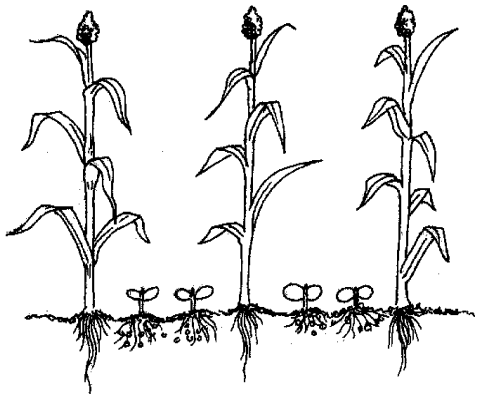
To minimize the risk of total crop failure, farmers in the wetter drylands traditionally grow several different crops. They may plant the crops in the same field at the same time ('intercropping'), or grow different crops in the same field from one season to the next ('crop rotation').

Intercropping

Intercropping means growing two or more crops on the same piece of land at the same time. Extension agents are at last encouraging this practice, because research has shown that it can produce a higher overall yield than a single crop, especially if the single crop does not get enough water. The different plants in an intercrop maximize the production capacity of the land. However, farmers must be careful to choose the right crop combinations. For instance, they often intercrop maize and sorghum with legumes such as pigeonpeas, cowpeas, greengrams and groundnuts.

Here are some of the benefits of intercropping:

- Legumes fix nitrogen which can be used by the other crops.
- Crops that cover the ground suppress weeds and reduce moisture loss due to evaporation.



Sorghum intercropped with legumes

- Mixed crops are grown at higher densities than are single crops.
- Damage by insect pests is often less serious in intercrops.
- The intercrops have different heights, ages and rooting patterns, so farmers can use small areas of fertile soil with minimal competition among the crops.
- The combination of crops provides a balanced diet.
- Legume stalks can be used as animal feed.
- Less labour is required for weeding.

Crop rotation

Various crops can be grown in succession. This practice is known as crop rotation. Benefits of crop rotation include the following:

- It maintains or improves soil fertility.
- It prevents a build-up of soil-borne diseases, pests and weeds.
- If one crop follows another immediately, the ground stays covered and soil erosion is reduced.

Continuous growing of cereals or pulses should be avoided. Crops that are attacked by the same root pests (such as nematodes) should not be grown in succession in order to break the pests' life cycle.

Crop diversification in Konso, southern Ethiopia

The Konso area receives only 400–700mm of rain a year. The rainy season is typically very short (February–March), with some light rains falling in September to October. The rest of the year is very dry.

Local farmers have come up with innovative farming systems to overcome the fluctuations in rainfall. A good example is crop diversification to increase productivity and minimize the risk of total crop failure.

The farmers grow different types of crops either together or in succession to ensure that food is always available. During the short rainy season, they plant hardy cereals, root crops and other crops at the same time. The crops chosen have different maturing periods (see table below). Harvesting is staggered. The sorghum is ratooned (cut so it regrows and produces a second harvest).

Type of crop	Planting	Harvesting season
Wheat, barley*	February–March	4–5 months
Sorghum*	Same season	First crop: 4–5 months Second crop: 8–9 months
Maize	Same season	4–5 months
Cassava	Same season	6–8 months
Potatoes*	Same season	3–4 months
Other crops	Same season	4–5 months
*Kolto***	Same season	

* Two harvests

** A local root crop that germinates quickly and provides food in times of drought. The leaves disappear within a month, but the roots continue to grow.

Some dryland crops

Type	Warm climate	Cool climate
Cereals	Maize, sorghum, millet	Wheat, barley, teff (Ethiopia)
Legumes	Cowpeas, beans, pigeonpeas	Chickpeas, peas
Oil crops	Sunflower, soybean, groundnut, safflower, sesame	
Root crops	Cassava, sweet potatoes	
Fruits and vegetables	Mango, pineapple, citrus, cashew, papaya	Banana, cabbage, kale
Fibre crops	Cotton, jute, sisal	

How farmers select crop varieties

Farmers identify and select the types of crops most likely to do well in their areas. They may determine suitability using the following criteria:

- **Size of cobs or grains** Bigger grains are able to germinate and survive better.
- **Utility** Varieties with multiple uses are better, but they should not require a lot of inputs such as fertilizer and labour.
- **Early maturity** Quick-maturing varieties avoid the risk of drought late in the season. Desirable varieties are also tolerant to drought and pests, and can grow under different soils and varying temperatures.
- **Intercropping** Varieties should be suitable for planting within the existing cropping pattern.
- **Handling** Varieties should be easy to harvest, thresh, shell or process.
- **Ratooning** Some varieties can regrow after they are cut. This gives a quick second harvest because the roots are already developed. However, ratooning should be limited to two harvests to prevent pests from multiplying.
- **Taste** Related considerations are palatability and nutritional value.

Sorghum is regaining its former popularity in many dry areas.

Learning from farmers in Nakuru, Kenya

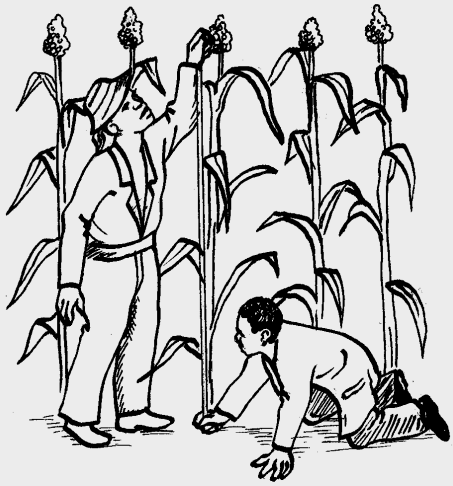
Very often, farmers do not accept new crop varieties developed for dry areas. As researchers at the Kenya Agricultural Research Institute (KARI) found out, involving farmers in trials can improve this situation.

Since 1993, KARI has developed and released high-yielding, drought-tolerant sorghum varieties. Every year since, scientists at Lanet, a research station in Kenya's Rift Valley Province, have reported good yields despite frequent droughts.

The researchers expected farmers to start growing the new varieties. But despite the near-total failure of maize and other crops, few farmers took to growing sorghum.

After consulting with extension workers, the researchers agreed that farmers must be involved in field-testing the new varieties so their preferences could be taken into account. A farmer who was already growing sorghum on part of her farm provided a site for the trials.

She ploughed a small field ready for planting. Just before the rains began, a field day was held for the farmers to identify different sorghum varieties for planting.



Farmers measuring crop growth

Fifteen varieties were planted, including those that had been released for cultivation and some new ones that were still being tested. The researchers and extension staff demonstrated how to sow the seed and explained how to grow the crop.

Farmers were invited to inspect the crop when it flowered and again when it matured. At every stage, they helped researchers collect data about the growth rate, pest tolerance and other factors. At harvest time, they compared the yield of the different varieties. All the farmers agreed that the new sorghum types had higher yields.

The next step was to get their views on which varieties should be promoted as an alternative or supplement to maize. With the help of home-economics extension staff, some farmers prepared recipes using five varieties of sorghum. The group who had participated in the trials were invited to sample the recipes and say which ones they preferred.

The rankings were then compared with the yield data the scientists had used to rank the varieties. What the researchers considered most suitable was not necessarily what the farmers preferred. The outcome demonstrated the benefits of participatory research.

—Gerald Ashiono

Controlling field pests

Pests such as insects, rodents and birds may cause serious losses in dryland crops. Plants that grow in poor soils or suffer from drought may be too weak to withstand pest attacks.

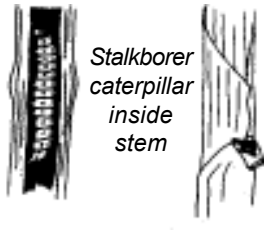
Farmers use various methods to control pests in their fields. Pesticides are expensive and may cause more problems than they solve because they also kill spiders and other natural enemies of the pests.

Non-chemical methods of controlling pests include:

- Avoiding planting a crop in an area during one part of the year. This reduces the number of pests because they have nothing to feed on during this 'closed season'.
- Soil cultivation to eliminate weeds that may act as hosts for the pests, hilling up soil around the plant stems, manuring, and watering.
- Appropriate sowing practices, intercropping, and managing the density of the plants in the field.
- Sanitation: clearing the field of dead or diseased plants, and picking off diseased leaves and pests by hand and burning or burying them.
- Sun-drying the harvested produce and storing it in airtight containers such as gourds or drums.
- Sieving, winnowing and shaking the harvested grain.
- Mixing mineral materials (such as fine sand, clay dust, and wood ash) or plant substances (neem leaves, crushed seeds or oil; extract from pyrethrum flowers; groundnut, castor or palm oil; chili peppers) with the stored produce.

Maize and sorghum

Stalkborers Young stalkborer caterpillars feed on the tender leaves of maize and sorghum plants, then bore into the stems. Older leaves have irregular holes and 'windows' made by the caterpillars when they feed. The caterpillars also tunnel into maize cobs or sorghum seedheads, severely reducing grain production. The caterpillars can be seen if the stalk is cut open. Seriously attacked plants may dry up completely.



Adult stalkborer moth

All dried stalks must be removed from the field after harvest to prevent the stalkborer population from carrying over to the next crop. Other control methods are planting early, removing alternate host plants, encouraging natural enemies (mainly wasps and birds),

and intercropping cowpeas with maize. As a last resort if severe infestation threatens the crop, commercial insecticides such as endosulphan, trichlorfon and fenitrothion are effective. These are costly and may also kill the natural enemies of the stalkborers.

Sorghum shootfly The shootfly larvae feed on the growing shoots of sorghum seedlings, causing a typical 'dead heart'. If growing conditions are good, the young plants can usually recover by producing new shoots, which may escape attack; however, the seed heads will ripen unevenly. If the plants are weakened by drought, repeated shootfly attacks can cause serious losses. Early sowing means the crop is already past the vulnerable stage when the shootfly larvae hatch.

Sorghum shootfly (magnified)

Common beans

Bean stem maggots (*Ophiomyia* spp.) Attacks by these maggots turn bean plants yellow and makes them stunted. The stems just above the soil surface are swollen and usually cracked, and the plants may die.

Stem maggots can be controlled by early planting and by hilling up soil around the plants to encourage new roots to form. During the non-cropping season, plants that could act a hosts (such as volunteer bean plants and weeds that produce beans) should be removed. It is also possible to use chemical insecticides to treat bean seeds, or to spray with diazinon or fenitrothion when the seedlings have two leaves.

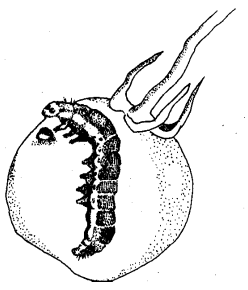
Black bean aphid (*Aphis fabae*) These aphids are tiny insects found in colonies around the stem, growing points and leaves of bean plants. The leaves turn yellow and die. The aphids also transmit mosaic virus.

Aphids can be controlled by planting early, intercopping beans with other crops, and by planting resistant varieties.

Cowpea and pigeonpea

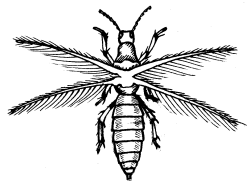
African bollworn (*Helicoverpa armigera*) Young caterpillars bore into cowpea and pigeonpea flower buds, which dry up and fall off. Older caterpillars bore into bean pods and cause heavy losses. Natural enemies such as tiny wasps can sometimes control these pests sufficiently.

Pod-sucking bugs attack cowpea and pigeonpea when the seeds are developing, making the seeds shrivel. Losses can be greatly reduced by picking the young insects off the pods and leaves.



African bollworn

Thrips (*Megalurothrips sjostedti*) are tiny insects that attack cowpea flowers and make them fall off. Spraying with neem extract can reduce losses.



Thrips (greatly magnified)

Cowpea aphid (*Aphis craccivora*) can be an important pest if not enough rain falls when the plants are young.

Maruca podborer (*Maruca vitrata*) Maruca caterpillars eat their way into the cowpea pods and eat the seeds. They also bore into flower buds and hollow them out. They may spin the leaves together and feed inside the web.

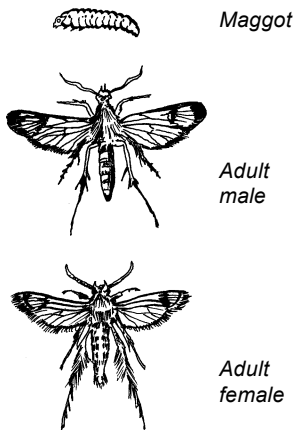
Podfly (*Melanagromyza chalcosoma*) The larvae feed on the immature seeds inside the pigeopea pods, without any damage being seen on the outside of the pods. Damaged seeds are worthless.

Avoiding planting pigeonpea in an area for some time reduces podfly numbers because there are no pods for them to feed on. Similarly, it is better not to grow a mixture of varieties that mature at different times. Growing a mixture of varieties means that there are pods over a long period, giving several generations of podflies the chance to reproduce.

Termites attack pigeonpea roots, making the plants dry up and fall over.

Cassava

Tobacco whitefly (*Bemisia tabaci*) Whiteflies are very small flies that carry cassava mosaic disease. Their maggots cluster on the underside of cassava leaves. The leaves of diseased plants are crumpled and twisted, and have yellow patches. Diseased plants are stunted and yield poorly.



Tobacco whitefly (magnified)

Cassava mosaic disease can be reduced by using disease-free planting material and by removing and destroying diseased plants. Some cassava varieties are more tolerant to the disease than others.

Sweet potato

Sweet potato weevil (*Cylas* spp.) The weevil maggots eat into the tubers and stem in the field, and continue to damage the tubers after harvest. Cultural management includes the following:

- Plant cuttings that are free of the pests.
- Plant the cuttings as deep as possible. Fill in deep cracks in the soil through which weevils can reach the tubers.
- Remove weeds that could act as hosts of the weevils.

- Harvest early to reduce infestation.
- After harvest, burn infested plant material on the spot.
- Keep harvested roots in a clean store.

Maggot

Adult

Sweet potato weevil (magnified)

Rodents Ground squirrels, rats and mice eat and damage sweet potato roots. They can be controlled by trapping, digging out their burrows, keeping vegetation along field edges short, and keeping the sweet potato crop free of weeds

Fruit trees

Fruit trees include cashew, citrus, coconut, mango and papaya. The major pests of these trees include aphids, mites, fruitflies, scale insects, thrips, fruit borers and whiteflies. Cultural management of these pests includes:

- Planting resistant tree varieties.
- Good seedbed preparation.
- Planting seedlings that are free of pests.
- Removing infested branches and dead material from the orchard.
- Intercropping fruit trees with crops that repel pests.
- Maintaining soil fertility by applying manure or fertilizer.
- Using biological control methods, such as releasing natural enemies of the pests.
- Mechanical control, such as picking off pests by hand.

Based on a manuscript by John Nderitu

Growing trees

Trees are used for many purposes: for fruit, fuel, fodder, fencing, poles and timber for construction, and to produce products for sale. That means that they are often in danger of being over-exploited. But trees are also important for the environment. It is necessary both to protect existing trees and to plant new ones.

Planting new trees reduces the amount to which existing stands are used, allowing them to recover. People often prefer trees that can be used for several purposes, so tree-planting programmes are more effective if they promote multipurpose species. Individually owned woodlots are preferable to village woodlots, which are rarely successful.

Water is the biggest constraint for establishing trees, so planting methods that conserve water are vital. Termites are a common problem: they can quickly destroy an otherwise well-managed nursery or seedling stand. There is little point in planting many trees where termites are abundant, unless termite-resistant species (such as neem) are given priority.

It is important to produce strong, well-adapted seedlings that have a good chance of survival in harsh conditions. Sow the seeds first in a germination bed. A few weeks after they have germinated, the seedlings can be transplanted to pots in a nursery, where they remain for several more weeks until they are ready for planting in the field.

Seed treatment and germination

Many types of dryland tree seeds have hard coats and use other survival mechanisms to withstand drought. However, a hard coat makes germination difficult, so pretreating the seed is necessary, especially for seeds gathered locally. The table on the next page shows how to do this. As a rule of thumb sow tree seeds soon after collecting them.

Most seeds with pulp (such as berries and fruit-bearing trees) do not require pretreatment. Sow them immediately as they lose viability very fast.

After treatment, the seeds should be sown in a shaded germination bed to encourage uniform sprouting. The best soil to sow in is a sandy loam. After planting, sprinkle the bed with wood ash to repel termites. Surround the germination bed with stones to prevent trampling or soil being washed into the germination beds, and cover lightly with grass mulch.

When the seedlings in the germination bed are ready for transplanting, water them to prevent them from drying out. Transplant them into the containers in the evening to allow them to recover a little before the heat of the next day. Avoid damaging the roots while transplanting.

How to treat tree seeds before planting

Pretreatment method	Species
Soak in cold water for 24 hours	*Balanites* (desert date)
	Acacia senegal (gum Arabic)
	Sesbania sesban
	Leucaena
Nick or score with a knife	*Adansonia digitata* (baobab)
	Acacia abyssinica (umbrella thorn)
	Acacia albida/Faidherbia albida
	Tamarindus
Soak in hot water and let cool for 24 hours	*Acacia albida*
	Acacia brevispica
	Adansonia digitata (baobab)
	Tamarindus
Scratch with a file or sandpaper	*Leucaena*
	Acacia abyssinica
Feed to a goat, then collect from the droppings	*Acacia tortilis*
De-wing with a knife, or allow termites to chew	*Terminalis brownii*

Nursery

The nursery should be sited near a water source, on very gently sloping land, and surrounded by trees to protect the seedlings from the wind and sun. It should be easily accessible to allow frequent watering and management.

Here are some more requirements for a good nursery:

- **Polythene tubes** or containers, one for each seedling. These promote the development of the tap root, and increase survival rate as long as the root is not damaged when the seedling is out-planted. If polytubes are not available, other types of recycled containers will do. Tins, milk cartons, bread bags, or whatever has a tube-like shape and is open on both ends can be used. A diameter of 10 cm is adequate for most trees. Fruit trees, however, need wider tubes of 15 cm or more.
- **A good potting soil** in the containers. Topsoil gathered from forest areas or fertile cropland, mixed with animal manure or compost at a ratio of 4 parts of soil to 1 part of compost or manure is best. Mixing in a small amount of wood ash helps keep away termites and other pests.

- **Shade** is important to protect the young trees from intense heat. A raised shade 1.5 m above the seedling beds is adequate. Use materials that are not prone to termite attack.

Sunken beds

In order to minimize water loss, the containers with the seedlings can be placed in a sunken nursery bed:

1. Mark out an area 1.5 m wide and of any length. Clear the surface of grass and stones. Dig a shallow pit about 7 cm deep. Set aside the soil and compact the bottom of the pit.
2. Spread leaves of neem (or other trees that are resistant to termites or insects) in the pit.
3. Stand the seedling containers neatly in the pit. Arrange them close together to prevent wasting water when watering.
4. Use the soil that has been set aside to make a low ridge around the sides of the pit.

Raised beds

If termites are a serious problem, it is necessary to make a raised nursery bed from termite-resistant or treated wood.

1. Mark out a rectangular area to build the raised bed, dig holes at each corner, and drive in a post at each corner. The posts should be about 1.5 m high.
2. Tie or nail poles between the tops of the posts to make a rectangular frame. Then put smaller sticks across the frame to hold the potted seedlings.
3. Spread leaves of plants that repel insects on the frame, then put the potted seedlings on top.
4. Water the seedlings twice a day.
5. Prune the roots that emerge under the pots with a knife or old scissors.

Hanging beds

For very small nurseries where termites are a problem, small hanging seedling containers are useful. Halves of old tyres, baskets, or any other lightweight containers can be used. Strings are attached to the containers so they can be suspended from branches of shade trees around the house.

The tree seeds are usually sown directly in the container rather than in a germination bed, and stay there until they are ready to be planted out in the field as bare-root seedlings. As with other types of nurseries, use good soil mixed with manure or compost.

Maintaining the nursery

- Water the seedlings twice a day, in the morning and evening. Use 20–30 litres of water per 1000 seedlings. Avoid using salty water, such as from a stagnant stream bed. To encourage watering, make a vegetable garden at the back of the nursery (people will always water the vegetables). If watering can be done only once a day, it should be done in the evenings.
- Prune the seedling roots every 2–3 weeks to prevent the roots from growing into the soil underneath the containers. Use a sharp knife to cut roots that grow out of the bottom of the pot.
- Fence the nursery with thorn branches to protect the seedlings from goats and other animals, and plant shade trees around it.
- Surround the nursery with aromatic plants (such as (tithonia, Mexican marigold, onions and garlic) that repel termites and other pests. Make sure there is no leaf litter or debris near a sunken-bed nursery. If pests attack the seedlings, use organic pesticides such as neem.
- Keep the nursery free of weeds to reduce competition for space and to control pests and diseases.
- Harden the tree seedlings by gradually simulating field conditions in the nursery. This means reducing the watering frequency one month before planting (from once a day to every second day), and gradually removing the shade.

Planting in the field

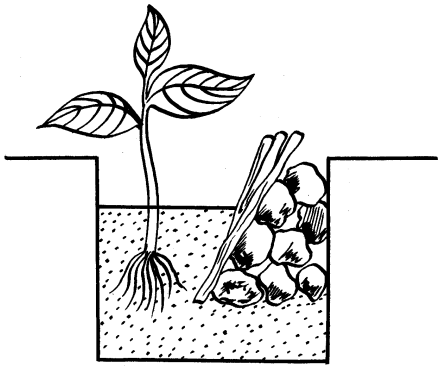
Tree seedlings must be strong enough to survive the harsh conditions in the drylands. They should be 30–50 cm tall and have a well-developed root system before they can be planted out. The length of time this takes depends on the species: sesbania can be planted out after a few months, while some fruit trees, such as mango, have to stay in the nursery for up to 2 years. Planting holes should be dug in advance, so that seedlings can go in directly at planting time.

The young trees need enough water in the soil near their roots. Irrigating is often the biggest job in keeping seedlings alive, so it is important to minimize the need for frequent watering. Planting trees at the beginning of the rains is one obvious way to do this.

1 Dig a hole 30–50 cm wide and 50 cm deep, keeping the topsoil and subsoil separate.
2 Mix the topsoil with manure or compost.
3 Put some topsoil/manure mixture back into the hole to a depth of 30 cm.
4 Stand the seedling in the hole and cover the roots with the mixed soil.
5 Water the seedling thoroughly, letting the water soak down to the roots. Repeat if necessary.

Below are some ways of making sure that water reaches the tree roots rather than staying on the surface or being absorbed by the surrounding soil.

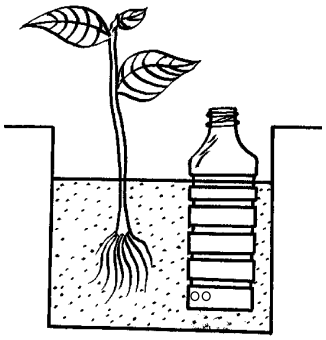
Stone method



When planting the seedling, place stones in the same hole beside the root ball, so the water trickles down to the seedling roots. The stones can be collected from around the farm, from roadsides or nearby stream beds.

Do not let the stones touch the seedling to prevent them from squashing the stem. The stones should be about the size of a fist. Do not use very small stones, as the spaces between them will quickly be filled up with soil.

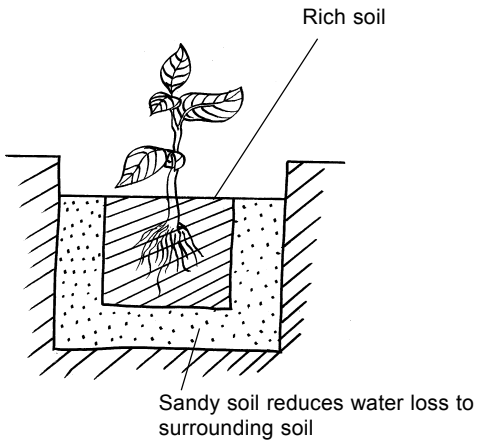
Recycled container method



Choose a 1-to-2 litre container such as a tin, clay pot, or plastic bottle, and punch a small hole near the bottom. Half-bury the container beside the seedling so the hole faces the roots. Fill the container with water and cover the top to prevent the water from evaporating. Refill the container about once a week.

A sturdy glass bottle can also be used. Fill it with water and push it upside-down at an angle into the soil beside the seedling. Cover the top of the bottle with soil or grass to prevent it from being heated by the sun. Avoid using coloured bottles; they heat the water and scorch the young roots.

Sand-planting method

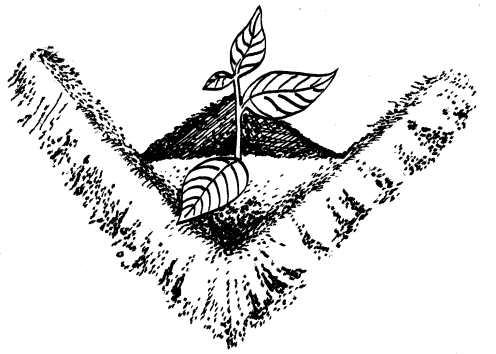


This method works because sandy soil can hold more water than a clay soil. Before planting the seedling, place a cylindrical or square container, open at both ends, in the middle of the planting hole. Fill the gap around the outside of the container with sand or coarse sandy soil. Plant the seedling inside the

container, then pull the container out and use it for the next seedling. The layer of sand holds water around the seedling roots.

Microcatchments for water harvesting

A microcatchment is a V-shaped or semi-circular ('half-moon') ridge of soil built around a seedling. It collects and holds runoff water so the seedling can use it. Although they take a lot of work to make, microcatchments greatly improve seedling survival rates. The size and lay-out of microcatchments vary according to local conditions. Where rainfall is relatively high (600–800 mm per year), a large number of small structures should be used to catch enough water but avoid flooding. In areas with lower rainfall, microcatchments may be quite large. Common sizes are 5 and 10 metres across.



Microcatchments are most effective on gentle slopes of 3–5%, in areas where watering cannot be done regularly. The soils should be fairly deep sandy loam, which can hold water in the soil during the dry season. A series of microcatchments can be built side by side, but on less steep land, farmers usually make the catchments separate from one other. A series of microcatchments may be arranged on a slope so they catch the overflow from microcatchments above (see page 93). Because microcatchments need a lot of work to build, they are best used for high-value trees, such as fruit trees. They should be used only with larger seedlings, as smaller ones may be waterlogged if it rains heavily.

The microcatchments should be prepared in advance so the seedlings can be planted immediately after they are removed from the nursery. The catchment should not be made too small or narrow, as it will trap too little water. Nor should it be too large or wide, as it will trap too much, and the water spill over the top and wash the ridges away. To find the best size, check other microcatchments nearby, or experiment with a few microcatchments of various sizes before building more.

Similar catchments (on a larger scale) can be used to grow sorghum and millet.

Making microcatchments

To lay out a microcatchment, you will need a line-level or A-frame, a piece of string the length of the two sides of the V-shaped ridge you want to make, two sticks, and a shovel or hoe. Make a mark on the string exactly in the middle.

1 Use the A-frame or line-level to find two points that are level with each other. These will be the top ends of the microcatchment 'V'. Push a stick into the ground at each point.

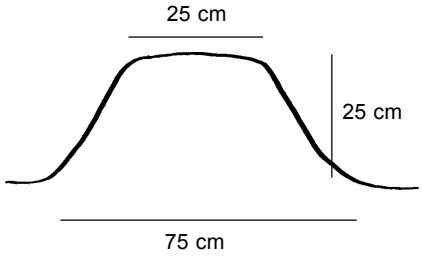
2 Tie one end of the string to one of the sticks, and the other end to the other stick. Hold the middle of the string and move down the slope until the string is tight and the angle is near 90°. Put a third stick in the ground here to mark the lower end or corner of the V.

3 Dig the planting hole just above the corner of the V. Keep the topsoil separate from the subsoil.

4 Use the subsoil to make ridges along the lines of the V. The ridges should be abour 25 cm high, 75 cm wide at the bottom, and 25 cm wide at the top, to prevent them from being washed away by the rainwater that collects.

5 Mix the topsoil with manure or compost, and put the mixture in the hole. Heap the mixture up above the level of the surrounding soil to make a small mound. This helps prevent the seedling from becoming waterlogged.

6 Plant the seedling in the mound.



Cross-section of catchment mound

Transplanting wildlings

Trees which sprout and grow naturally are called 'wildlings'. Wildlings are a good source of hardy planting material, especially for indigenous trees. Very young wildlings (15–25 cm tall) can be transplanted into containers and raised in a nursery, or they can be looked after under the mother tree until they reach out-planting height.

Transplanting into tubes

1 Fill containers in the nursery with soil mixed with manure or compost (see above).

2 In the evening, dig out the wildlings and put them in a bucket containing water.

3 Quickly plant the wildlings into the nursery containers. Water them immediately.

4 Care for the seedlings in the same way as other seedlings, but with very minimal root pruning, as indigenous trees are sensitive to this.

Neem: A tree for all reasons

Neem (*Azadirachta indica*) is a member of the mahogany family (Meliaceae). Native to India and Burma, the tree was introduced to Africa in the 19th century, though the general feeling is that it has been there since time immemorial. It has many local names throughout Africa.

Neem trees are attractive, broad-leaved evergreens that can grow up to 30 m tall and 2.5 m in girth. A neem tree normally begins bearing fruit after 3–5 years, becomes fully productive in 10 years, and from then on can produce up to 50 kg of fruit a year. It may live for more than 200 years.

Many benefits

The neem tree has great potential to improve the livelihoods of many rural families by generating income and improving health. Among its many benefits include:

- Human medicine
- Control of farm and household pests
- Livestock medicine
- Hygiene (e.g., of teeth)
- Shade
- Oil
- Feed
- Organic fertilizer
- Seed cake to improve soil fertility and control diseases and pests
- Employment in production and processing
- Environmental conservation

The medicinal properties of neem are awesome. The Swahili call it *mwarubaini*, meaning it cures up to 40 diseases. Experts and doctors have listed over 60 diseases that neem can cure. In many societies, people use neem in herbal medicines and cure-baths, and use its sticks as toothbrushes. People in some societies even believe that it wards off evil.

Many neem products are made and sold locally, but the economic potential of this tree can be exploited further.

Truly, this amazing tree has the potential to offer hope to many poor families in sub-Saharan Africa.

Outplanting

If wildlings are to be outplanted directly, rather than being cared for in a nursery:

1 Prepare the planting holes in advance.
2 When rains start, dig out the wildlings, protecting the roots in a ball of soil.
3 Place gently in a basket or container and transplant into the holes on the same day.

Microcatchments for wildlings

Microcatchments can be used to collect water for indigenous seedlings that are already growing. Watch how the water flows when it is raining to work out the direction of the slope. Instead of the V-shape, a semicircular ridge can be built

downslope from the seedling to collect the runoff. The semicircular shape does not concentrate the water directly on the plant as the V-shape does, but holds it in a larger area.

Controlling termites

Termite attacks can become a serious problem for seedlings, especially with exotic tree species such as *Grevillea robusta*. Here are some suggestions for protecting seedlings that will increase their survival rate. Most of these methods are less effective in the wet season as the rains will wash away the organic remedy.

- Mix kitchen ash, or the ash of tree species known to be termite resistant, with topsoil and put into the planting hole. Plant the seedling in the mixture.
- Make a circular groove 3 cm deep and 15 cm in diameter around the planted seedling. Sprinkle the ash in this groove. Repeat if necessary, e.g., after the rains.
- Collect green material from tithonia, neem or any other plant that repels termites. Chop it in small pieces and soak in water for 14 days, stirring occasionally. Make a circular groove around the seedling and pour in the mixture. Repeat after 7 days.
- Dig a planting hole 60 cm wide and 60 cm deep. Fill it with fresh vegetation and sprinkle with powdered chili pepper. Cover the hole with topsoil and mulch (if available). After some months, when the vegetation has decomposed, plant the seedling and water it well.

For more information, contact KEFRI or ICRAF

Drying surplus food

Preserving food is essential for good nutrition, especially in drylands where fresh food is unavailable for long periods.

There are many simple ways of processing and preserving foods. Drying is one of the oldest. Many types of food can be dried: grains, legumes, root crops, fruits and leafy vegetables. They can be dried when they are cheap and abundant just after harvest, and consumed or sold later in the year when they are scarce and food prices are high.

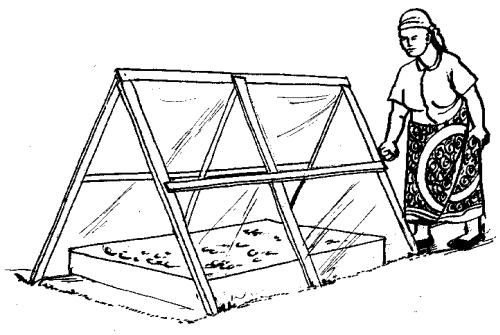
Why dry food?

- Drying prevents growth of fungi and bacteria.
- It prevents or delays infestation by insects and mites.
- It increases storage life of the produce.
- It increases the value of the produce by making it available for sale when it is scarce or unavailable.
- It raises the concentration of nutrients: proteins, carbohydrates and fats are present in larger amounts per unit weight in dried foods than in the fresh counterpart. (However, some important vitamins, such as vitamin B and C are lost in dried foods.)

If possible, plan beforehand which crops to dry and when, and when to eat or sell them. Dry them for storage immediately after harvest, and eat or sell them when prices are highest (probably just before the next harvest). Make sure that the dried food is still in good condition before eating or selling it.

Dryers

Various types of dryers, commerical and home-made, can be used. The humidity of the air moving through the dryer must be low enough to remove moisture from the food. The dryer must keep out rain, dirt, insects, animals and even children. The dryer should be large enough to accommodate the crops to be dried at harvest time.



Food can also be dried on tarpaulins, mats or plastic sheets. Some areas have special concrete drying floors. Platforms

can be used to raise the food off the ground, allowing air to pass up through the food and drying it faster.

In East Africa, food is often put to dry inside a cone of sticks to protect it from animals and children.

Foods (usually grains such as maize) placed in the roof of a cookhouse are dried by the heat from the cooking fire, while the smoke repels insects. The food takes on a smoked flavour, which some people like but others do not.

Tips for drying

Drying food is not complicated, but needs careful attention. The following tips apply to most types of fresh vegetables or fruits. Modify the method to suit the local climate, the type of dryer, your daily schedule and the type of food.

- Choose fresh, firm and ripe foods. Do not use over-ripe foods.
- Wash fruits, vegetables and roots before drying. Scrub if necessary.
- Slice fruits, vegetables and roots into thin, uniform pieces, less than 1 cm thick (the width of a woman's little finger).
- Cut and prepare foods quickly, and keep the food clean.
- Prepare other foods by shelling, hulling, peeling or slicing. Threshed grains dry faster than whole heads. Smaller pieces dry faster. Some foods (e.g., sweet potato, cassava, yams) dry better if blanched first (see below).
- Spread foods evenly on drying racks. Thinner layers dry faster.
- Cover food to keep out insects that might lay eggs on or in the food.
- Dry the food with warm, dry, circulating air. Stir or turn the food 2–3 times a day so it dries evenly. Do not allow the food to get too hot, as this can crack, break or discolour the grains, reduce the protein quality, and kill seeds (if they are to be used for planting).

After 3 days, test for dryness. Fruits and vegetables are dry enough for storage when they weigh 1/5 of their fresh weight. Grains and legumes are dry enough when they weigh 3/4 of their weight before drying. The drying time depends on the type of food and its moisture content, the air humidity, and the weather (e.g., sunshine all day, partly cloudy, hot and windy).

Drying different crops

Cassava Wherever cassava is grown, farmers know how to process it, but methods vary from region to region. Remove the toxic parts (pith and skins) before drying.

Maize Remove the husks and dry 2–4 cobs thick. Or shell the cobs and spread in a layer 4–15 cm thick. The best temperature is 40°C; do not heat above 45°C.

Groundnuts Remove dirt from the shells. Dry in the shells or after shelling. The best temperature for drying is 30°; do not heat above 35°C.

Storing crops

Crops	Traditional methods	Modern methods
Cereals maize, sorghum, millets	○ Sun-dry, mix with ash, and store in granary. Sorghum and millet are also stored in pots and other containers. ○ Grain can also be stored underground. ○ Mix smaller grains (finger millet, teff) with bigger grains such as maize to protect them against weevils. ○ Mix seed for planting with soil or dry cow dung.	○ Dust dried seeds with deptrex, actelic powder or other chemicals and store in bags.
Legumes beans, cowpeas, pigeonpeas	○ Sun-dry, mix with ash, and store in granary or big pots.	○ Same as cereals.
Root crops cassava, sweet potatoes	○ Peel, chop into pieces and dry. Store in granary. ○ Ferment or boil cassava before drying.	○ Chop, dry and store. ○ Make fritters.
Fruits and vegetables	○ Store in a small pot inside a larger pot containing water.	○ Most fruits can be made into jams. ○ Slice mangoes, dry and store.

Yams, sweet potatoes Wash and peel, then slice, grate or shred before drying (see also below).

Mangoes

Mangoes can be preserved very simply by drying. You will need a simple solar dryer or trays for sun drying, and a heat-sealer if you expect to package the dried mangoes for larger markets. Using trays may not be suitable for commercial purposes because they allow dust and insects to get into the product.

Peel the ripe mangoes, slice them thinly (0.5 cm thick or less), flatten them by hand, and briefly soak them in lemon juice or a honey solution as a preservative before drying. Dry from one to a few days, turning 2–3 times a day. Do not overdry. The better the drying process, the better the quality and look of the produce. The colour should be bright orange. Protect the produce from flies and other insects by packaging immediately or covering with a clean cloth.

Sweet potatoes

Here is a traditional way of preserving sweet potatoes used by small-scale farmers in Southern Province of Zambia.

1 Wash the sweet potatoes after harvest.
2 Boil in a large pot for 20 minutes.
3 Allow to cool, then peel the sweet potatoes and chop them into small pieces.
4 Dry them on a drying rack until brittle.
5 When dry, store in sacks until ready to use or sell.

Vegetables

Vegetables for drying should be young, fresh and tender. Make sure they are free of insects and contaminants. Separate any bruised produce for immediate consumption. Before drying, blanch (boil for a short time) vegetables to kill bacteria and fungi, and halt the ripening process:

1 Wash the vegetables thoroughly in clean water. Shell, peel or cut into small pieces.
2 Put the vegatable in salted, boiling water. The amount of time differs from one vegetable to another: cowpeas and kale need 3 minutes; carrots and potatoes a little longer. Onions need no blanching
3 After blanching, drain the hot water and dip the vegetable in cold (boiled) water, then drain and dry. Spread evenly on a tray (avoid metal trays) or a vegetable drier. Then dry in a drier or in the sun, protected from dust and insects. Turn regularly to ensure even drying.
4 When the food is thoroughly dry, store it in an airtight container or sealed plastic bags.

While cooking vegetables, boil the water first, add the food and bring it back to boiling point. Cook for as short a time as possible to keep vitamins in the food.

Tomatoes

The following method is used in Kelema Balai village, Dodoma, Tanzania. Dried tomatoes keep the nutritional quality and are easy to store and use. Full sunshine and an efficient dryer are important to remove the high water content of tomatoes.

1 Pick red tomatoes and wash them in clean water.
2 Cut with sharp knife into quarters and remove the seeds.
3 Spread on a clean surface under the sun to dry (4–7 days under hot sun).
4 Crush into powder in a hammer-mill (with its sieve removed).
5 Store in clean dry plastic or metal container. Used in the same way as fresh tomatoes when cooking.

Based on a manuscript by Philigona Ooko

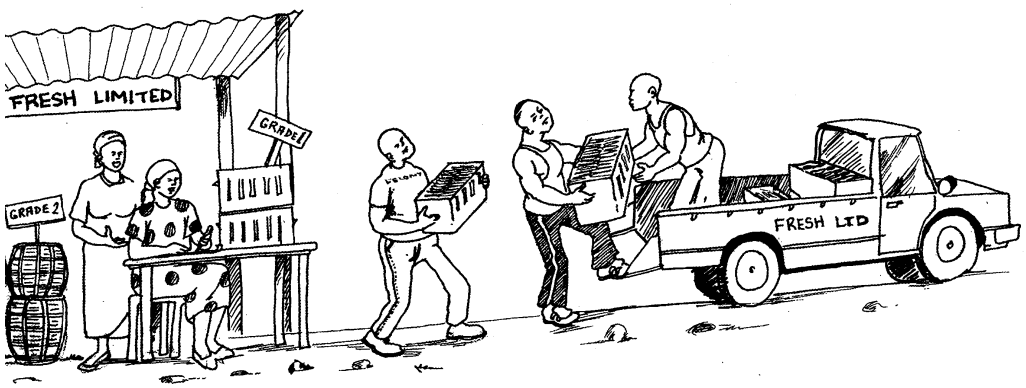
Marketing horticultural crops

Small pockets of irrigated land in the drylands produce a considerable amount of horticultural produce, much of which is exported to Europe and the Middle East. The irrigated drylands have the advantage that they can produce vegetables off-season, and the warm climate provides good growing conditions if water is available. If the roads are good and an airport is nearby, the produce can be flown to the market the same day it is harvested. As long as the irrigated areas are small, conflicts with pastoralists are limited.

The European Union, especially, has strict regulations governing imports. Growers and traders must comply with regulations covering quality, use of pesticides, labour use and record keeping. If they fail to comply, their produce will be rejected, and further imports from the whole country may be banned.

Fulfilling these requirements is a challenge. Increasingly, independent producers are being replaced by large multinational corporations. To survive in this competitive environment, growers and traders must have a good business relationship. They must ensure the highest quality in both production and in post-harvest handling.

A code of conduct agreed by the growers and traders, backed by a contract, is in the interests of both. The traders can be sure of the quality, quantity and harvest time of the produce. The sellers have an assured market and price, receive guidance on practices, and are protected from unscrupulous traders. One party can take legal action if the other breaks the agreement. Buyers are generally in a more



Growers organized into associations gain valuable business and marketing skills.

powerful position than the growers. But by organizing into groups, growers can increase their bargaining power and get better prices, access extension services and other inputs (such as credit) more easily, and sustain production – so increasing buyer confidence.

Challenges

This approach to marketing involves several challenges and dangers. In a tropical climate it is difficult to maintain the freshness of produce and conform to hygiene and sanitation requirements. These include the safe use of pesticides, or in the case of organically grown produce, eliminating pesticide use altogether.

Opportunistic traders seek out growers and may offer them higher prices than specified in their contracts. This is tempting for the grower. If the contract involves a group of growers, some members of the group may be dishonest or fail to abide by the rules. Adequate pressure within the group is needed to make sure that no one cheats.

A disloyal grower may mean the trader cannot meet the client's requirements, losing credibility with the buyer. Consistent quality is crucial when marketing fresh produce.

The lack of product diversification exposes growers to changes in demand in international markets. Few have the ability to anticipate these changes and adjust their production accordingly. Nevertheless, facing the rigours of the international market may also make growers better able to produce for the increasingly stringent demands of the domestic market. It is necessary to explore the possibility of producing also for the local market.

Off-season mangoes in Marakwet District, Kenya

The main mango season in eastern Kenya is from February to July. In Marakwet, a dryland district in Rift Valley Province, however, the season lasts from August to March. Mango farmers here have an opportunity to get high prices.

Transporting mangoes to market has been a problem, though. For many years, the road was poor, so the mangoes went to waste. The road has now been repaired, allowing lorries to collect the mangoes. Trucking firms charge KSh 20,000 (about US$ 250) for carrying a load of 200 sacks of fruit to Kitale, 250 km away.

Farmers typically sell their mangoes for KSh 100 per sack. The fruit sells in Kitale for about KSh 350 per sack. After deducting KSh 100 for transport, this leaves KSh 150 to cover the trader's other expenses and profit.

Many farmers bring their fruit to a collection point in Sang'ach, in the north of Marakwet District. During the mango season, an average of four lorries may be loading fruit here at any one time.

—Joel Kipchumba

Code of conduct

Below is the outline of a code of conduct, based on that recommended by the Kenyan government's Horticultural Crops Development Authority for export crops. This code could be adapted to other situations, such as growing crops for the domestic market.

Growers' obligations Farmers must be organized into well-managed groups, registered with the relevant authorities.

Buyers' obligations Buyers should always enter into a contract with growers they buy from. They should respect one another's contracts, and not buy produce from schemes they have not sponsored. They should provide extension services for growers.

Obligations of both Both growers and buyers must respect the terms of the contract. They should involve the relevant authorities when drawing up the contract. Growers are not encouraged to enter several contracts with different buyers, especially when the buyer provides the inputs and needs assurance that they are applied as specified.

Obligations of service providers Government agencies, parastatal organizations or NGOs can assist traders and growers to draw up a contract. They can promote the formation of growers' groups, and provide advisory services. A representative of the relevant authority should witness the contract agreement, and may arbitrate in case of disputes.

Essential elements of a contract

The following items can be covered by the contract.

Quantities, quality and price of produce This clause specifies the amount to be supplied over a period of time, the quality levels according to the market requirements, and the prices for produce at different quality grades.

Seeds, chemicals and fertilizer inputs This states who is responsible for supplying or procuring high-quality seeds or planting materials.

Record keeping Minimum requirements should include the identity of the previous crop, the type of seed and seed treatment used, the planting date, the rates and dates of any chemical applications, irrigation dates and quantities, and harvesting date. These records allow produce to be traced back to its source – a requirement of the importing country.

Harvesting and post-harvest practices This specifies the use of clean and proper harvesting containers, protection from heat and direct sunlight, maintenance of sanitation and hygiene.

Inspection and grading Responsibility for inspecting, grading and labelling produce (when, where, how documented) must be clear.

Packaging This states who is responsible for supplying packaging materials,

Vegetable growing in Dodoma, Tanzania

Horticulturists in Matumbulu, a village in Dodoma Region in Tanzania, grow vegetables on 1-ha plots of irrigated land. They sell their produce in local markets, and also sell to distant buyers and exporters.

Before deciding what crop to grow, they visit the towns nearby to see which types of produce that fetch a good price. They also check on the size and appearance of produce in demand; for example, some consumers prefer small onions. To spread their risk, the farmers grow a variety of vegetables, including non-perishable crops such as onions.

The reservoir that feeds the farmers' irrigated area sometimes dries out. The farmers are considering harvesting rainwater from the slopes nearby to supplement the water supply in their fields.

—Patrick Lameck

packaging procedures, the condition and quantity of produce, the placement and orientation of produce in the container.

Conditions of collection or delivery This covers the time and season that the produce is to be collected, and the responsibility for loss in case the produce is collected late or not at all.

Rejected produce The point of rejection must be agreed. Where the buyer rejects produce, conditions for returning the produce must be stated.

Payment terms The payment procedure should allow the safe and timely transfer of funds. The payment period and intervals must be clear.

Penalties This clause specifies the compensation to be provided to one party if the other fails to abide with the agreement, and how disputes will be settled (e.g., by the relevant government service or by the courts).

Duration of contract This states the number of months the contract will be in force, as well as the time intervals that may be relevant.

Termination The conditions for termination, such as a written notice within a reasonable pre-agreed period, must be agreed.

Natural calamities and non-commercial risks The affected party should not be penalized if it cannot fulfill the contract because of factors outside its control, such as flood, hail, social disturbances and strikes.

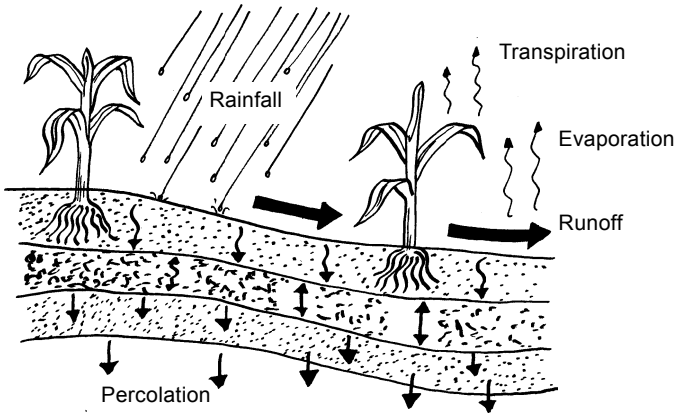
Based on a manuscript by Susan Wambugu

4

Soils and water

Soil and water conservation

A significant percentage of rainwater in dryland areas is lost as surface runoff. Much of the rest evaporates or percolates deep into the ground where plant roots cannot reach it. Plants quickly absorb the little moisture still in the soil, and soon the ground becomes dry, incapable of supporting crops.



Rainwater lost through evaporation, runoff and deep percolation is not available to the crop.

Erosion is a related problem. Dryland soils are often thin, have poor soil structure, are low in organic matter and are bare of vegetation. Crusts form on the surface of many soils, reducing the amount of water that can seep into the soil. The water runs off easily, forming gullies and carrying valuable topsoil with it.

Crop farmers cannot afford to lose the little moisture and soil there is, so they have for centuries used indigenous conservation techniques. These range from stone terraces in mountainous areas to tillage practices in flat areas. They focus on conserving moisture to improve crop yields. However, the main priority (from the farmers' viewpoint) is higher production, with soil conservation coming second. Only crop farmers are willing to invest in conservation measures; pastoralists are not very interested because they are mobile.

Degradation of grazing lands is a problem in wetter areas with many people and livestock, and around communal watering points. Degradation is caused by continuous grazing and tracking, shifting cultivation, indiscriminate cutting of trees and uncontrolled burning.

Below are guidelines on how farmers can conserve water and soil either by building on and improving indigenous techniques, or by adopting new methods.

Agronomic and mechanical practices

Soil and water conservation includes ways to protect the soil from the impact of raindrops, prevent runoff that can cause erosion, increase the amount of water that seeps into the soil, and increase the roughness of the surface to reduce the speed of runoff and wind.

Agronomic and mechanical conservation measures

Agronomic

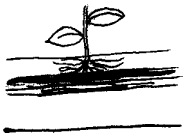
- **Conservation tillage**: contour ploughing, ridging, tied ridging, minimum tillage, ripping and subsoiling, plough-planting
- **Conservation farming**: crop rotation, intercropping, alternative crop varieties, fallows and area closures
- **Soil fertility management**: manure application, fertility pits, composting
- **Agroforestry** (see page 63)

Mechanical

- **Bunds**: contour bunds, graded bunds, trench bunds, *fanya juu*
- **Terraces**: bench terraces, hillside terraces
- **Catchments**: half-moon catchments, microcatchments
- **Gully rehabilitation** (see page 97)

Soil and water problems, and some ways to address them



Problem	High runoff	Low soil moisture	Poor soil structure	Crusting and compaction
Causes	○ Slope ○ Low infiltration ○ Poor ground cover ○ Crusting and compaction	○ Poor ground cover ○ Poor infiltration ○ Increased runoff and evaporation	○ Low organic matter content ○ Erosion of topsoil ○ Leaching of nutrients	○ Hard/plough pan ○ Animal trampling ○ Structural instability of soil
Solutions	○ Physical and biological conservation (terraces, ridging, vegetative cover) ○ Legume cover	○ Mulching ○ Cover crop ○ Irrigation	○ Increased organic matter ○ Minimum tillage ○ Legume cover crop	○ Subsoiling and ripping ○ Manure application




Soil and water conservation practices can be divided into agronomic and mechanical measures. Agronomic measures include crops, vegetation and tillage practices. Mechanical measures entail moving larger amounts of earth or using stone or concrete to build (semi-)permanent structures such as terraces, bunds and gully plugs.

Generally, agronomic measures are preferable to mechanical measures because they are cheaper and need less labour. Farmers also usually prefer them for the same reasons. If used, mechanical measures should always supplement agronomic practices. Vegetation can also be used to stabilize structures such as bunds, terraces and gully plugs. If they are properly maintained, mechanical measures can become permanent features, providing benefits year after year with little further investment.

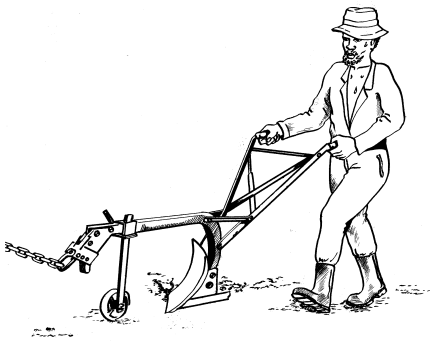
There are many different types of conservation practices. The most suitable depends on various factors, including the local climate, the soil type, the length and steepness of the slope, and the availability of labour, capital, draught power and implements.

Caution Approaches that work well in wetter areas may not be appropriate for the drylands because of the difficulty in establishing permanent vegetative cover to protect the soil. And a technique suited for a heavy soil may be a disaster in a sandy soil. Poorly designed structures can cause erosion rather than reduce it, for example if water in a terrace overflows in a heavy rainstorm and creates a gully. It may be best to try out a measure on a small scale before recommending it widely in the area.

Problems of conventional tillage

Ploughing is hard work. Farmers do it for several reasons:

- To loosen and aerate the soil, enabling seeds to germinate and roots to grow.
- To break up surface crusts and enable water to percolate into the soil easily.
- To kill weeds.
- To incorporate weeds and crop residues into the soil so they rot quickly and their nutrients can be used by the next crop.



Traditional mouldboard plough

However, conventional tillage with a mouldboard plough (one that turns the soil over) has several disadvantages:

- Repeated ploughing and harrowing

make the surface fine and powdery – good for seed germination, but bad because the soil can be eroded easily by wind and water.

- Intensive ploughing destroys the soil structure and forms a 'plough pan' – a compact layer in the soil that restricts water percolation and prevents roots from growing down deeper. Hand-hoeing can cause shallow hardpans because the hoes do not penetrate deep and have a similar action to the mouldboard.
- The exposed soil can dry out, reducing the amount of moisture available for the crop. Organic matter is lost easily.
- Ploughing up and down a slope can encourage the formation of gullies.

Various 'conservation tillage' methods can be used to overcome these difficulties. They include contour ploughing, ridging, and various ways to reduce the amount of ploughing and to loosen the hardpan. They can be used by both large-scale and smallholder farmers.

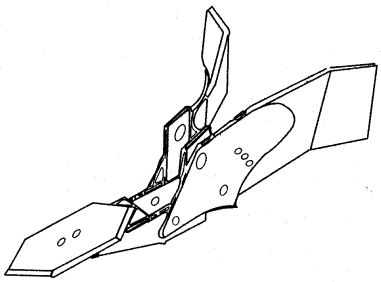
Conservation tillage

Contour ploughing

Ploughing along the contour (across the slope, rather than up and down) helps slow runoff and prevent gullies from forming. Many farmers have used contour ploughing for years with little need of external advice.

Ridging

Ridges (especially those running along the contour) made with a plough or hoe encourage water to seep into the soil, increasing the amount of moisture available for the crop. Crops are planted on the ridge to prevent them from being drowned in a heavy downpour.



Ridger

Tied ridging

Tied ridges are normal ridges (preferably running along the contour) that are 'tied' together every few metres by a cross-ridge of soil, slightly lower than the normal ridges. The main ridges can be made with a plough; the ties are added later with a hoe. Rainwater is trapped in the furrows between the ridges, and cannot flow along the furrows because of the ties. This reduces erosion and increases the amount of water that seeps into the soil. Tied ridges are not suitable on impermeable soils and in areas with intense rainfall, as the ridges may be overtopped, resulting in severe erosion.

Conservation tillage in Machakos, Kenya

Farmers in the very dry Iiuni area of Machakos, in Kenya's Eastern Province, have improved their yields by switching from conventional farming practices that emphasize erosion control to techniques that manage moisture and nutrients and directly influence soil and crop productivity. These techniques include subsoiling, minimum tillage, pitting, and the application of farmyard manure.

Where using draught animals is not possible, manual subsoiling using a pickaxe is becoming popular, even though it is very labour intensive.

—Elijah Biamah

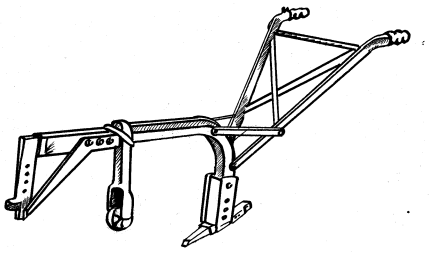
Minimum tillage

Minimum tillage is so called because it involves minimal turning of the soil. This helps maintaining the soil structure and reduces the cost of land preparation. Only the planting rows are ploughed; the area between is left undisturbed. Minimum tillage helps to maintain or improve the soil organic matter content by protecting the soil from erosion and decreasing the mineralization of organic matter. Minimum tillage is good on sloping, well-drained, coarse- and medium-textured soils, but less effective on poorly drained soils or on soils that form surface crusts easily. Regular ripping (see below) may be necessary to loosen the soil.

Weeds may be a problem at first in minimum tillage. It is necessary to weed more or to use mulch to smother the weeds. It is possible to spray herbicides, but these are expensive and may harm the environment and farmers' health. After 4–5 years the unploughed ground between the rows becomes less conducive for weed growth.

Ripping and subsoiling

Ripping and subsoiling dig deeper than the mouldboard plough, breaking up the hardpan (which may be caused by normal ploughing). They increase infiltration and enhance the water storage capacity of the soil. The implements used open up the soil only along planting lines, leaving the previous year's residue on the surface.



Subsoiler

Planting deep-rooted crops such as pigeonpea or cowpea after deep ploughing discourages formation of hard pans.

Plough-plant in South Tigray, Ethiopia

Farmers in lowland areas in south Tigray use the plough-plant method to reduce risk when growing crops. The average rainfall is 400–800 mm a year; it falls during the short rains (March–May) and the main rainy season (June–September). Rainfall is unreliable, especially in May and June.

The main crops are maize, finger millet, sorghum, teff, barley and various pulses. Farmers sow long-duration varieties of maize and sorghum in mid-March to mid-April. If the rainfall in May and June is good, the yields can reach 6–8 tons per hectare without fertilizer, and 11–14 t/ha with fertilizer.

However, if the rains stop in May, the farmers fear the critical flowering stage of the crop will happen during a dry spell, perhaps causing the crop to fail completely. So they plough the crop under, and sow a short-duration variety in its place.

Ploughing under the early-planted crop releases moisture to the soil. The green manure adds fertility and a significant amount of nitrogen for the new crop. The plough strips also conserve soil and moisture.

—Melaku Gebremichael

Plough-planting

In plough-planting, a plough is used to weed between rows after the crop has been sown and the plants are 25–50 cm high. It is used with cereal crops such as maize, finger millet and sorghum. Some of the growing plants are cut and buried by the plough; they act as green manure for the remaining plants. The plough damages the surviving plants' side roots, retarding growth but encouraging the other roots to penetrate deeper to find moisture. This makes the plant hardier and more able to withstand drought.

Breaking the plough-pan in Arusha, Tanzania

When farmer Noel Raphael Ayo volunteered to take part in soil-tillage trials, he was not sure of what to expect. The maize yields on his small farm had been declining each year, and he was very willing to listen to the extension workers who were to carry out the trials.

The extension workers from the Soil and Water Conservation Programme in Arusha (SCAPA), Tanzania, discussed the problem of declining yields with the farmers. They suspected the problem was due to formation of a plough pan. Ayo's field was one of those chosen for tests. The project provided an ox-drawn ripper and Ayo used it to deep-dig his the test field. He then planted maize as normal.

Soon after the rains, his neighbours' crops were stunted, but Ayo's maize thrived. That season he harvested 18 bags of 100 kg each. One unfortunate farmer in the same village harvested less than one bag.

After learning the secret behind Ayo's harvest, every farmer now wants to practise ripping. SCAPA is helping them form groups to buy communal rippers.

—Joseph Mwalley

Conservation farming

Crop rotations

Many farmers rotate the crops they plant in a field from one season to the next. For example, they alternate a cereal (barley, wheat, maize or sorghum) with a legume (field peas, horse beans, chickpeas, lentils). The various crops have different moisture and nutrient requirements and rooting patterns. Legumes improve the soil fertility by fixing nitrogen in the soil, making it available for the cereal in the next season. Crop rotations also help control pests and diseases by breaking their life cycle.

Intercropping

Intercropping involves planting two crops in the same field – often a combination of a nitrogen-fixing legume (such as cowpea) with a taller cereal (such as maize). The dense ground cover reduces erosion, lowers evaporation and increases infiltration into the soil. Intercropping also has various other advantages (see *Crop selection*, page 55). The crops should have different rooting profiles to avoid competition for soil nutrients and moisture, and should mature at different times. The crops can be planted at the same time, or one can be planted after the other is already established. For example, cowpeas can be planted in a maize field after the first cultivation has removed weeds.

Using permanent planting lines

The Blomfontein region of South Africa receives an annual rainfall of 400–600 mm. Although most of this comes in the March–April growing season, crop failure is frequent because the rainfall is unreliable. The chance of a good harvest depends on timely planting – and the best time to plant is not easy to judge. Farmers therefore plough their field several times so the soil absorbs as much moisture as possible before the opportune time for planting. This increases the cost of labour and the demand for draught power.

A local researcher, who is also a farmer, has introduced a way to improve the use of rainwater for maize growing. He has doubled the recommended inter-row spacing (80 cm) for maize. Every year, he ploughs and plants along the same lines. He uses a ripper to increase the depth of water infiltration and root penetration into the soil.

During the rains, the space between the rows generates runoff, which is captured by the planting lines. The weeds that grow between the lines are cut and used as mulch for the growing plants. Since the space between the rows is not cultivated, the population of weeds has declined over the years.

Permanent planting lines and certain other practices create a better environment for plant growth. Although the farmer has fewer plants, his harvest averages 10 tonnes every year.

This innovative method also reduces his costs. He plants less seed and uses less labour, fertilizer and animal draught power. Many small-scale farmers have adopted this method in the northern part of South Africa and in Botswana.

—Gedion Shone

Combining tillage techniques in Kenya

The Laikipia Plateau to the northwest of Mount Kenya is semi-arid land that was opened to small-scale farmers in the 1970s when former ranches and wheat plantations were subdivided. The settlers, who were mainly from high-potential areas, changed the land use to dairy cattle rearing and more intensive farming of maize, beans and potatoes.

Low rainfall is the main limitation to crop farming in this area. Recurrent crop failure and high soil erosion called for the introduction of soil and water conservation measures. The Laikipia Research Programme tested conservation practices such as mulching, minimum tillage and ridging. Later these techniques were tried out in farmers' fields.

When used separately, minimum tillage and mulching with crop residues were not very effective when compared to the local tillage method. But when the two methods were applied together, soil erosion was reduced appreciably and more moisture was stored in the soil. Maize yields also increased.

As a result, farmers are now advised to use a combination of conservation techniques to improve production.

—Geoffrey Kironchi

Alternative crop varieties

Many common varieties take a long time to mature and require a lot of moisture. They are being replaced by crops and varieties that mature early (so avoid drought) or are drought-tolerant. Such varieties are also preferred because they yield well in shallow, infertile soils with normal rainfall. However, early maturity is not easy to breed into traditional crops.

Fallows and area closures

When farmers see the productivity of their land falling, they often fallow the land – leaving it uncultivated for several years to allow the soil structure to recover and to rebuild organic matter and soil nutrient levels.

Overgrazed areas and land heavily eroded by livestock can be fenced or closed off with thorn bushes to allow the natural vegetation to recover. Mechanical measures such as half-moon structures and check dams can be built to halt erosion. Crop farmers may accept area closures more readily if they may cut and carry grass from the area to feed to their livestock.

Khram or *tsigee* fallowing in Tigray

This type of fallowing is practised in the central and eastern Tigray. Land with shallow and very poor soils are fallowed, the cropping interval varying with soil fertility. In the 1960s, the fallow lasted three years, but since the late 1970s, it has been cut to one year because of land-security problems. Fallowing improves the soil fertility and moisture content: even a 10–20% increase in moisture is significant in low-rainfall areas.

—Melaku Gebremichael

Soil fertility management

Dryland soils are often very low in inherent fertility and in organic matter. Imported artificial fertilizer is expensive, so is commonly used only where the risk of crop failure is low (for example, in irrigated areas).

Applying organic matter improves the soil structure, which in turn increases infiltration and the amount of water the soil can hold. It also increases the nutrient level in the soil and the activity of soil organisms.

Organic matter can be added in various ways: by recycling crop residues, adding mulch or compost (see page 94), working green manure into the soil, or applying manure either directly or allowing animals to graze on crop residues in a field.

The effectiveness of organic fertilizer can be increased if it are placed close to the plant roots rather than distributed evenly throughout the soil. This can be done in various ways, for example by putting compost in the planting holes and by using 'fertility pits' (see box on next page). The effectiveness of artificial fertilizer can also be increased if it is applied close to the plants, but if it is too close, it can easily 'burn' the roots and damage them.

Mechanical measures

Mechanical measures typically require more labour, time, equipment and expense than agronomic measures. They also take land out of crop production, and their suitability depends on the topography. However, they may be the only way to prevent erosion on easily degraded land, or to restore eroded land to a productive state. There are many different forms of mechanical measures, only a few of which are covered here. One way to reclaim gullies is described on page 97.

The size and catchment area of structures such as bunds and ponds will depend on the soil type and the intensity of the rainfall. Heavy rain may overtop poorly designed structures and cause severe erosion.

Contour bunds

A contour bund is a line of stones laid along a contour on gently sloping land. The bund is made of a heap of stones some 25 cm high and 35–40 cm wide, set in a shallow trench 5–10 cm deep. The trench reduces the risk of the structure being swept away by runoff. Stone bunds are constructed 15–30 m apart (closer on steeper slopes).

When constructing the bund, place bigger stones on the downslope side and smaller ones on the upper side. The smaller stones filter runoff, reduce the speed of the water and help the water percolate into the soil.

Local grass varieties or vetiver grass can be planted along the bund. However, it is difficult to establish permanent vegetation bunds in the drylands because of the lack of moisture.

Petro Muyamba's soil fertility pits, Zambia

Petro Muyamba is a farmer in in Southern Province, Zambia, who has developed a unique crop-management method. He grows a bumper crop of maize where his neighbours rarely get a good crop.

How? He plants his maize in carefully prepared pits. Each pit is 120 cm across and 60 cm deep, and holds 16 maize plants. The pit is filled with chopped maize stalks and fresh-cut grass. This organic material is packed down and covered with topsoil. After the rains begin in November, Petro plants 16 seeds in each pit.

The main idea of the pits is to concentrate the fertility for the maize plants. The circular crater-like shape of each pit also collects rain and minimizes runoff. Rainfall in the area normally averages 500 to 800 mm for the one season. Each pit can grow a crop for up to five seasons before it is re-dug and fresh organic material is added. No purchased fertilizer is needed.

The initial digging is a lot of work, but needs to be done only once every five years; only light hand-cultivating in each pit is required at planting time in the other seasons. So the pit method may actually *reduce* the total labour involved in maize growing. A lot of organic material is needed to fill the pits, but the vigorous plants produce a lot of stalks that can be recycled.

The tools used are a wheelbarrow, garden forks, a digging hoe, a planting board with four planting stations**,** spaced 70 cm apart. The only cost is labour – the two people needed to dig the pits.

Preparing the planting pits

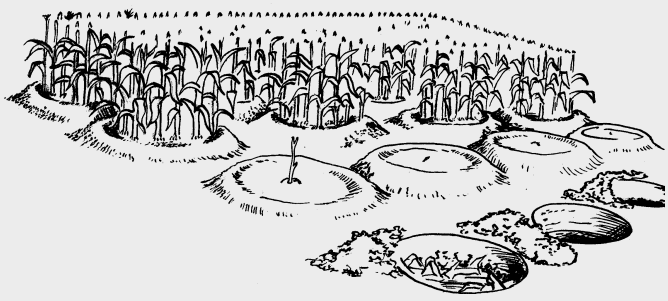
1 New pits are dug only when the soil is moist. A month or so after the rains begin, Petro pegs out the area to mark the position of the pits. He measures centre points for each pit, 1.5 m apart, then uses a 60 cm piece of twine to mark a circle around each peg.

2 When digging the pits he is careful to separate top soil and subsoil. He leaves the new pits open until the maize growing in other pits is harvested.

3 He collects maize stalks, fresh grass and any other organic material, chops it into small pieces with a hoe to make it rot faster, and fills the pits up to the top. He does not use manure because he has no livestock.

4 Next he packs down the organic material and covers each pit with the original top-soil**.** After making a ridge around each pit using the subsoil, the job is done.

5 Four weeks later, the organic matter has decomposed and Petro plants 16 seeds in each pit, in four squares of four seeds each.



Petro has over 1300 maize pits in a 0.5 ha field. His harvests are the envy of his neighbours; his plot yields up to eighty 90 kg bags. After the maize harvest, Petro plants tomatoes, cabbage or onions to use the residual moisture.

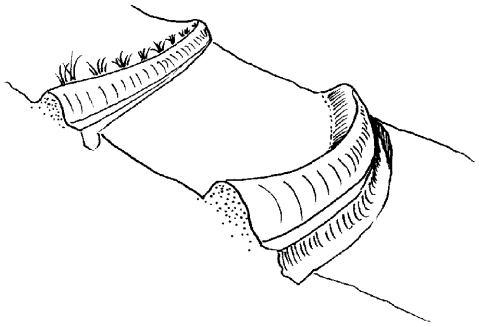
—Petro Muyamba

Trash bunds, made of crop residues, weeds and other debris found on the soil surface, are used in some localities, but they are unsuitable in most dryland areas because of the lack of vegetation, and they do not last very long.

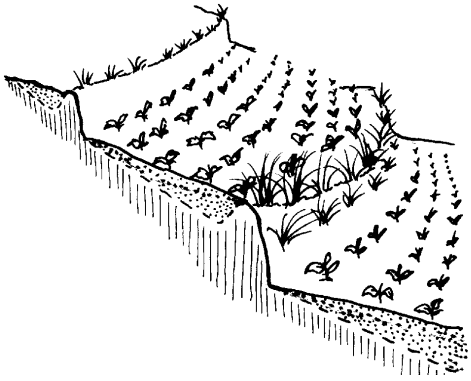
Building a fanya juu *terrace*

Fanya juu terraces

Fanya juu terraces are made by digging a trench along the contour, or at a slight gradient, and throwing the soil uphill to form a ridge or bank. This can be stabilized with grass. The space between the embankments is used to grow crops. Over time, soil accumulates behind the ridge, forming a more-or-less level bench terrace.



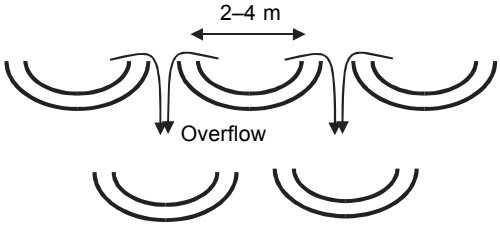
New fanya juu *terrace*



Same terrace after 5 years

Half-moon catchments

These semi-circular structures can be used on gentle slopes to collect runoff from smaller rainstorms for tree seedlings. They have small catchment areas, 2–4 m across. The structures are staggered on alternate rows so that the overflow from one row runs into the next row downslope. See page 68 for how to construct half-moon structures.



Half-moon catchments

Based on manuscripts by Melaku Gebremichael, Geoffrey Kironchi, Dickson Nyariki and Elijah Biamah

Pit composting

Why compost? Most dryland soils are low in organic material, giving very low and declining crop yields. The soils in dry areas are often sandy and are easily eroded. But some farmers – especially those who make compost, are able to maintain or increase their yields. They collect crop residues and weeds from large areas and throw them into a pit to decompose. Returning this compost to their field increases soil fertility and improves the soil's water-holding capacity. Mature compost is rich in humus, which acts like a sponge in absorbing rainwater and making it available to crop roots.

Although it is hard to gather organic materials in dryland areas, the improved yields will usually make the extra work worthwhile. Many farmers have dramatically improved their farm economy by making compost every season.

Many advantages

Compost needs no skilled labour to make, and it uses locally available materials, so costs nothing. Compost is rich in nutrients and has no negative side-effects if it comes in direct contact with planted seeds. It may only need to be applied once every three planting seasons, unless the soil is very poor or sandy.

The most important consideration when making compost in a dry environment is keeping the pit from drying out, so the decomposition process continues. For this reason, a pit is used, rather than the above-ground heaps popular in wetter areas. The pit protects the materials from dry wind and hot sun. Depending on how much organic material is available, the pit can be made larger or smaller. More than one pit can be dug to handle compost in successive stages of preparation.

Minimal requirements

- **Labour** It takes two people roughly three days to dig a large pit.
- **Tools** Hoe, buckets, machete and spade.
- **Organic materials** Old bedding from the livestock pen, and all crop residues not fed to animals should be used. They can be kept moist by sprinkling them daily with bath and washing water.

Making compost

1 Dig the pit

Try to locate the pit in the shade of a tree to protect the pile from direct sun. Dig out the pit with a hoe or spade, and pile the excavated soil around the sides to

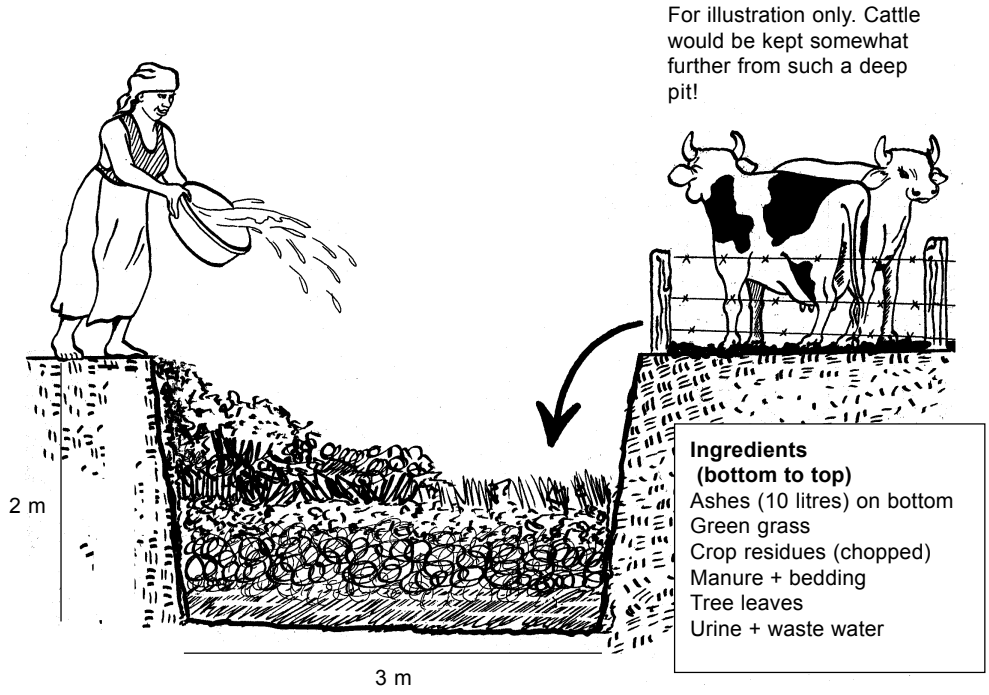
prevent the pit from flooding. This job takes three days if the site has no rocks. The ideal size of the pit is 3 m across and 2 m deep. The pit can be round or rectangular. Keep the sides smooth, and if the soil is sandy, use sticks or blocks to stabilize them.

2 Fill the pit

At the bottom, spread about 10 litres (half a bucket) of dry ashes from the cooking fire. This helps speed up the decomposition of organic matter at the very bottom. Follow this coating with a layer of fresh grass. Over time, gradually add organic materials such as the following:

- Farmyard manure – at least one 20-litre tin a day.
- Waste animal fodder and bedding collected weekly.
- Grass from the village football pitch, roadsides or any other places not grazed.
- Crop residues from maize, beans, pigeonpeas, millet, cowpeas, etc.
- About one small tin of ashes per week, sprinkled over the heap.
- Livestock urine – whatever can be collected. One or two litres a day is enough; it may be diluted with dirty washing water before pouring on the heap.

Ideally these materials should be added in alternating layers. Throw household washing water into the pit to keep the contents moist. Fill the pit until the pile is 0.75 m above ground level. When it reaches this height, cover it with green grass to retain moisture and heat, but still allow water to penetrate easily when pouring.



Pouring waste water onto the organic materials in the pit keeps them moist.

How one Tanzanian farmer makes compost

Suzana Silvesta makes her compost in a deep pit to cope with the hot dryland climate of the Dodoma Region in central Tanzania. In Dodoma, the soil fertility is low. Most farmers normally harvest 7 bags of maize or less per hectare. With 'Mapambano' compost (her name for the technique she has developed), Suzana's maize yield per hectare has increased from three bags to 50 bags of 90 kg each.

Suzana makes 'Mapambano' compost in a large pit, into which she throws all types of waste organic matter. She has two other people help her at planting time. The first person digs shallow planting holes along the row. The next person follows behind, applying the compost. The third person puts seeds in each hole by hand and covers them using her foot. Unlike with artificial fertilizers, there is no harm done if the compost touches the seed. Bringing the compost to the field is heavy work, so Suzana gets school students to help; in exchange, she gives them compost to use on their school plots.

Composting has proved popular with other farmers. In 1999, 96 other farmers had started using this method; of these, 59 were members of UNDP's 'Promoting Farmer Innovation' programme. INADES Formation Tanzania, an international NGO, has documented the method to teach other farmers how to do it. Suzana also uses her position as a board member of the Central Zone Livestock Production and Research Institute to share her experiences with others.

Suzana even sells compost – for TSh 100 per 20-litre tin (US$ 1 = TSh 800). Compost earns her money as well as helping her crops grow.

3 Use the compost

After the compost has completely decomposed – normally just before the rains begin – remove it from the pit and carry it to the field. Keep it covered with the grass until it is spread on the field to prevent nitrogen and other valuable nutrients from being lost. Some farmers use ox carts to carry their compost; some even use compost to pay for hiring a cart. The compost can also be transported to the fields at harvest time. Be sure it is kept covered until it is spread.

On very poor soil, use compost each year, but if the soil is more fertile, apply it only once every three years. Put it in small planting pits about 10–15 cm deep for cereal crops, at the normal spacing (e.g., for maize, 90 × 60 cm for two maize plants per hill). For each planting hole, apply a 0.5-litre cup (about two handfuls) of dry compost.

Do's and don'ts

- Use as many different kinds of organic material as possible. Diversity makes a balanced end-product.
- Don't throw synthetic materials such as plastic or tin containers in the pit.
- You can handle the compost with your bare hands – it is harmless.

Based on a manuscript by Patrick Lameck

The old man who transformed a gully

Ato Yifru's land lies below a hill in Adama Wereda, in East Shoa, Ethiopia. Heavy downpours in the rainy season have carved a deep gully down the hillside, eating into Ato Yifru's land. But the old man is fighting back: he is reclaiming the gully.

In Ethiopia, all land belongs to the state; farmers only have user rights. At the local level, farmers are organized into Farmers' Associations, which act on behalf of the government. Under President Mengistu's regime, farmland was subdivided and redistributed every seven years or so to accommodate the growing population within each Association. But that meant that farmers have become uninterested in improving their land in the long term. Grazing areas and other wastelands are seen as 'everybody's property but nobody's responsibility'. All Association members have open access to 'communal' land, leading to abuses such as overgrazing and excessive cutting of trees and bushes. Many communal lands are on hillsides and steep slopes; they produce swift runoff that erodes the soil, creating rills and gullies. Ato Yifru's farm was in the path of one of these gullies.

Even though gullies are communal property, Ato Yifru had no choice but to attack the problem. He first diverted some of the floodwater at the head of the gully by digging a series of shallow trenches to lead the water away and distribute it on his fields and the adjoining communal land. He then planted grass at the bottom of the gully and tree seedlings on the sides. To give time for the grass to grow, he diverted the bottom flow to either side of the gully, so bringing water towards the trees he had planted. Where the flow was stronger, he planted cactus, elephant grass and other hardy native shrubs.

When he saw that the soil had been stabilized, Ato Yifru planted higher-value trees such as eucalyptus and *Acacia saligna*. He discovered that if he bent an acacia branch to the ground and covered it with soil, the branch would grow roots and send up shoots. He also planted guava and citrus trees.

The Kechema Farmers' Association summoned Ato Yifru to ask what right he had to use land not allocated to him. He replied that the gully had been his

Ato Yifru's land was threatened by a growing gully. Now, the gully only grows grass and trees.

land once, and that if he did not do something, his entire farm would be eaten up by the gully – and the Farmers' Association would not have the land to administer any more. He said that rainwater is a God-given resource; if we do not use it properly, it becomes a curse and causes destruction. The Farmers' Association was not convinced and fined him 100 birr (US$ 10) for trespassing. After hard negotiation, he was allowed to keep the trees he had planted. But he did not give up, and he continued to make the gully more productive.

A soil-conservation technician working to reforest the nearby hillside was surprised to see one person tackling such a big gully (more than 4 m deep and dozens of metres wide) on his own. At the same time, the government was struggling to convince local people to terrace and reforest the hill through a 'Food for Work' scheme. The reforestation sites were proving difficult to maintain and tree survival was very poor.

The Farmers' Association had punished Ato Yifru for reclaiming the gully for productive purposes... while the same government sought foreign assistance to pay people to build terraces and plant trees on bare hills. To the soil conservation technician, the contradiction was incredible.

The technician was most surprised by the difference in the survival rate of the trees. Free-roaming animals frequently damaged the communal terraced and reforested sites, forcing the government to organize more Food for Work activities. The local people were coming to depend on Food for Work as a source of employment. They saw reforested sites as conservation schemes, not as production systems they could invest in to get benefits.

Ato Yifru used a different method from conventional gully reclamation. He used no high stone check-dams, no gabions and no surveying instruments. He simply controlled the water by planting vegetation strategically to trap silt, causing the gully bottom to fill in and allowing grass and trees to grow.

Conventional wisdom sees gullies as wounds on the landscape that should be healed by filling them to the original level. But Ato Yifru has accepted that the gully is a path where excess water would flow. So he concentrates on taming the swift floodwater and using it for productive purposes. Unlike the extension workers who report on the number of check-dams or other structures constructed, Ato Yifru looks at the direct benefit he gets from the reclaimed gully land.

The far-sighted technician organized a study tour to Ato Yifru's site. The participants were so impressed by his efforts that they gave him 100 birr to cover the fine he had paid. His effort became well known in local government circles, and he started getting many visitors. The regional government head also visited the site and persuaded the Farmers' Association leaders to support similar schemes.

Ato Yifru's work became a model. The Farmers' Association allocated all the gullies in its area to interested individuals. Presently, 180 households have been allocated gullies, and many use reclamation methods like Ato Yifru's. Trees growing in gullies are now a landmark of the Kechema Farmers' Association.

Policy and strategy issues

- The government policy of playing the 'guardian' role for safekeeping of the land has brought about negative effects. The lack of well-defined benefits to community members has led to increasing exploitation and massive land degradation.
- The policy was revised and progressive management tools introduced to guarantee a well-defined benefit-distribution system. This meant the land users were able to manage their resources more sustainably and productively.
- A visit by the Regional Commissioner and his positive view of Ato Yifru's efforts changed the Peasant Association's attitude. They realized that they had misinterpreted the land reform proclamation.
- Gully-reclamation techniques can be modified to make gullies more productive rather than merely conserving them.
- Gullies can best be made productive if individuals can benefit directly by using the gully land, rather than through outside intervention to 'conserve the land resource' – an abstract idea to land users.

Ato Yifru's work shows it is possible to tackle gully reclamation using common sense to manage runoff and by vegetative (vs mechanical) methods. Some more lessons from this one man's work:

- One individual's effort can kindle inspiration for many.
- Government Food for Work leads to long-term dependency.
- Government policy (absence of land ownership or well-defined user rights) can produce negative attitudes towards good land management.

Based on a manuscript by Gedion Shone

Some principles of gully reclamation

In arid regions, existing gullies might be considered *assets* where favourable conditions for plant growth or production can be created. From this perspective, gullies can be seen as micro-environments with special characteristics:

- Runoff and sediments that are otherwise lost can be trapped and harnessed by gully-reclamation works.
- A gully may be viewed as concentration of valuable, scarce natural resources – soil, water, fertility – where new fields can be created.
- This land creation depends on a certain rate of erosion on adjacent slopes or upstream in the catchment.
- Erosion may thus be viewed as a *positive* process, as long as the *rate* is controlled and the benefit is secured.
- Gully cultivation is especially useful where steep, rocky slopes with very shallow soils make cropping otherwise impossible.
- Gullies are 'footprints' of storm runoff which can be harnessed for productive use.

Irrigation

Rainfall in the drylands is usually not enough to guarantee reliable, steady production of crops. So some kind of irrigation is helpful, either to provide extra water to a rainfed crop, or to water a second crop during the dry season.

If water is available, the dryland climate favours irrigated crops. High temperatures stimulate plant growth. Pests are few due to the low humidity. The extended dry season and the lack of a winter enables growers to produce crops when demand is high in the export market.

Large irrigation projects have been built in the heart of pastoral areas. They can raise the production of food, offer employment and yield foreign exchange. But at the same time they destroy the local pastoral system that may rely on these areas, thus harming the national economy. Economic studies of irrigation schemes show a very poor record, even without including the negative effects on pastoralists. The costs of irrigation schemes often exceed the returns. The schemes block access of herds to water sources, so cause conflicts with pastoralists. They reduce water flow in rivers, so may harm downstream grazing areas and flood-recession farming by pastoralists. Inappropriate irrigation and drainage can cause salt to build up in the soil.

For small-scale crop farmers, irrigation may mean the difference between a secure harvest and no yield at all. There is a wide range of traditional small-scale irrigation practices, mostly along small rivers in mountainous terrain, along riverbeds, using residual moisture in valley bottoms, or tapping shallow groundwater. Farmers using these practices use very few external inputs and often show a remarkable talent for improvisation when confronted with new situations (see page 161). New techniques, such as drip irrigation (page 104) and manually operated treadle pumps, have shown promise on small farms ranging from small gardens (15–30 m^2) to over 1.5 ha.

Irrigated areas are generally small, from under 1 ha to 20–40 ha. Most farmers own less than 1 ha of irrigated land. The fields are located as close as possible to the source of water.

Families use irrigation to grow a range of crops, including pigeonpea, cassava, maize, millet, and vegetables, in small homestead plots or gardens. Okra, bitter gourd, aubergines, chili, French beans and other high-values vegetables are grown for export.

Growing such vegetables for export is an attractive new source of income for small horticulturalists (see page 76). This has increased interest in expanding irrigation and developing new, more efficient techniques to apply water to the crops. Most of these growers are close to the main towns or roads so they have easy access to markets. Despite the efficient use of water, the lack of water is an

growing problem, and conflicts over water among growers (and with pastoralists) may increase if vegetable growing expands.

Pastoralists rarely use irrigation, though they do grow crops using techniques such as flood-recession agriculture and water harvesting (see page 111).

Water sources

Irrigated farming is very different from rainfed farming. In rainfed farming, the farmer prepares the field and waits for the rain to come and make the crop flourish. With irrigation, the farmer must obtain and manage the water. This can take a lot of time and money. The cropping pattern is closely related to the amount of water and how it is obtained. The size of the irrigated area depends on how much water is available.

Small perennial or seasonal rivers are the main sources of irrigation water. Water can be lifted directly from the river, or diverted into irrigation canals or pipes using dams or weirs. Wells can be dug to tap groundwater, which can be lifted up by hand or with pumps. In some places, it is possible to tap water beneath dry stream beds (see *Water from sand rivers*, page 118). Rain and runoff water can collected and stored in small reservoirs or tanks (see *Rainwater harvesting*, page 111).

Water sources can be unreliable. Rainfall in the drylands is notoriously unpredictable. Rivers may dry up seasonally, and flows may be hard to predict. Springs and wells may dry up gradually if over-use of the groundwater lowers the water table. Water quality is also important: groundwater may be too salty to use for irrigation, or may lead to crusting of the surface and poor infiltration rates (see below).

Irrigation methods

Irrigation water can be applied in various ways:

- **Flooding** The simplest form of irrigation, this uses the force of gravity to lead water through small canals to the fields, where it is run through furrows or used to flood the whole field (basin irrigation). A lot of water is lost through percolation and evaporation, but costs are low.
- **Overhead sprinkling** The water is led through pipes or hoses into a sprinkler system, which sprays or dribbles the water onto the crop from above. It uses water more efficiently than flooding, but it requires a source of water under pressure, and the pumps, pipes, sprinklers and other equipment can be expensive.
- **Drip irrigation** uses perforated hoses to deliver small amounts of water to the plant roots. It requires some investment in equipment, but it is a very efficient method of applying water to plants. It is suitable for irrigating small gardens where crops are grown for own household consumption. Fortunately, low-cost drip-irrigation systems have been developed (see *Drip irrigation*, page 104).

- **Watering** Farmers often use watering cans or buckets to water high-value crops such as vegetables.
- **Water harvesting** involves collecting rainwater or runoff and storing it in reservoirs, tanks or in the soil (see *Rainwater harvesting*, page 111).

The types of irrigation can vary:

- **Full irrigation** is where irrigation provides all the crop's water requirements.
- **Supplementary irrigation** is where irrigation provides only part of the crop's water needs; rain supplies the rest. For example, a crop may be given a head start by sowing under irrigation a month before the rains begin, or water may be applied only during the critical crop-maturing stage.

Soil structure and organic matter

During irrigation, the amount of water that soaks into the soil depends on the soil structure and stability. If the structure is weak, soil particles collapse, and the pores that could hold water close. The result is surface crusting or sealing. Irrigation or rainwater cannot seep into the soil, so runs off. Soil erosion and decreased yields follow.

The soil structure commonly breaks down if the soil contains a lot of sodium and little organic matter. Excessive sodium damages the soil structure through chemical processes. Organic matter binds soil particles together and makes them stable against the effect of sodium and the destructive impact of raindrops.

Solutions to poor soil structure include:

- Increasing the organic-matter content of the soil with manure, compost and green manures such as tithonia.
- Applying irrigation water slowly so it has time to seep into the soil
- Appropriate cultivation practices (such as scraping off the surface crusts before irrigating).

Farmers may need training and advice on how to use these practices.

Irrigation management practices

Here are some factors to consider when deciding on management practices for an irrigated area.

- The location, quantity and seasonality of the water available.
- The sodium concentration and salinity of the water, which determine the availability of water to crops.
- The soil type and water-holding capacity, including the soil texture (sandy, clay, etc.) and organic matter content.
- The presence and depth to an impermeable (compacted) layer in the soil, called the 'plough-pan'. This influences how fast the water will percolate down below the root zone and so be lost.

- The slope of the field, which influences how fast the water runs off.

Once these factors have been identified, it is possible to select the appropriate type of irrigation and look for techniques that might overcome any limitations, e.g., adding manure or other types of organic matter, selecting crop types or improved varieties, planting intercrops, appropriately timing planting and other field activities, and ensuring adequate drainage to carry away salts that would otherwise build up in the soil.

Organizations and policies

Compared with rainfed farming, irrigation requires more labour – to build and maintain dams, canals, etc., distribute water, maintain equipment, and manage the crop. Depending on the size of the irrigated area and the source of water, it may be advisable to form a water-users' association. This may have various tasks: water distribution, marketing, buying inputs, making decisions about crop management, etc. The cultivation of vegetables for export involves many regulations and can be a major challenge for these associations. Many require support to build their capacity (see page 76).

Countries generally lack clear policies on water rights. Pastoralists' rights to water are often ignored, and permits are not necessarily required to build permanent structures to divert water.

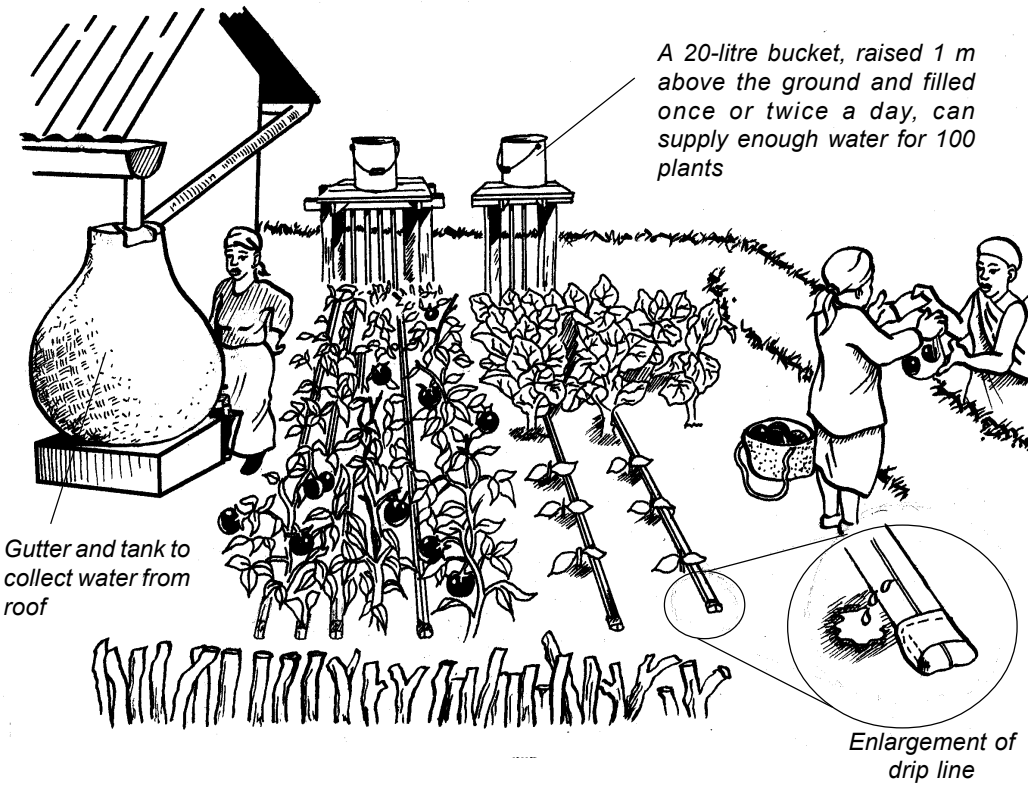
Based on manuscripts by Edward Muya and Ben Haagsma

Drip irrigation

Bucket-kit drip irrigation is a simple, effective, water-saving way to irrigate small gardens. Water flows into plastic tubes (called 'drip lines') from a bucket placed 1 m above the ground. The drip lines come ready-made with very small holes (drip outlets). Droplets of water leak through the holes and soak into the soil.

The bucket holds 20–30 litres of water. The farmer fills it once or twice a day. A connection in the base allows the water to flow through a simple screen filter, which removes silt and debris to prevent clogging the pipes and drip outlets. From there the water passes through tubing to 2, 4 or 6 drip lines. The total length of drip tube per bucket system for vegetables is usually 30 m. This can supply enough water to about 100 vegetable plants.

The drip lines applies water uniformly along their length. With proper handling, they can withstand heat and sunlight for up to 5 years.



Low-pressure drip-irrigation system: simple to set up and manage, and affordable for most small-scale farmers.

Drip irrigation supplies small amounts of water close to the plant, so only the soil closest to the roots is wetted. Frequent applications maintain an optimal level of moisture in the soil for the plants to flourish.

The cost of a bucket kit depends on the components used, plus costs such as import duty, labour for assembling the kits, and the trader's profit margin. In Kenya, traders charge KSh 1,100–1,500 for drip kits, including a bucket and simple instruction manual. See the end of this section for a list of suppliers in Kenya and other countries.

A farmer with a larger plot and enough water can install one or more bucket kits. For five or more buckets, however, it is more cost-effective to use a single 200-litre drum instead of the smaller buckets.

Advantages

- Drip irrigation can achieve 90–95% water-use efficiency (only 5–10% of the water does not reach the plant). Only 40–60 litres are needed per day to grow 50 to 300 plants. Compare this to sprinkler and furrow-irrigation methods, which have efficiencies of 60–70% in well-managed systems.
- No expensive pump or pressurized water supply is required to operate a drip-irrigation system.
- Slightly saline water can be used because the frequent watering allows the salts to be diluted within the plant root-zone.
- It is possible to intensify crop production in a very small area.
- Drip systems can be used in difficult climate and soil conditions.
- For a very small investment (US$ 15) a farmer can buy and set up a bucket drip-irrigation system. The farmer can earn money by selling surplus crops to neighbours or at a local market.

Disadvantages

- Drip irrigation is still new to most farmers, so requires initial training. Few people are knowledgeable about drip irrigation, making it difficult to use existing agricultural extension networks.

Promoting drip irrigation in Kenya

In Kenya, Chapin 'bucket-kit' systems have been used since the late 1980s. They were introduced by missionaries who wanted to help people in the dry lands grow vegetables in small gardens. They distributed the drip kits freely, but this was not sustainable. In 1996, farmers in Eldoret identified the technology for their development programme and worked with the Kenya Agricultural Research Institute and Chapin Watermatics, an American company, to introduce drip irrigation in western Kenya. KARI set up a demonstration centre in Nairobi in 1997 and introduced the technology in several other pilot areas, including Kibwezi, Ngong and Machakos. By the end of 2000, KARI had sold over 5000 kits. The Fresh Produce Exporters Association of Kenya has also sold over 1000 kits.

KARI imports drip-irrigation components from Chapin Watermatics and packages kits according to farmers' needs.

A Kenyan farmer group invests in new irrigation techniques

Farmers in Kibargoi Location, Keiyo District in Kenya, were finding it harder and harder to grow their crops. Persistent drought, low water levels and increased demands for irrigation water made their usual method of flood irrigation impractical. Too much valuable water was being lost in the open canals and fields. A more efficient system was needed.

In search of solutions, 60 farmers organized themselves into the Cheptebo group. They had a clear idea of what they wanted: they wanted to earn more by planting fruit trees and other cash crops on their irrigated land. But they lacked the information and skills needed. Motivated by a field day at a local church farm, they decided to take action.

In 1999, the farmers began using hosepipes and perforated PVC pipes to water their crops. This proved inadequate. The next step was to construct storage tanks for all members to ensure a reliable supply of water. Needing technical and financial support, they asked the Semi Arid Rural Development Programme (SARDEP) for help.

With a SARDEP grant of KSh 400,000 and their own contribution of KSh 100,000 (US$ 1450), the group began constructing tanks. By early 2001, they had built 20, each of which could hold 14,000 litres. The group also installed a permanent weir at the water intake, a main reservoir tank and lateral links to the first 20 farms.

The water supply improved, the group acquired fruit seedlings for the 20 members in the first phase to plant. Each member bought 30 mango and 20 citrus seedlings and 50 banana suckers. They also intercropped papaya trees. These trees mature at different times: bananas yield more quickly, while the other trees take longer to produce fruit.

For the irrigation system to function smoothly, it must be maintained adequately. A filtration unit must be installed; and the whole system must be flushed regularly and checked for blockages.

Management

The group's management has been just as important as the technical aspects. The farmers elected a 5-member management committee to be responsible for day-to-day activities. The group also registered with the Ministry of Culture and Social Services as a community-based organization.

Construction of the water tanks was divided into three phases, spread over 3 years. The needs of 20 group members will be addressed each year. The first beneficiaries of the project were selected during the annual general meeting. Those who could contribute an amount of KSh 4000 ($50) within a timeframe of two months were selected.

Some lessons

Changing from a traditional production system to an efficient modern one requires financial investment as well as new knowledge and improved organizational and management structures. The inputs required by the Cheptebo group are more easily achieved in a group structure where members contribute towards common resources such as improving the water intake. But clear communication and negotiation channels were needed to ensure fair and equitable access to the water resources.

The group still faces several challenges. One of these has been the slow payment of member contributions: some members feared their group might collapse, as had happened with a women group some years beforehand. Another challenge is the group's continued need for training and information on irrigation and farming methods.

—Joel Kipchumba

- The drip-irrigation system components are not readily available in rural areas.
- Rodents may damage the drip tubes, especially if the garden is located in a bushy place or far from the homestead.
- Clean water is needed. Water heavily laden with silt and green algae should be filtered before use. Farmers can do this by pouring the water through a clean cloth tied over the top of the bucket.

Requirements

Materials and equipment

- Land: Small plot of 15–25 m^2 per bucket kit, depending on the layout.
- Timber to build a stand for the buckets or drum.
- Sturdy bucket (do not use a white bucket, as algae will grow in it).
- Drip-irrigation kit.
- Digging implements such as hoes and shovels.
- Old farmyard manure: about 2 wheelbarrow loads or 100 kg recommended, or enough to put 1 kg into each planting hole.
- Planting material: seedlings which are freshly uprooted and well moistened. Keep in water and shade until time to plant! Never plant in the midday sun. Evening, just before the sun sets, is best.

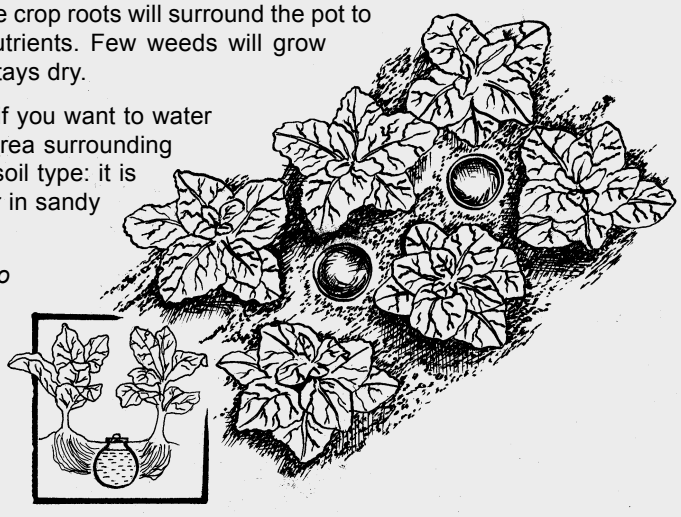
Clay pots for irrigation

Prepare rectangular vegetable beds in the normal way and plant vegetables such as rapeseed, cabbage, tomato and peppers. In between every 4 plants, bury a burnt porous clay pot so that its top is level with the soil surface. The pot should hold at least 2.5 litres. Pour water into the pot and put a lid on top.

Refill the pot every 7–10 days, or according to how fast the water percolates into the soil. The crop roots will surround the pot to draw on the water and nutrients. Few weeds will grow because the soil surface stays dry.

You can use several pots if you want to water more plants. The wetted area surrounding each pot depends on the soil type: it is larger in clay soils, smaller in sandy soils.

—Philigona Ooko



Human resources

It is important to have one person who has been exposed to the technology (see the list of resource organizations). Initial training on drip irrigation includes:

- Bed preparation.
- Installing the drip system.
- Basic crop management (for those with limited gardening experience).
- System maintenance and trouble-shooting (e.g., flushing clogged lines).
- Kit economics (e.g., using income from vegetable sales to buy more kits).

Once the plots are prepared (steps 1–3 below), installing a drip-irrigation system normally takes 2–3 hours.

Procedure

1 Mark the garden on the ground according to the required number of drip lines. Each bucket can feed about 30 m of drip line, so a design with 2 drip lines will need a plot measurung 1.5 x 15 m. A design with 4 drip lines needs 3 x 7.5 m, while one with 6 drip lines will need 4.5 x 5 m.

2 Dig the plot well, to a depth of at least 20 cm. Dig a trench 50 cm wide and 30 cm deep in the middle of the bed along its whole length. Put banana leaves or other green materials in the trench to a depth of about 15 cm. Then put a 5-cm layer of aged manure on the top of the green materials. Cover the trench with soil and level the surface for planting.

3 Prepare a bucket stand at one end of the plot. Mount the bucket on the stand so that the bottom is at least 1 m above the soil surface.

4 Assemble the drip-irrigation components according to the instruction manual.

5 Fill the bucket with clean water, or filter it if it is silty. Before closing the ends of the drip lines, allow some water to run out the ends to flush out any dirt inside.

6 Close the ends of the drip lines, then allow a second bucketful of water to drip out (this takes about 20–25 minutes).

7 Transplant seedlings into the wetted soil, close to where the water drips out of the drip lines.

8 Fill the bucket once, twice or three times per day, depending on the climate and growth of crop. It is better to supply half the daily water in the morning and the other half in the evening.

When and where to use

Drip lines are the irrigation method of choice when:

- Water is scarce or expensive.
- Water quality is poor.
- Vegetables are to be grown in long dry seasons.

- Watering with conventional irrigation systems is problematic or too expensive.

When *not* to use

- During the rainy season in high-potential areas.
- When access to water for basic requirements such as cooking and personal hygiene is difficult.

Do's

- Locate the garden close to your house, and fence it.
- Clean filters regularly (more often if you are using dirty water).
- Put mulch directly over the drip tube to reduce evaporation.
- Inspect the drip outlets for blockage.
- Ensure that the drip outlets face upwards.
- Control rats and squirrels that may damage the drip tubes.
- When irrigating with saline water, irrigate more frequently to flush away salts from the root zone.
- Consult an experienced farmer or extension officer for advice.

Don'ts

- Never force a sharp object into the drip outlet. This ruins the drip tube!
- Don't bury the drip tube under the soil.
- Don't cut the drip tube with farming implements, e.g., while weeding.
- Don't store the drip irrigation kit for too long in a hot place or where rats might chew the pipes.

Based on a manuscript by Isaya Sijali

Suppliers of drip-irrigation equipment and information

Kenya

Agro-Irrigation and Pump Services
Lunga Lunga Road, PO Box 32111, Nairobi. Tel. +254 2 540 392, 554 121
—Commercial drip irrigation components and systems; Shadenet drip-irrigation tapes.

Amiran Kenya Ltd.
Old Airport North Road, PO Box 30327, Nairobi. Email amiran@africaonline.co.ke
—Commercial drip-irrigation components and systems.

Appropriate Technologies for Enterprise Creation (ApproTEC)
PO Box 64142, Nairobi.
—Treadle pumps and drip-irrigation technology.

Arid Lands Information Network (ALIN)
PO Box 39493, Nairobi. Tel. +254 2 719 413
—Training and information; extension booklets.

Booth Irrigation Ltd.
Jirore Road Industrial Area, PO Box 57789, Nairobi
—Commercial drip-irrigation components and systems.

Fresh Produce Exporters Association of Kenya (FPEAK)
Kabarnet Road, PO Box 40312, Nairobi. Email Fpeak@africaonline.co.ke
—Small-scale drip-irrigation systems and information.

Kenya Agricultural Research Institute
National Agricultural Research Laboratories, Waiyaki Way, Westlands, PO Box 14733, Nairobi. Tel. +254 2 444 029–30, email Lisguest@kari.org
—Information, packaging, demonstration and sale of small-scale drip-irrigation systems.

Super Drip Ltd.
Avon Centre Industrial Area, PO Box 57376, Nairobi. Tel. +254 2 555 066, 553 357
—Commercial drip-irrigation components and systems.

South Africa

Dr Gerrie Albertse, ARC Fruit, Vine & Wine Research Institute
Private Bag X5026, Stellenbosch 7599. Tel. +27 21 809 3006, fax +27 21 809 3002, email gerrie@nietvoor.agric.za

Tanzania

SCAPA
PO Box 3163, Arusha. Tel +255 027 4685, email scapa@habari.tz
—Information on bucket drip-irrigation.

Uganda

Lars Eriksson, Waterboys Uganda Ltd.
PO Box 25969, Kampala, Uganda. Tel. +256 41 543 121, fax +256 41 543 122

USA

Chapin Living Waters Foundation
364 N Colorado Avenue, Watertown, NY 13601. Fax +1 315 782 1490, email rchapinw@imcnet.net

Zimbabwe

Integrated Irrigation Systems
PO Box 11C 258 Highlands, Harare. Tel. +263 4 746 131, +263 4 746 475

Rainwater harvesting

'Water harvesting' involves collecting rainwater or runoff from a surface and storing it for domestic use, livestock and crop production. The surface can be a roof, rock or simply the ground surface. Storage options include tanks, ponds, reservoirs, and in the soil itself.

Storing water in the soil

Pastoralists seldom irrigate the crops they grow, but they do use various water-management practices to grow crops. These include water harvesting, flood-recession agriculture and runoff farming. They have developed several effective techniques to harvest runoff water to grow crops, mainly sorghum and millet. These systems fail only during a serious drought, and they enable production where purely rainfed crops would fail.

The pastoralists construct shallow basins on gently sloping land with deep soils. These basins are surrounded by earthen bunds on three sides. The fourth, upslope side is open. Runoff water is guided towards these basins, is trapped in them and percolates into the soil. The pastoralists sow the crop as soon as the surface is dry enough, and the plants use the slowly receding water. A few good rains are enough for a harvest. The soil needs to be deep and not too sandy in order to store enough water.

Turkana women's sorghum gardens are well-known examples of this technique. These water harvesting systems are very efficient, and yields have reached optimal levels.

See page 68 for a similar technique to harvest water for individual tree seedlings.

Tanks to store water

Water-storage tanks are more suitable in the drylands than reservoirs and ponds because they lose less water through evaporation. The type of tank to build will depend on the water usage, the availability and cost of building materials, skilled labour, the soil type and topography, and the information available on the technical options.

Tanks can be of any shape, made from various materials, and built above or below the ground surface. Underground spherical (ball-shaped) and cylindrical (sausage) tanks made from baked bricks are well-suited for small-scale farmers in semi-arid areas. Such tanks have not been widely spread because few people know how to build them. The materials and methods used to build these two kinds of tanks are similar.

On a slope, the tank can be built completely underground, and the water can flow into the tank by gravity and out through a pipe, avoiding the need to pump or to draw the water out with a bucket. On flatter ground, part of the tank can be raised slightly above the ground and the sides supported by excavated soil.

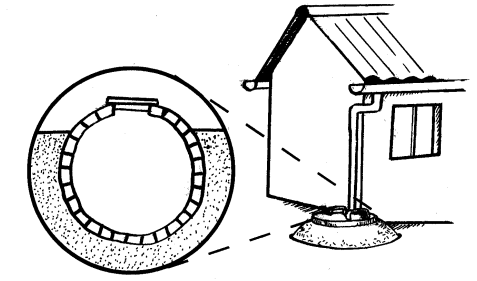
- If the water is for domestic use, locate the tank close to the house so that water can easily be collected from the roof.
- For irrigation, site the tank on higher ground where runoff can be diverted into it and stored as close as possible to the plot to be irrigated. Select a location where an outlet pipe can allow water to flow out of the tank by itself.
- In both cases, choose a site with stable soil. Avoid clays that expand and contract when they get wet or dry out.

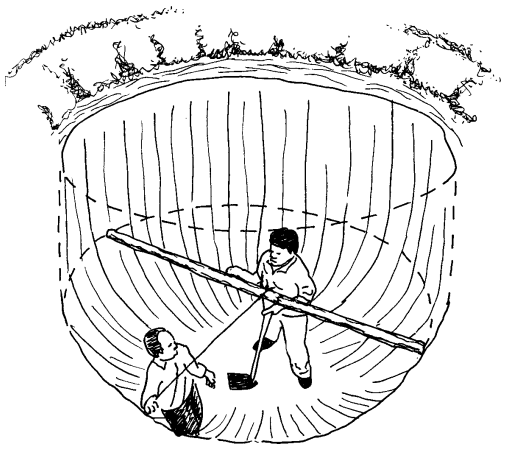
Spherical underground tanks

Spherical or 'ball-shaped' underground tanks are more suited to dry lands than conventional (cylindrical or rectangular) upright tanks. They are less costly to construct and stronger because they are supported by ground and use less building material than other shapes.

Excavation

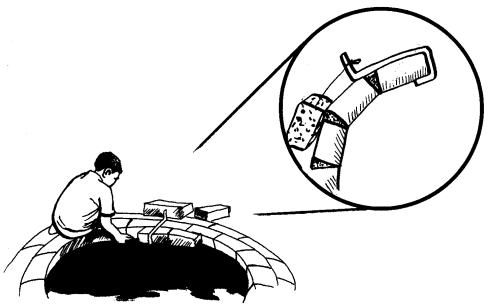
After you have chosen the best location, put a peg into the ground to mark the centre of the tank. Using a string the length of the radius of the tank you want to build, mark out the circumference of the circle. Using the circle as a guide, dig out soil to a depth equal to the length of the radius. Ensure the walls of the hole are vertical. Place a long pole along the bottom of the cylindrical pit and mark the centre with a nail. Attach the string to this nail. This will provide a guide for digging out the lower half of the sphere. Remove loose soil around the pit so it does not fall in. Avoid digging too much soil out, as replacing it will create patches of loose soil that cannot support the tank walls.





If you want to let water flow out of the tank by gravity, dig a trench to the bottom of the tank-pit to hold the outlet pipe. Make sure the trench slopes gently away from the pit.

Construction



- Lay a 2.5 cm outlet pipe (if you have chosen to use one) in the trench and into the bottom of the pit. The end of the pipe should be about 20 cm above the base of the tank to allow silt to settle below it. Remember to allow for the thickness of the tank walls. Protect the pipe from damage while you are building the tank itself.
- Put a thick layer of sand (2 cm) at the bottom of the pit. Mix cement and sand at a ratio of 1:3 by volume to make mortar. Start laying bricks and mortar from the centre of the bottom in a spiral. Use the string used in excavation as a guide.
- Continue until one layer of bricks passes the middle section. Here, the structure will start curving in and additional support is needed. Apply a layer of cement, lime and sand mortar mixture (ratio 2:1:6) to quicken hardening. As the structure curves inwards, use wire hooks to hold the bricks in place. The hooks can be made on site (see illustration above).
- Using the hooks to support newly-laid bricks, continue building until a sphere is almost formed. Leave a gap near the top for a water inlet. At the top, leave an access hole with a diameter of 60 cm. The access hole should be shaped to support a lid.
- Fix a 10 cm PVC or metal pipe in place as the water inlet.
- Plaster the inside of tank with cement–sand mortar (1:3) to a thickness of at least 2 cm. Next apply a surface coat of pure cement slurry. The tank will be much stronger if it is reinforced with chicken-wire mesh during plastering.
- Cast a lid using ballast (1:3:3) with twisted bar or wire mesh reinforcement. The lid should be 5 cm thick and 70 cm in diameter.
- Construct gutters or ditches to feed water into the tank. If you are using runoff water, dig a silt trap to prevent the tank from being clogged. Fit a sieve to the inlet to prevent debris and animals from getting into the tank.

Cylindrical or 'sausage' tank

The sausage tank is like a metal drum lying on its side. It is subject to less pressure than an upright tank of the same size and is strengthened by the soil supporting it. The sausage tank can be made longer to store more water. For instance, it could be built above a terrace bench, where it can trap runoff and supply water by gravity to irrigate the cropland below.

Excavation

Pick a suitable site on a terrace. The dimensions will depend on the size of tank you want to build. When marking the foundation leave sufficient space to the edge of the terrace. Use four wooden pegs to mark the corners, and using them as a guide, dig a pit to a depth equal to the width of the sausage tank, plus 35 cm to allow the tank to be covered with soil at completion. Curve the walls in towards the base to make the bottom half of a cylinder. You can use a rod and string (as in the spherical tank) as a guide. As with the spherical pit, dig a trench for the outlet pipe.

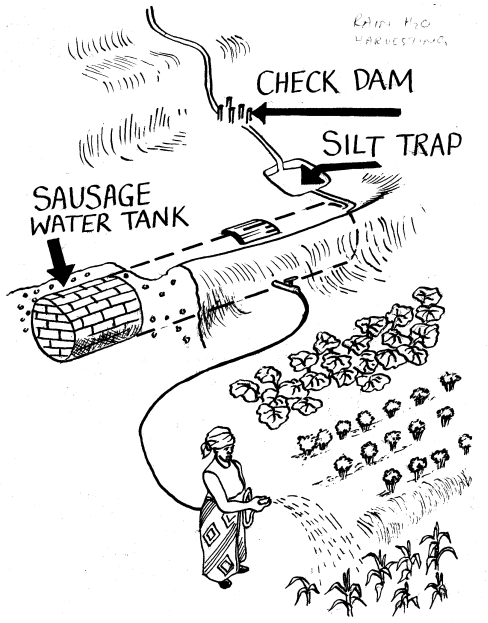
Construction

Lay the outlet pipe about 20 cm above the bottom of the tank to allow silt to settle. Along the bottom of the pit, pour a concrete slab 30 cm wide and 5 cm thick using a mix of cement, sand and ballast (1:3:4). Using bricks and a cement–sand mortar (1:3), build the tank wall starting from the bottom centre. Ensure proper curing at every construction stage. Use the rod and string as a guide for the curved walls.

Following the same procedure as for the spherical tank, continue until the top half of the cylinder is completed. Leave a 40 cm x 40 cm access hole, and make a lid to fit the hole. Make a 10-cm inlet at one or both ends of the tank. Line the tank with plaster, as with the spherical tank.

Advantages of underground tanks

- Underground tanks are supported by soil, eliminating the need for costly reinforcing.
- Low cost: in Kenya's Machakos District, farmers have built a 15,000 litre tank at a cost of KSh 17,000 (US $ 200): one-third of the cost of conventional tanks.
- The tanks are made of locally available materials (bricks and sand). Only cement must be brought from outside.
- Evaporation is minimal.
- The tanks can be built by artisans and community members after minimal training.
- The tanks do not use up productive land. The soil above the tank can be used to grow shallow-rooted crops.



Layout of an underground water tank used for irrigation

Meeting a community's water needs in Makueni, Kenya

The Kavilo Women's Group in Tilimani Location started making and selling traditional clay pots in 1994. They made different sizes of pots, up to 50 litres in volume. Assisted by GTZ, they also specialized in making charcoal stoves.

In 1998, with RELMA assistance, they started making larger pots for storing water underground. Drawing on their experience making traditional pots, the women dug a large pit and constructed a clay pot within it. They cured and fired the pot as usual, then returned the soil around the outside of the pot to support it when it held water. They finished the pot by using bricks to narrow the pot's neck, which serves as a water inlet and access hole.

Assisted by extension agents and RELMA, the women improved their technique and were able to make underground clay tanks that hold up to 2000 litres. By 1999, the group had constructed 20 such tanks, one for each member.

Their domestic water needs met, the group started seeking ways to use water for irrigation. RELMA again helped by training several members, together with two local artisans, how to build larger (10,000–15,000 litre) cylindrical and spherical underground tanks.

The group and the artisans together built two spherical tanks holding 15,000 litres each. Using water from these tanks, the women are able to grow French beans, tomatoes, kale and other vegetables. They have added a plastic-lined pond to store runoff and water tapped from a nearby sand-river dam. This pond can hold up to 35,000 litres of water, enough to expand the area under irrigation. The women plan to use their profits to build a spherical tank for each group member. To ensure the stored water is not contaminated, the group have built pit latrines for each member, as well as 40 latrines for non-members.

News of the group's success has spread to nearby areas. Extension workers frequently bring farmers to visit and learn the new water-harvesting techniques. The group has also started earning money by helping other villages to build tanks.

—Dorcas Muthoka and Miriam Kyenze

- The tank can provide water for crop production and for animals during the dry season.

Limitations

- Cracks and leaks are not easily detected.
- Training is needed to build the tanks.

Do's

- Select strong bricks and ensure good handiwork.
- Use the right mortar mixture.
- Wet the bricks before laying.
- Keep the mortar damp for several days to allow it to cure and to avoid cracking.
- While building the structure, protect it from the weather.

On-farm reservoirs for gardening in Ethiopia

Tesfaye Tirore, 68, was desperate. Like many farmers in his village of Hambo, he could not earn enough from his small farm to meet even basic family needs. His three cows and one ox did not have enough pasture to produce enough milk for sale. Yet he could not sell off the animals. Apart from the land, they were his biggest asset.

He had relied on a meagre income from coffee until the crop was struck by coffee berry disease. He could not afford chemicals to control the disease, and the coffee yields declined.

Relief only came during the short rainy season when he could grow small quantities of wheat, beans and maize. But whatever he harvested was soon eaten. Another period of scarcity would follow until the next rains.

In 1996, the Adventist Development and Relief Agency (ADRA) started a project to promote bio-intensive gardening to improve food security in Tirore's home district of Kadida Gamella, in southern Ethiopia. The project taught farmers new gardening techniques and helped them harvest and store irrigation water in small on-farm reservoirs.

Through the training he received, Tesfaye learned to keep his soil fertile by feeding it with organic matter, including manure from his cattle and household waste. By collecting and storing rainwater, he realized that he could also grow vegetables for sale during the dry season when prices were high.

With help from project extension workers, he built a small on-farm reservoir that he used to collect runoff during the rainy season. Today, using water from the reservoir for irrigation, he grows kale, carrots, cabbages, onions, tomatoes, leeks and aubergines. The crops occupy a small portion of his farm, leaving the rest to his cattle and crops such as wheat and bananas. Neighbouring farmers are now learning from Tirore and the other farmers taking part in the project.

Don'ts

- Don't fill gaps using loose soil material.
- Avoid furrowing, uneven or incomplete filling of joints.
- Avoid mortar joints that are too thick.

Maintenance

Make sure that there is always water in the tank (dead storage). The outlet should be some centimetres from the bottom to ensure some water is always left in the tank.

Protect waterways from erosion by building check dams and silt traps. Lining channels using vegetation will also help. Place a sieve at the opening of the inlet pipes.

Regularly inspect the inlet channel and collecting area. Clean the silt traps and the sieve. Just before the rains begin, drain the tank and remove any accumulated silt. A pump can be used to drain out the slurry. Check the tank regularly for cracks and have them repaired promptly.

On-farm reservoirs

A small on-farm reservoir is easy to build. It requires no special skills, and the maintenance cost is low.

The reservoir should be located in an elevated area above the garden to allow irrigation by gravity. The site should have a good catchment so water flows into it naturally or can easily be diverted into it. The pond can be of any size.

Excavate a pit of the desired size, making sure the sides slope inwards towards the bottom. Keep the excavated topsoil separate (it can be used elsewhere to grow crops). Use the sub-soil or broken hardpan to make an embankment around the lower sides of the pit. Compact the embankment well to increase its strength. Bury an outlet pipe near the base of the embankment to allow water to flow out by itself.

Mix cement, straw and soil in a ratio 1:1:3 or 1:1:4 and add water to make a plaster. Start plastering from the sides of the embankment and finish with the floor. Water the plaster every 5–10 minutes until the surface dries. Do not allow runoff into the pond until after the third day.

Cover the reservoir with a reed mat, grass thatch or roofing made from other materials to reduce evaporation. Climbing plants like passion fruit planted around the reservoir can also provide a cover.

Repair cracks by applying a mixture of cement, soil and straw (2:3:1). The reservoir can also be lined with a tough plastic sheet rather than plaster.

Based on manuscripts by Pius Kyululi, Dorcas Muthoka and Miriam Kyenze

Water from sand rivers

For centuries, people in arid areas have survived by drawing water from wells dug in sandy river beds, known variously as sand rivers, *luggas*, or *wadis*. Such wells are fed by seasonal floodwater that is trapped in the sand long after the surface has dried up. People often use this water for drinking because it is often of better quality than surface water.

Sand rivers are common features in arid lands. They are formed as flash floods erode rocky hills, carrying sand downstream. The underlying rock may be impermeable, and large amounts of water may be trapped in sand-filled depressions in this rock. A natural dyke of rock or clay across the river, below the surface of the sand, may also trap water behind it.

One only needs to identify where the depression is and dig into the sand to find water. In wilderness areas with such rivers, elephants are known to do this.

The amount of water that can be stored in these natural reservoirs can be increased by building a dam across the sand river. This barrier stops the subsurface water moving downstream. It can be built on the crest of the natural dike, up to the level of the sand in the riverbed. It can be made of clay-packed stones, stone masonry, solid concrete, or plastic. The most important consideration is that the material used is impermeable: it does not allow water to seep through.

Identifying a suitable river

Not all parts of a river are suitable for harvesting ground water. Riverbeds that have steep slopes and are in rocky areas generally have more subsurface water than those in flat areas and with gentle slopes. This is because steep rivers flow fast and carry away fine sand and silt, leaving behind coarse sand and rocks. Coarse sand has bigger spaces and can store a lot of water (up to 50% of its volume). Fine sand, typical of the beds of slow-moving rivers, is closely packed and leaves little room for water.

Whether a dam will justify the costs of building it depends on the amount of water it can hold, the potential uses of the water, the availability of skilled labour to build the dam, and the construction costs.

1 Consult local people to check their support for a dam. Men may not give improved access to clean water as high a priority as women.

2 Tour the area surrounding the river to confirm suitability of the river for damming. Ask local people to help identify suitable dam sites. The ideal sites are in steep, rocky hills that yield coarse sand through erosion. The sand river should be at least 5 m wide and 1 m deep. The dam should be at a narrow point along the river to limit the amount of materials used and to keep costs down. The river should be straight for some distance upstream because water

will damage the sides of a dam constructed at a bend.

3 At the site, check whether there is a natural underground dyke across the river bed. Certain types of vegetation will indicate the presence of water even during the dry season. The best sites will also have hand-dug wells where local people draw water during the dry season. You can also check for the presence of an underground dyke by probing with a metal rod. Hammer the rod into the sand at different points across and along the river. By measuring the depth reached you can identify the deepest part of the reservoir and the walls of the dike. Use an augur for probing if you can afford one.

4 Once you have identified an underground reservoir, study the site in detail to ensure the reservoir is watertight. This can be done using a number of techniques. The simplest one is by building a test dam. Dig a trench across the river and fill it with clay. After the rains, dig a few trial waterholes. If these yield water, this shows that the reservoir can be used to hold water and is suitable for building a permanent dam.

How much water can be stored?

The reservoir might be watertight but contain fine sand that stores only a little water. Here is how to test the amount of water the sand can hold.

1 Choose the middle section of the reservoir (based on the probing) and dig up to half the depth reached by the rod. Scoop out enough sand to fill a 20-litre bucket.

2 Make a small hole in the bottom of a bucket, and fill the bucket with the sand.

3 Pour clean water into the bucket until the sand is saturated.

4 Place the bucket on a chair and allow the water to drain through the hole for 24 hours into another container. Measure the amount of water collected.

5 By comparing the amount of water recovered with the volume of sand in the bucket, it is possible to estimate the amount of water the sand in the reservoir can hold.

Making a sub-surface dam of clay

A cheap sub-surface dam is a wall of clay built across the riverbed. To minimize the work, build the dam on the crest of an underground dyke. The size of the dam will depend on the depth and width of the river. Use good clay to ensure water does not percolate through the wall. Suitable clay can usually be gathered from the river banks.

Construction

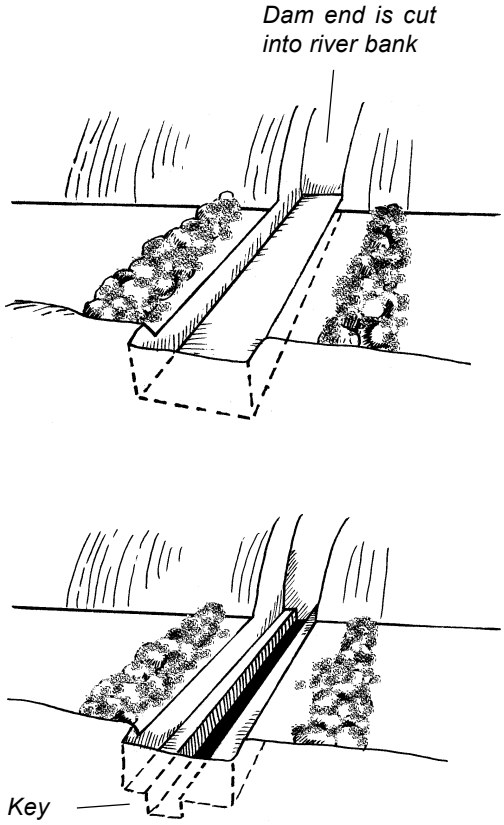
1 Dig a trench across the riverbed. Dig down into the sand until you reach the clay or bedrock beneath. Remove the sand and pile it on both sides of the dam site. Also cut into the banks: the dam will extend into them.

2 If there is clay below the sand, excavate a narrow groove (called a 'key') at least 60 cm deep along the centre of the base and into the banks. If there is bedrock below the sand, there is no key. The purpose of the key is to reduce the chances of water percolating underneath the dam.

3 Fill the key with clay and trample on it to compact it well. Add more clay on top in layers of about 20 cm thick, compacting each layer. Build up a wall to the top of the trench – the original height of the sand. If there is no water, compact the soil dry.

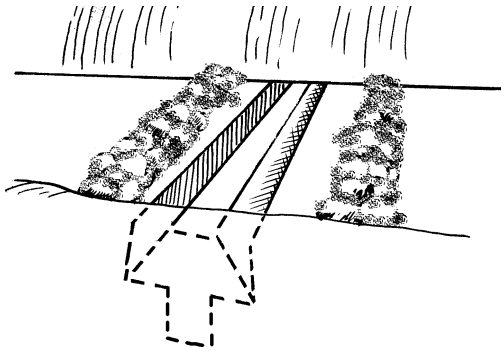
4 Cut the sides of the wall you have made to a 45° slope, and smooth them using a wooden plank. A wider base makes the dam stronger.

6. Bury the wall by filling the trench with sand to the level of the riverbed. The crest of the dam should be buried slightly below the surface to avoid damage by flowing water.



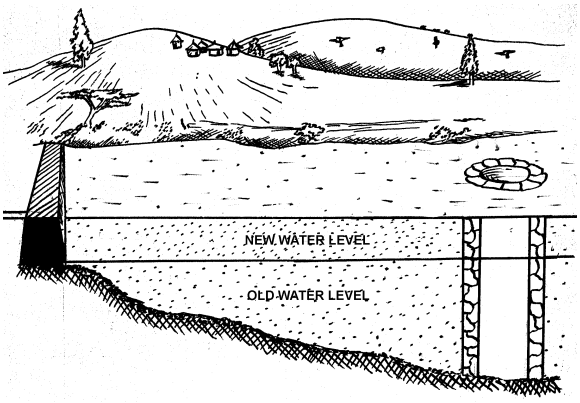
Extracting water

Dig a well 20–50 m upstream from the dam, or at the deepest point in the reservoir. The well walls may be made of bricks or stone. Make a stone base first, then line the well with bricks. Make a lid from cement to prevent the well from filling with sand during a flood. Use a bucket and rope or a pump to lift water. Do not allow harvesting of sand near the dam.



Dams built of other materials

Polythene sheet Heavy gauge plastic sheets are being used more and more to construct subsurface dams. A similar procedure with that for clay dams is used. First a trench is dug to the clay layer or bedrock. The plastic sheet is laid across the river in an L-shape, facing upstream. The bottom of the L is held secure with



Water is drawn from the waterhole using a bucket. A portable pump may also be used.

a layer of clay. The upper part of the L is supported by sand. The trench is filled in as with the clay dam.

Rubble masonry dam This type of dam can be raised above the riverbed to increase the capacity of the reservoir. However, the dam is expensive as it requires materials such as cement and wire mesh, and skilled artisans are needed to build it.

Advantages of subsurface dams

- The water is stored underground in the sand, so little evaporates and it is protected from contamination.
- Dams do not compete with other land uses.
- Sand may be harvested for construction before the start of the rainy season.
- Local materials are used.
- The dam is easy to maintain.

Disadvantages

- Dams can be built only in sloping and rocky areas with fast-flowing rivers that supply enough sand.
- Survey, design and construction require a trained person.
- Seepage is difficult to detect.
- The volume of water that can be stored depends on the coarseness of the sand.

Based on manuscripts by Eric Nissen-Petersen and John Mbugua

5
Livestock

Rangeland management

Rainfall in rangelands is highly variable, and pastures vary from place to place and from year to year. Herds must be mobile to take advantage of this variability.

Pastoralists have developed their grazing practices and patterns according to the quality and availability of available fodder and water. Mostly, these rangelands were properly managed, but over the last decades the situation has changed. Government-controlled rangeland schemes in the 1960s and 70s upset the existing local rules and regulations, introduced rotational or block grazing, and tried to sedentarize pastoral groups. These schemes were costly failures. Increasing external population pressure has forced settlers to invade the rangelands and to remove the best pieces for farming. New settlements have been established in the rangelands without proper land-use arrangements. Private pasture enclosures have violated communal property rights. Bans on bush fires have allowed the invasion of unpalatable vegetation. Insecurity in many areas has led to the concentration of livestock into smaller areas. These factors have caused considerable degradation of the available rangeland.

A dominant feature of this development has been the complete neglect and bypassing of local institutions that traditionally manage the range. Pastoralists have not been involved in any of these developments. It is now increasingly acknowl-

Protecting pastures in Tigray, Ethiopia

The Tigray region of northern Ethiopia has vast areas of rocky, barren land. Centuries of environmental degradation have taken their toll. Many local people eke out a living by raising livestock and tilling small parcels of land. Communities have learned to cope with the harsh climate and unproductive soils.

In southern and eastern Tigray, communities manage communal grazing land in a traditional system called *hizati*. This practice of setting aside protected pasture has been going on for as long as local people can remember.

The *hizati* system demarcates tracts of common grazing land, and protects and manages them all year round. Herds are allowed to graze only until the available grass is nearly finished. After that, cattle are not allowed to graze or even trek through these areas. When sufficient grass has regrown, the area can be used again.

Hizati operates in two ways. In eastern Tigray, villagers divide the grazing lands and assign them to households to manage and control. Each household supplements what their livestock graze at the assigned plot with fodder grown on their own small farms. A cut-and-carry system is commonly used.

In southern Tigray, the grazing is done communally. Households put out their animals in turn to graze in the common pasture. Sometimes they hire people to look after their livestock there. These workers, who usually do not have their own cattle, are paid in cash or may use draught oxen to plough their own farms in the planting season.

—Melaku Gebremichael

edged that pastoralists' institutions have to be incorporated in planning. They have valuable knowledge, and they know how to protect or regenerate rangelands using traditional and newly introduced approaches.

Herding duties are assigned to different members of the Borana community.

Managing grazing and herd movement

Pastoralists move their animals in search of water and fodder. Both animals and herders are grouped according to their age and ability to migrate:

- Elders, children, and women with small children, take care of the old and weak animals, milking animals and those with calves. They stay at semi-sedentary camps near the water points. These herders use the grazing land around the semi-sedentary encampments.
- Able-bodied men and women herd the healthier animals in distant grazing areas where pasture is abundant.

The use of grazing lands in rotation during the wet and dry seasons reduces overgrazing. Grazing of wet-season rangelands depends on temporary water sources in natural depressions and excavated ponds. When these temporary water sources dry up, the herds move on to the dry-season pastures with permanent wells. The grazing resources are not overused unless insecurity or other external pressure comes into play.

Fire is an important tool to maintain pasture by restricting the growth of bush. Where burning has been banned, fast-growing bush often takes over, leaving little grass for animals to graze on. Fire may not be enough to restore the grasses. Cutting the bush requires a lot of labour, which is unavailable in the sparsely populated rangelands. If fire is used, care must be taken to it from spreading beyond the area under control, such as burning at night when there is no wind.

Traditional pastoralist communities are potentially the most reliable and knowledgeable practitioners of range management. Government structures do not have the capacity and local knowledge to adequately deal with range management issues. Traditional institutions agree on grazing patterns, set rules and regulations, and prohibit inappropriate cultivation or enclosure. They ensure water sources are used and maintained properly. They coordinate the patterns and places for grazing and settlement. They also coordinate the management of grazing land and prevent overgrazing.

Based on manuscripts by Ahmed Jemal, Bilal Mohamed Yussuf and Alusala Nelson

Range and water management in Borana, Ethiopia

Clusters of wells are central to the functioning of the pastoral economy in the Borana lowlands of southern Ethiopia. The Borana have developed an elaborate water management system. Each well is the property of the clan that initiated the digging, but others may also use it as long as there is enough water.

The clan alliance is responsible for excavating and maintaining wells. The alliance contributes labour and oxen, and members regulate livestock watering each day. An elaborate system of authorities manages the wells and the associated grazing areas:

- The **abba-herega** is the water manager. He coordinates the use and maintenance of the water points. He establishes watering rights by fixing water-rotation schedules.
- A **dhedha** is a grazing area surrounding specific water points and well clusters.
- The **abba dhedha/jarsa dhedha** is an elder (or group of elders) who oversees grazing movements and announces the opening or closing of wet- and dry-season grazing reserves.
- A **hayyu** is a member of the council representing the clans. The *hayyu* councillors make sure the wells are used properly.
- **Jarssa ardha** are groups of elders who coordinate range management of each *ardha* (sub-unit of the *dhedha*).
- An **olla** is an encampment or cluster of households. The *abba olla* is the elder who makes sure the member households implement the agreed range-management activities.

Since 1998, the Borana Livestock Production Development Programme has been helping communities in the Dirre, Arero and Liban districts of Borana Zone to strengthen their traditional rangeland management systems. Steps have included:

1. Using participatory rural appraisal to assess Borana pastoralists' indigenous knowledge of range management. Sharing, discussing and analysing the results with stakeholders and the larger community.
2. Establishing working groups on natural resources management at various levels. These facilitate the reintegration of the traditional range-management systems.
3. Agreeing to strengthen the *dhedha* (grazing) council. The number of council members is determined by the size of the grazing unit.
4. Elaborating on criteria for selecting council members. Most of the selected elders are those who have already been handling the issues.
5. Revising the responsibilities of the appointed elders and the council. Council members are facilitators, while all community members or range users make decisions.

Districts that have taken these steps have benefited in the following ways:

- The elders have developed confidence for decision-making. They ordered the relocation of *ollas* (encampments) or private enclosures that have been established inappropriately or that hamper livestock movement.
- Enclosures for wet and dry season grazing areas for *foora (*lactating*)* and *waara* (non-lactating) herds have been redefined and made communal.
- Crop fields in the prime wet-season grazing areas and around water points have been vacated. The owners have been given alternative plots of land.
- Rules now control where people can settle, cultivate, construct private enclosures and move livestock.
- Provisions now allow herds to graze temporarily on other land during critical periods.

—Sora Adi

Animal trampling and rock dams rehabilitate the range

Buran village in eastern Sanaag Region of Somalia is strategic to pastoralists due to the availability of water. Bali Busle, a neighbouring village, is a charcoal-producing centre. All the trees in the neighbouring areas have been cleared for charcoal-making, leading to serious environmental degradation.

Resource Management Somali Network, co-ordinated by Horn Relief, helped the local community to rehabilitate the area. It mobilized pastoralists to assess the causes of degradation and plan how to restore the land. Most pastoralists blamed degradation on deforestation and overgrazing. RMSN provided training on animal trampling and semi-permeable rock dams.

Trampling

Animal trampling involves holding livestock in a temporary enclosure for several weeks. The animals deposit a large quantity of manure and urine on the ground, loosen the crusted soil with their hooves, and mix the dung and urine with the soil. The enclosures are moved roughly each fortnight to cover a different area. When the rains return, the trampled areas quickly turn green.

Local people in Buran chose 4 ha of bare land as a trial. Volunteers surrounded the area with thorny branches and herded their animals into the enclosure. Up to 500 head of cattle were accommodated at a time. When the people saw the pasture regrowing, they begain to apply the technique to other areas.

Semi-permeable rock dams

Rock dams are loose piles of stones, spaced at intervals along a small gully. These dams control the speed of water running down the slope, helping prevent erosion. Topsoil collects above the dams and supports natural regrowth of grass, shrubs and even trees. Horn Relief has helped mobilize the communities to build more than 1000 dams in the Buran area. Villagers organized themselves into work brigades, which gathered stones, moved them to where they were needed, and built the dams.

Like animal trampling, building rock dams is labour-intensive. It may only be practical if a lorry is used to haul enough stones.

Feeding and care of livestock

The most important animals to farmers in dryland Africa are cattle, sheep, goats, camels and donkeys. These animals tolerate the harsh climatic conditions. However, the availability of pasture and water is still a big problem for livestock keepers. Although pasture is readily available during and after the short rainy season, it is exhausted within a short time.

Pastoralists in the more arid drylands use indigenous practices to ensure there is enough forage for animals throughout the year. For example, they move from one place to another in an established pattern that allows pasture to regenerate before they return with their animals. This method of managing pasture depends on large tracts of land being available (see *Rangeland management*, page 123).

However, in many of the more humid drylands, land previously set aside for livestock is being taken up for crop farming and other uses. This has made traditional practices difficult or impossible. Livestock keepers with limited land (agropastoralists and crop farmers who keep a few animals) need to adopt improved practices that conserve forage. These practices include controlled or rotational grazing, mixed stocking, and storing forage as hay.

The most common forage is the hardy, naturally growing grasses. In cultivated areas, the residue of legumes such as cowpeas, and cereal by-products (maize, sorghum, wheat and barley) are also important sources of animal feed. Most of these can be conserved for use during drought.

Forage should be cut while green and preserved as hay. It can also be conserved as standing pasture through rotational grazing.

Rotational grazing

Rotational grazing has been used in other parts of the world (e.g., Australia), but all attempts in dryland Africa have failed. The traditional pastoralists' approach of herd maximization is a better way to support people in the more arid drylands.

In the slightly more humid drylands, however, rotational grazing may be useful. This method divides a pasture into sections, and allows animals to graze on each section in turn. This allows the closed pasture to recover before it is grazed again.

The animals should not be returned to young or immature pasture. The right time to allow animals onto a pasture is when the grasses have started to flower. If the grass is grazed when it is too young, it will not have a good root system and will not have produced the seeds it needs to regrow.

Other points to observe:

- Where possible, graze animals with different feeding habits in turn. For example, sheep may follow cattle.

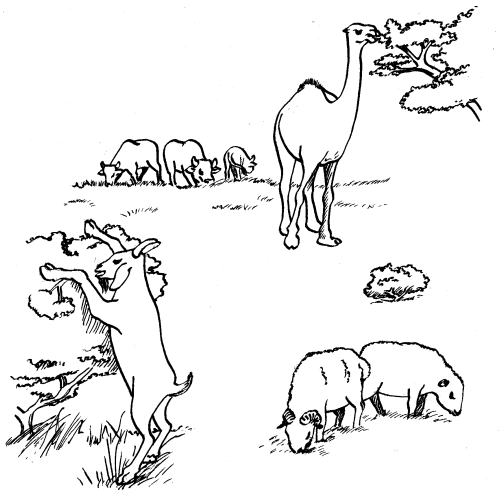
- Introduce high-yielding types of grass and trees to improve the pasture.
- Do not allow overgrazing. Sell some animals when they become too many for the pasture, for example, during the dry season.
- Time calving and lambing to occur during the rainy season when pasture and water are readily available.
- Replant grass on overgrazed land.

If too many animals are kept or pastures are opened to livestock too early, rotational grazing may lead to the land being stripped bare.

Mixed stocking

Mixed stocking is where different types of livestock are kept. They may or may not be grazed together but they use the same pasture. Different animals have different feeding habits. For example, sheep and cattle feed mainly on grass, while camels and goats feed on trees and shrubs that would otherwise be under-utilized.

Pastoralists have long known that keeping a variety of animals allows a pasture to be well used without being overgrazed. It also increases the total number of livestock that can be kept on a given piece of land, so boosting the owner's income from sale of animals, milk and other products. Mixed stocking also reduces the risk of losing all one's livestock through drought or disease. The types of animals kept should be well-adapted to the dry conditions.



Mixed stocking improves pasture productivity.

Hay

Livestock prefer fresh grass and other leafy vegetation, but they can also eat dry grass or hay. To ensure enough feed is available during drought, crop farmers who have a few livestock harvest green grass and other forage and preserve it as hay. They cut forage during short dry spells which are common in the rainy season. That means they may be able to cut twice, once during and again just after the rains.

Some pastoralist groups prepare or stock hay to feed to milking cows, calves and sick animals that remain at the homestead.

Types of nutrients and feed

Farmers who feed their animals (as opposed to allowing them only to graze) need to give them the right types of feed. Some of these feeds can be bought from shops. You can grow or gather others yourself.

Roughage Roughage forms the bulk of animal feeds. Ruminants (cattle, goats and sheep) need enough roughage to digest properly. Examples of feeds high in roughage:

- Stalks or straw of cereals such as maize, millet, sorghum and wheat.
- Dry grass, hay, fresh green grass (dry grass has more roughage and less protein than straw).
- Rice hulls.
- Bean straw, bean hulls.

Carbohydrate feeds Carbohydrate feeds give energy to the animal and are needed to produce meat, milk and eggs. Examples of feeds that are high in carbohydrates:

- Cereal grains, such as maize, sorghum, millet and wheat.
- Molasses.
- Brewing waste.
- Root crops such as cassava.

Proteins Protein feeds are essential for growth. Feed them to sensitive or high-yielding stock (milking cows, breeding bulls or sick animals).

- *Acacia tortilis* pods.
- *Leucaena* leaves (dry).
- Oilseed meals such as sunflower seed cake and cottonseed cake.
- Local types of leaves, pods, flowers, bark, seeds that animals are known to eat.

Water Enough water is vital for an animal's survival and health. Thirsty animals do not feed well.

Fats Fats provide the animal with energy. Sources: cereals, oil cakes and their products.

Minerals Minerals promote growth and give the animal appetite. They are found in different foods, common salt, soil, and commercial salt licks.

To make good hay, cut grass when it starts to flower. Both natural and planted grass can be used. Spread the grass on the ground to dry for 2–3 days. On the second day, turn over the grass so that it dries evenly. Careful drying avoids rotting. Make sure that the grass is not exposed to excessive heat from the sun, as over-drying will destroy nutrients in the forage. Mix in the stalks and hulls of beans to add protein. You could also add the stalks or straw of cereals such as maize, sorghum, wheat or barley to enrich the hay.

When the grass is dry the best thing to do is to bale it. Bales are easier to store and transport than bulky, loose hay. They allow forage to be used from areas where grazing is not allowed.

Wealthy farmers use tractor-powered machines to bale the hay. The machines compress and tie the hay into bales. Small-scale farmers can make bales using a simpler manual baler. A wooden box made with basic carpentry tools also works.

Using a simple baler

A simple hay baler is made of a rectangular box with an open top and bottom. To use the baler, place it on the ground. Lay two pieces of sisal twine across the box. Make sure the ends are long enough to be tied when the bale is ready. Put the hay into the box and trampling on it to compact it. Repeat the process until the hay can be compacted no more. Bind the finished bale with the twine.

Making hay bales with a simple baler

Storing hay

Hay is best stored in a shed to protect it from the sun and rain. It should be stacked on a raised platform to keep away pests. If a shed is not available,

Improved baler

Wealthy farmers use tractor-driven equipment to bale hay. For small-scale farmers, an improved manual hay baler is an option worth considering. A skilled artisan can make such a baler from light, durable metal. The baler has a plunger-driven sliding mechanism that multiplies the force exerted by the operator to compact the hay. In a day's work, two people can make 50–80 bales of 10–16 kg each.

The baler is easy to operate and maintain. It has wheels, so can easily be pulled by a draught animal or one person. It can make bales as compact as those made by a tractor baler. The high capacity of the baler makes it suitable for use by farmers' groups, which can also use it for income generation.

Because it is too expensive for individual small-scale farmers, a baler could serve the needs of a farmer group.

clear a patch of ground and store the hay in a heap. Cover the hay with grass thatch. Sprinkle ash around the hay to protect it from termites, and use thorny branches to keep animals away.

Farmers often use grass from areas restricted to grazing, such as roadsides. Grass is also harvested from steep valleys which are too difficult for animals to reach. Many farmers buy baled grass from people who have more land or no animals to graze it.

Water

Different animals have very different water needs. Cattle need to drink more often than other livestock and should be watered every day where possible. Zebu cattle require 20–30 litres of water a day. In very dry weather, ensure they drink adequate water at least once every two days.

Indigenous goats and sheep need at least 5 litres per animal, at least once in 3 days. Camels are highly adapted to dry conditions and can drink 80–100 litres to last a week.

- Do not keep animals away from water for too long. They may drink too much water at one time if they are very thirsty. This can lead to water intoxication, especially in young animals. If the animals have not been watered for a long time, allow them to drink only a little at a time.
- Lead the animals to water when it is cool, either early in the morning or late in the evening. Animals drink more if the water is cool. Giving animals water in the morning increases their appetite.
- The need for water increases with calving and milk production, using the animal for draught, trekking long distances, and in hot weather.
- Some water sources become salty in the dry season. This could lead to mineral poisoning if no other water is available.

Pastoralists and experienced livestock holders are very familiar with their animals' water requirements and are not likely to need any advice.

An unusual source of water for livestock

In 1987–89 an improved cattle breed was introduced to the Mpwapwa region of central Tanzania. Within a short time, many farmers were keeping the cross-breed as it gave more milk and fetched higher prices. But there was one problem. The cattle could not trek long distances in search of water and pasture during drought. Farmers came up with many innovative ways to keep their animals healthy and producing milk.

Many local farmers intercropped cereals with watermelons. One farmer, Zebedeyo Muchuwa, found out that he could feed his livestock on watermelons instead of herding then over long distances to the river. Research showed that one hectare could produce 250–400 melons.

Care of calves and weak animals

Calves, sick animals and those producing milk need special care. These are kept near the homestead where they get special attention. Wherever possible, water is brought to them. They may also get feed supplements to speed their growth or recovery.

- Set aside grazing land for young and weak animals.
- In rotational grazing, allow weak animals first into new pasture.
- Ensure they have adequate water intake.
- Give them preference in deworming.

Young calves rely on milk for growth. Allow them to suckle the yellowish milk (called colostrum) produced during the first week after calving. This milk contains antibodies and nutrients that help the young animal fight diseases. After the first week, leave at least a quarter of the milk for the calf. You may milk only in the morning and leave the calf to suckle as the cow grazes.

- Give a calf milk from another cow if its mother dies.
- Breed animals so that births occur during the rainy season, when pasture is available.
- Allow kids and lambs to run with the mother for 5–7 days. After this, allow them to suckle only one teat as children milk the other.
- Collect fresh grass and hang it where the young animals can feed on it.
- Watch for signs of malnutrition: the animal appears thin, has a rough coat or produces a yellow, mucus-like dung. Give malnourished animals more and better food.

Experienced livestock holders know a great deal about the care of sick animals. Their indigenous expertise can be a valuable resource for development. It is not possible to describe here the many diseases that afflict livestock in the drylands, or the treatments used by local experts or veterinarians. For this, see *Ethnoveterinary medicine in Kenya* (ITDG and IIRR 1996), *A field guide to camel diseases* (Köhler-Rollefson et al, 2001) and *Where there is no vet* (Forse, 1999) (see *Reference and training materials*, page 211).

Based on a manuscript by Jack Ouda

Livestock marketing

Livestock marketing is a major source of income and wealth for pastoralists and agropastoralists. Livestock are a living bank account for many people in the drylands.

Exports of livestock products are a major earner of foreign currency for many African countries. Marketing is an integral component of the livestock industry. Over the years, it has evolved into a chain of links connecting local farm-level markets to regional and national channels, and on to the international or export markets.

Marketing involves market identification, grading, animal health checks, pricing, licensing, buying and selling, branding, transport, processing, packaging and retailing. It covers not only live animals and meat, but also feed, hides and skins, and other raw materials for formal and informal industries. These activities create many jobs. However, much of the livestock trade is not reflected in official statistics, as it includes informal transactions such as barter and cross-border trade, and exchange for grain with crop farmers.

While governments and the private sector acknowledge the economic importance of the livestock industry, there is little investment in developing the livestock market. Market information is unavailable, infrastructure to transport livestock is underdeveloped, and policies to open new markets are absent. This has harmed dryland communities that depend on livestock. A usual complaint is: 'Where can we sell our animals?'

Another important factor is stagnation or decline in the wider economy, which reduces meat consumption and harms livestock sales.

Marketing strategies and decisions

The decision as to when and how many animals to sell depends on the type and urgency of the household's needs. Pastoralists and agropastoralists need to pay school fees and buy food, drugs and other essentials. In addition, agropastoralists sell livestock so they can invest in their farm or build permanent buildings.

Pastoralists' strategies

Pastoralists have become more integrated into the market system over recent decades because they have been eating more and more grains. They often barter animals for grain, so the relative prices of grains and meat is very important. In normal years this prices favour pastoralists: one kilogramme of meat can buy several kilogrammes of grain. But in times of drought, livestock prices drop and maize prices rise, placing pastoralists at a disadvantage.

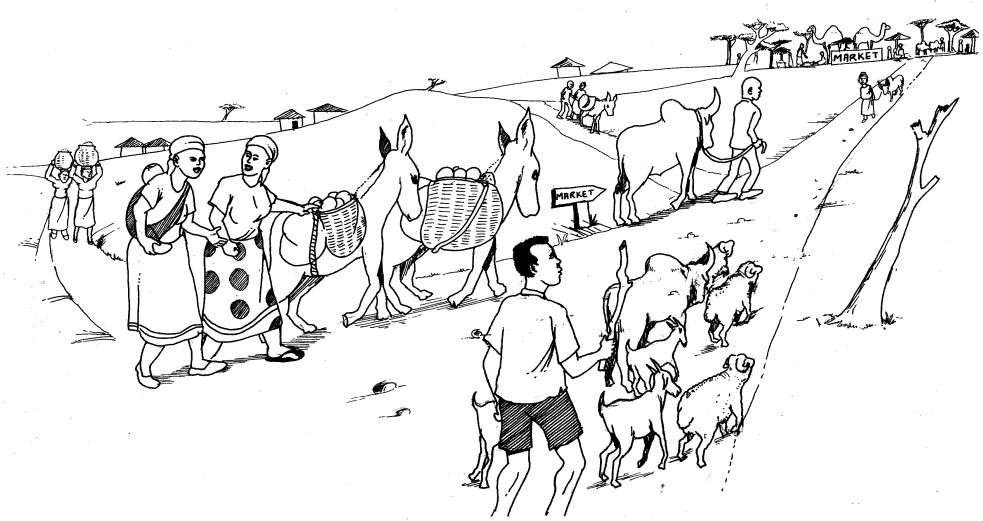
The decision on when and how many animals to sell is driven less by the market prices than by the pastoralist's judgement that the herd has become too large to handle or the range has reached its holding capacity. Herd maximization is a central strategy for coping with drought. The bigger the herd, the better the opportunity to utilize the range in good years, and the greater the chance to build up a herd rapidly after a setback. Unfortunately, this strategy does not match with the best market prices. During droughts, livestock prices are usually at their lowest, while the supply is high. Pastoralists are reluctant to sell their animals when the prices are good, as this may make the herd too small to support the household. They often gamble that rains will return soon, enabling them to rebuild the herd.

Without local banking facilities where pastoralists could put their money, livestock remain their only means of saving. Interestingly, education has become a popular investment for a growing number of pastoralists.

Agropastoralists' strategies

In addition to meeting their basic needs for food, medicines and school fees, agropastoralists at times make the hard but strategic decision to sell their livestock. They make these decisions in stages. For temporary problems such as shortage of food, sickness in the family, taxes and for quick cash, agropastoralists sell smaller stock such as sheep, goats, and poultry. Women and grown-up children may decide to sell such smaller stock without getting the men's permission.

Decisions to sell milk cows or draught oxen are more critical. The farmer may want to dig a well, build a new house, buy extra farmland, or repay a debt that cannot be paid by selling small stock. The man needs to consult his wife, his children and even relatives. Selling a milking cow or ox may deprive the family of a source of milk or draught power.



Unless they must pay for an emergency such as a funeral or illness, agropastoralists usually time the sale for when they can get a good price. They wait until the ploughing is done before selling draught animals. Some farmers fatten draught oxen and dry cows and sell these when demand is high. In southern Ethiopia, agropastoralists time the sale of livestock for festivities such as the new year, the end of fasting, wedding months, and other religious and traditional holidays.

Livestock market dynamics

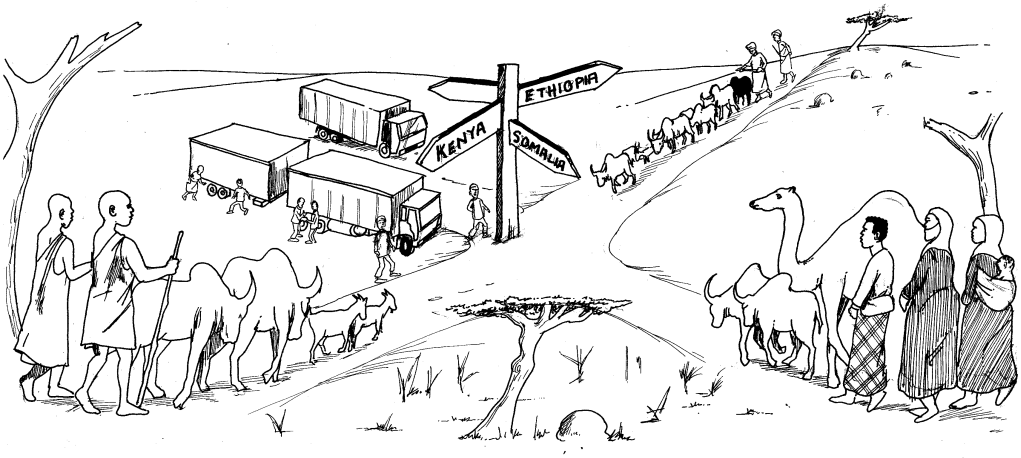
The livestock market chain starts at the farm level and extends to international export markets. Some of its dynamics are described below.

Farm-level markets

Agropastoralists and pastoralists may engage in trading their own livestock. They take their animals to the markets themselves with the help of drovers. Middlemen or traders go from village to village with their trucks to purchase livestock. This is a minimum-risk transaction since the buyers and sellers know each other. Information about farm-level marketing is passed by word of mouth during social events and at market centres. The farm-level market is especially important for animals for breeding, milk and calving, since the animals' origin and quality can be easily identified. The market is relatively free from the risk of theft and animal diseases because the location and individuals involved are known.

Open markets

Half-day or whole-day open-air markets are common in many African villages and market centres. These markets take place once or twice a week. Pastoralists and agropastoralists from several communities come to trade livestock and goods. For agropastoralists, these markets are the main places to buy and sell livestock for meat, breeding, traction and further trading. Below are some features of these markets.



Regional and cross-border markets

The Borana, Gebbra, Gerri, Degodia, Merihan, and Burji are ethnic groups who live near the borders of Kenya, Somalia, and Ethiopia. They are pastoralists and livestock traders. Their major markets are Addis Ababa in Ethiopia, Nairobi in Kenya, and Baidoa and Mogadishu in Somalia. Many of the traders have relatives across the borders, and they carry multiple national identity cards as they cross the borders frequently.

The traders are pastoralists themselves who have strong links with pastoralists and farmers in the area. They select trustworthy herders from their villages and pay them to trek with their livestock. Each drover herds up to 10 cattle or seven camels at a time to the border. Drovers usually travel in groups for security reasons. They carry their own rations. Even Somali women (called *gadily*) trek livestock for a small fee per animal. It takes 9–30 days for livestock on the hoof to reach the markets. Livestock graze on natural pasture along the way. When they reach towns, the traders pay for lodging, fodder and water.

Once the animals reach the border markets, a broker facilitates the sale by linking the trader to a buyer. These buyers load the animals onto lorries and send them to the cities for slaughter. Some brokers save enough to become full-fledged traders themselves.

Traders incur various costs. They buy animals, pay the drovers and brokers and people to search for animals that get lost on the way. They must also pay the broker costs of transport. Transactions are done in Kenyan and Somalian shillings and in Ethiopian birr. Much of the trade is without official papers such as export clearances and fees or letters of credit. When the livestock reach their final destinations, most are sold for slaughter.

Benefits of the trade

- Pastoralists and agropastoralists earn better prices for their animals at large urban markets where demand is high.
- Trading stimulates the economy in the border market towns. Local people can sell food and other items to the people involved in the livestock trade. Foreign goods are also available at the border markets.

Problems

- Restrictions and bans imposed by customs authorities hamper the efforts of pastoralists to market their livestock. Border patrols sometimes confiscate animals.
- Price fluctuations, taxes and duties affect sales. During droughts, livestock are sold at throwaway prices.
- Services such as banks, quarantine, market information and security measures are lacking. Traders incur losses through skirmishes and banditry near the border.
- The trade may affect the prices of animals and meat in both the importing country (where prices go down) and the exporting country (where prices may rise).
- Animal diseases take a heavy toll. Health checks are not rigorous. Consumers may question the quality of the meat from across the border.
- Because much of the cross-border livestock trade is illegal, governments lose revenue from taxes and fees.

Recommendations

Despite many problems, on balance, the livestock trade benefits both producers and consumers. It stimulates the economy and helps local people cope with crises such as drought. Governments should support the trade by providing marketing facilities, easing financial transactions and enforcing appropriate quarantine restrictions.

—Ayele Gebre Mariam

Livestock contracts in southern Ethiopia

The town of Shone in southern Ethiopia is a commercial centre for four districts. Livestock trading is held once a week. Farmers take their animals on foot. Traders who supply livestock for meat to regional towns and Addis Ababa come with lorries to transport cattle, sheep and goats. Local people trade livestock for meat, breeding, draught and milk production, or for resale in more profitable markets. Drawing up and signing a contractual agreement is integral to the market functioning. Although simple and ceremonial, the agreement provides a safety mechanism to avoid the risk of buying stolen or sick animals. The contract-signing process is as follows.

- Three witnesses who know the origin and owner of the animal(s) affix their signatures to the contractual document. This documentation is often prepared by young men who have some education (many older farmers are illiterate).
- An elder of good repute, known to both parties, acts as a guarantor. He ensures that the animal is risk-free. He brings the seller to book if the animal is found to have defects.
- The contractual document may be only a small piece of paper, but it contains the signatures of all the parties involved. Details of each animal – its colour, sex, price and place of origin – are recorded so the animal can be identified in case of problems.
- When the transaction is complete, both parties celebrate with food and drink.

- Restrictions such as quarantine and licensing are relaxed or absent.
- They risk spreading epidemic diseases, since quarantine and other animal health precautions are lacking.
- There are no predetermined routes. Trekkers often use short cuts or trails to reach their destination.
- Some markets keep animals in enclosures to avoid disturbance to the public and also as a control to allow taxation. Stray livestock may be stolen.
- The risk of buying stolen livestock is minimized by signing contractual agreements witnessed and guaranteed by reputable residents.
- Stress to the animals is reduced because trekking is limited to one day at most.

Stolen livestock

Livestock theft is common among many pastoral communities. Fast-moving, armed groups steal animals from enclosures, grazing areas, market places and homes. They sell these animals in distant markets, where unwitting buyers risk purchasing stolen stock.

Animal fattening

Fattening cattle for the meat market is done commercially and by individuals on their own premises. Farmers take advantage of seasonal markets and the availability of fodder. Those who do not have their own animals team up with those who do but who cannot fatten them on their own. Many farmers select male cattle and castrate them to speed up weight gain.

Farmers' efforts to organize livestock marketing: The LISSA/Bahati initiative in Kenya

Until 1983, most livestock trade in Kenya was handled by the government through the Ministry of Agriculture's Livestock Marketing Division and the Kenya Meat Commission. When Kenya's economy was liberalized, these agencies closed down. Livestock trade and processing were left to private entrepreneurs. The liberalization of the meat industry in Kenya had both positive and negative impacts. Private investors were allowed to operate in a competitive environment. On the other hand, operation capacity, quality standards and trade practices became disorganized. Pastoralists reverted to traditional systems of livestock trade.

In November 1999, a group of pastoralists, livestock farmers, traders, meat processors and butchers formed themselves into a nonprofit grassroots association, the Livestock Stakeholders Self-help Association (LISSA). LISSA aims to restore order in the livestock trade and to serve those who are not accommodated by large multinational livestock trading companies and meat processors. Members pooled their resources and invested in the construction of the Bahati slaughterhouse in Limuru.

LISSA has formed a market chain. It provides market information such as the current prices and potential buyers. A directory facilitates links between pastoralists and farmers with other dealers in live animals for private butcheries, meat-processing plants, and other buyers for non-meat products. Stakeholders are updated on veterinary services, events such as training, lobbying seminars, and workshops. Meat processors get information on market demands and quality standards for processing and packaging.

LISSA assists pastoralists to get their livestock to the abbatoir. When animals reach the Bahati slaughterhouse, they are kept in sanitary holding pens. They are also grazed and watered during a waiting period. This relieves the animals from the stress of transport. Farmers near the slaughterhouse buy blood to mix with pig feed, and manure for fertilizer.

LISSA members pay an annual membership fee of KSh 500. A livestock owner pays KSh 300 for each ox processed and marketed through LISSA. This fee includes payments to the slaughterhouse, for government quality inspection, and for the association levy. The association ensures that buyers pay the animal owners promptly and fairly. The membership fees go into a fund to cover operating costs. Any withdrawals from the group account must be authorized and signed by three signatories. The government inspects the association's financial records to ensure transparent accountability.

LISSA hopes to promote its services and advertise its meat and meat products through posters, television, radio and newspapers.

—Michael Kibue and Ngethe Mburu

Animals are fattened for 2 or 3 months before they are sold. A poor farmer without animals may use crop residues and cut-and-carry fodder to fatten a neighbour's cattle. The farmer can use these animals later to plough the household's own fields. When the fattened cattle are sold, the carer gets a share of the profit.

Role of middlemen

Poor infrastructure and long distances separate many pastoralists from their markets. Nevertheless, trade has always taken place. Middlemen play a role in transporting cattle to market and providing essential goods to the pastoralists. They take high risks

in transporting animals along very poor and insecure roads. Pastoralists have a choice: they can either move their cattle to the market themselves, or they can use the services of middlemen. In either case, very poor roads discourage truckers from reaching remote areas, so the animals must be herded over long distances. Animals lose condition and fetch low prices, and the drovers also risk attacks by rustlers.

The middlemen may be brokers or may themselves purchase livestock from cheap markets and transport them to more lucrative places. Sometimes they manipulate prices to make large profits at the expense of the livestock owners. It is important to assess specific situations: many informal trade channels operate satisfactorily and should not be replaced unless really good alternatives are ready. Support agencies such as NGOs could help pastoralists and farmers in isolated communities by providing them with current information on markets and prices to help them negotiate.

Types of markets

Meat The meat market is the biggest and probably the most developed market for livestock. Young steers are fattened for sale. In local open markets, animal owners sell a small number of livestock during seasonal events or holidays when the prices are good.

Regional and international export These markets are expanding. Cattle, sheep and goats from east and central Africa are being exported to the Middle East, primarily for meat. However, livestock exports may fail to meet high import standards, and may suffer from unreliable transport, restrictive export and import policies, and breed preferences.

Restocking Restocking is a process of rebuilding herds after pastoralists or agropastoralists lose livestock through wars, epidemics, droughts or cattle rustling. Development agencies assist individuals who lose their herds to obtain animals for breeding. In most cases female cattle and bulls are bought (see *Restocking livestock*, page 144).

Breeding Agropastoralists look for good-quality stock for livestock breeding. They look for particular qualities and sometimes ask for help from breeding experts. Breeding animals are often purchased from known people (neighbours, relatives or friends) or research centres where the livestock pedigree and quality is well established. For dairy animals, the quantity of milk, fat content and age determine the price.

Animal traction Most agropastoralists use animal traction to cultivate their fields. They select hardy animals for speed and endurance in pulling ploughs. Draught or traction animals are normally leaner than those for meat.

Traditional methods of pricing

- **Physical appearance** Local experts assess the physical appearance of the animal to estimate its price.

- **Checking body parts** The fat and muscle tone of the animal is determined by feeling the hump, rump, loins and other critical points. Buyers decide whether they want animals that are lean and hardy, or those that are fat.
- **Age, sex, and status of the animal** Local livestock experts determine the animal's age by inspecting the teeth. In the meat market, younger animals fetch more because of their tender meat, and castrated males fetch more than young bulls.
- **Animal origin** Animals from the highlands are priced higher than those from the lowlands. This is because they are typically better cared for in shelters, and may have been given more nutritious fodder. These management practices produce better-quality meat.

Payment

Livestock may be paid for in cash, in the form of credit, or as an exchange with products the seller needs. Payment with credit earns more than on-the-spot cash, but it involves a risk of delayed payment or default.

Livestock transport

Transporting livestock to the market involves the mode of transport, the trekking route, licensing, quarantine measures, permits and risks. Livestock traders who trek the animals use short cuts and routes where they can find water and grazing. To cut costs, they may bypass licensing, taxation, quarantine regulations and police checkpoints, where extortion is frequent. Many pastoralists hire drovers who know the routes well and have established contacts along them.

Some governments try to ban trekking livestock to towns. Animals must be transported by lorries, which get the animals to the market faster. Some livestock owners organize transport collectively. By going through checkpoints at night, some traders manage to avoid complying with regulations. Bad roads and overcrowding in the lorries may mean some animals get trampled. Traders must be ready to bear such losses.

The Dukana truck

Dukana is a very isolated community in northern Kenya, close to the Ethiopian border. Middlemen and traders seldom reach Dukana because it is too far from the trade routes. The local pastoralists have been restricted to traditional local markets. FARMAfrica drew up a simple business plan with the community. It gave the village group a loan to purchase a second-hand lorry on credit. The lorry is used to transport cattle to Nairobi. On its way back it brings essential consumer items for the village. This venture has proved very successful and has boosted the local economy. Having paid off their loan, the villagers now plan to buy a second lorry to meet the growing demand for transport.

—Ben Haagsma

Branding

Branding involves marking an animal using different coloured dyes or by scarring. It is done to separate animals that have been sold in a holding pen or enclosure from those still awaiting sale. Owners also brand their cattle to separate animals of different grades and to keep track of them during trucking or trekking. Various ethnic groups brand their livestock with traditional marks. Some nick their animals' ears in particular ways.

Quarantine

Moving animals across district boundaries requires compliance with quarantine regulations (holding animals in stockyards for an observation period, to inspect them for symptoms of contagious disease), especially during disease outbreaks. Unfortunately, such services are not available in most rural areas. Where they are available, the services are not very effective. Some livestock traders are issued quarantine clearance even though the animals have not been inspected. A little cash goes a long way. It is difficult to monitor or control livestock movement since herders also move animals by night and use short cuts.

Challenges to livestock marketing

- Infrastructure such as roads and markets must be developed and maintained.
- When livestock traders do not have the required permits, their animals may be confiscated or they are forced to pay bribes to corrupt officials. Permit hassles must be reduced.
- During the trek, livestock may be attacked by wild animals. Drovers may need armed escorts to protect themselves and the animals.
- Cattle in overcrowded trucks may be trampled. The trucks must be equipped with holding crates.
- Quarantine regulations should be enforced to control disease outbreaks.
- Bandits and rustlers inflict heavy losses on traders. Governments can improve security by deploying the army and police to patrol problematic areas, as in parts of eastern Ethiopia.
- Governments should help link local markets systematically to national, regional and export markets.

Based on a manuscript by Ayele Gebre Mariam

Restocking livestock

Livestock represent the majority of pastoralists' wealth. Pastoralists sell animals when they need cash, barter them for grain, or slaughter them for meat. The herd is like a bank account: the size of the herd represents the owner's wealth; the calves that are born are the 'interest'. If the animals could be converted to cash, pastoralists would generally be wealthier than sedentary farmers, whose major asset is land.

However, disasters such as severe droughts, disease epidemics, cattle raids or war may decimate a herd. Rebuilding an economically viable herd may be impossible for people who have lost most or all of their animals. Such people may become destitute.

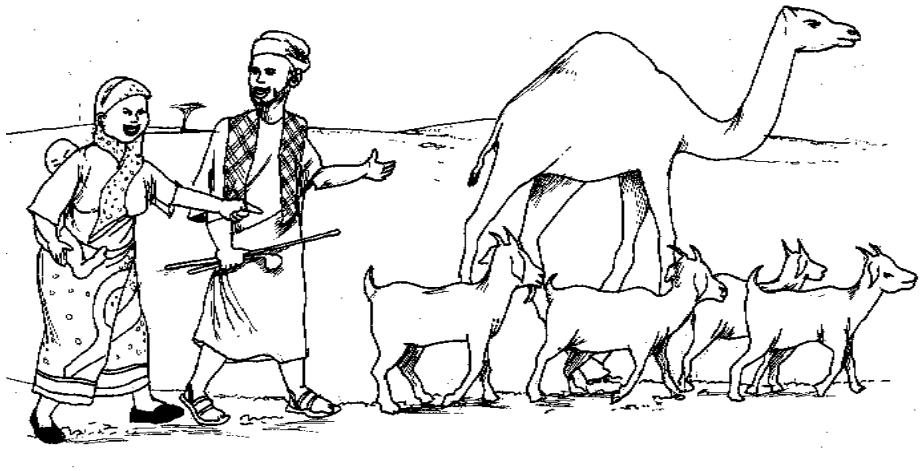
Sedentary farmers may also rely heavily on livestock, though their herds tend to be much smaller. The loss of a cow means no milk for the family; the loss of a bull means the land cannot be ploughed.

Restocking helps pastoralists rebuild their herds and allows sedentary farmers to farm more productively.

Traditional approaches to restocking

Pastoralists have various approaches to restocking, based on a network of social obligations. After a disaster, they can call on these obligations to rebuild their herds.

- They distribute their herds in several locations as insurance against disaster.
- Herders lend animals to friends and relatives, and richer people may loan out cattle to others. The caretaker consumes the milk and may keep some or all of the offspring, depending on the type of animal and local customs.
- Families may share the ownership of animals such as a bull (used for ploughing) or cow (for milk).
- When women marry, the husband or his family must pay a dowry in cattle or other animals. This debt may be paid gradually rather than all at once. After a disaster, the bride's family can call on this dowry.
- Each household in a community may give cash or a few animals to a destitute family. Community members may also give animals as wedding gifts or to support a child's schooling.
- Some communities prevent infectious diseases such as foot-and-mouth disease from spreading by requiring the owner to slaughter the whole herd if some animals are infected. Each member of the community then contributes a few animals to rebuild the herd.



- Herders may sell hides, jewellery or other assets to buy animals.
- Pastoralists raid the herds of other groups – both pastoralists and sedentary farmers (see *Managing conflicts*, page 45).

Approaches used by outsiders

Development organizations may distribute livestock during the 'normal' stage of the drought cycle, or during the 'recovery' stage after a disaster (see *Managing the drought cycle*, p. 26).

During the normal stage, the aim may be to improve the productivity of existing herds (for example, by providing crossbred animals), or to introduce alternative income sources to certain groups (such as women or sedentary farmers). The development organization may also try to promote a change in lifestyles, for example by providing crossbreeds or exotic breeds to encourage people to keep smaller but more productive herds.

After a disaster, the aim is to enable destitute people to rebuild their livelihoods and reduce their dependence on handouts. Agencies should not restock the herds of people who lack the appropriate skills, as they are likely to fail again. Instead, they should help such people seek other sources of income. Organizations use two general approaches to restocking: grants and credit.

Restocking policies in Uganda

The animals given to pastoralists during restocking programmes may help them return to their normal way of life quickly. Or they may force change. The Ugandan government is trying to persuade Basongora agropastoralists in the wetter drylands to change their lifestyle. So in 1999, it gave them Friesian dairy cattle and crossbreeds. Many of the recipients have since become sedentary farmers, though others have returned to pastoralism.

—Tumwine Yasin

Grants

Outright grants of animals are often made to pastoralists who have lost most or all of their animals. The animals are given without preconditions: the new owners can use them to rebuild their herds, or can sell them if they wish.

Credit

Animals may be provided on credit. The new owner must repay the cost to the donating organization, or pass on the offspring to someone else – often a member of the same community. Credit is often used with sedentary farmers or womens' groups who have small numbers of livestock, and to introduce new animal species (or new breeds). The distribution of livestock is often part of a broader development programme covering community organizing, veterinary services, training and marketing. The new owners may be required to keep records and submit reports to the community organization. Some groups do not allow beneficiaries to sell the animal for several years so they can repay their debt.

Principles of restocking

Assess the importance of livestock to the community The approaches used with pure pastoralists will differ from those for crop farmers or where the menfolk

Restocking Borana pastoralists

The Borana on either side of the Kenya–Ethiopia border use a system known as *busa gonofa* to restock the herds of community members. The clan identifies people who are destitute and provides them with animals. People with poor herding skills or who have lost their animals through carelessness are not selected.

As a result of droughts in 1972–74 and 1984–85, some Borana in southern Ethiopia lost all their livestock. The *busa gonofa* system broke down, leaving many people dependent on relief food. Some settled as farmers; others migrated to towns.

In 1985–87, the South Ethiopia Synod of Mekane Yesus and the local government provided each of 500 households with some animals so they could begin to support themselves. Some households received a heifer and a bull; others received some female goats.

An evaluation in 1989 showed that the families which had received cattle still had 85% of the original heifers and 80% of the bulls. The remainder had died of disease, or had been sold or stolen. Some heifers were sold because they had mastitis. The family herd had grown, by an average of two calves each. The cows provided milk; the bulls were used for farm work.

The number of goats had also increased, despite many deaths due to liverfluke and diarrhoea. Each dam had at least two kids.

The restocking programme clearly benefited most of its recipients. They were in the process of rebuilding their herds, and some had moved out of their temporary accommodation to traditional encampments. However, the herds were still below the level needed to support the whole family.

—Ayele Gebre Mariam

'Passing on the gift' in Zimbabwe

After the 1991–92 drought in Matabeleland, over 80% of the crop farmers in Guyu were left without cattle. The local people approached Christian Care for help.

The original idea was to give each household one or two heifers to restart its herd. But lack of funding meant this was not possible. Instead, some families were given a heifer to look after. They agreed to pass this animal on to another family once it had given birth and the calf was 8 months old. The original family was allowed to keep female calves; male calves could be exchanged for a heifer. After it had calved five times, the cow was sold and replaced with a heifer.

The communities agreed that only those families with three cattle or less could qualify for the scheme. The communities themselves selected the 120 families to participate. Some families who had never before owned cattle were included, with the hope that they would learn the necessary skills from other beneficiaries. The families were organized into two groups, and committees were formed at ward and village levels to manage the scheme.

Christian Care bought nearly 100 heifers and four bulls for distribution. The participating families paid a subscription into a common fund to cover veterinary and other expenses. They agreed not to sell their animals for at least 5 years, keep records on cattle births, deaths and transfers, and submit regular reports to the committee. Members held monthly meetings to discuss village activities.

Some families have been reluctant to pass on the cow (rather than the calf) to the next family in line. The committees were also weak at first because they were not adequately trained. However, the project has been successful enough to be replicated elsewhere in Zimbabwe.

—Likani Lebani

work in the cities for much of the year. Because pastoralists rely more heavily on livestock, they need a bigger herd to support them.

The community decides Herders have much better knowledge of the production system than do outsiders. They should decide on the criteria used to select beneficiaries (e.g., people who have lost cattle due to drought, or households headed by women), and use these criteria to select the beneficiaries. They can also decide on the type and numbers of animals to be distributed (don't give a cow to someone who wants a goat), and select which animals to buy. Disputes should be settled by local people rather than by outsiders. Ensuring that the community controls the process helps sustain traditional restocking mechanisms. It may be necessary to give clear information on the purpose of the scheme beforehand.

Ensure viable herds A pastoralist family cannot survive if it has too few animals. To ensure that the herd can be rebuilt to an economically viable level reasonably quickly, aid agencies may have to provide several animals to each family.

Choose the right time There is no point in restocking during a drought, or if a drought is imminent. During the recovery stage, however, there may be more than enough grazing available because many animals have died. This is the time to restock.

Restocking cattle in Zambia

In the late 1990s many cattle in Monze East, Zambia, were killed by Corridor disease. A restocking programme organized by Africare uses a similar approach to Christian Care in Zimbabwe (see previous box). Five crop farmers who had lost their cattle in each area have each received a cow and a bull. The farmers attend lessons on livestock management with a veterinarian each week, and they are required to dip their animals regularly to control parasites. Eight months after a calf is born, they must pass the weaned calf on to another farmer. The original farmer then receives a certificate of competence and may keep the cow and bull, as well as any further calves.

—Mwangala Sitali

Buy locally If possible, animals should be bought from local markets rather than brought in from outside. This avoids introducing diseases into the area. It may be necessary to bring in animals from outside if livestock numbers have been severely reduced by drought, or if the aim is to introduce crossbreeds.

Support skilled livestock managers Some pastoralists become destitute because of carelessness or poor management rather than bad luck. Only the best managers survive. The pastoral system has limited capacity; it cannot accommodate all the drop-outs, and there is no point in trying to do so (see *Pastoral production systems*, page 13).

Provide adequate support If the aim is to introduce livestock or new breeds to people who have no experience with them, then training in livestock management and health care will be needed. Other types of support may include developing community organizations, training paraveterinarians or linking with veterinary services, providing drugs, and assisting with marketing.

Check the security situation There is no point in providing livestock if they will quickly be stolen by rustlers.

Make sure the rules are clear The beneficiaries and other community members must understand and agree to the rules of a particular scheme. These may include a requirement to pass on the offspring, restrictions on selling animals, and a need for transparent record-keeping to prevent corruption.

Check on gender issues Men and women often take care of different types of livestock. Providing cattle may benefit men rather than women, who may prefer goats or even chickens.

Based on manuscripts by Ayele Gebre Mariam and Likani Lebani

6

Communities and organizations

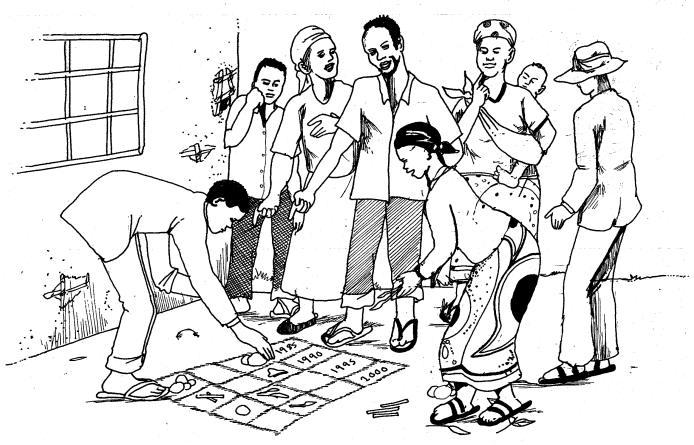
Community organizing

When people organize themselves into groups with a common purpose, they are able to achieve things that they may not be able to accomplish as individuals. They exchange ideas, encourage one another, and get access to services. Organized communities enhance their capacity to manage their own development. They have a stronger voice to negotiate with government and non-government institutions. Community organization releases people's potential and empowers them to achieve sustainable development.

Organizing communities in drylands presents community workers with special challenges. People in these areas pattern their lives to the seasons. That means that livelihood-support activities are also dictated by the seasons. Community workers need to time interventions to suit the local calendar. In addition, pastoralists are mobile, making it hard for organizations based in towns to serve them. The limited levels of natural, physical, financial and human resources prevent the people from diversifying their sources of income. Their immediate concern is to survive from day to day. Development organizations should assist such people to improve their lifestyles.

Benefits and challenges

When people analyse their own situation, they understand why they must act to improve it. They feel proud to own and control the development process. Organized groups pool their resources to undertake projects and activities that they could not sustain or carry out on their own. Because the groups implement activities together, they become more cohesive. Technical support such as extension services, skills training and funding are easier to access. Members become aware



Using a trend chart to do a situation analysis

of the need to conserve their common resources. They participate willingly in conservation activities because they accomplish more, faster. Organized communities also contribute to better local governance.

However, community organizing requires a lot of time and patience, and the results are difficult to predict. Different groups in the community may have different needs and priorities. Outsiders must understand these needs and priorities, and know the strengths of village partners if they are to implement projects effectively. If checks and balances are not put in place, influential people in the community may abuse the development process to suit their own purposes. For example, if committee members are not properly selected and screened, kinship relations, levels of income, gender and levels of education can cause distrust and may even polarize the community.

How to organize

Here is one way to help a community organize itself:

1 **Community entry** Meet with concerned government officials, community leaders and members. Sensitize them to the development process. These people can reduce suspicion among your target groups.

2 **Invitation** Let the community know you are willing to work with them. If they are interested, ask them to invite you. Visit the community and assess their interest.

3 **Awareness** Share information with the host community to clarify issues.

4 **Participatory analysis of situation** Use participatory appraisal techniques to help the local people identify their problems and priorities. Ask the people to list their priorities in areas such as health, livelihood, environment, water, education, social relationships, agriculture and other issues. Have them provide information on:

   - Physical features and infrastructure of the community
   - Demographic and historical profile of the community
   - Social groups, gender and age differences
   - Economic categories of community members
   - Existing resources and services.

5 **Planning** Assist the community members to generate clear action plans to address their priority needs. Have them assign specific teams to take charge of various tasks.

6 **Implementation** Have leaders organize different groups to implement what they have agreed. Get them to assign people to monitor progress, keep records and report.

7 **Evaluation and (re)planning** Let the community assess their short- and long-term plans. Provide them with tools to monitor and evaluate progress and to re-plan future actions.

Community organizing in Kwale, Kenya

The Kwale Rural Support Programme, also known as 'Sombeza', operates in Kwale District. It helps establish community institutions, develop productive physical infrastructure, and mobilize savings and credit extension. Sombeza promotes appropriate technologies in agriculture and develops small businesses and human resources. It helps communities organize groups which link up with wider networks and obtains formal government recognition so they can get help for their projects.

Sombeza establishes the following types of organization:

- **Supra organization** This group coordinates discussion on issues and plans and implements inter-village projects such as road development and inter-village meetings. It links with government agencies to deal with land disputes, HIV/AIDS control, and other cross-cutting issues.
- **Village development organization** This coordinates activities in the village. It shares reports with the supra-organization, facilitates linkages between the village and external institutions, and resolves disputes involving members. It manages village resources such as sand and stone for building, and identifies community members for training as para-professionals.
- **Interest groups and special-project groups** These groups coordinate the implementation of specific projects. They prepare progress reports for the village development organization.

How Mwabila built reservoirs

The people of Mwabila, a village in Mwavumbo, Kwale District, grow vegetables such as cowpeas, tomatoes and kale. But since they depend on the rains, their vegetables are ready for sale at the time as everyone else's. The market is flooded and prices fall. The people of Mwabila needed a better way to earn their living.

Sombeza assisted the community to improve their farming techniques and introduce irrigation. The farmers asked the Sombeza extension team to help them to get their vegetables ready for market during the dry season when prices are better. With help from the team, the villagers formed vegetable-production interest groups, which developed detailed action plans.

The groups decided to dig small reservoirs so they could water their vegetables using buckets. To dig the reservoirs, the villagers revived a tradition called *mweria*: work groups assigned duties in rotation. The people organized themselves into subgroups of five households each, and worked on a voluntary basis to excavate six reservoirs at strategic locations. Sombeza provided shovels, mattocks, and wheelbarrows. After the reservoirs had been completed, members paid the village development organization to use the tools in their own gardens. These fees are used to maintain the tools and replace damaged ones.

Some 30 households in Mwabila now produce vegetables throughout the year. They have enough for their families, and they sell the surplus. They are planning to buy manual pumps so they no longer have carry buckets of water from the reservoirs.

—Peter Otinda

8 **Exit strategy** Make a graceful and gradual exit. The organized community should own the development intervention since they have been involved in its inception. Delegate accountability to the community.

A partnership agreement (or 'memorandum of understanding') can be useful to spell out the roles of each party, state what the outside organization will (and will not) support, give the level of support, etc. After 2–3 years, review these relationships so the community can take over and continue working.

Do's and don'ts

Do's

- Facilitate, interact, and support – but give the communities a chance to lead.
- Appreciate indigenous knowledge and mobilize the community to use it best.
- Keep time, be transparent, be ready to learn.
- Be familiar with government administrative procedures. Help the organized group to get registered with relevant authorities. This will allow them freedom of movement and association.
- Encourage traditional institutions such as councils of elders and womens' clubs to play an active role.
- Get the community to network with other institutions, including government agencies, and to draw on the extension services.
- Encourage community groups to focus on specific activities where they can succeed, rather than spreading themselves too thinly.

Don'ts

- Don't waste their time. Never keep communities waiting.
- Don't lead or drive.
- Avoid handouts: they encourage dependency and laziness.
- Don't have patrons. Avoid political, religious and social interference.
- Don't take part in partisan politics: it will endanger your autonomy.
- Don't form new groups parallel to or replacing existing governance structures.

Based on a manuscript by Peter Otinda

Participatory extension

Agricultural extension and advisory efforts face particular problems in the drylands. Government extension services are generally weak, or do not exist at all. Population densities are low, forcing extension officers to cover huge areas. Extension workers may be reluctant to live and work in remote areas. In some countries, newly privatized extension services charge fees that most crop farmers cannot afford. Top-down approaches to extension have failed because they fail to take variable local conditions into account. And many extension messages are poorly adapted to dryland conditions.

Pastoralists are mobile, and many agropastoralists also spend much of the time away from home. Sedentary farmers also may migrate to the towns in search of work during the off-season. This makes it difficult to plan activities, and farmers are not able to attend meetings. Dropout rates are high.

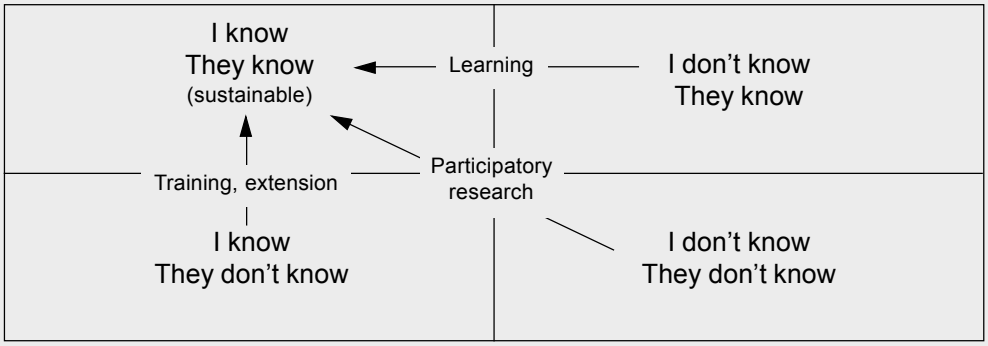
The unpredictable environment makes both pastoralism and (especially) crop farming risky. Producers cannot afford to take any more risks, so prefer to stick with tried-and-tested practices. Technology demonstrations may fail because of drought or other problems. Crop farmers, especially, have little capital, so they

Is research or training needed?

It depends on whether the answer to a problem exists, and who knows it.

- If no one knows the answer, then research is required (bottom right cell in the diagram below) (see *Participatory research*, page 183).
- If the organization knows the solution but local people do not, then training and extension are needed (bottom left; see this section).
- If an organization finds that local people have a solution to a problem, then the organization staff can learn this indigenous knowledge from them (top right).

The aim is to reach the sustainable situation where everyone who needs the solution, knows it (top left).



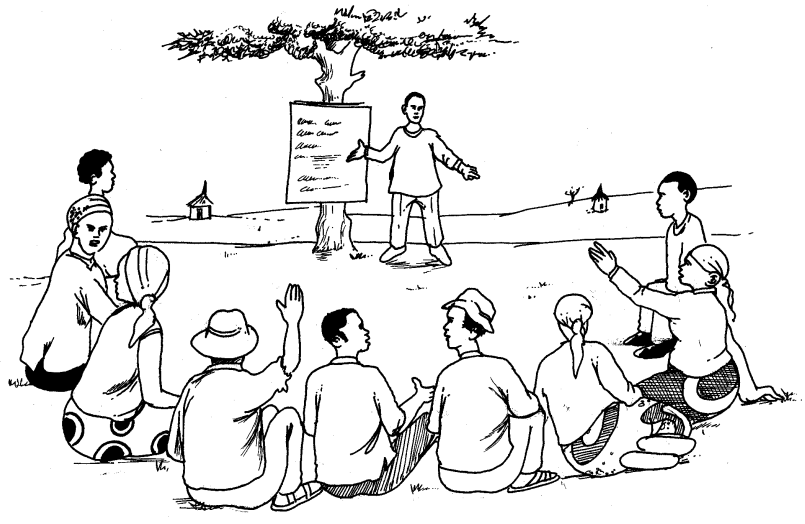
may not be able to buy the extra inputs needed to grow improved varieties or adopt other practices.

Participatory extension: an answer?

Participatory extension is an attempt to overcome these problems. The key difference between participatory and conventional extension is that the former relies heavily on the farmers themselves to manage and implement extension activities. In some participatory approaches, the extensionist is a member of staff of a non-government organization or government agency who facilitates (rather than teaches) groups of farmers. In others, farmers themselves act as extensionists; the outside organization helps train and organize them and provides them with information.

Various approaches can be used in participatory extension. Here are some common ones:

- **Farmer-to-farmer extension** is where one farmer in the community trains his or her neighbours. The farmer-trainer may hold regular meetings with individuals, or help organize a group of other farmers who are interested in certain practices.
- **Innovative farmers** are a source of information and inspiration for their neighbours.
- **Field days, demonstrations, fairs and exhibitions** range from one-day events in a farmer's field, to larger shows that last several days.
- **Cross-visits** involve visits by one group of farmers to another.
- **Farmer field schools** are an approach where a facilitator helps a group of farmers learn for themselves about their farming system.



A group of farmer-trainers meets to discuss the next season's activities.

- **The mobile approach** is sometimes used with pastoralists who move around in search of fresh pasture. The extensionist (often a staff member of an NGO) lives and travels with the pastoralist group. This is effective, but is hard on the staff member, who must be away from his or her family for several months at a time. This means that staff turnover is high.

Participatory extension is often managed by, or takes place through, an existing community organization. If a suitable organization does not exist, it may be necessary to help local people form one (see *Community organizing*, p. 151). This type of extension can reach more people than is possible through conventional extension.

Participatory research and participatory extension often go together. Farmers who have tried out a new technology and got to know its benefits and drawbacks are the best people to advise other farmers on whether it is suitable for them (see *Participatory research*, p. 183).

Farmer-to-farmer extension

Instead of training and employing extension workers and sending them to remote areas, farmer-to-farmer extension relies on farmers themselves to spread news about improved technologies. The development organization (usually a non-government organization) trains selected members of the community to provide extension services. Typically, one such community extensionist can cover 5–10 homesteads.

The main advantage of this approach is that the extensionists live in, and are members of, the community. They know firsthand about the problems and potential of their friends and neighbours, and they speak the same language. As farmers themselves, they will be interested in promoting only practical technologies that they are confident will work. They can use their own fields and animals to test and demonstrate new techniques.

Many farmer-extensionists are themselves innovators. Participatory extension harnesses their energy, dedication and creativity to help others in the community (see *Innovative farmers* below).

This approach also has limitations. Farmer-extensionists must actively seek information; if not, the system will cease to function once the outside organization scales back its involvement. The farmer-extensionists may be reluctant to provide services free of charge, and they are difficult to replace if they resign or move out of the area. Local people may think it is not worth coming to meetings if no outsiders are involved, or conversely, they may be disappointed when they find out that the farmer-extensionist has no free seeds or fertilizer to give away.

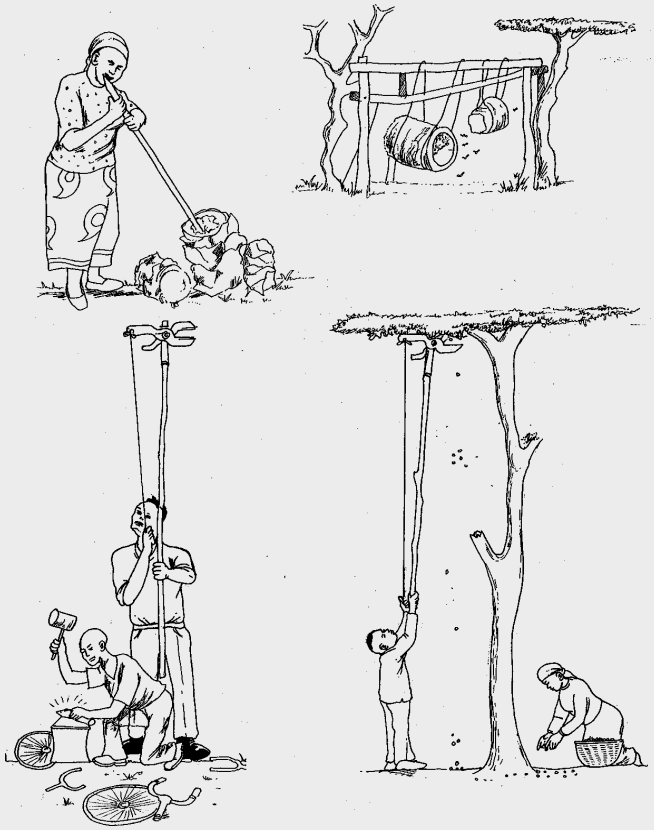
Farmer-extensionists should be selected carefully and according to set criteria. They should be successful farmers, residents of the area (or members of the pastoral community), and be able to read and write. They should be liked and respected by the community. They must have time to attend training and to de-

The father of invention?

'Necessity is the mother of invention' asserts Paul Karomo, a self-reliant farmer and mason in Nachu. His 5 acre-farm here in Kiambu District, Kenya, was part of a settlement scheme. The government gave parcels of land to landless farmers like Paul.

When he started tilling the farm, it was degraded and bare, except for a few acacia and euphorbia trees. The Karomo family had to travel 15 km to get poles to build their house and other buildings. Even firewood and water were scarce.

The family started a tree nursery. They collected used car tyres and turned them into seedbeds for tree and vegetable seedlings. They planted various trees for shade, fruit, timber, and fuelwood, and as a source of seeds. They also built two stone-and-concrete water tanks and installed a roof catchment to harvest rainwater. This saved Mrs Karomo the burden of fetching water with a donkey cart from 2 km away twice a week.



The Karomos used old sisal trunks for beehives (top) and made a seed harvester from old bicycle parts (bottom).

In addition to his farming, Paul also repairs bicycles. Using scrap parts, he devised a unique tool to harvest seeds from his trees. Any adult can use this handy harvester to collect seeds from the higher branches.

Paul used a crowbar to make beehives from sisal trunks, which farmers often discard when clearing land. He installed the hives in a mixed-species woodlot away from the house. Bees stay on the Karomo farm because there is a good supply of nectar from the numerous trees. Paul also started a herbal garden for medicinal plants and spices. The nearest shop is 1.5 km away, so the garden is an immediate source of the family's basic health care needs.

US Peace Corps volunteers promoting energy conservation and agroforestry, the University of Nairobi, the Forest Department, the Kenya Forestry Research Institute and other farmers have commended Paul's innovations. The Kenya Forestry Research Institute has even awarded him a prize for planting trees.

Training

For participatory extension to function, the people who do the work – staff of community organizations and farmer-extensionists – may need various types of training. Obviously, the type of training depends on their individual skills and needs as well as their roles in the system. Training should be practical and locally relevant.

Here are some possible topics for training:

- **Technologies** Seed selection, seed technology, water harvesting, soil and water conservation, use of draught animals, livestock diseases.
- **Project management** Community leadership, development management, rural development concepts, proposal and report-writing, monitoring and evaluation.
- **Training techniques** Communication skills, extension methods, preparation of visual materials.
- **Social approaches** Group management and dynamics, leadership, team building, institutional capacity-building, accounting.
- **Research** Adaptive research, experimental design, data collection and analysis, presentation of results.

vote to extension activities. Local people can decide on these and other criteria themselves. Of course, the people selected should also be keen to take on this task.

After assessing their knowledge and skills, the development organization provides the nominee extensionists with training. This should cover both technical subjects (irrigation, animal health care, seed selection, etc.) and skills such as training methods, monitoring and evaluation, and running simple experiments in the field.

An ongoing training and networking programme keeps farmer-extensionists up to date with new ideas, and allows them to exchange experiences with others. Other forms of support include visits to research centres, printed information, payment for expenses, and administrative guidance. Depending on the amount of time and labour the farmer-extensionists commit, it may be appropriate to pay them a small salary.

Innovative farmers

Certain individuals in every community introduce innovations and try out new farming techniques. They devise new tools (or adapt existing ones) to solve problems they themselves face. They are usually hardworking, determined, and diligent. They are often happy to demonstrate their initiatives to their friends, neighbours and others.

These innovators are often ordinary people and in some cases, founders of community-based organizations. What motivates them? Problems in their environ-

Farmer-focused natural resource management

In 1983, Nelson and Florence Nyangile bought a hilly, unproductive 8-acre farm in Chamabare, Migori District, Kenya. This dry area lies in the Lake Victoria basin rain shadow; it receives 600 to 900 mm per year.

When Nelson retired in 1988, he used his retirement package to rehabilitate the farm. With his family, he repaired the gullies to check soil erosion. Nelson collected wildlings to start a tree nursery. He also installed a roof catchment to harvest water for his seedlings. Within 7 years, he had planted over 1,500 trees for soil conservation, shade, fruit, timber, firewood, and as source of seeds. Florence started a business to produce fruit juice, which she sold to local schoolchildren. The family expanded their orchard by adding improved varieties of oranges and mangoes.

Encouraged by their success with the tree farm, the Nyangiles diversified their activities. They set up a tailoring shop and poultry project. Several school leavers received training in tailoring. The Nyangiles also went into organic farming, growing vegetables, potatoes, pineapples and groundnuts.

Word about the Nyangiles' success spread. Neighbours, other farmers, government officials and non-government organization staff visited the farm. They were impressed with the Nyangiles' innovations, and the Kenya Forestry Research Institute awarded Nelson a prize. He decided to transform his land into a demonstration farm where different organizations could send people to learn how to manage natural resources in a sustainable way.

In 1995, the Nyangiles started a community-based organization called Lower Midland Zone Agro-forestry services (Lomizone). Lomizone trains farmers and youth in soil and water conservation, seedling production, organic farming, pest control and agroforestry. It also offers training in carpentry and joinery, knitting and brick-making.

ment, perhaps; pride in the recognition their work gives them; a desire to serve their communities; religious conviction; a willingness to learn and share.

Innovators can be engines for growth and change in the community and beyond. Recognizing and documenting their innovations, and sharing them more widely, can provide an effective, locally adapted, farmer-to-farmer extension service. Outside organizations can support their initiatives in various ways:

- Competitions that recognize outstanding work with prizes and certificates.
- Training for potential innovators and imitators.
- Video or audio interviews with innovators, to be shared with others.
- Provision of seed capital, grants and loans to boost exposure of successful initiatives.
- Study visits by schools.
- Identification, development and promotion of sustainable packages to motivate innovative farmers without creating dependency.
- Support through networking and appropriate information and communication services.

Growing maize in sand deposits in Tanzania

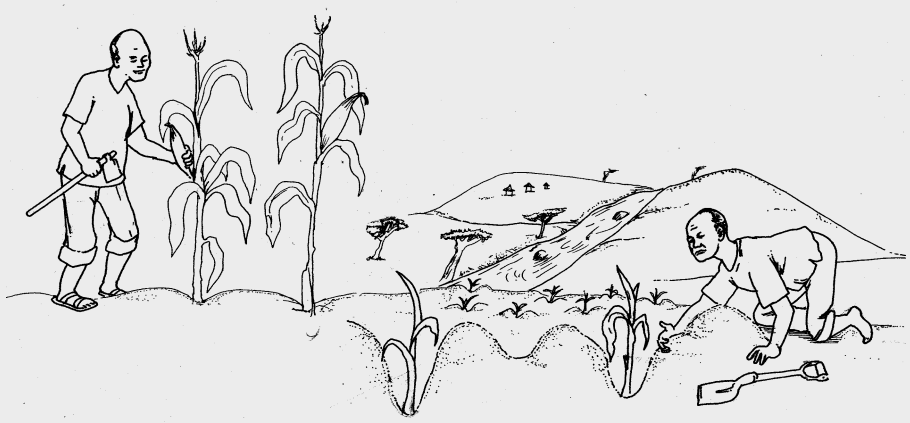
In 1998, torrential El Niño rains caused havoc across eastern Africa. Swollen rivers flooded many farms. When the waters receded, large tracts of land were covered with heavy deposits of sand.

Flumence Vincent was among thousands of farmers affected in semi-arid Kondoa District in Tanzania's Dodoma region. Almost half of his farm had been covered with sand by the fast-flowing Bubu River.

Vincent dug into the sand in an attempt to reach the soil. He reached the soil at a depth of about a metre, and discovered that although the surface was dry, the sand underneath was moist. But he had no way of removing the vast amount of sand from his farm.

He decided to experiment with growing maize in the sand. He dug several pits deep enough to reach the soil. He then planted maize. As the seeds germinated, he returned the sand little by little into the pit. He repeated this process until the maize was above the ground level. To his surprise, the few plants produced a good yield. The following year, Vincent planted more maize. The yield was equally impressive. Encouraged by the result, other farmers started to copy him, and today more than 600 farmers have adopted the technique.

—Patrick Lameck



Field days, demonstrations, fairs and exhibitions

Various events can be used to introduce improved technologies to farmers. These range from individual demonstrations, through field days for a few dozen people, to large fairs and agricultural shows with thousands of visitors.

Community organizations hold field days where farmer-extensionists and group members can demonstrate technologies that are useful in the area. Typical topics include water harvesting and moisture conservation, farm implements, planting techniques, new crop varieties, and pest-management methods.

These events are planned well beforehand – before the beginning of the planting season. The field day is held on one farmer's land; the farmer may be proud to host the event, so may not require any payment. Demonstrations of various technologies are sited at various places around the farm. On the field day itself, farmer-extensionists demonstrate the various technologies to the visitors and answer questions. The visitors can try out the techniques themselves and can make up their minds whether to use them on their own farms. They can even arrange to get seeds of new varieties after the harvest.

The villagers are often pleased to invite government officials and NGO staff to these field days. This publicizes the villagers' efforts, and the officials can help promote the successes in other areas.

Fairs and exhibitions are larger-scale events with thousands of visitors, lasting several days. They are usually organized by local governments or NGOs, and feature a larger number of technologies. Research and development organizations are often involved in planning these events. The larger fairs are attractive venues for local companies to demonstrate farm equipment, promote inputs and offer their services. However, most of the stands rely on portable exhibits rather than live demonstrations, and farmers observe rather than participate.

Field days in Kenya

The Locational Management Committee, a community organization in Rachuonyo near Lake Victoria, organizes seasonal field days for up to 200 local people. Group members demonstrate fast-maturing varieties of maize and other crops, pest-management methods, and techniques such as water harvesting. Watermelons, pineapples and bananas are some of the new crops that have been introduced through the fairs.

—Loice Omoro

A visit to the market

Farmers in Homa Bay, Suba and Rachuonyo districts in Kenya often grow kale and tomatoes. Desperate to sell, they accept the first price the buyers offer.

CARE–Kenya took a group of growers to several markets in Kisumu, the largest town in the province. The farmers met with traders and discussed prices and the source of produce being sold. They learned how the transport and marketing was organized, and consumers' preferences for different types of produce. They also found out about the seasonal demand for crops, and which crops fetched the best prices.

The group realized that indigenous vegetables such as *Solanum nigrum* and spiderweed fetched better prices than kale. They also realized that they would have to grow and market their produce as a group. This was so they could collect a large enough amount at any one time to cut transport costs and make the sale profitable.

One group of growers has created a marketing association to do this. This association can negotiate better prices for produce than any one farmer could alone. The association also allocates certain vegetable types to each grower to diversify their production.

—Loice Omoro

Cross-visits

Farmers in different places face similar problems, but may find different solutions to them. Techniques that work in one place might also be successful somewhere else. Farmers from one area can learn an enormous amount by visiting other farmers, seeing for themselves, questioning, and trading ideas.

Farmers do this anyway when they visit their friends and relatives, or when they travel to other areas. Development organizations can help facilitate this process by identifying promising technologies, helping farmer groups get in touch with each other, and by arranging transport. The group that travels may be able to pay for at least some of the costs: meals, accommodation and vehicles.

The visits are productive for both visitors and hosts. The visitors see a new area, learn the problems their hosts face and how they deal with them, and can take seeds and other planting materials back home (though this may be a problem if it helps spread diseases). The hosts also gain: they can learn how their visitors deal with the same problems. A visit is highly motivating for both.

Visits need not be only to other villages. Groups may visit research institutes, demonstration farms and markets.

Farmer field schools

Farmer field schools are schools without walls. A group of farmers meets regularly to study their crops or livestock, discuss what they have learned, and try out new ideas. The field school approach was developed in Southeast Asia to help

farmers learn about integrated pest management in their rice fields. It has since spread to Africa, where it is also being used for integrated pest management, soil fertility, and livestock diseases and management.

The field school approach draws on the wealth of knowledge and experience that farmers have. A group of 10–20 farmers decides what subjects they want to study. The farmers learn by observing, discovering and doing – not by listening. The role of the extension worker is to help them learn, to ask questions, coordinate and facilitate – not to lecture or run demonstrations.

In integrated pest management, for example, a field school lasts an entire crop season, from land preparation to harvesting. The farmers meet every week, observe and capture the pests in the field and keep them in jars as 'insect zoos'. They draw pictures of them, and watch what they eat – and which insects and spiders eat them. They observe what happens to both pests and natural enemies when they are sprayed with insecticide.

In this way, the farmers gain a deep understanding of the ecosystem in the fields; they learn which insects are pests and which are beneficial, and they discover how best to manage pests on their crops. They also learn about many things other than pure pest management: crop development and physiology, agronomic methods, the characteristics of different crop varieties, soil fertility, handling of pesticides and health issues, and economic management skills.

Based on manuscripts by Loice Omollo and Maina Njoroge

Land-use planning and titling

A village land-use plan is a map showing the settlement and its surrounding area, the roads, rivers and water sources, and the way that the villagers would like to use the land in the next 3–5 years. The plan also details how the villagers will go about putting these intentions into practice, and a set of rules and regulations governing activities. It is not just a set of documents: it represents the villagers' commitment to improve their land use in a way that they themselves decide.

The land-use plan allocates land, water and grazing areas to specific uses. This has two main benefits:

- It helps local people manage their resources rationally, so raising productivity. Controlling cutting and browsing of trees allows forest areas to regenerate. Allocating separate areas for grazing prevents livestock from damaging crops. Soil-conservation measures and pasture enhancements raise the yields of crops and livestock. Building a dam improves the water supply.
- It helps prevent conflicts over land and improves the community's security of tenure. Formal government recognition of the plan prevents outsiders from appropriating land. If such conflicts are not resolved, some or all community members suffer.

Land-use planning works best where communities are settled and where villagers work harmoniously with their leaders and local government. Unfortunately, it is far more challenging to apply such land-use planning methods to mobile pastoralist communities, although it is not impossible.

Developing and implementing a plan is expensive. In Tanzania for example, it costs about TSh 1,500,000 per village ($US 2000 for an area of about 15–20 km^2). Finance for preparing the plans normally comes from international donors or a development agency.

The planning process

A development organization can take the following steps to help a village develop a land-use plan. These steps are based on an approach used by the Handeni Integrated Agroforestry Project in Tanzania.

1 **Situation analysis** The organization helps the villagers analyse their present situation, using maps drawn on the ground. They assess the status of their natural resources and identify the five most important problems.

2 **Village land-use planning committee** The villagers form a committee to manage and implement the planning process. Technical staff from the organization and government extension workers train and assist the committee.

3 **Technical data collection** Guided by the villagers, a team of specialists

gathers technical and social data on the village, its people and the land resources. They collect these data through survey questionnaires, interviews with knowledgeable individuals, and direct observation. They also examine official statistics, maps and aerial photographs.

4 **Issue-based workshop** The technical staff facilitates a meeting of the committee to discuss issues such as water sources, vegetation cover, infrastructure, soils, the existing land use, and livestock husbandry. This committee drafts an initial land-use map showing initial agreements on land use. It is important that the committee be the main authors of this, as they must see it as the result of their own efforts.

5 **Decision on land uses** The committee submits its recommendations to the villagers as a whole. It is the villagers who make a final decision on the uses of particular areas of land. Some may decide to visit certain areas to check for themselves. The decisions are then transferred to the master land-use map.

6 **Land and water development plan** The committee uses the land-use map and the technical data that have been collected as a basis for a detailed land and water development strategy. This shows how to increase the productivity of each area delineated in the land-use plan. It gives guidelines of how this is to be done over the next 2–5 years. The technical team helps make sure that the strategy is based on sound principles of watershed management to ensure sustainable use of the land, water, vegetation and livestock resources. The strategy should also take into account future needs, for example by setting land aside as a grazing reserve.

7 **Rules and regulations** Formal and informal village leaders develop bylaws in order to enforce the agreements that have been made. A village general assembly endorses these bylaws and forwards them to the local government for approval.

Villagers developing land-use plans

A successful plan in Nkama

People in Nkama, a village of about 3000 people in southwestern Handeni District in Tanzania, developed a land-use plan in 1995. They allocated land to crops, grazing, water catchment, forestry and housing. For their cropland areas, they applied *fanya juu* terracing (a type of soil-conservation measure), cut-off drains, hedges of vetiver grass, check dams, and proper cropping practices. They planted legumes and perennial grasses to improve pastures, and constructed boreholes and earth dams. They provided watering troughs for livestock, and planted local species of trees. They dug trenches on slopes to trap water and reduce erosion. For their residential areas, the villagers aligned their houses to optimize the use of space. They planted grass and trees to check erosion and as a source of animal fodder.

Most of these efforts to implement the land-use plan were successful. The conserved forest increased the village water supply. Bush fires have decreased by 80% because of the strategic locations of grazing, forest and croplands. Trees planted around houses and farm boundaries supplied much of the fuelwood. This has reduced cutting of trees in the forest. A reservoir has been stocked with fish, and maize yields have increased by over 50%. Conflicts over land have disappeared.

Encouraged by such successes, the Tanzanian government issued a decree in 1999 promoting the development of village land-use plans.

8 **Approval of final plan** The plan must be approved by the village general assembly before it comes into force. The final plan consists of:
   - A village map showing agreements on land use.
   - A detailed land and water development strategy.
   - A copy of the agreed bylaws.

9 **Annual work plan** An annual work plan can then be developed. This specifies who is responsible for each activity, dates and locations, the resources and technical assistance needed, and tasks to be accomplished by certain dates. The technical staff help the villagers make sure this plan is realistic, but by this time, the villagers are more confident in their own abilities and can take on an increasing amount of the planning and implementation themselves.

10 **Implementation** The villagers then implement the annual work plan. The technical staff help them by providing technical advice, inputs or funds.

11 **Monitoring and evaluation** The villagers monitor progress and conduct an evaluation at least once a year. This allows adjustments to be made as required. Major changes require the agreement of the village assembly.

Land titling

In Tanzania, attempts have been made to sustain common property resources of pastoralists (particularly the Maasai) through village land-titling. The government recognizes that pastoralists are mobile and need a lot of space to survive. But

Land-use planning and titling

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7 At the time of titling, the village council registers the village residents. Along with the title deed, this village register is an effective mechanism to monitor and control immigration of outsiders.

Attempts to acquire water rights jointly or individually have failed. Water resources remain a common-access property. Communities need to coordinate cross-border pastures and water sources so that various users can have free access.

Based on manuscripts by Anase Kajias and Ole Lembulung Kosyando

Savings and credit

Farmers need credit to bridge financial gaps that they cannot overcome themselves. Examples are before planting so they can buy inputs, after a drought so they can rebuild their herds, and for medical emergencies.

Savings are important in relation to credit. They are needed as security to obtain a loan, and to sustain the activity after the credit has been paid back.

Savings demonstrate a person's capacity to mobilize his or her own resources and to plan ahead. They give a feeling of pride and self-esteem, and they make the person more independent. Poor people are often able to save more than outsiders may think.

Traditional savings and credit

Savings and credit are not new in the drylands. People have saved and loaned money to one other for a long time. This takes various forms:

- Elders' saving groups (for funeral expenses).
- Local groups with their own capital, loaning money to other villagers.
- Merry-go-round groups to meet personal needs.
- Local moneylenders for immediate needs. They usually charge high interest rates, but using their services is easier than going to the bank.
- Borrowing from relatives, friends or from people in high-potential areas.
- Savings in the form of jewellery, livestock and other assets that can be sold.

When designing savings-and-credit schemes, development agencies should learn from these traditional mechanisms. The introduced schemes should complement existing mechanisms rather than replace them. They should satisfy financial needs that cannot be met either by traditional means or by a bank loan. Banks ask for collateral, such as property title-deeds, which most poor people do not have. Although banks may be interested in helping poor farmers, their business guidelines prevent them from doing so.

Beneficiaries of credit schemes

With assets in the form of livestock, pastoralists are generally better off than crop farmers. They save automatically as their herd grows. They can easily sell animals to get cash. They have their own credit mechanisms involving exchanges of animals with relatives and friends (see *Restocking livestock*, page 144). For these reasons, pastoralists are usually not targeted by savings-and-credit schemes.

For various reasons (drought, disease, rustling, poor management), some pastoralists no longer have animals, and they are not likely to return to pastoralism. These

'destitute pastoralists' need new sources of income. They may need credit to help them find these.

Crop farmers are a second group who are frequent beneficiaries of credit schemes. They need credit because they are not able to save enough to pay for sudden needs or for new activities. But loans may not be appropriate to support crop production in drought-prone areas as there is a high risk of crop failure, forcing the borrower to default. Overall, there are fewer opportunities for development institutions to lend for agricultural purposes in the drylands than in high-potential areas.

Financial instruments

The word 'credit' covers a broad range of financial instruments, and is used by different people to mean different things. We can distinguish between loans (which must be repaid) and grants (which do not). Loans may be repaid in full or in part, with varying levels of interest, at one time or in installments, and over different time periods. The lending (or granting) institution may or may not require collateral, and may impose restrictions on how the money can be used (e.g., for economic activities or to cover emergencies). The lending institution may have a social and developmental agenda, or it may be profit-oriented. It will set conditions under which a loan is forgiven or written off (e.g., if there is widespread drought).

Both loans and grants can be in cash or in kind. Loans are often given in the form of animals (with repayment in the form of the offspring). Grants are often in the form of food (e.g., as emergency relief), though it is relief agencies rather than financial institutions which usually provide such assistance.

Other instruments include subsidies, seed money, social loans, development or investment funds, micro-credit and micro-finance. It is important to distinguish these different instruments clearly. Each fits a particular type of activity. Some of these are discussed below.

Loans

Because of the high risk of default, loans should be used mainly to support viable, productive activities with proven benefits for the borrower. Dryland crop farming, such as purchases of seeds, fertilizers and other inputs, is often too risky to be financed through loans. An example of an inappropriate loan scheme is one where agropastoralists in Borana, Ethiopia, were encouraged to take credit for fertilizers. When the harvest failed because of lack of rain, they fell into debt, and were worse off than before.

Loans are better suited to non-cropping activities such as trading or micro-enterprises, or small, privately owned irrigation methods such as bucket drip-irrigation kits that will make cropping more profitable or sustainable (see *Drip irrigation*, page 104).

Infrastructure grants

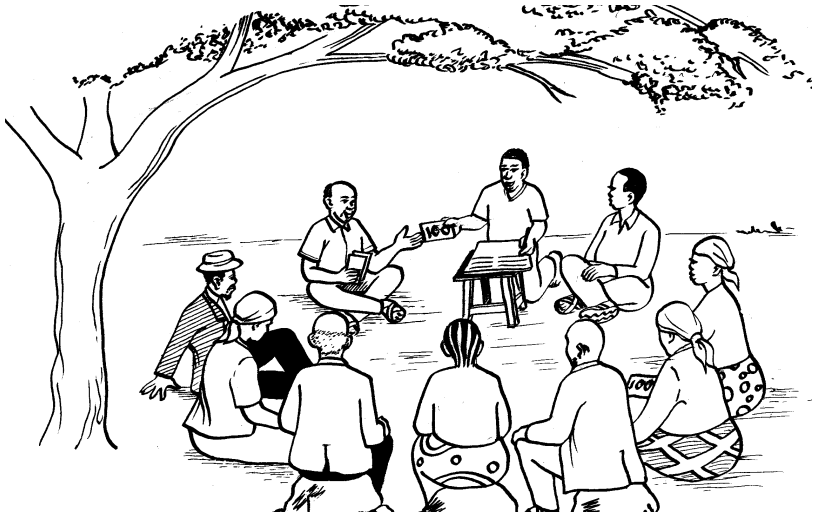
Grants can be used to build roads, bridges, schools, water points, community latrines and similar projects. They could also be used for soil- and water-conservation structures or community irrigation schemes. Such infrastructure is often vital to ensure the success of enterprises financed by credit. The grant is given to the community and will not be repaid. The community typically contributes labour and materials rather than cash. Once the project is completed, the community is responsible for operating and maintaining it.

Experimental grants

Grants can be used to stimulate new types of activity. Experience may be lacking, and it may not be certain that the activity will be successful. It would be unfair on the borrower to require full repayment.

For example, a group of dryland farmers may agree with a development organization to buy and test a breed of goats from a different region. The organization gives a grant to the group; the group selects a member who is loaned a female goat and cares for it until it produces offspring. The kids are then passed on to another group member, while the caretaker becomes the owner of the original animal. Each recipient must in turn pass on a kid when their goat gives birth. The organization often provides support in the form of training and supervision. See *Restocking livestock* (p. 144) for details.

Such a scheme enables other interested people to continue the activity if it proves to be successful. If it fails, the development organization writes the idea off; if it succeeds, the organization may consider extending it via a credit scheme.



Community savings and credit groups can manage small amounts of money efficiently and in a transparent way.

Two-tier schemes

Grants and loans may be combined in a two-tier system. A frequent approach is for a development agency to give a large grant to an intermediary organization. This organization then organizes groups of people in the community. Group members can apply for a small loan, and their application is vetted by other members of their group. The other group members cannot borrow until the loan has been repaid, and if the borrower defaults, they are collectively responsible for repaying. Peer pressure is a very effective way of ensuring repayment. The intermediary organization uses the interest from the loans to expand its lending activities.

Micro-credit

Micro-credit is often used to satisfy smaller financial needs, be it for direct consumption or for production. In most cases savings are used for this purpose: group members pay into a common fund, which can be loaned out to members as required. The precise rules for this use can be decided upon by the group. A certain saving discipline is needed.

Micro-finance

Micro-finance institutions are a relatively new phenomenon. They are organized along the same line as formal banks, and form a link with them. Like banks, they have strict rules for who they will give loans to, and under what conditions. They differ from banks in that they lend much smaller amounts, and have different collateral requirements. They differ from savings-and-credit schemes because they lack a social dimension: they do not provide grants or extension support, and do not cater for community-oriented needs.

Savings-and-credit institutions

Most savings-and-credit schemes share a number of crucial features. Foremost, all deal with organized groups. These groups must have a bank account, a track record, and active savings to sustain the activity when credit stops. They must have rules and regulations, be able to formulate viable proposals for small businesses or micro-enterprises, and properly record their activities and accounts.

Savings-and-credit schemes need to have proper arrangements for securing their loans. They provide borrowers with training both on production techniques (such as how to raise goats) and on financial management. This helps the borrowers repay their loans and learn to deal with the financial world, and makes the credit scheme more sustainable.

To remain solvent, a lending organization must charge interest on loans. This interest is used for three main purposes: to cover defaults, pay for administrative expenses, and expand the amount of money available to lend. Lenders who do

not charge enough interest will see their capital decline, and it will be unable to continue lending. In fact, once the lender has calculated the interest rates needed to cover these costs, the rates are not very different from those charged by commercial banks.

Credit schemes (and moneylenders) are attractive for borrowers because they make it easy to borrow money. The borrower does not have to travel to the bank branch in town, and does not have to offer collateral. The interest rate may be secondary to this ease of access.

Lending institutions need to have appropriate, flexible, but clear repayment rules. Repayment is in the interests of the lending institution, borrowers and savers. If the lender runs out of money, borrowers can no longer borrow, and they will lose confidence in the lender's ability to help them. Savers must be confident that their

Savings and credit in Kwale District, Kenya

The Kwale Rural Support Programme (KRSP) has established a savings-and-credit scheme for communities in Kwale District, Kenya. The scheme operates through a series of village development organizations, each controlled by its members.

The savings part of the scheme has two components:

- **Personal savings** paid by individual members. The individual holds a passbook that records how much he or she has contributed into the village account. Personal savings help build an individual's financial base and provide financial security.
- **A village development fund**, built through contributions agreed by the members, and pooled as a common fund. Three other sources of income for this fund are the fees charged by the village organization for services to members, matching funds provided by KRSP, and interest on the credit provided to members.

The credit part of the scheme has four components:

- **Agro-credit**, provided to the village organizations for on-lending to their members. Examples are credit for land preparation and buying seed.
- **Business credit**, used to support small enterprises.
- **Technology grants** given to the village organization, which then loans money to its members. A technology grant aims to support the introduction of new technologies.
- **Infrastructure development grants** This supports the construction of community water resources and rural access roads.

The pure credit extended to the village organizations earns 18% interest per year. Of this, KRSP keeps 15% to build up the loan fund; the village organization keeps the remaining 3% to build up its development fund. The loan scheme is supported by intensive training. Members can repay in cash or in kind.

In a related programme, KRSP supports beekeeping to help villagers raise money. It has introduced two types of improved hives, and has made arrangements with Honey Care Africa, a private company, to market the honey.

The savings-and-credit scheme builds the capital base of the villagers through regular savings. It is the glue that holds the village organization together because it requires members to meet regularly to pay in money and discuss management issues.

—Peter Otinda

money is being managed properly, and know that they can withdraw it if they need to.

Because droughts and other emergencies affect large numbers of people, many are likely to default at the same time. The lending organization cannot afford this: it will either have to raise its interest rates, or become bankrupt. To survive, it may need a bridging loan or insurance to cover the period of shortfall.

Compared with banks, savings-and-credit schemes have different and often more flexible arrangements. These may include enabling people to pay back in kind (in goats or grain rather than in cash), and adjusting repayment schedules in case of calamities.

Each scheme needs to develop its own procedures for group selection, savings rates and methods, lending methods, interest rates, repayment rates and timing, default procedure, type of activities eligible for loans, etc. The procedures need to be flexible and follow local conditions and practices. Flexibility does not mean lack of firmness, though: if farmers think they can default on their loans without penalty, they may be less careful about how they use the money. If they see others defaulting and getting away with it, they may do the same.

Problems

Savings-and-credit schemes are confronted with a number of problems and constraints.

- **Funding of unviable activities or enterprises** The borrower may lack a viable business plan, and the credit scheme may not detect its flaws. This leads to an underestimation of the risks involved.
- **Poor assessment of needs** by the group or community.
- **Lack of support** The borrower may need training and technical support in order to succeed. The credit scheme may not be in a position to provide this.
- **Bad timing of loans** This holds especially true for agricultural loans, where proper timing for the season is crucial.
- **Social obligations of the borrower** Someone who has money may be expected to support relatives, pay emergency medical expenses, and cover various other costs. It is difficult for even the most diligent of borrowers to resist such obligations. People with less integrity may use the money in less responsible ways.
- **Misuse by the borrower** of the position of the lending institution. The loan is seen as 'easy money'.
- **Emergencies** or unforeseen personal circumstances.
- **Lack of training** of office bearers in the community groups.
- **Lack of information** to the borrowers about the conditions they must fulfill.
- **Lack of management capacity** in the lending institution.
- **Corruption** among the credit-scheme management.

When considering a credit scheme…

- Check whether credit is the basic input that is lacking.
- Study local credit mechanisms that are still functioning, and build on them.
- Assess the amount that can be saved, and stimulate people to save.
- Make a clear distinction between viable, productive activities on the one hand, and social development projects on the other.
- Make realistic judgments of the risks involved.
- Be flexible in procedures for grants, but don't compromise on procedures for loans.

These problems may lead to:

- **High default rates**, leading to quick depletion of the loan capital.
- **Returning loans** without using them. Someone who borrows a large sum but does not invest it in productive activities is using money that could be lent out to someone else. This is known as 'dead capital'.
- **Loss of confidence** in the savings-and-credit scheme.

If unchecked, these problems is may lead to the collapse of the scheme.

Some solutions

Here are some ways to stimulate a more effective use of credit, leading to better repayment rates.

- **Critically evaluate** each group of borrowers' assessment of its needs.
- **Analyse the viability of the proposal strictly**, assessing the risks involved. Realistically consider the risk of drought and its effect on repayment.
- **Identify existing social institutions** that can provide peer pressure to ensure repayment.
- **Improve the scheme's professional standards.** Account carefully for capital flows.
- **Change borrowers' attitudes** towards the scheme. Organizations which combine social development efforts with the running of a savings-and-credit scheme may confuse the two. One solution is to separate the social development and credit functions into two different institutions (see below).

Additionally, the savings-and-credit scheme may:

- **Implement its own activities** to generate income, and create a risk-management or reserve fund. Such a fund might also be created by adjusting interest rates on loans.
- **Raise funds** from donors or other sources.
- **Plan how to deal with drought**, when many defaults can be expected. The plan should include guidelines on how to deal with defaulters (forgiveness of loans, extension of repayment period, freezing of interest, etc.) as well as maintaining the solvency of the institution itself (e.g., through risk insurance).

Separate institutions

Donors have emphasized the need for specialized credit institutions, separate from social development organizations. In their eyes, credit schemes need to be run by professionals. This is to guarantee the quality of their services, so that they will be able to serve borrowers in the future. Such credit institutions should have a strong capacity to assess proposed projects, so minimizing the risk of default.

This does not imply that social development based on community needs is excluded. But it should be run by an organization different from the one providing credit. The social development organization should be in direct contact with the community, and jointly plan and implement activities to stimulate community development. The social development organization should have its own funds to implement community projects, improve infrastructure, and undertake experimental activities. But it should normally fund these activities on a grant basis.

If economically viable projects have been identified, the social development organization can ask the credit institution to provide loans. The community and the two organizations can then negotiate terms that are acceptable to all.

Based on manuscripts by Ben Haagsma and Peter Otinda

Economic diversification

Although livestock are the backbone of their economy, pastoralists have always utilized other natural resources as well – to earn extra money, supplement their diets, treat diseases, construct buildings, and use for cultural purposes. The contribution of these other resources may seem negligible compared to livestock, but it cannot be ignored. In times of drought they may even become fundamental; they are one of the ways pastoralists are able to cope with drought. For pastoralists who adopt a sedentary lifestyle, these resources provide an increasingly important contribution to the household economy.

For pastoralists, crop farming is a form of diversification. Its importance depends on the dryness of the area and the presence of water. Pastoralists have developed various ways of farming using clever water management methods: water harvesting, small-scale irrigation and flood-recession agriculture (see *Rainwater harvesting*, page 111).

Faced with a high risk of crop failure, crop farmers constantly look for extra income opportunities. Many of them seek out the same opportunities as the pastoralists, but they are often in a weaker position because they are less flexible and have less disposable capital.

The types of activities vary widely from place to place. Success cannot be guaranteed. When promoting livelihood options, it is important that local people identify the possibilities. They have the best knowledge of their surroundings and will have useful previous experience.

Even after an opportunity is identified, it may not be easy to exploit it. Two particular concerns are the market situation, and the low or variable quality of products. Before an initiative is supported, the market should be studied carefully and the potential assessed to avoid disappointment.

Wild plants for food

Dryland peoples have always gathered wild plants for food. Fresh leaves can be picked during the rainy season; dried leaves, fruits and seeds can be found in the dry season. Children often pick and eat fruits while they are herding cattle.

Many kinds of fruits grow in reasonable quantities, they are often found in local markets. Studies could help communities identify potential markets for such produce. Better varieties might be introduced if the existing ones are inadequate.

Medicines

Local people frequently use medicinal plants to treat both humans and livestock. In remote areas, medical and veterinary services are scarce, so traditional practi-

Organic herbs for export

In Tharaka district in eastern Kenya, the Nghuru-Gakirwe Water Irrigation Project has started growing herbs for export. The herbs are grown organically. Carcade is made into juice or jam, while camomile and lemongrass are used to flavour tea. There are no local markets for these products as they are not well known in Kenya.

The farmers grow the plants and bring them to the processing plant. The produce is graded and dried in the sun, then either packed as whole plants, or ground and packed into teabags before it is exported.

Production has proven popular as the plants are easily grown, and the methods of organic farming are easily understood. The land used must isolated and fenced off from other activities, and located on the windward side of other farmland. Only other organically grown crops may be grown on the land in rotation.

tioners deal with most cases. These practitioners know how to identify medicinal plants, and how to prepare and to apply medicines. Traditional medicines are also sold on the local market. Demand for certain plants may be so large that the plants are over-exploited and become scarce. The supply might be maintained through cultivation or conservation efforts – for example, raising seedlings and cuttings and distributing them to local people to cultivate.

The identity of many medicinal plants is already known, but much remains to be studied: their efficacy, mode of action, standard dosages and processing techniques. Collaboration between professionals, local healers and entrepreneurs is required if they are to be commercialized for the benefit of dryland peoples.

Some plants that have been studied include *Aloe vera*, *A. secundiflora* and *A. turkanensis*, which are used in medicines and cosmetics. Production has been tested and markets assessed for these species. *Lawsonia* trees produce henna, also used as a cosmetic.

Others species that could studied are *Toddalia asiatica* (sold as a remedy for brucellosis in humans), *alkokola* (its Maasai name; used to treat stomach problems and venereal diseases), and *endepelikwa* (another Maasai name; used to treat headaches).

Gums and resins

Gums and resins are very important for the local economy. Gum Arabic (*Acacia senegal*) is widely known and is exported. Trees in northern Kenya produce very high-quality gum; those in the south produce a poorer product. Pastoralists collect the gum while herding their animals. Their frequent movements mean the collection of gum, and hence the supply in the market, are irregular. Another problem is the varying quality, which varies from tree to tree, and with the han-

Elangata Wuas Ecosystem Management Programme, Kenya

Three Maasai communities in Kajiado District have started businesses based on using local resources in a sustainable way. The businesses aim to appeal especially to women and young people. With help from the Centre for Biodiversity of Kenya and the Kenya Wildlife Service, the local people have started the following activities:

- **Ostrich farming** The birds are herded with cattle. Women use the feathers to make brushes.
- **Guinea-fowl raising**.
- **Ecotourism** Two base camps have been established, with sleeping, dining and meeting facilities. The camp programme offers nature walks, camel safaris and game drives.
- **Charcoal production** This is based on low-intensity harvesting of trees. Each family can earn about KSh 3400 per month from selling charcoal at the roadside (see box on the next page).
- **Beekeeping** This was new for the Maasai. The modern Kenya Top Bar Hive has been introduced.
- **Handicrafts and beadwork** Traditional beadwork fetches low prices, so new designs are being tested.

dling method. To improve production and commercialization, attention to local variations in yield and quality, improved planting stock and sound methods of gum production and handling are needed.

Other valuable products are myrrh (from *Commiphora myrrha*) and frankincense (from *Boswellia* sp.).

Wood and charcoal

Where trees abound, they can be exploited by careful harvesting. Charcoal burning can be managed sustainably by proper care in cutting.

Communities or individuals can establish tree nurseries and woodlots to produce various products: tree seedlings for sale, fuelwood, charcoal and poles.

Handicrafts

The wood of some dryland trees is valuable. Ebony (*Dalbergia melanoxylon*), for example, can be used for carving, and can be cultivated to ensure sustainable supplies. Acacia thorns can be picked and boiled to make toothpicks, but additional work such as beading is necessary to make them attractive for sale.

Dryland people can make handicrafts for tourists and for export, but the markets are limited and subject to the vagaries of fashion, and prices for producers can be low. Marketing studies are required to identify opportunities, and linkages with wholesalers, retailers, exporters and importers are vital. Local people must develop skills to create and package the types of products that customers will buy.

Sustainable charcoal production

One component of the Elangata Wuas Ecosystem Management Programme in Kajiado, Kenya, has been to develop sustainable charcoal production. The programme identified the high demand for charcoal in Kenya, and assessed the potential for producing and marketing charcoal in the Elangata Wuas area. The most abundant species in the area, *Acacia tortilis* and *Balanites*, make the best charcoal.

A self-help group, known as the Sustainable Woodland Management Unit was organized. It was registered with the authorities and opened a bank account. Members are divided into four blocks, each of which has an area to collect charcoal and people assigned to manage the depot. The group members pay a registration fee of KSh 200, and contribute the same amount towards a revolving fund. Sixty members have registered with the unit. Members of each block elect representatives to the overall committee.

The group members are advised on the best tree species and sizes to use, and how many trees can be harvested without depleting the supplies. All members have agreed to harvest using 15–20 year rotation cycle, and to ensure that tree stands regenerate naturally.

Experience has shown that the production and sale of charcoal is a viable, sustainable business in the Elangata Wuas area.

—Meshack Malo

Tourism

In areas with abundant wildlife or natural beauty, tourism offers increasing opportunities for dryland people. It generates income directly for guides and drivers, the staff of hotels, travel firms and safari base-camps, handicraft producers, and cultural entertainers. It generates income indirectly for the people who produce food, service vehicles, construct facilities and supply various other services to the tourism sector.

Various types of tourism facilities exist, ranging from highly capital-intensive luxury hotels to simple camps with tents and minimal facilities. Activities include game watching, hunting and cultural shows. While many hotels import most of what they need from the cities, they still rely on local labour and services. Dryland people can take jobs with firms that serve the tourists, work as independent guides and entertainers, sell handicrafts and food, and establish facilities such as restaurants, shops, and cultural attractions. Community-based wildlife management (see page 190) is one way communities can exploit this income potential.

Ostrich farming

Ostrich farming was practised more than a century ago, but is still relatively rare. The main products are feathers and leather, with meat being of secondary importance. The infrastructure is lacking, with a tannery in Harare but none in East Africa. High fencing is also needed to keep the birds in.

Since 1990, pastoralists have been testing a new, low-cost approach in which they herd the ostriches along with their other livestock. This is possible because ostriches and livestock browse different plants, so do not compete with each other.

Fisheries

A few specialized groups practice fishing. Fisheries are confined to lakes and rivers such as the Omo, Tana and Athi. Fish can be farmed in reservoirs behind larger dams. If the water is seasonal, fish species that mature quickly can be used. However, the supply of fingerlings is difficult, and fisheries may compete with the need of pastoralists to access the few water resources in the dryland areas.

Poultry

Diseases such as Newcastle disease and pneumonia are a major problem in raising chickens. Marketing may also be a problem.

Guinea fowl are more promising. They are docile, forage with chickens, and unlike chickens, are fairly free of diseases and do not depend on commercial feeds. It is possible to collect eggs from wild birds, incubate them and raise the chicks for meat. The supply of eggs can be supplemented with eggs from the wild.

Beekeeping

Interest in beekeeping is growing. Small-scale equipment needed to keep bees and make honey is not expensive. The product is high-value and not perishable. However, local people need training in how to raise bees and produce honey.

Water sale

People who have a metal roof on their house can build a tank to collect rainwater. They can sell surplus water for domestic use.

Minerals

Various mining and quarrying activities take place in the drylands:

- Sand or gravel digging for construction.
- Gold: young men dig in shallow pans, often under very harsh conditions.
- Precious stones (tanzanite).
- Marble quarrying.
- Oil exploration.

Mining and quarrying can have negative environmental effects: they may lower the water tables and cause pollution. Uncontrolled settlements near mines may also damage the environment.

Participatory research

As the name implies, participatory research involves the active participation of all stakeholders in developing and testing technologies to improve agricultural yields and sustainability. The role of farmers is paramount. Participatory research builds upon the indigenous knowledge already in the community and blends it with the researchers' and development agents' ideas and knowledge. It is an interactive, iterative process with learning-by-doing as the central pillar.

Farmers already do research: every plant, every field, every animal in every season is an experiment. Farmers are not blind followers of tradition: they constantly adapt, test and evaluate new ways of doing things. Just as in modern science, some of their discoveries are accidental; others are the result of conscious, systematic experiments. Over the centuries, they have developed sustainable ways of producing food in very difficult conditions. Participatory research taps into the enormous potential of this indigenous knowledge and experimentation.

Participatory research trials are conducted on the farm (in the farmer's fields or using the farmer's livestock). The research is 'client-driven': it tackles problems that the farmers themselves have identified – rather than those that scientists or policymakers may be interested in. The idea for a study may come either from the researcher or from the farmers, or it may emerge from a discussion between the two. Research that is initiated by the farmers gives the researcher insight into the farmers' perceptions, attitudes and needs.

In participatory research, farmers manage the experiments themselves.

Why participatory research?

The trials are managed by farmers, using inputs that they can afford, in their own fields (or using their own animals). This means that if the trials are successful, the technologies will be suited to local conditions. Farmers are likely to accept them readily, and they will spread quickly.

Participatory research may modify what researchers do in their on-station research. It may reveal new problems, or show constraints (such as high cost, risk or labour inputs) that specialized researchers had not previously considered. It may point to new solutions for old problems. It helps make the research more relevant to farmers' needs, and helps researchers achieve field-level impact (an especially important consideration in this time of limited resources).

This type of research is often part of an overall extension programme. The research plots are ideal places for farmer-extensionists to demonstrate to other farmers the methods they have developed. The research farmers may be known as local innovators in their own right (see *Participatory extension*, page 155).

Participatory research has several other advantages over conventional research in an experiment station. The participating farmers and the community as a whole feel they 'own' the results. They learn how to do research in a more systematic way, and may continue to do so after the development organization has pulled out. Because it uses local resources, participatory research may be more cost-effective than conventional research, at least from the point of view of the development organization. Overall, sustainability is enhanced.

It may be impossible to do conventional research on some topics: a problem may be confined to a small area; the research institute may not have the resources to tackle it or may have different priorities. This is particularly true in the drylands, since most research institutions in eastern and southern Africa are geared towards

Some research jargon

Treatment A particular technology you want to test. An experiment may contain two or more treatments. For example, farmers may decide to test three different improved maize varieties. They plant each variety in a separate plot, and apply the same level of inputs on all the plots. Each plot is a 'treatment'.

Control The technology that you want to compare the treatments with. This is often the usual local practice (e.g., the local maize variety, grown with the level of inputs common in the area). By comparing the treatments with the control, farmers can tell whether they yield better.

Replicate A treatment that is repeated in several different plots. A single plot may be attacked by pests or washed away in a flood, meaning that the experiment must be repeated. Planting several different plots with the same teatment avoids this waste of time. It also shows the different results from the treatment on slightly different soil types or locations. Carefully designed replicates (designed by a researcher) are also needed if the results are to be analysed statistically.

Animal trampling in Somalia

A highly visible experiment by Horn Relief, an NGO in Somalia, acted as its own extension agent (see also *Participatory extension*, page 155). Horn Relief identified a barren area of about 2 hectares in Buran village, and fenced it off with thorn bushes. The nearby herders were asked to drive their herds into the enclosure every day after grazing. The animals' dung fertilized the soil, and their trampling loosened the surface, allowing rainwater to percolate in. After 6 months, plants had begun to grow in the enclosure.

Encouraged, the pastoralists soon started making similar enclosures for their herds to trample and encourage new grasses to grow. The practice has since become common in the area (see also *Rangeland management*, page 125).

—Alusala Nelson

high-potential areas. Participatory research may be the only hope of finding a solution.

People who live in dryland areas have a rich store of indigenous knowledge. They can draw on this and blend it with technologies developed by scientists to improve the productivity and sustainability of their farming systems. Participatory research helps draw on and adapt these two sources of knowledge to suit the local situation.

At the same time, other people from high-potential areas are moving into the drylands, bringing with them the crops and farming systems that may not be appropriate for their new homes. Participatory research is an ideal way to help them adapt practices to suit their new surroundings.

Partners in research

Research farmers are key to the participatory research process. They test the technologies on part of their land (or on some of their animals). They are responsible for managing the trials, monitoring progress, collecting information such as pest attacks and yield, and reporting to the community as a whole.

Crop variety trials in Kenya

Certain improved varieties of maize may escape a drought because they mature early. CARE works with farmers in Suba, Rachuonyo and Homa Bay districts in western Kenya to identify varieties that are suitable for local conditions. The farmers manage research trials on their own land. They collect various types of data: they count the percentage of seeds that germinate, the number of days to flowering or tasselling, the number of days it takes for the plant to mature, the number of cobs, and yields. CARE extension staff help them analyse the data and present the results to the community.

The farmers have identified one variety, Lagrotech Early, as the best. They have started producing seed for the community and to sell to farmers in other areas.

—Loice Omoro

Other members of the community may provide labour, tools, seed, manure and other inputs, as well as their own knowledge. They monitor and evaluate the experiments, learning enough to implement the successful methods and spread them to others in the area.

The institute researchers conduct an initial analysis of the farming system to identify problems and potential solutions. They may contribute ideas on promising methods and help the farmers avoid wasting time on useless experiments. They guide the farmers on how to design the experiment and analyse the results, but must avoid the temptation of taking control or designing it with statistical validity in mind rather than the farmers' understanding. The research institute also covers at least part of the risk of doing the research. For example, if some research farmers agree not to spray insecticides as part of an experiment, the research institute should agree to share the costs if the crop fails because of pest attack.

How to do participatory research

It is important that representatives of the relevant groups be involved in the research. Do not conduct research with rich people if the intended beneficiaries are the poor. Likewise, make sure that women are involved if they are among the intended beneficiaries. Local people should be involved throughout the whole process.

There are various ways of doing participatory research, depending how much control the researchers have. At one end of the spectrum, the researchers may try to ensure that the experiments include certain promising technologies developed by a university or research institute, and that the design produces data that can be analysed statistically. At the other end of the spectrum, researchers may not be involved at all: the farmers or a community organization may decide to do research on their own, and if necessary call on an NGO or extension agent to help them (for instance, to get seeds of new varieties to test).

The procedure below describes an approach in the middle of this spectrum. The steps are in rough order; it may be necessary to do some steps at the same time or to repeat them.

Criteria for choosing research farmers

Farmers in Kibwezi, in Kenya's Eastern Province, working with the ARIDSAK project agreed on the following criteria for research farmers:

- Own land legally
- Cooperative
- Hardworking
- Accessible to all
- Within reach of the other farmers who selected him or her.
- Good teacher
- Welcoming
- Creative
- Honest and humble

—Qureshi Noordin

Improved fallows in western Kenya

Poor soil fertility is a major factor causing low crop yields in western Kenya. The low fertility is a result of continuous cropping, inadequate use of organic and inorganic fertilizers, and soil erosion.

Together with local farmers, researchers from Maseno Regional Research Centre developed some agroforestry methods to improve the soil. Farmers visited researcher-managed plots at the Maseno centre. They evaluated the technologies and chose some to try out. One that caught their eye was the use of fast-growing leguminous shrubs such as *Sesbania*, *Crotolaria* and *Tephrosia* to improve natural fallows. The researchers recommended planting stands of one of these species.

The farmers took planting materials home and planted them on their land. Two years later, the researchers noticed that many farmers were mixing the species instead of planting single-species stands. The farmers said they had seen several advantages from the mixed fallows: yields of crops were higher, and stayed higher for longer, and there were fewer pests. In addition, the mixed stands of bushes produced more by-products: fodder, fuelwood, and nectar for honey bees.

The researchers in turn decided to take up this new approach, and it is now recommended for improved fallows in western Kenya.

—Qureshi Noordin

1 **Problem analysis** Help the farmers list the problems they want to solve. Make sure that the discussion reflects the opinions of all farmers, not just those of a few leaders or of men rather than women. Help the farmers select what they see as the most important problems, making sure that they are stated in a way that there is a potential technological solution. (For example, 'drought' is not a problem that can be solved; 'lack of soil moisture' has several potential solutions, some of which are described in this book.)

2 **Potential solutions** Help the farmers identify potential solutions to the problems. These solutions should draw on indigenous techniques and the farmers' ideas, as well as research findings (suggested by the researchers). Some of these solutions may need to be adapted to suit local needs.

3 **Research plan** Jointly draw up a research plan. For each problem, this should show what technologies are to be tested (the 'treatments', see the box

A mistake, or a valuable lesson?

After a participatory assessment of soil fertility in Tulimani Division, Kajiado District in Kenya, one farmer had decided to use a particular type and amount of fertilizer that suited the soil on his farm. He obtained good yields from his crop. Seeing this, other farmers decided to try the same type of fertilizer. Unfortunately, their soils were completely different, and they got very low yields. They learned the hard way that different types of soil require different types and amounts of fertilizer.

—Edward Muya

Do's and don'ts in participatory research

- Look at the farming system as an integrated system.
- Provide a variety of options.
- Document the results, and the process used to reach them. Video is a useful way to do this.
- Make sure the materials being tested (such as seed) are readily available.
- Don't impose research ideas or solutions from other areas. But by all means suggest such ideas, discuss them with the farmers, and reach consensus.
- Don't try to collect too much scientific data. The process must be controlled by and benefit farmers. Formal analysis is secondary.

on page 184), the local technology that is to be used as a comparison (the 'control'), how they are to be tested, where, when, and by whom (see below). The treatments and their location should be based on the conditions at each site. For example, don't plant research plots on different soil types unless the idea is to test whether the technology is useful on each type of soil.

4 **Selection of research farmers** Explain the roles and responsibilities of the research farmers and the other community members. Jointly set up criteria to select the farmers (criteria suggested by the farmers are more important than those put forward by the researchers). Ensure that enough women and men are represented (where relevant), and that the trials are located over a large (or small) enough area. Also ensure the farmers are genuine representatives of the different farmer categories (poor, average, wealthy), otherwise the results may not be representative (abandoned fields, very weak or very well-nourished animals). Ask the farmers which treatments they would like to try out.

5 **Experiment design** The design should be as simple as possible. Farmers may be used as replicates (a farmer can pick just one technology as a treatment, and his or her neighbour becomes the control). Or there may be two or more treatments on one farm.

6 **Community action plan** Develop a community action plan. This is what binds the people to do the work. Plan how to get the necessary inputs (seed, fertilizer, chemicals, tools, water) when needed. Encourage other farmers to experiment on their own.

7 **Implementation** When the trials are being started, make sure that other farmers also are present, so they can see what is done. While the trials are going on, hold farmer meetings at the different sites for them to discuss the performance and the reasons for any differences. Make sure that the research farmers monitor their trials and keep records.

8 **Training** Building the farmers' capacity enables them to conduct the trials. It also means they can continue experimenting after the research organization has withdrawn from the area. Various types of training are needed throughout the research process. Consider short training courses and exchange visits to other farmer groups and research institutions. Topics may include layout and

management of field trials, record keeping, and monitoring and evaluation.

9 **Sharing results** The research farmers share their findings with other community members and evaluate the results. This is an excellent way of identifying useful technologies and passing them on to others. This forum can also capture any research that farmers have carried out on their own (this could be adaptations, modifications of earlier studies, or new ideas).

10 **Next steps** Help the community decide what to do next. How much progress has been made towards solving the original problem? How can they build on their findings? What research is still needed? What other problems should be tackled? How can the findings be shared with others? Make another plan of action for further research and dissemination (see *Participatory extension*, page 155).

Based on manuscripts by Loice Omoro and Qureshi Noordin

Wildlife management

Wildlife management involves protecting wild animals and plants in their natural habitat. It seeks to strike a balance between the needs of human beings and those of wild animals and plants. It identifies areas that contain valuable wildlife: such as national parks, game reserves, sanctuaries, and forest reserves. These are protected by the government. Communities may often also conserve wildlife in unprotected areas because they find it is in their own interests to do so.

Governments have designated large tracts of drylands as national parks and game reserves. These are major sources of foreign exchange. Parks and reserves are used for ecological research, revenue generation, and tourism. Some reserves have been allocated to individuals for game ranching. Many governments in Africa have created bodies to manage wildlife.

Both colonial and present-day governments have ignored the role of pastoralists in shaping the landscape, or have seen them as enemies of wildlife. This has led to the exclusion of pastoralists from important grazing areas.

Wildlife conservation in Uganda

This section describes the situation in Uganda, which is similar to that in other African countries where tourism is an important economic sector. The Uganda Wildlife Authority manages wildlife in protected areas. It plays a number of roles: formulating policies and plans, coordinating park activities, advocating improved infrastructure such as access roads, water points and tourist-amenity centres, and licensing entrepreneurs who invest in wildlife-conservation businesses.

However, little attention has been given to the welfare of communities who depend on the protected lands. Worst affected are pastoralists, whose grazing lands are reduced. Agro-pastoralists also compete to use land and water. Conflicts erupt among different users, and between communities and the government.

Involving communities in conservation in Zimbabwe

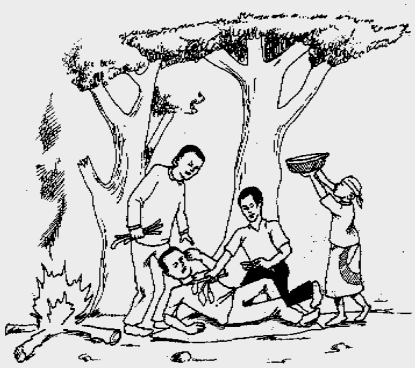
The Communal Area Management Programme for Indigenous Resources ('Campfire') in Zimbabwe is a long-term community-based wildlife management programme. It works with local communities through the rural district councils. The locals are allowed to harvest wildlife products through organized safari hunting. The Wildlife Department also turns culled wildlife over to villagers.

Communities prioritize projects into which money will be channelled on a village-by-village basis. The villages have the final word on how the funds are used. Poaching has been controlled, and the villages have been able to build schools and clinics. However, damage to crops and livestock by wildlife is still a challenge.

—Likani Lebani

Traditional protection of trees in Uganda...

The people of Batagwenda, in Kamwegye District in western Uganda, view African fig and *markamia* trees (*omutoma* and *omusambya*) as sacred. Locals perform rites and rituals around such trees. The mahogany is a legendary symbol of strength and protection. Harming the trees is strictly prohibited because they are spiritual guardians of their communities.



...and in Ethiopia

Trees are protected in Ethiopia, particularly around mosques and churches. Forests are traditional burial grounds, and trees are planted around family cemeteries. Clearing old-growth forests is seen as uncovering the people's ancestors. Old trees are commonly found in Orthodox Church compounds and around monasteries. Eating meat of wild animals is taboo. Such deeply entrenched beliefs have contributed to the conservation of forests and wildlife.

—Tumwine Yasin and Isaac Bekalo

The Queen Elizabeth National Park in western Uganda faces challenges common to many parks:

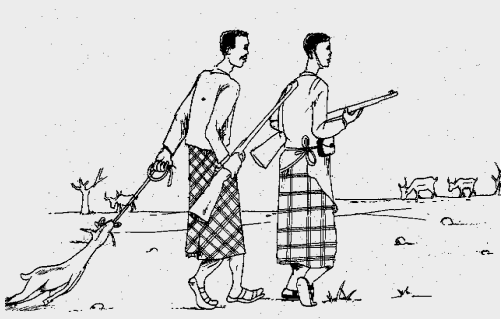
- Land encroachment, unclear boundary demarcation, and tenure disputes involving fishing villages within the Park.
- Crop and livestock destruction by wildlife in and around the Park, with no compensation for the communities affected.

Marauding elephants given a haven

The Mwaluganje Elephant Sanctuary in Kenya was established to protect elephants from people, and vice-versa. The Kenya Wildlife Service trained community-based rangers who are employed in the sanctuary. The Wildlife Service provided the initial capital for handicraft enterprises, and local people operate a craft shop for tourists. The community uses revenue from the sanctuary to fund local development projects.

Sorry, dik-dik's off the menu

The dinker and dik-dik are antelopes which once freely roamed the Buran rangelands. Somalia is one of the few countries in the world with viable populations of dinker. Into the late 1980s and early 1990s, these animals were hunted for meat, and their numbers dwindled drastically.



In 1996, the Resource Management Somali Network of Horn Relief assessed the devastation of wildlife in the Buran rangelands, particularly the fate of the dinker and dik-dik.

Horn Relief organized campaigns to sensitize the communities on wildlife conservation. The local people realized that keeping the animals alive could bring more benefits than hunting them down for meat. Former hunters and other community members banned the transport and sale of antelope meat. A case of foreign poaching was reported. Foreign agents had hired poachers to capture some species of antelopes to boost the dwindling or near-extinct populations in foreign countries; the villagers impounded the poachers' vehicles.

Because the communities realized that conservation pays, they have become more cooperative. Horn Relief has trained former hunters as wildlife-conservation agents.

—Bilal Mohamed Yussuf

- Outdated Park regulations: these have not been reviewed since 1952, and many do not serve the people's interests.
- Strict limits to access by local communities to Park resources.
- Pollutions threats to the Lake George fishery.
- Corruption among Park officials, who engage in shady deals with poachers and entrepreneurs.
- Insecurity caused by Allied Democratic Forces rebels, discouraging tourists.
- Evictions of villagers from parts of the Park, resulting in hostility.

There is no government policy on animals raiding farmer's crops and destroying livestock. People are not compensated for their losses. Some neighbouring communities are hostile to uncontrolled wildlife. Certain wild animals can transmit livestock diseases. Treatment of diseases such as trypanosomosis is often difficult or not available.

Community wildlife conservation

People have adapted to the harsh dryland ecosystem and have for centuries lived with and conserved wildlife. Their indigenous methods of controlling and utilizing the resources have been passed down from generation to generation.

There is an emerging trend away from top-down, heavy-handed nature conserva-

tion to a more inclusive, bottom-up approach to meet the needs of both people and wildlife. Development initiatives can be sustainable only if they are economically viable and nature-friendly. Indigenous wildlife conservation offers a variety of benefits:

- Local communities resolve conflicts more effectively using customary law than through distant courts.
- Locals can help authorities deal with poaching effectively because they are familiar with the territory.
- They can also help control bush fires and emergencies such as disease outbreaks, as their livelihoods are most affected when disaster strikes.
- The community takes pride in a sense of ownership of common resources.
- Individual entrepreneurs or groups can engage in innovative practices such as game ranches, eco-tourism, beekeeping, and harvesting non-timber forest products for medicine, ornamentals and food.
- Pastoralists can graze in parks during droughts.
- Local communities can construct and manage small lodging facilities for tourists.
- Improved tourism provides a market for handicrafts and employment for local people. They work as rangers, tourist guides and hotel staff. Some agencies train communities living near parks in skills such as craft marketing.
- Communities in and near parks use tourism revenue received from the government to build facilities such as schools, health centers and wells. They use park access-roads to transport produce to the market.
- Some governments delegate power to settle disputes to local village councils. This can improve security in the community.

Governments are learning to work more closely with communities near or in parks and reserves. Goodwill and cooperation can be rallied when communities and governments co-manage common resources.

Based on a manuscript by Swaibu Balaba

7
Appendices

Participants' profiles

This list contains profiles and contact information for the participants and staff who compiled this manual.

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John has worked with sustainable agriculture projects for 8 years as an extension worker and trainer. He is currently a trainer and consultant with IIRR on food security and natural resource management.

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Sora holds an MSc in animal sciences from New Mexico State University, USA. He specializes in livestock, rangeland management and desert farming systems. After working for the Ministry of Agriculture for 32 years, he joined the Boorana Lowland Pastoral Development Programme in 1997.

Gerald Ashiono

Research scientist, Kenya Agricultural Research Institute (KARI)

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Gerald has a MSc in agronomy and farming systems from the University of Adelaide, Australia. He has worked with dryland crops for the last 16 years, and is currently co-ordinating the dry highland sorghum and millet programme at KARI.

Swaibu Balaba

Community development officer, Centre for Agricultural Conservation and Community Development

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Swaibu holds a BA in social sciences from Makerere University, and a diploma in public administration. He is a founding member of 'Missing Link', a women's support centre, as well as the Centre for Agricultural Conservation and Community Development.

Isaac Bekalo

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Isaac holds a PhD in organizational development and planning. His work experience include teaching, NGO training, curriculum design and organizational development. He has provided consultancy services on strategic planning, participatory monitoring and evaluation, project design and proposal writing. He specializes in participatory development approaches and organizational development.

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Nyotumba Bonaventure

Freelance artist and graphic designer

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Bonaventure holds a diploma in fine and graphic arts and has undertaken assignments for the children's magazine *Rainbow*, CARE–Kenya, Bellerive Foundation, Samburu Serena, the Giraffe Centre, *The African Illustrated*, and IIRR.

Prusevie Boncato-Bekalo

Educator, homemaker

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Prusevie holds an MA in elementary education and English teaching and an MPh in nutrition. She has taught in elementary, college and graduate schools since 1979. She designs educational materials for pre- and primary schools and does freelance editing.

Schola Busingye

Programme officer, Karu Women Development Association

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Busingye qualified at Makerere University and holds certificates in bio-intensive agriculture, gender and computer science. She has been working with women groups for the last 2 years, encouraging community initiatives and economic empowerment.

Kipruto Cherogony

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Kipruto holds an MSc in agricultural engineering from the University of Nairobi. He worked as a research assistant and teacher before becoming a freelance consultant on land tenure and natural resource management, soil and water management and environmental conservation. He is currently consulting for RELMA on water harvesting and utilization.

Desalegn Desta

Community facilitator, Adventist Development and Relief Agency (ADRA)

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Desalegn holds a diploma on general agriculture and has worked for more than 6 years in bio-intensive gardening in Kadida Gamela District in Ethiopia.

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Melaku holds an MSc in agriculture, environment and development from the University of East Anglia, UK. After working on animal feed technologies, he took up management positions in various livestock institutions. Since 1991 he has worked mainly in Tigray.

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Communication specialist, International Institute of Rural Reconstruction (IIRR)

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Tenkir taught in secondary schools before specializing in the production of educational media programmes. After working at the Educational Media Agency of Ethiopia as the head of educational radio programmes, he joined IIRR as a communication specialist in 2000.

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Assefa holds an MSc in development planning and management from the University of Science and Technology, Kumasi, Ghana. With a background of development planning in both the government and NGO sectors, he has been working with AFD since 1998.

Ben Haagsma

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Ben studied land and water management at the Agricultural University of Wageningen. He worked in Tanzania and Cape Verde before joining the Free University of Amsterdam. In collaboration with a network of African researchers, he studied indigenous soil and water management practices in Africa. For the last 7 years, he has been working for IC Consult, supporting NGOs in sustainable land use and pastoral production systems.

Ali Hersi

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Ali holds an MA in political science and has extensive training on programme development and management with special reference to pastoralist communities and natural resources. He has worked for 7 years in northern Kenya in relief, rehabilitation and project development. He currently directs Saltlick, a NGO involved in training, resource management and advocacy among pastoralist communities.

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Bonface holds a BA in veterinary medicine and has extensive experience in decentralized animal health services. Before joining FARM Africa, he worked with the UN and the government of Kenya.

Anase Kajias

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Anase holds an MSc in forestry from Lakehead University in Canada. He worked in forestry in Tanzania, before specializing in land-use planning and management. He has been with HIAP since 1992.

Anna Karlsson-Lindqvist

Information and publications advisor, Regional Land Management Unit (RELMA)

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Anna holds an MSc in agriculture and has worked as a journalist, extension consultant and market information specialist in Sweden and Zambia. She is currently based in Nairobi.

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Godfrey holds a BSc in agriculture, and diplomas in environmental management, sustainable agriculture, and business management. He was manager of the Karusawadara Mixed Farming Project before becoming CETRUD programme director. He is active in various networks and has written on environmental conservation and sustainable agriculture.

Alice Kaudia

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Alice holds a PhD in social forestry extension. She has over 16 years of experience in agroforestry research and development and is specialized in the production of training and extension materials and the transfer of technologies.

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Harrie holds an MA in anthropology from the University of Nairobi, a diploma in soil survey from ETC Enschede in The Netherlands, and a BSc in agriculture from West Virginia State University, USA.

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After working with the Ministry of Agriculture and Rural Development, Joel joined the SARDEP programme in Marakwet district. He is experienced in community organizing, project management and resource mobilization.

Geoffrey Kironchi

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Geoffrey holds a PhD in soil science and specializes in soil and water management in arid and semi-arid areas. He has worked as a researcher in the drylands of Laikipia and has wide experience in conservation practices for both uplands and grazing lands. Since 1993, he has been a lecturer at the Department of Soil Science of the University of Nairobi.

Kithinji Kiruja

Independent consultant in design and advertising, Access Code Communication

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Kithinji holds a BA degree in design and has a wide experience in the design and production of information materials. He has worked on various IIRR publications, and has also produced materials for the Centre for African Family Studies (CAFS), Forum for African Women Educationalists (FAWE) and Plan International.

Aichi Kitalyi

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Aichi holds a PhD in agriculture from Reading University, UK. She has worked for RELMA since 1998. Before that, she was with the Ministry of Agriculture in Tanzania for 18 years, where she undertook a lot of on-farm research. She has been a member of various rural development evaluation teams.

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Lembulung has training in Tanzania, Kenya (Corat Africa), India and the United States (Clark University). He worked for various organizations before joining Naadutaro Pastoralists' Survival Options.

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Miriam practises pottery, water harvesting, and small-scale irrigation. She also plants trees.

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Patrick holds an MSc in irrigation engineering and has worked as a tutor at Ukinguru Agriculture College. He previously did research in the Soil and Water Management Programme of Sokoine University.

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Likani holds a BSc in agricultural economics and is currently studying for a postgraduate diploma in development studies with UNISA. He has 6 years of experience in rural development with an emphasis on food-security issues.

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Benson has worked with various non-government organizations in publication production, including with IIRR and the *Journal of Food Technology in Africa*.

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Nicholas holds an MSc in agronomy from the University of Nairobi. He is currently in charge of the World Vision-funded Kaloleni Food Security Project. Before joining World Vision, he was a researcher at the University of Nairobi.

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A water engineer, John is founder of the Kenya Rainwater Association, and director of the International Rainwater Catchment Systems Association Africa. He works for a firm that is establishing rainwater harvesting networks in Kenya and beyond.

Ngethe Mburu

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Michael holds an MSc in environment and development from the University of Natal, South Africa. Specialized in biodiversity conservation, he has experience in social forestry, on-farm biodiversity conservation, training needs assessment and the development of intensive in-service curricula for community-oriented projects.

Paul Mundy

Development communication specialist

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Paul is a British consultant in development communication. He holds a PhD in journalism and mass communications from the University of

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Dorcas Muthoka

Farmer and secretary, Kavilo Women Group

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Dorcas has a 3-acre farm in Tulimani, Makueni, Kenya. She has one cow. As secretary of the Kavilo Women Group, she has been active in clay work, rainwater harvesting and small-scale irrigation. Dorcas has trained and encouraged many other groups and village committees to engage in income-generating activities.

Edward Muya

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Edward holds a MSc in soil and water management and specializes in soil and water engineering. He has written many publications on sustainable use of land resources and food security. He has done research with various partners and acted as focal point for FAO, providing information on land degradation in Kenya.

Petro Muyamba

Farmer

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Petro started farming in 1971, and has been growing maize, oranges, groundnuts, cowpeas and watermelons. He applies conservation farming successfully, and his promoting the 'fertility pit' technique he developed in 1993 to other farmers in the Monze region.

Joseph Mwalley

Agricultural officer, Soil Conservation and Agroforestry Programme (SCAPA)

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Joseph holds a diploma in agromechanics and has more than 17 years of experience as a rural extension officer on the use of animal and tractor power in farming.

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John is trained as an agricultural entomologist and has worked for the Kenya Agricultural Research Institute for 15 years. Since 1993 he has been assigned to the University of Nairobi as a senior lecturer. He has implemented integrated pest management programmes in farmers' field for the last 3 years and also works as an pest-management consultant.

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Alusala has an MA in diplomacy and international relations. He specializes in conflict management and writes publications on this topic. He also lectures in French and does research for Horn Relief.

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David holds a BSc in agricultural engineering. He has worked with the Ministry of Agriculture, the Sustainable Agriculture Development Programme, and as a specialist on draft animal power. He currently specializes in agricultural mechanization.

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Qureshi holds an MSc in forestry from Moi University. After working with the Kenya Woodfuel and Agroforestry Project and the US Peace Corps, he joined ICRAF's Maseno station.

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Vincent has a diploma in graphic design from Creative Art College. He has worked with Star Newspapers as a cartoonist and with ITDG and IIRR as an artist. He also paints as a freelancer.

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Dickson holds a PhD in agricultural economics. He has published widely on pastoral production, wildlife management, livestock economics and related areas. He currently heads the University of Nairobi's Department of Range Management.

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George holds a postgraduate diploma in mass communications. He has worked as a journalist and communications specialist in the NGO sector for the last 8 years.

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Jeff is a forest ecology specialist with a PhD in forest management. He served as deputy director of KARI and is the founding director of KEFRI. He is currently managing the SIDA-funded regional dryland biodiversity management programme.

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Loice holds an MSc in forest resources and conservation, and a postgraduate diploma in soil conservation. She has worked mainly in extension with an emphasis on natural resource management with small-scale farmers.

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Philigona holds a BSc in agriculture and home economic extension from Egerton University and has has been a nutritionist for 8 years in Nakuru. She has worked extensively with women groups on livelihood issues and community development. She is a member of the African Women Leaders in Agriculture and Environment.

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Peter holds an MA in population studies and a postgraduate diploma in mass communication from the University of Nairobi. He has worked for the Ministry of Planning and National Development and the Kenya Times Media Trust, and was editor of Climate Network Africa. He is an associate member of the Kenya Institute of Management.

Jack Ouda

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Jack holds an MSc in animal production and a MPhil in animal traction from the University of Wales. He has worked as a district range officer and lecturer at the Animal Health and Industry Training Institute, and later joined the National Arid Lands Research Centre of KARI's Beef Research Centre in Nakuru.

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Reuben studied social work and development, and has received training in various aspects of development, including human resource development, project planning, AIDS counselling, disaster preparedness, business planning, environmental assessment, and appreciative inquiry. After working as a field officer for the Red Cross, he joined the Kasese Women Development Association as a programme officer.

Abdullahi Shandey

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Abdullahi holds a diploma in animal health from Egerton University and a certificate in community development from the Institute of Rural Management in India. Before joining ActionAid, he worked as a livestock officer with the Ministry of Livestock Development.

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Gedion holds an MSc in soil sciences and is specialized in land resources management. He has been working in soil-conservation-based agricultural development projects in East Africa and Lesotho since 1970.

Isaya Sijali

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Isaya holds an MSc in irrigation engineering from Cranfield Institute of Technology, UK. He has worked in research for over 15 years and has published on irrigation drainage and soil physics.

Mwangala Sitali

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Mwangala holds a certificate in general agriculture and has received training on water tank construction, improved storage structures and the facilitation of farmer schools. As a block supervisor, he oversees extension work in Monze and works closely with NGOs and unions on soil and water conservation.

Frank Vermeulen

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Frank holds an MA in European development policies. After working in Zimbabwe on rural development with a local NGO, he joined ILO, focusing on small enterprise development, both

in Indonesia and from ILO headquarters. He later worked at the Council of Belgian Universities. Frank has an interest in organizational development and management.

Bob Wagner

Communications specialist

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Bob holds an MSc in arid lands ecology from the University of Beersheba, Israel. He has worked for US Peace Corps in Machakos, Kenya, and the Rodale Institute in the USA. Until 1999 he was regional coordinator of the Arid Lands Information Network, where he also edited the magazine *Baobab*. He is currently doing freelance editorial and communications work in East Africa.

Susan Wambugu

Technical services officer, Horticultural Crops Development Authority (HCDA)

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Susan specializes in horticulture marketing. She has a BSc in horticulture and a diploma in business management. After working for 3 years in horticultural extension, she is now involved in horticulture marketing for HCDA, a parastatal under the Ministry of Agriculture and Rural Development. She deals mainly with small-scale horticultural growers.

Ernest Wangombe

Engineer, Steelhead Engineering

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After working as a telecommunications engineer, Ernest founded 'Operation Comfort' in 1993. This led to the development of improved harnessing devices for draft animals. He also trained artisans on standardization of farm tools and equipment under programmes of KARI, ILO and other development agencies. He later worked with ITDG on donkey utilization. Ernest specializes in technology development of farm implements.

Simon Wanjogu

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Simon holds an MSc in soil science from the University of Nairobi, and a postgraduate diploma from ITC. He has worked with various development programmes in arid and semi-arid areas (JICA, UNDP, FAO) on soil-degradation issues. He also does consulting work and specializes in soil assessment.

Tumwine Yasin

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Yasin holds a BSc in environmental management and has received training on project planning and management, agricultural technologies and computer science. He is a founding member of CETRUD and has been doing consultancy work for NGOs and community organizations as well as the Ministry of Agriculture and Environment. He is also a national youth leader.

Bilal Mohamed Yussuf

Research assistant, Horn of Africa Relief and Development Organization

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Bilal holds a BA in community development and sociology from Agra University in India, as well as a diploma in United Nations and international understanding from the United Nations Institute in New Delhi. He has now left Horn Relief (see address above) and is working with the Constitution of Kenya Review Commission.

Resource organizations

Below is an incomplete listing of organizations involved in dryland resource management in eastern and southern Africa. This list was compiled from suggestions made by the workshop participants.

Networks and associations

Arid Lands Information Network (ALIN), PO Box 39493, Nairobi, Kenya. Tel +254 2 719 413, email baobab@iconnect.co.ke

Community Development Resource Network, PO Box 3791, Kampala, Uganda. Tel +256 41 542 995, fax +256 41 267 669, email cdrn@imul.com

Development Network of Indigenous Voluntary Associations (DENIVA), PO Box 11224, Kampala, Uganda. Tel +256 41 530 575, 531 150, fax +256 41 531 236

Natural Farming Network, PO Box CY 301, Causeway, Harare, Zimbabwe. Tel +263 4 731 541, fax +263 4 723 056

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Awasa Agriculture Research Centre, PO Box 6, Awasa, Ethiopia. Tel +251 6 200 224, 200 045, fax +251 6 201 527, email kelsa.k@padis.gn.apc.org

FARM Africa, PO Box 495, Awasa, Ethiopia. Tel +251 6 200 710, fax +251 552 143

Farmers' research project. Helps research institutions conduct research with farmers using participatory methods. Capacity building in participatory planning for agricultural development.

International Livestock Research Institute (ILRI), Addis Ababa site, PO Box 5689, Addis Ababa, Ethiopia. Tel +251 1 613 215, fax +251 1 611 892, email ilri-ethiopia@cgnet.com

Research on livestock management.

Relief Society of Tigray, PO Box 906, Tigray, Ethiopia, Tel +251 4 407 508, 407 730

SOS Sahel, PO Box 3262, Addis Ababa, Ethiopia. Tel +251 1 189 585, fax +251 1 613 744, email sossahel@padis.gn.apc.org

Produces the WASP (Wollo Agricultural Support Project) series of technical papers, covering participatory land-use planning, runoff control, natural resource management, etc.

Kenya

ActionAid–Kenya, PO Box 42814, Nairobi, Kenya. Tel +254 2 440 440, 440 444, fax +254 2 445 843

Training in bio-intensive agriculture. Field projects with sustainable agriculture components.

Association for Better Land Husbandry, PO Box 39042, Nairobi, Kenya. Tel +254 2 521 090, 521 482

Baraka Agricultural College, PO Box 52, Molo, Kenya. Tel +254 363 21091, fax +254 363 21100

Bungoma Family Development Programme, PO Box 2472, Bungoma, Kenya. Tel +254 337 30296, fax +254 337 20235

Deals with micro-credit to small businesses, including farming and livestock. Promotes sustainable agriculture in Bungoma. Provides training in micro-credit management and revolving-loan funds.

CARE–Kenya, PO Box 43864 (or PO Box 67191), Nairobi, Kenya. Tel +254 2 724 674, 724 601, 630 566, fax +254 2 728 493

Catholic Diocese of Kenya, PO Box 938, Nakuru, Kenya. Tel +254 37 42614, fax +254 37 42614

CBHC Community, PO Box 111, Subukia, Via Nakuru, Kenya

Church Province of Kenya–Nakuru Diocese, Christian Community Service, PO Box 56, Nakuru, Kenya. Tel +254 37 212 151, 212 155, fax +254 311 20764, 20193, 44379

Community Management Against Desertification (C–MAD), Box 155, Rongo, Kenya. Tel +254 387 42289, fax +254 387 42278

Training and information on sustainable agriculture.

Environmental Liaison Centre International (ELCI), PO Box 72461, Nairobi, Kenya. Tel. +254 2 562 015, 562 022, fax +254 2 562 175, email ecoforum@users.africaonline.co.ke

FARM-Africa, PO Box 49502, Nairobi, Kenya. Tel +254 2 501 997, fax +254 2 501 997, email kenrep@africaonline.co.ke

Heifer Project International, PO Box 5968, Malindi, Kenya. Tel +254 123 30585

Horn of Africa Relief and Development Organization, PO Box 70331, Nairobi, Kenya. Tel +254 2 576 646 572 641, email horn-rel@nbnet.co.ke

Horticultural Crops Development Authority, PO Box 42601, Nairobi, Kenya, email hphfp@swiftkenya.com

Intermediate Technology Development Group–Kenya (ITDG), 22 Chiromo Access Road, PO Box 39493, Nairobi, Kenya. Tel +254 2 442 108, 446 243, 444 887, fax +254 2 445 166, email itdg@tt.gn.apc.org

Field projects in sustainable agriculture; training for paravets.

International Centre for Research in Agroforestry (ICRAF), UN Avenue, Gigiri, PO Box 30677, Nairobi, Kenya. Tel +254 2 521 450, fax +254 2 521 001, email icraf@cgnet.com

International Centre of Insect Physiology and Ecology, PO Box 30772 Nairobi, Kenya. Email icipe@cgnet.com

Research on insect pests and their control, including the use of neem as a pest repellent.

International Institute for Biological Control (IIBC), PO Box 76520, Nairobi, Kenya. Tel +254 2 747 329, 747 337, fax +254 2 747 340, 252 2150, email cabi-roaf@cabi.org

International Institute of Rural Reconstruction (IIRR), Africa Regional Office, PO Box 66873, Nairobi, Kenya. Tel +254 2 442 610, fax +254 2 448 148, email admin@iirr-africa.org

Training and consultancies in project management, natural resources, agriculture, health, and institutional capacity-building; production of information materials; conferences and seminars.

International Livestock Research Institute (ILRI), PO Box 30709, Nairobi, Kenya. Tel +254 2 630 743, fax +254 2 631 499, email ilri-kenya@cgnet.com

Research on livestock management and diseases.

Kenya Agricultural Research Institute (KARI), National Agricultural Research Laboratories, PO Box 14733, Nairobi, Kenya. Tel +254 2 444 029, 444 030, fax +254 2 443 956, 444 029

Demonstration and sale of small-scale drip-irrigation systems.

Kenya Forestry Research Institute (KEFRI), PO Box 20412, Kenya. Tel +254 154 32541, 32891, fax +254 154 32844, 44235, email kefri@arcc-or.ke

Kenya Institute of Organic Farming (KIOF), PO Box 34972, Nairobi. Tel +254 2 583 383, 583 194, fax +254 2 583 570

Publications on organic farming; resource centre on sustainable agriculture; training for extension workers, farmers and students on organic farming; field attachments for students.

Land Use Consultants Ltd, PO Box 13047, Nakuru, Kenya, Tel +254 372 214 181, 621 598, fax +254 37 214 601, email jmbugua@net2000ke.com

Manor House Agriculture Centre, Private Bag, Kitale, Kenya. Tel +254 325 20488, 30423, fax +254 325 20488, email mhac@africaonline.co.ke

Ministry of Agriculture and Rural Development, PO Box 44, Nakuru, Kenya. Tel +254 37 213 260, 42432, email ooko@bisec.africaonline.com

National Agricultural Research Labs, PO Box 14733 Nairobi, Kenya. Tel +254 2 444 029, 444 032, +254 154 32143 email hkinyanjui@yahoo.co.uk

NCCK Sustainable Agriculture Project, PO Box 1600, Nakuru, Kenya. Tel +254 37 211 465, fax +254 37 211 863

Organic Farming Outreach Programme (OFOP), PO Box 1447, Kisumu, Kenya

Project Assessment Services, PO Box 159, Kikuyu, Kenya, Tel +254 72 737 433, 32009, Fax +254 2 443 530, pas@net2000ke.com

Regional Land Management Unit (RELMA), PO Box 63403, Nairobi, Kenya. Tel +254 2 524 414, fax +254 2 524 401, email a.karlsson-lindqvist@cgiar.org

Saltlick, PO Box 301, Isiolo, Kenya. Tel +254 165 2350, 2436, fax +254 165 2414, email saltlick@arcc.or.ke

SARDEP, Semiarid Rural Development Programme, PO Box 30776, Nairobi, Kenya. Tel +254 2 573 656, fax 254 2 566 460, email sardepcmu@insightkenya.com

Works in Kajiado, Keiyo-Marakwet and Laikipia districts.

Sustainable Agriculture Community Development Programme (SACDEP), PO Box 1134, Thika, Kenya. Tel +254 151 30541, fax +254 151 30055

Promotion of sustainable agriculture methods. Short courses (1 day–2 weeks or longer) for farmers and development workers. Baseline surveys and evaluation studies.

Sustainable Community Development Services (SCODE), Box 70051, Nairobi, Kenya. Tel/fax +254 2 335 765

Tropical Soil Biology and Fertility Programme, UN Complex, Gigiri (Block B), PO Box 30592, Nairobi, Kenya. Tel +254 2 622 659, fax +254 2 622 733, 521 159, email tsbfinfo@tsbf.unom.org

Research on soil fertility management.

University of Nairobi, PO Box 29053, Nairobi, Kenya. Tel +254 2 631 2254, 631 989, fax +254 2 631 226, email pinep@net2000ke.com

World Vision, PO Box 396, Kaloleni, Kenya. Tel. +254 125 33476, email nickmati@yahoo.com

Netherlands

Cordaid, PO Box 16440 2500 BK, The Hague, The Netherlands. Email cordaid@cordaid.nl

Interchurch Organisation for Development Cooperation (ICCO), PO Box 151, 3700 AD Zeist, The Netherlands. Tel.+31 30 692 7811, fax +31 30 692 5614

I/C Consult, PO Box 16440, 2500 BK The Hague, The Netherlands. Tel +31 70 313 6880, fax +31 70 313 6895, email icc@icconsult.nl

South Africa

Environmental Development Agency Trust, PO Box 15934, Doorfontein 2028, Johannesburg, South Africa. Tel +27 11 402 5161, fax +27 11 402 0298, email eda@wn.apc.org

Community Development Resource Association, PO Box 221, Woodstock 7015, South Africa. Tel +27 21 462 3902, fax +27 21 462 3918, email cdra@wn.apc.org

Department of Environmental Affairs, Private Bag 11233, Nelspruit 1200, South Africa. Tel +27 13 752 5195, fax +27 13 752 5464

Farmer Support Group, Private Bag X01, Scottsville, Pietermaritzburg 3209, South Africa. Tel +27 331 68385–7, fax +27 331 68485, email lax@fsg.unp.ac.za

Kommetjie Environmental Awareness Group, PO Box 308, Kommetjie 7976, Cape Town, South Africa. Tel +27 21 783 3433, fax +27 21 783 3433, email keag@ct.lia.net

The Valley Trust, PO Box 33, Bothas Hill 3660, KwaZulu Natal, South Africa. Tel +27 31 777 1955, fax +27 31 777 1114, email vtrust@wn.apc.org

Thlolego, PO Box 1668, Rustenburg 0300, South Africa. Tel +27 142 27090, 25322, fax +27 142 27090

Tlhavhama Training Initiative, PO Box 4603, Pietersburg 0700, South Africa. Tel +27 15 291 3312, fax +27 15 291 3323, email tsh@wn.apc.org

Tanzania

Agricultural Development Programme–Mbozi, PO Box 204, Mbeya Region, Tanzania

Field projects and training in participatory research and extension for sustainable agriculture.

Agricultural Mechanism Management, PO Box 14578, Arusha, Tanzania. Tel +255 57 4298, fax +255 57 4486, email amm@habari.co.tz

COOPIBO–Tanzania, Box 60753, Dar es Salaam, Tanzania. Tel +255 51 68368, fax +255 51 44709

Earth Green Activities Japan (EGAJ), PO Box 3091, Dodoma, Tanzania. Tel +255 61 24300

Handemi Integrated Agroforestry Project (HIAP), PO Box 183, Handeni, Tanzania. Tel +255 264 3366, email hiap@raham.com

Inades-Formation Tanzania, PO Box 203, Dodoma, Tanzania. Tel +255 61 354 230, fax +255 61 354 722, email inades-fo@maf.org

Laela Agricultural Centre, PO Box 21, Rukwa Region, Tanzania

Land Management Programme (LAMP), PO Box 537, Babati, Arusha, Tanzania. Tel +255 57 8875, 4298

Mogabiri Farm Extension Centre, PO Box 134, Tarime, Tanzania. Tel Tarime 69

Naadutaro Pastoralists' Survival Options, PO Box 46, Kibaya, Arusha, Tanzania. Tel +255 27 255 2064, 255 2179, fax +255 27 255 2005, email lembulung@hotmail.com

SARI, PO Box 6024, Arusha, Tanzania. Tel +255 57 3883, 4298

Soil Conservation and Agroforestry Programme (SCAPA), PO Box 3169, Arusha, Tanzania. Tel/fax +255 4685, email mbengwe@yahoo.com, scapa@habari.co.tz

Uganda

ActionAid Uganda, PO Box 676, Kampala, Uganda. Tel +256 41 267 863, 267 738, fax +256 41 268 414, email actaid@aau.uu.imul.com

Centre for Environment, Technology and Rural Development (CETRUD), PO Box 259, Kasese, Uganda, Tel +256 77 466 461, +256 483 44080, fax +256 483 44312, 44459, 44235, email cetrud@yahoo.com

COOPIBO–Uganda, PO Box 7844, Kampala, Uganda. Tel +256 41 266 099, fax +256 41 266 109

Environmental Alert, PO Box 11259, Kampala, Uganda. Tel +256 41 233 684, 258 528, fax +256 41 233 684, 220 780, email invalert@imul.com

Short courses and consultancies on sustainable agriculture.

Foundation for Urban and Rural Advancement (FURA), PO Box 20 Kasese, Uganda. Tel +256 483 444 280, +256 77 610 820, fax +256 483 44312, 44235, email dalfala@africaonline.co.ug

International Centre for Tropical Agriculture, Kawanda ARI, PO Box 6247, Kampala, Uganda. Tel +256 41 567 0670, 57814, fax +256 41 567 635

Karu Women Development Association, PO Box 20 Kasese, Uganda. Tel +256 77 466 461, +256 483 44080, fax +256 483 44312, 44459, 44235, email cetrud@yahoo.com

SNV, PO Box 8339, Kampala, Uganda

Training on participatory technology development in low external-input agriculture.

Uganda Centre for Sustainable Agriculture, PO Box 23250, Kampala, Uganda. Tel +256 41 233 485, 251 779, fax +256 41 251 778, email nbsfd@imul.com

United Kingdom

International Institute for Environment and Development (IIED), Drylands Programme, 4 Hanover Street, Edinburgh EH2 2EN, UK. Tel +44 131 226 7040, fax: +44 131 624 7050, email drylands@iied.org, internet www.iied.org

Zambia

Agriculture Development Programme, Diocese of Ndola, PO Box 70244, Ndola, Zambia. Tel +260 2 612 241

CARE-Zambia, Box 36238, Lusaka, Zambia. Tel +260 4 220 134–37, 238 042, fax +260 1 227 108

Gwembe South Development Project, Box 4, Sinazongwe, Zambia. Tel +260 1 261 580

Hodi, Kasiye Crescent, PO Box 36548, Lusaka, Zambia. Tel +260 1 290 455, fax +260 290 455, 292 376, email hodi@zamnet.zm

Ministry of Agriculture, Food and Fisheries, PO Box 660006, Monze, Zambia. Tel +260 32 50488, fax +260 32 50488, email zafesp@zamnet.zm

National Association for Peasant and Small Scale Farmers of Zambia, Box 37398, Lusaka, Zambia. Tel +260 1 238 370

Sigubbu Basic School, PO Box 660037, Monze, Zambia

Zimbabwe

Africa Centre for Holistic Resource Management, PO Box MP266, Mount Pleasant, Harare, Zimbabwe. Tel +263 4 776 942, fax +263 4 776 942

Association of Zimbabwean Traditional Environmental Conservationists, Bag 9286, Masvingo, Zimbabwe. Tel +263 139 66006, fax +263 139 64035, email aztrec@mango.zw

Christian Care, PO Box 3391, Bulawayo, Zimbabwe. Tel +263 9 65804, +263 91 32404, fax +263 9 74014, email llebani@byo.ccare.co.zw

COOPIBO-Zimbabwe, PO Box CY 892, Causeway, Harare, Zimbabwe. Tel +263 4 720 709, fax +263 4 732 585, email coopibo@ samara.co.zw

Fambidzanai Training Centre, PO Box CY 301, Causeway, Harare, Zimbabwe. Tel +263 4 307 557, 726 911, fax +263 4 726 911, 723 056, email fambidzanai@mango.zw

Intermediate Technology Development Group–Zimbabwe, PO Box 1744, Harare, Zimbabwe. Tel +263 120 67606, fax +263 120 60469, email itdg@harare.iafrica.com

Projects promoting sustainable agriculture; training in participatory rural development approaches; local institutional capacity building.

Mwenezi Development Training Centre, P/A Neshuro, Masvingo, Zimbabwe. Tel +263 136 208

Nyahode Union Learning Centre, PO Box 9, Chimanimani, Zimbabwe. Tel +263 126 22451

Phiri Maseko's farm, PO Box 118, Zvishavane, Zimbabwe. Tel/fax +263 151 3250

Demonstration farm for soil conservation and water harvesting.

Reference and training materials

Books and manuals

Adams, Martin. 'Agriculture, livestock and forestry: An environmental strategy for semi-arid areas'. *Drylands Paper* 1. International Institute for Environment and Development (IIED), London. www.iied.org/drylands/

Bingham, S. 1990. *Holistic resource management workbook*. Island Press, Covelo, California. (Africa Centre for Holistic Resources Management, PO Box MP 266, Mount Pleasant, Harare, Zimbabwe)

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Dupriez, H. and J. Cheleg. *Vanishing land and water: Soil and water conservation*. Macmillan.

Dupriez, H. and P. Deleener. *African gardens and orchards: Growing vegetables and fruits*. Macmillan.

Dupriez, H. and P. Deleener. *Agriculture in African rural communities: Crops and soil*. Macmillan.

Dupriez, H. and P. Deleener. *Ways of water: Irrigation, runoff and drainage*. Macmillan.

Elwell, Henry and Anita Maas. 1995. *Natural pest and disease control*. Natural Farming Network, Box CY 301, Causeway, Harare, Zimbabwe.

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IIRR. 1994. *Agroforestry in Ghana: A technology information kit*. Ghana Rural Reconstruction Movement and International Institute of Rural Reconstruction, Nairobi.

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Oloka-Onyango, Joe, Gariyo Zie and Frank Muhereza. 1993. *Pastoralism, crisis and transformation in Karamoja*. International Institute for Environment and Development (IIED), Center for Basic Research.

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Pretty, Jules N., Irene Gujit, John Thompson and Ian Scoones. 1995. *Participatory learning and action: A trainer's guide*. International Institute for Environment and Development (IIED), London, 3 Endsleigh St, London WC1H 0DD, UK. www.iied.org

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Rocheleau, D. et al. *Agroforestry in dryland Africa*. International Centre for Research in Agroforestry (ICRAF), UN Avenue, Gigiri, PO Box 30677, Nairobi, Kenya.

Salem, Murdock Muneera and Niasse Madiodio.1996. 'Water conflict in the Senegal valley: Implications of a "no flood" scenario'. *Drylands Issue Papers* 61. International Institute for Environment and Development (IIED), London. www.iied.org/drylands/

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Training videos and slide sets

Agroforestry in dryland Africa. International Centre for Research in Agroforestry (ICRAF), UN Avenue, Gigiri, PO Box 30677, Nairobi, Kenya.

Looking after our land. Arid Lands Information Network (ALIN), PO Box 39493, Nairobi, Kenya.

Newsletters and magazines

Agroforestry Today. International Centre for Research in Agroforestry (ICRAF), UN Avenue, Gigiri, PO Box 30677, Nairobi, Kenya.

Baobab. Arid Lands Information Network (ALIN), PO Box 39493, Nairobi, Kenya.

Echo Development News. 17430 Durrance Road, North Fort Myers, FL 33917-2239, USA.

Gatekeeper Series. Sustainable Agriculture Programme, International Institute for Environment and Development (IIED), 3 Endsleigh St, London WC1H 0DD, UK. www.iied.org

Ground Up. PELUM Association, Box MP 1059, Mount Pleasant, Harare, Zimbabwe.

Haramata. Drylands Programme, International Institute for Environment and Development, 3 Endsleigh St, London WC1H 0DD, UK.

Holistic Resource Management Quarterly. 1010 Tijeras NW, Albuquerque, New Mexico 87194, USA.

ILEIA Newsletter. ILEIA, PO Box 64, 3830 AB Leusden, Netherlands.

Indigenous Knowledge and Development Monitor. CIRAN/NUFFIC, PO Box 29777, 2502 LT The Hague, Netherlands.

People and the Planet. 1 Woburn Walk, London WC1H 0JJ, UK.

Spore. CTA, Postbus 380, 6700 AJ Wageningen, Netherlands.