Introduction

Millions of African smallholders—farmers, herders and fisherfolk—are resource-poor and suffer from food insecurity. Their low incomes mean they are unable to make investments and take on risks. Their agricultural systems are buffeted by sudden, acute shocks caused by natural and man-made hazards—drought, flooding, erosion, conflicts. Long-term trends, in part the result of international markets, national policy decisions and institutional frameworks, often move against them.

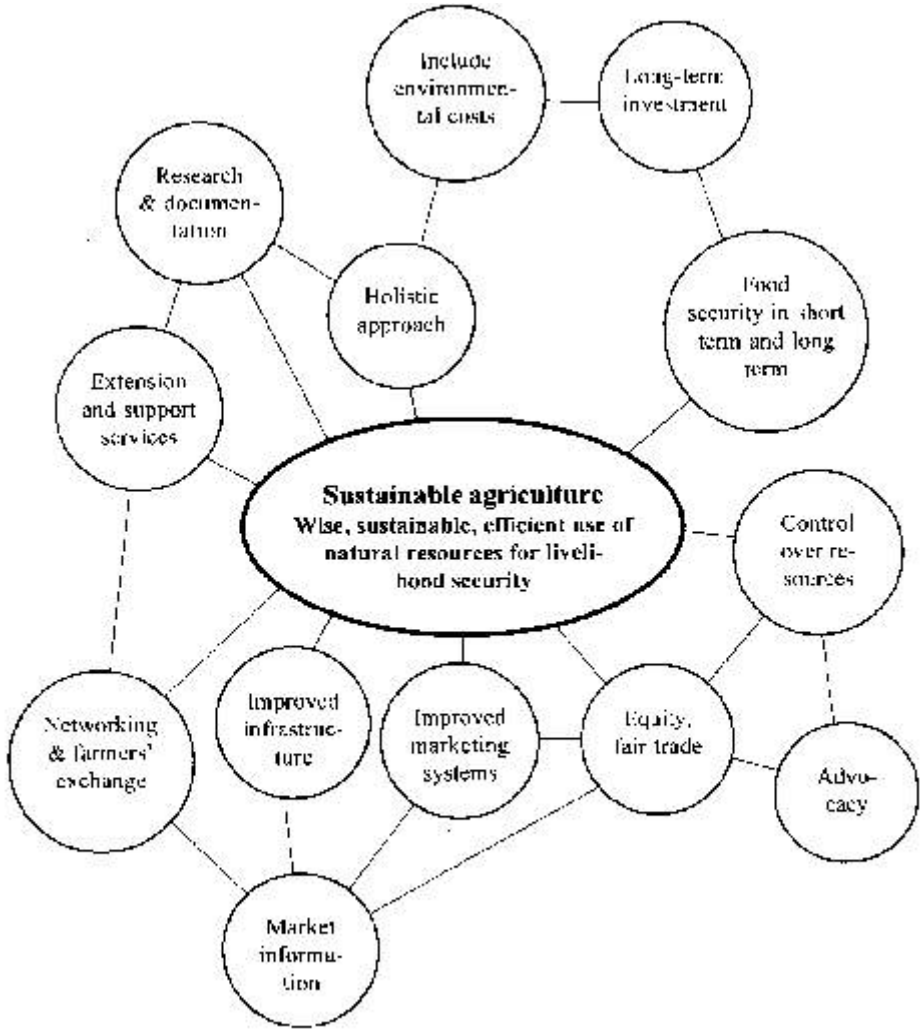
The food-security problem is not merely an inability to produce enough food to keep pace with population growth. Such a simplistic reckoning fails to take into account the ecological, cultural, social and economic features which are the bedrock of sustainable agriculture. Environmental degradation and a diminishing resource base seriously affect African farmers who depend on rainfed agriculture. As critical watersheds are deforested, water supplies have become unreliable and the climate less predictable. Local actors are seldom consulted when agricultural policies are formulated. Small-scale farmers (especially women) find it hard to get credit, seeds and other inputs, and the information they need to farm their land in a profitable, sustainable way. Some governments still control the prices of key farm outputs, and unscrupulous traders manipulate the prices of others. In addition, political instability is a major obstacle to food security and sustainable agriculture in many countries.

Access to sufficient food is a sustainable manner is a fundamental human right. Realizing this, NGOs, community organizations, research institutions and governments in Africa have been testing alternative agricultural technologies and approaches for over a decade. Such approaches as "conservation farming" and organic agriculture are becoming part of the technical packages of both international and national research and extension institutions. It is this growing experience and interest that has prompted IIRR and its partners to document and share the lessons learned so far.

The participants in the workshop that produced this manual took a broad view of sustainable agriculture, including not only farming technologies (contour planting, feeding cattle with crop by-products, and so on), but also its social and economic dimensions (for example, the marketing of produce and the organization of extension services). And around the core concept of the wise, sustainable and efficient use of natural resources for livelihood security, the workshop participants identified a range of policy issues that determine whether attempts to promote sustainable agriculture will be successful (see the diagram on the next page). This manual tries to show the relationships among the physical technologies, the social, economic and policy frameworks within which they are implemented, and the organizational processes that can be used to promote sustainable agriculture.

Purpose of the manual

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.



The manual provides an overview of selected problems and issues in sustainable 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 cases of individual farmers' and communities' experiences.

The book draws on experiences from a huge area—from Ethiopia in the north to Lesotho in the south. This region includes a wide variety of agroecosystems and socio-economic systems. Naturally, what has worked in one place may not be appropriate in another. So the reader should not view this book as a set of prescriptions to be followed word-for-word. Rather, it 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.

Because of the size of the area covered and the breadth and complexity of the topic of sustainable agriculture, a manual such as this cannot hope to be comprehensive. Its focus is on the less arid areas of Eastern and Southern Africa, where sustainable agriculture approaches have achieved most success. It does not include the mainly pastoral, semi-arid areas that cover much of the region. Nor is its coverage of the wetter areas complete: numerous organizations and countless farmers engage in sustainable agriculture, and have developed a wealth of technologies and approaches that are not yet reflected here.

So this manual is by no means a finished product. Rather, it presents a sampling of sustainable agriculture experiences in the region. It should be seen as an initial draft that will serve as a base for gathering feedback for revision and translation into several Eastern and Southern Africa languages—initially into Swahili. Comments and corrections are most welcome: please send them to IIRR at the address in the front of the book.

Parts of the manual

The manual falls into 10 parts. The first four focus on the social processes and issues involved in sustainable agriculture. **Part 1** describes how organizations might promote the development, testing and sharing of farm technologies by groups of farmers, and gives examples of cases where such approaches have proved successful. **Part 2** outlines some approaches to improving credit and marketing by farmers' groups. **Part 3** describes methods of planning land use and strengthening users' rights, while **Part 4** addresses the issue of gender.

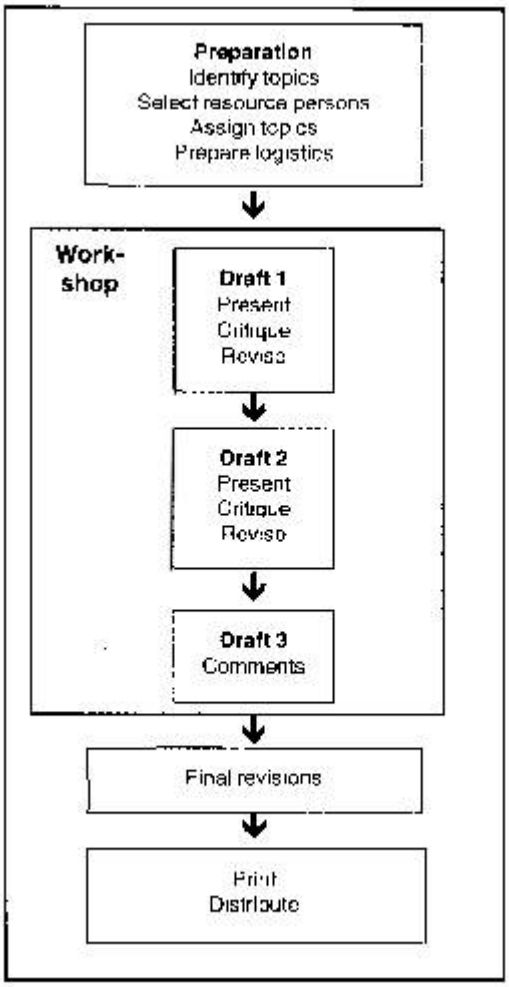
Part 5 then turns to the physical technologies for soil and water conservation, many of which have been developed and promoted through the approaches described in Part 1. **Part 6** describes ways of conserving and enhancing soil fertility using various types of organic matter. **Part 7** details some technologies relating to cropping systems. This section, in particular, makes no attempt to cover all the many crops and cropping systems used in Eastern and Southern Africa; rather, the examples have been chosen to illustrate some of the principles involved in planning and implementing cropping systems in a sustainable agriculture context. Parts 8 and 9 address livestock issues: **Part 8** focuses on approaches to livestock extension, while **Part 9** provides some livestock management technologies.

Part 10 contains lists of resources and sources of further information, including profiles of the 60 people who contributed to the publication through the workshop (described below), a list of resource organizations with relevant expertise and experience in the field, and references and training materials on sustainable agriculture.

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 workshop. The overall administration and technical management was guided by a steering committee composed of staff from Baraka Agricultural College, the Sustainable Agriculture Community Development Programme (SACDEP), the Regional Land Management Association (RELMA), Intermediate Technology Development Group (ITDG_Kenya), the Ford Foundation, and the Africa Regional Office of the International Institute of Rural Reconstruction (IIRR). IIRR served as the secretariat of the steering committee and organized the production workshop itself.

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 staff of NGOs, government departments, farmers, universities, research institutions and private individuals.

The participants in this preparatory workshop agreed on a common understanding of what constitutes sustainable agriculture, the major sections in the manual, as well as specific topics to appear in each of the major sections. They also drew up a list of institutions with relevant experience and contact individuals 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.

Production workshop

The manual itself was the product of a second, two-week intensive workshop, which involved some 60 farmers, researchers, extension experts, field practitioners, artists, editors and desktop-publishing specialists. During the workshop, each participant presented his or her draft manuscript using overhead transparencies of each page. Copies of each draft were also given to all other participants, who critiqued it and suggested revisions.

After each presentation, an editor helped the author revise and edit the manuscript and incorporate the comments that had been received. 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 then in turn worked with the team of editors and artists to revise and illustrate the text.

Early in the workshop, the participants generated ideas for new topics, and these were assigned to individuals with relevant experiences and expertise to draft. The editorial team also assisted the farmer participants to write and illustrate their cases and experiences, which the farmers also presented to the group.

Each participant then 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 again helped revise the manuscript and developed a third draft. Towards the end of the workshop, this third draft was made available to participants for their final comments and revisions. After this, only minor editing and adjustments were necessary before the finished manual could be printed.

This workshop approach had several advantages: it speeded up the production of information materials, taking full advantage of expertise of the various workshop participants. The process of writing, getting comments, revising and illustrating the manual took place at the same time, considerably shortening the often-difficult process of writing, editing and publishing. A large number of workshop participants were able to contribute to each topic: in effect, the workshop

provided 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 workshop brought together a large number of people from different 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 workshop will continue long into the future.

Sustainable Agriculture Extension Manual

Part 1 

Technology development and extension

Organizing a field visit, 35

Participatory agricultural extension

Participatory agricultural extension consists of a basket of approaches to extension that involve "outsider" facilitators working closely with local communities. The farmers take on more active, participatory roles than in conventional extension. Many of the approaches described in the following sections and elsewhere in this book are parts of this approach; they can be selected, mixed and adapted as necessary to suit a particular situation.

Participatory extension is best used with smallholder farming communities. The communities are encouraged to identify their agricultural problems, prioritize them and seek solutions. Participatory extension aims to strengthen the community's ability to carry out these activities with limited assistance from outsiders. It does this by:

- Building the capacity of local institutions to plan and manage their own development.
- Conducting research and extension using a participatory technology development process, which develops technologies that fit the diverse, complex farming system of smallholder farmers (see the section on *Participatory technology development*).

While there are many different approaches to participatory extension, many follow the broad sequence outlined below. Many participatory rural appraisal methods are useful in various steps of the sequence. This book does not provide detailed descriptions of these methods, but further information on these can be found in the *References and training materials* section in the Appendices.

The guidelines below are based on the approach used in the Chivi Food Security Project in Zimbabwe (described later in this section). Clearly, other approaches could be used, depending on the local situation and the particular purpose of the project.

Meetings to raise awareness

Initially, the facilitator approaches community leaders to organize a community meeting. During this meeting, the facilitator introduces himself (or herself) to the community and describes the process, clearly outlining the purpose, the key steps, and the expected outputs. The facilitator should emphasize that "self-help" is a theme that will guide the process. He or she shouldnot make any promises that cannot be fulfilled.

Institutional survey

After the facilitator has been introduced into the community, an institutional survey is carried out over a 2-week period. This is designed to:

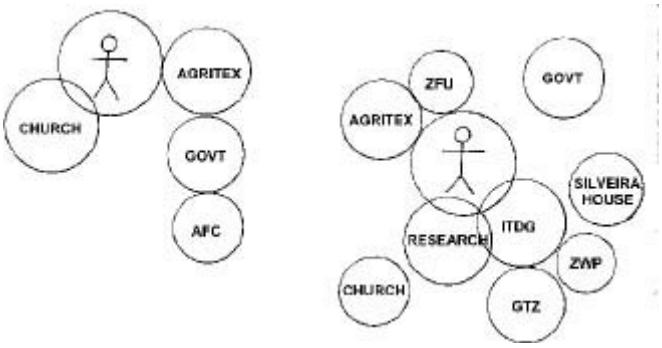
- Identify all institutions within the community, defining their roles and responsibilities.

- Conduct a strength, weakness, opportunities and threats (SWOT) analysis of key institutions in the community.
- Discover the strength of relationships between the community and key institutions.

The survey results can help the facilitator identify which institutions to liaise with in order to promote agricultural development in the community. It can also help the facilitator and local people understand the institutional capacity-building needs.

The survey is carried out through semi-structured interviews with key informants, and through focused group discussions using diagramming or visualisation techniques such as Venn diagrams. The facilitator should work with small groups to encourage everyone in the group to participate in the exercise. Where appropriate, the group should be divided according to age and gender.

Conducting an institutional survey using Venn diagrams (also known as chapati diagrams)



1991 **1995**

Venn diagrams showing relationships between the community and institutions, before and after the Chivi project

Wealth ranking

The needs of individual households

depend in part on their economic status, which in turn influences the household's social standing. For several reasons, it is important to know how wealthy individual households in the community are: to help select people to include in a needs-assessment survey (see below), to identify target groups or beneficiaries, to determine membership of groups, and to understand the social structure of the village

Wealth-ranking exercise using cards

Using a technique known as "wealth ranking", members of the community use their own criteria to define and identify different categories of wealth. A wealth-ranking exercise has several steps.

1. List all the households in the community.

2. Identify 2_4 key informants who know all of the households.

3. Write the name of each household on a small card (about 5 x 10 cm).

4. Ask the key informants to put the cards into different wealth groupings of their choosing.

5. After they have put all the cards into the wealth groupings, ask them to define the categories they have identified. Ask them to give objectively verifiable indicators (eg, "has house with metal roof") rather than subjective indicators (eg, "looks unhappy").

6. Record each household's wealth category on the card with its name. If the informants identified four groups, give the wealthiest group a score of 1, the second wealthiest a score of 0.75, the third 0.5, and the poorest 0.25. If the informants identified five groups, give them scores of 1, 0.8, 0.6, 0.4 and 0.2.

7. Repeat the process at least three times with different key informants.

8. Add up the scores given to each household by each of the key informants. Calculate the average score for each household, and then put them into wealth categories.

Needs-assessment survey

A needs-assessment survey aims to discover the needs felt by each of the different groups in the community. It can be conducted with the wealth groups identified above, or with other categories, such as unemployed youths or young couples (see the section on *Gender and development*).

1. For a needs-assessment survey, draw a random sample from each of the wealth categories identified in the wealth-ranking exercise. Select at least 10% of the total number of households.

2. Conduct semi-structured interviews with members of the selected households to gather information about the community and farming systems. If possible, record separately the impressions of men, women, elderly and youth; the data may help to identify specific activities for each of the groups.

3. Compile the results into a report describing the following:

- The purpose and methodology of the survey.
- The physical environment.
- The socio-economic context.
- The farming enterprises, highlighting constraints and potentials for development.
- The needs of the community as highlighted by the interviewees. Represent the interviewees' impressions of the importance of the needs they have expressed.

4. Prepare diagrams to shows linkages between the needs which have been identified. Share the results with the community during a community meeting. This allows the community an opportunity to comment on the findings before the report is finalized.

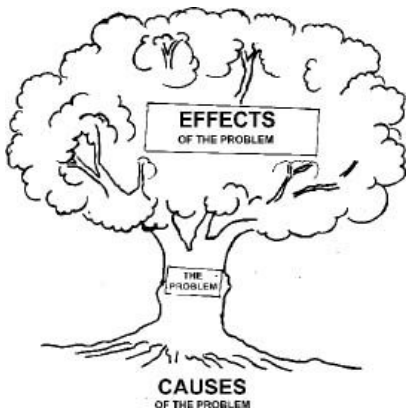
Learning about local practices

Participatory extension acknowledges that every community has problems and needs, and that local people are doing something about them. Therefore, the starting point for any agricultural improvement should be learning how the community's agricultural system is currently working.

1. Use guided group discussions and diagramming exercises to identify practices the community uses to address its needs, as well as technological gaps that may exist.

2. Conduct a SWOT (strengths, weaknesses, opportunities, threats) analysis with the community of each of the practices. Use participatory appraisal tools such as scoring, matrix ranking and group discussions to do this.

3. Recommend practices that have potential to fulfill the community's needs better.



Planning

Hold a series of planning meetings to help the local community to:

- Prioritize its needs (use participatory appraisal tools such as matrix ranking or scoring).
- Analyse its needs and the constraints it faces by identifying and elaborating on the causes and effects of the problems. A problem tree is a useful way of doing this.
- Screen current practices, indigenous technical knowledge and past experimentation for suitable methods.
- Assess possible solutions to the expressed needs and problems.
- Establish criteria for choosing the first activities to be carried out.
- Develop an action plan clearly spelling out what action is to be carried out, when, how, where, and by whom.

Participatory technology development

The needs-assessment survey informs and guides the process of learning about farmers' local practices. Using a participatory technology development approach, the facilitators and the local people are able to increase the range of technologies

available to smallholder farmers which would address their needs. PTD builds on the local knowledge, skills and experiences of farmers, but encourages them to experiment and be innovative, as well as seeking new information from other farmers and support institutions. Experiences are then shared with other farmers.

The following is a list of important methods (see the section on *Participatory technology development* for more information).

- Exposure visits to innovative farmers, research stations and training centres.
- Farmer-based experimentation, assisted by the facilitators to provide training on experiment design and analysis.
- Demonstrations in the community of specific technologies (these are best conducted by innovative farmers with support from researchers and extension workers).
- The use of farmer-to-farmer extension through field days, seed fairs, and farming competitions organized by the farmers themselves.

Building capacity of local institutions

Local institutions are identified as being the vehicle for improving agriculture. Efforts to strengthen local institutions aim to:

- Enhance the community's ability to plan and mobilize resources to implement their plan.
- Improve the institution's organizational structure to enable it to deal with new demands placed on it as the development process advances.
- Link the local community with a wider range of support institutions (eg, research, extension, local government).
- Encourage more active and wider participation of all members of the community.

Local capacity-building efforts are conducted by:

Providing training on the principles and practice of leadership and organizational management.

Promoting networking among community and support institutions.

Training for Transformation

Training for Transformation ***(Hope and Timmel, 1996) has been an important method for supporting and facilitating greater participation, and greater levels of community management and control. The leadership training is based on the concepts of "conscientization" originally developed by Paulo Freire in Brazil, adapted for a Zimbabwean context. It is a set of awareness-raising techniques that assist groups to analyse their formation and management, their roles, opportunities and constraints, and to plan courses of action together. The training has been very effective to stimulate greater democratization of leadership and more transparent decision-making. It has also brought about changes in the approaches and attitudes of the government extension staff towards farmers and their communities.*** **—Source: Adapted from S. Croxton and K. Murwira. 1997. IIED Gatekeeper Series no. SA70.**

- Using a training-for-transformation approach (see the box below).
- Holding meetings for project planning and review.

Participatory monitoring and evaluation

Project monitoring and evaluation activities should also actively involve community members. The criteria for assessing performance can be determined by the community itself. The role of the facilitator is to help the community members develop the monitoring and evaluation system and make it their own. Activities should be monitored on a continual basis; evaluation should be carried out at different times and at different levels. Annual group review meetings can be effective opportunities for participatory monitoring, evaluation and re-planning exercises.

The Chivi Food Security Project

The Chivi Food Security Project in southeastern Zimbabwe successfully uses the participatory extension approaches outlined above.

Background

Over 70% of Zimbabwe's 12 million people live in the rural areas. The majority are smallholder farmers whose primary source of livelihood is agriculture. More than two-thirds

of these live in semi-arid regions with less than 600 mm of rainfall a year, frequent droughts, and poor soil fertility.

Land is generally divided into arable land used by an individual farmer, and grazing land which is communally used. Local institutions are too weak and poorly organized to take control and manage the common resources. The choice of technologies for smallholder farmers to enhance their productivity is limited, so food production is low and household food insecurity is rife.

Despite tremendous government investment in human and financial resources for agricultural research and extension, the smallholder agricultural sector has not greatly ben-

efited. The ineffectiveness of these institutions is at least in part a result of the top-down approaches they have used. Technological solutions are developed by researchers and passed on to extension workers. The extension workers in turn pass them on to smallholder farmers without having an adequate understanding of the farmers' priority needs and socio-economic situation. This has lead to "blanket" extension recommendations to farmers in very different physical environments. A classic example was the country-wide promotion of a contour drain that drains water away from the field: not a very useful practice for the very dry areas like Chivi.

The extension system did not acknowledge the importance of local knowledge, and saw itself as being responsible for promoting technologies which had been tested and proven by agricultural researchers. The realization of these weaknesses lead to the search for more effective extension approaches that generate location-specific and appropriate technologies in response to the needs and problems of smallholder farmers.

Project objectives

Within this context, ITDG conceived the Chivi Food Security Project to demonstrate how principles of participatory approaches can be applied to agricultural extension. The project started working in 1991 in the Chivi district of Masvingo province in southeast Zimbabwe. It has three main objectives:

- To help farmers' institutions to identify their priority needs and strengthen their capacity to bring about solutions.

- To work with local institutions to identify and develop technological options by building on their traditional knowledge.
- To influence government agricultural policies to take into account the production needs of smallholder farmers, by demonstrating the effectiveness of participatory approaches in enhancing household-level food security.

Key project partners include the Department of Agricultural Technical and Extension, the Department of Research and Specialist Services, and the Zimbabwe Farmers Union.

Results

In 1995, a participatory study of the project was conducted. It showed that the number of farmers participating in project activities had increased by over 200% from the original 320. Farmers ranked in the poorer wealth groups comprised about 60% of all project participants, with 34% of these occupying leadership positions (compared with only 21% before the project). The number of women holding leadership positions had increased from almost zero to around 35%.

As part of the project strategy, ITDG actively linked communities to a wide range of support institutions: training, research and extension institutions, as well as innovative farmers. Farmers then identified a range of technologies which they wanted to work with. The table on the next page highlights adoption rates of some of the technologies and emphasizes the wide range of sources the farmers have got these innovations from. *—For more information, contact Blessing Bataumocho, ITDG_Zimbabwe.*

Technology adoption rates and sources of innovations in the Chivi project

Technology	Source	No. of households adopting in 1996 (of total of 1200)
Water conservation for field crops		
Tied ridges	Chiredzi & Makoholi research stations, Institute of Agricultural Engineering, Mutoko	> 450
Infiltration pits	Farmer innovation (from another district)	> 850
Rock catchment	Zvishavane Water Project (an NGO)	14
Modified contour ridges	Farmer-designed	> 40
Mulching and ripping	Makoholi research station	> 50
Fanya juu terraces	Contil project (Masvingo)	> 4
Winter ploughing	Revived traditional practice	> 800
Intercropping	Traditional practice	> 450
Using farm/arda soil (to raise fertility and conserve moisture)	Traditional knowledge	> 800
Water conservation for vegetable gardens		
Clay pipes for sub-surface irrigation	Chiredzi research station	> 450
Mulching	Fambidzana Organic Training Centre (an NGO)	> 800
Plastic sheets buried in beds	Fambidzana Organic Training Centre	> 250
Inverted bottles	Fambidzana Organic Training Centre	> 300
Gully reclamation	Dept. of Natural Resources	2 gardens & 4 villages
Shallow well improvement	Zvishavane Water Project	8 gardens

Group extension

Group extension is a way of disseminating information and technologies on agricultural and rural development through groups of farmers. It aims to develop local skills and empower local people to solve their own problems. It is a key part of participatory extension processes (see the section on *Participatory agricultural extension*).

Government and non-government organizations have too few staff and resources to provide extension advice to every farmer individually. Traditional extension approaches are often top-down and ineffective. Working with groups of farmers allows staff to interact with larger numbers of farmers at the same time, thus using scarce resources efficiently. In addition, many activities are best performed by groups of

farmers rather than individuals. Group members can pool their labour and other resources, divide tasks into manageable units, learn from one another, and make decisions jointly. The examples later in this section illustrate this.

Advantages

- By uniting and contributing to a common pool, the group members are able to achieve things they would not be able to do as individuals. Many sustainable agriculture techniques are labour-intensive; the groups allow farmers to share labour to make improvements in their farms. They reduce the burden of work for individual farmers by sharing it among many.
- Farmers can share farm implements and machinery, planting materials and other resources.
- Every group member receives a tangible benefit (such as a water tank, a cow, or seedlings).
- Groups can help even the poorest people to improve their livelihoods.
- Groups provide an opportunity for strengthening friendship and teamwork, allowing members to share ideas, insights, experiences and problems.
- Groups provide a forum for extensionists and development agents to introduce ideas and skills that may be relevant to the farmers' problems and needs.

- Groups may form to do certain things—often a money-making activity such as poultry-raising, vegetable-growing and selling crops (see the section on *Marketing produce as a group*). These activities can make money for the group as a whole or for its members. But the groups can also take on other tasks that do not make money directly, such as compost-making, health education, or other community-related tasks.
- Groups can seek funding and advice from NGOs or donor organizations to support their development work. This type of support is not usually available for individuals.

Disadvantages

- Groups may become dependent on outside organizations such as an NGO. The outside organization should be careful to avoid this: it should strive to empower the group to manage and finance its own affairs, so it becomes "self-propelled".
- Groups may fail because of conflicts among their members. The members must have similar interests and understandings about the group, and what it will (and will not) achieve. The benefits should be distributed fairly, according to the amount of effort each member puts in.
- Groups also fail because the members feel they put in more than they get out. Activities should have a reasonably quick payback: one that members see as important.

Procedure

Many of the activities in the list below are continuous and happen at the same time. The development worker should help and guide the group members through a participatory process, rather than forcing them or making decisions for them.

1. Conduct an initial survey to find out people's attitudes and priorities, and to gain an understanding of the community and its environment. Collect information on the local land, soil and climate types, vegetation and crops, social and economic characteristics. This survey can use a combination of participatory appraisal techniques, questionnaires, and a review of existing information collected by village officials and local authorities. The survey can be conducted by the local people themselves. See the section on *Participatory agricultural extension* for more information.

2. As part of this process, help the people prioritize their problems and identify possible solutions and opportunities. If a group of outsiders with different specializations is involved in the survey, they can call on their own experience to suggest solutions to the problems identified.

3. Discuss the group approach with members of the community. Discover if they are interested in forming a group.

4. Identify villagers willing to participate in the group. Group members should have important features in common: they may farm the same type of land, grow the same crop, raise the same type of livestock, or get fuelwood from the same forest. They should be able to attend group meetings, be interested in the topic, and willing to learn and share their knowledge with others. The ideal size of a group depends on its

aims and focus. Groups of about 20-30 people seem to work well for many topics. It may be possible to base such groups on existing local organizations, such as a credit co-operative or irrigation association. Women-only groups provide an opportunity for women to learn, generate income, and take on responsibilities and leadership within the community.

5. Help the group to determine what it wants to do: its aims and activities, plans and responsibilities. This should be a continuous process: the group should review its plans on a regular basis as conditions change.

6. Help the group work out its dynamics and working procedures: how are meetings conducted, how is work organized, how are activities evaluated? Provide training on subjects such as facilitation, leadership, management, group dynamics and record-keeping if required.

7. Help the group decide how to run itself. It should develop a set of rules and bye-laws (see the box below for some of these). Determining these rules and procedures is a continuous process. The group should not try to fix them all at once, and should be willing to review its decisions as conditions change.

8. Help the group decide how to handle money (see the box for some guidelines).

Rules for groups

Each group must establish a set of working rules. These can be formal or informal, but they must be clearly understood. There should be benefits for following the rules, and penalties for breaking them.

Bye-laws

- How much labour must each member contribute, and should this be free or paid (in cash or as meals)?
- Who should the group officials (chairperson, secretary, treasurer, etc.) be, and how should they be chosen? How often should the officials be changed? What is the role of each official?
- What are other bye-laws and rules: punctuality for meetings, attendance at workdays, penalties for breaking the rules, etc.

Financial

- How much money must each member contribute, and how often?
- How should this money be spent? How should the group purchase equipment and supplies?
- Who controls the money: who makes decisions on spending and allocation, and who looks after the money?
- What are the requirements for registering the group with the authorities? How can the group open a bank account? What are its tax obligations?
- How are the accounts kept? Who keeps them, in what form, and who else is involved in the book-keeping? How easy is it to understand the records? How transparent are they? What safeguards are there against corruption?

9. Identify information from outside the village that the group can use: technical packages from universities, research institutes or other villages that might be useful to solve the problems identified in the survey.

10. Help the villagers identify promising technologies that they wish to test and adapt. Help them design and implement field tests of these technologies (see the section on *Participatory technology development*).

11. Arrange training and field visits to introduce the new technologies to the group members. Visits to research sites or other villages are particularly useful to demonstrate new technologies and how problems can be solved.

12. Assist the group to refine and implement its plans.

13. Create linkages with government agencies, universities and NGOs so the group can access services and resources such as seed, fertilizer, credit and marketing facilities.

14. Evaluate the results with the group members. Arrange evaluation sessions with all group members, and invite members from other groups to help disseminate information more widely. Such sessions are a good opportunity to learn the feelings, needs and priorities of farmers.

Group extension for tree and coffee seedlings in Ethiopia

Farmers in Mareka Gena, in southern Ethiopia, face twin problems of deforestation and a disease attacking coffee berries. Deforestation causes severe soil erosion and a lack of fuelwood and building poles, while the berry disease cuts coffee yields by more than 30%.

ActionAid-Ethiopia helps form local savings-and-credit groups and works with them using the approach described above. It has found that groups with 20-30 members function better and suffer from fewer internal conflicts than do village co-operatives. This is because the groups are smaller and more manageable, and their members have more in common than do the much larger village-wide co-operatives. The groups can focus on problems they feel are important, rather than those identified by outsiders. However, ActionAid found that regular meetings and refresher workshops are necessary to maintain the groups' skills and enthusiasm.

ActionAid provides the groups with advice on coffee cultivation. One or two farmers in each group volunteered to establish nurseries to produce coffee seedlings of varieties resistant to the berry disease. ActionAid trained them in nursery management, coffee production and forestry activities, and provided them with subsidized seeds. These "resource farmers" have established nurseries on their own land and grow seedlings to plant or to sell to their neighbours. The resource farmers have become effective extensionists, spreading their new knowledge among their neighbours.

Unlike the government's coffee-seedling nurseries, these nurseries are managed entirely by farmers themselves. They require minimum inputs from outside, and information that seedlings are available spreads rapidly by word-of-mouth throughout the area.

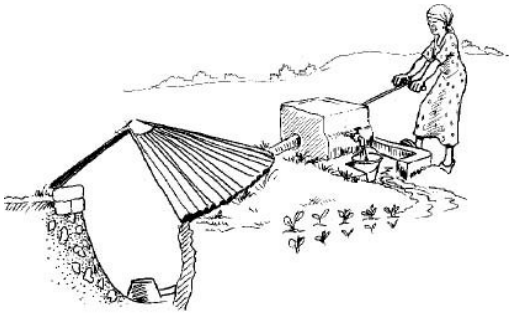
In 1996, Ato Alemaye Aydeko, one of the resource farmers, sold coffee seedlings worth about birr 1200 (US$ 175). In this year, 15 farmers were engaged in raising coffee seedlings. In 1997, ActionAid began using the same approach to introduce forest-tree seedlings. In the first year, five groups with a total of 50 farmers began raising forest-tree seedlings. *—For more information, contact Moges Bekele, ActionAid-Ethiopia.*

Rainwater harvesting in Kenya

Lack of water is a major problem in Olmoran and Sipili in Laikipia district, Kenya. With a rainfall of 400-600 mm, these villages suffer from drought and famine. Dams, ponds and scattered boreholes (averaging 100 m deep) provide water, but about 20% of the people rely on shallow wells and springs for their domestic water. To the nearest water source is an average round trip of 6 km—more in the dry season.

The Church Province of Kenya has tried to alleviate this problem by helping villagers harvest rainwater and build water-storage tanks. It worked with villagers (995 families in all) to form 32 groups, ranging in size from 12 to 50 people each. Each group formed its own bye-laws. The government provided technical inputs; CPK provided materials to build the tanks, and community members contributed labour and part of the costs. The project was overseen by a steering committee consisting of government representatives, with the district officer as its chairperson and the CPK regional manager as the committee secretary.

The members of each group worked with artisans at one member's house to build a water tank: either above-ground to store rainwater off the roof, or underground to collect surface runoff. The host family provided food for everyone working there. When the work was completed, the group moved on to another member's house.



Underground tank and pump

The members built a total of 151 lined underground tanks and 90 above-ground tanks, and installed 56 pumps. A total of 20 artisans were trained through the project. Besides making water more readily available for household use, the tanks enabled families to start kitchen-gardens, thereby improving their diets.

Above-ground tank. This can be used only with a metal roof.

Most of the tanks were roofed with grass, but this tended to be eaten by termites.Tanks without a roof were breeding-grounds for mosquitoes, and were a danger to children and livestock. The project introduced fish to eat the mosquito larvae.

Gutters to collect water from the roof were not part of the project. Some families put up poor-quality gutters, which were not effective in collecting water in a heavy storm. With hindsight, the project should have put more emphasis on maintaining the gutters, tanks and pumps, and on training people (especially the women) how to do this. *—For more information, contact Joseph Ndegwa, CPK.*

A multi-purpose women's group in Kenya

In 1988, a group of 25 women in Kiamunyeki village, Nakuru, formed the Mahoya Women's Group. The Church Province of Kenya trained them in how to improve their farming methods and increase their production so they would have a surplus for sale. This training covered topics such as compost-making, intensive kitchen-gardening, deep soil preparation, agroforestry, zero-grazing, and poultry production.

The group decided that its priority was to construct tanks to hold water for drinking and for watering livestock. CPK guided the women in group

dynamics and help them organize so they could build the tanks. CPK donated money to buy sand and cement, and the group also saved money and contributed labour. The members built one tank for each family in turn; it took about 2 months to save up enough money to build each tank. The group drew lots to decide whose tank should be built first.

Since then, the group has also bought a cow fro each members, and is in the processor buying some land on which to build a shop where it can sell produce.

The members also are engaged in many other activities: they make compost, keep poultry, plant trees, make their own soap, and invite specialists to train them in family planning, AIDS prevention and other health-related topics. *—For more information, contact Hilda Mukui, CPK.*

Agricultural extension in Zambia

Following the devastating 1991-92 drought, thousands of Zambian farmers were left with almost no seed to plant. In 1994, after the forming a partnership with the Ministry of Agriculture in Livingstone and Kalomo districts, CARE-Zambia began supporting farmers through a seed-distribution project. The problem was how to have close contact with a very large number of farmers over a big area, using a small but highly motivated extension team.

The extension team first assessed existing local institutions, to learn what type of groups exist and how they function, and to create an understanding of what CARE hoped to achieve. This initial fieldwork was very important to avoid duplicating any structures that were already there.

The next step was to encourage the formation of small groups of farmers (where none existed) and get each of these to elect a leader. Several groups within each village formed a village mangement committee, and elected three (chairman, secretary and

treasurer), at least one of whom was a woman. Several village committees then formed an area management committee.

The area management committee is the main point of contact and training support from CARE. This structure enables the 8-person CARE extension team to reach as many as 10,000

individual farmers. The CARE staff visit each area committee once every two weeks for co-ordination and extension work. The committee members are responsible for co-ordinating the activities of the members of their farmer groups, and for passing on information to them. Because the village and area committee members are also farmers and the meetings take place in the villages, the CARE team can meet other farmers and help them seek solutions to local problems. *—For more information, contact Robby Mwiinga, CARE-Zambia.*

Community labour-sharing groups in Kenya

In many parts of Africa, farmers organize small, voluntary work groups to allow the members to help each other to accomplish heavy farm tasks such as ploughing, planting, and harvesting. These groups may also be organized for other community work, such as building houses, or preparing food during a wedding or funeral. Some development organizations try to build on these local institutions to carry out their agricultural extension work.

The Environmental Action Team, a Kenyan NGO, is using such an approach in Kitale district. The work groups are common in many parts of Kenya, and are known by several names, including *saga*, *ngwatio* and *m'wthya*. In Kitale they are known as *bulala*, and are being used by the Environmental Action Team to promote and share new farming and conservation practices. Using *bulala* groups is a form of farmer-to-farmer extension, as farmers learn a particular innovation and share their knowledge and skills to other farmers. Farmers are generally enthusiastic to share their skills with other farmers.

The Environmental Action Team encourages farmers who are interested to learn new practices to form a *bulala*. The ideal number of members in a *bulala* is four to six; if there are more than six members, the rotation scheme is very slow. A *bulala* is usually formed by a group of neighbours. The members elect a farmer-instructor, who then helps the group to decide how they want to work together and what they want to learn. The farmer-instructor works

With the EAT extension staff. A *bulala* may meet twice a week to work on each others' fields, rotating among the members' farms to ensure that work is equitably distributed.

On *bulala* work days, the farmer-instructor shares insights about a particular farming practice with the members of the *bulala*. This takes place right on the farm, sometimes with an extension workers also there. Working as a group, the members review and implement the practice. At the end of the day, the members review and reflect on their activities and lessons from the day.

There have been problems, of course. Some members show up late on work days, do not arrive at all, or send their children in their place. And some members keep their colleagues in the field long periods. This reduces the members' enthusiasm to work hard.

Using farmers' knowledge about soil types

In some countries, ministries of agriculture issue blanket recommendations for fertilizer applications and crop types, covering large areas of the country. While these are useful as a general guide, the best amounts and types of fertilizer and organic matter will vary from place to place, even within a very short distance. Extension services do not have the staff or resources to test the soil in every field to develop specific recommendations for that field. But by drawing on the farmers' knowledge about their soil types and matching this with the scientific knowledge on the same soils, extensionists and researchers can suggest new crops or crop varieties, recommend fertilizer rates and ways of improving the soil fertility, or work with farmers to test new technologies.

Farmers have a detailed knowledge of their local soil types: the soil characteristics, problems, and their suitability for various crops. They may use many different criteria to distinguish one soil from another: for example, texture (sandy, clayey), colour, origin (eg, from limestone), fertility, organic matter content, depth, ability to retain water, ease of ploughing, type of vegetation, and presence of a hardpan or stones. The way they classify the soils is likely to reflect features that they have found important in growing crops.

In order to draw on this knowledge, the scientist or development worker must ask farmers to identify the various soil types in their area and to describe their characteristics. These characteristics can then be compared with the scientific classification. On this basis, scientific information on the soil can be translated into terms that the farmers can understand and use. Instead of having to do soil tests in many different places, development workers can suggest fertilizer rates or crops that are likely to perform well in the whole area covered by a particular type of soil.

The local names of the same soil type may differ from place to place, even among people who speak the same language. By matching the local names against a common standard (the scientific classification), development workers can advise farmers in different areas that share the same type of soil.

Location

This approach is most useful in areas where farmers have a detailed knowledge of their soils (for example, in areas that have been settled for a long time). It is less useful where farmers are new to an area (since they know less about their soils), or where extension and soil-analysis services are strong and can provide detailed advice to large numbers of farmers.

Procedure

The procedure below describes one way of involving farmers in identifying local soil types, matching them with the scientific classification, and then using this information to run on-farm trials on promising technologies. A similar technique can be used to collect and map information for land-use planning (see the section on *Participatory land-use planning*).

If the farmers are involved in this, they can use the skills they have learned to teach others how to map their soils, analyse them and test new farming methods. Throughout the process, make sure that all farmers participate freely. Provide guidance on the next step in the process, but do not interfere in the farmers' decision-making.

In the village (during the dry season)

1. Ask farmers to draw a map of their village, their fields and the surrounding area. They can draw on the ground using sticks or chalk, or on a large sheet of paper. Ask them to include on the map rivers, wooded areas, fields, administrative boundaries, and other important features.

2. Ask the farmers to name the different soil types in the area and to mark them on the map. They can use black beans to show black soils, red beans for sandy soils, etc. Make sure that all farmers agree on the types of soils shown and their locations. Copy the map onto paper to get a permanent copy.

3. Verify the map by walking with groups of farmers along one or more transects (lines or paths from one edge of the area to the other). Make sure you walk across all the different types of soil the farmers have identified.

4. During the walk, ask farmers to describe the type of soil in each place, and the farming practices they use on each type of soil. Write this information on a transect diagram showing the location, topography, crops and vegetation and soil types.

5. Ask the farmers to dig small pits (about 1 m long and 50 cm wide, and up to 1 m deep) in each soil type. At

least one side of the pit should be "clean": a smooth, vertical face that shows the layers in the soil.

6. The soil scientist notes the soil profile (eg, the soil colour and texture in each layer), and takes samples of soil from various layers each pit.

In the laboratory

7. Take these samples to a soil laboratory for chemical and physical analysis. Determine the soil type according to the scientific classification (eg, the classification used by FAO, USAID or UNESCO).

8. Match the farmers' descriptions and the local names with the scientific classification. Try to match each individual local name with a scientific soil type. If a soil map of the area already exists, compare it with the samples collected from the farms. However, may soil maps are drawn at too small a scale to be useful for making recommendations for individual farms or fields.

9. On the basis of the scientific classification, identify major problems and ways of overcoming these for each soil type.

In the village (before the planting season)

10. Discuss with the group of farmers the problems and possible improvements in the farming system for each soil type. Ask them to suggest technologies (eg, a new crop type or fertilization method) that might help overcome the problems. Also suggest possible solutions based on the scientific evidence you have obtained.

11. Help the farmers plan on-farm trials to test the most promising technologies. Identify volunteer farmers cultivating each soil type to carry out the trials in their own fields.

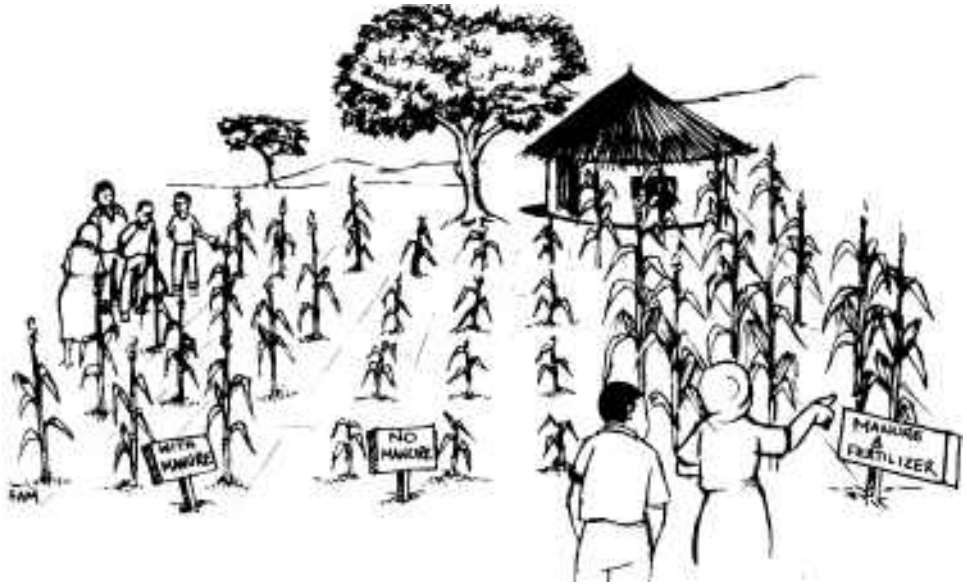
12. Help the farmers to implement the on-farm trials and to maintain records of what they have done (eg, inputs, timing of activities, and labour used). See also the section on *On-farm technology testing* in this book.

13. At an appropriate stage during the season, organize field days for groups of farmers to inspect the results of the trials.

14. When the trial plots are harvested, make sure that the farmers record the yield and other important information.

15. Evaluate the results of the trials together with the group of farmers. Help the farmers decide which technologies have performed well enough for them to want to use on a larger scale in the next season.

16. Discuss plans for further trials in the next crop season. For example, the farmers may want to verify promising technologies on similar soil types, or adapt a technology to suit the amount of labour they have available.



Soil classification in Kindo Koysha, southern Ethiopia

The Awasa Research Centre has helped farmers in three villages in southern Ethiopia identify and characterize their soils. The farmers identified several soil types, and the researchers matched them with the equivalents in the FAO classification. Some of these are shown in the table below.

As a result, the farmers are testing several varieties of wheat, haricot beans and teff, and several levels of fertilizer inputs on three of the soil types: *gobo bita*, *talla bita* and *kareta bita*. *—For more information, contact Kelsa Kena, Awasa Research Centre, Ethiopia.*

Farmers' name for soil	Farmers' description of soil	FAO name for soil
Gobo bita	Red to reddish-brown soil, widely distributed in the area, workable, has variable depth of topsoil. Gives good yields, particularly with the application of DAP fertilizer, which contains both nitrogen and phosphorus.	Nitosol
Talla bita	Clay texture, heavy to work, cracks when dry, difficult to walk on footpaths barefoot. Slippery when wet. Workable and productive when moist. Requires draining in heavy rainy seasons. Fertilizer application improves yields of teff, maize and haricot beans. Crop rotation and intercropping of maize and haricot beans is common. Mostly used for grazing.	Vertisol
Kareta bita	*Kareta* means "black" in the Wolaita language. Deep and fertile. Teff, haricot beans, sorghum and coffee do not need to be fertilized, but maize yields improve with a combined application of fertilizers containing nitrogen and phosphorus. This soil is not used for grazing; it is seen as "rich-man's soil".	Molisol
Chare	*Chare* means "marshy soil" in Wolaita. Wet for most of the year. Mainly left for grazing; some is used to grow taro, sorghum and teff.	Gleysol

Participatory technology development

Participatory technology development, or PTD, is an approach which involves farmers in developing agricultural technologies that are appropriate to their particular situation. It is a practical process: farmers, as "insiders", bring their knowledge and practical abilities to test technologies, and interact with researchers and extension workers—the "outsiders". In this way, farmers and the outside facilitators are able to identify, develop, test and apply new technologies and practices. PTD seeks to reinforce the existing creativity and experimental capacity of farmers, and to help them keep control over the process of generating innovations. It can be an integral part of community-based extension approaches (see also the sections on *Participatory agricultural extension* and *Group extension* in this manual).

Advantages

- PTD builds trust between farmers and outsiders. This helps to build the farmers' confidence, tapping their potential for innovation and initiative.
- It strengthens the links between indigenous and scientific knowledge.
- It builds human capacity for self-reliance.

Disadvantages

- The PTD approach takes a long time, and demands patience and humility on the part of the outsiders.

Procedure

The PTD approach has five basic phases: building trust, identifying alternatives and setting priorities, designing the experiment, conducting the experiment, and sharing the experience.

Build trust

1. Develop and strengthen your relationship with the farmers, aiming to go beyond that of a professional with a client. Listen and try to understand the farmers' views, and try to help them become comfortable making suggestions and expressing their opinions.

2. Help the farmers identify the problems they want to solve. Consider the situation from the farmers' perspective. Look at issues in a holistic manner, taking various aspects into consideration. As far as possible, involve all of the members of the household: men, women, and children.

Identify alternatives and set priorities

3. Identify indigenous knowledge and skills that may be relevant to the problems selected.

4. Help the farmers identify several different ways they might solve the problems. Ideas for the alternatives may come from the farmers themselves, or from outsiders. Link these alternatives to the farmers' situation and experiences.

5. Together with the farmers, examine the advantages and disadvantages of each of the alternatives.

6. Assist the farmers to choose one or more of the alternatives for testing in the field.

Design the experiment

7. Help the farmers decide how to test the alternatives they have chosen. The experiment should involve both farmers and outsiders. The experiment design should show the difference between the various alternatives, as well as with the current practice. See *On-farm technology testing* for details of how to do on-farm tests.

8. Help the farmers decide how to measure the results, so they can tell which alternative is best. Both farmers and outsiders should be involved in evaluating the results and assessing the impacts.

9. Train farmers how to conduct the experiment and manage the research process.

Conduct the experiment

10. Help the farmers do the experiment, following the agreed design.

11. Measure and record the results of the various alternatives, as well as the current practice.

12. Evaluate the results from the alternatives by comparing them with the current practice.

13. Modify the alternatives as needed, and if needed, test them again in the next season.

Share the experience

14. Organize ways of sharing the experiences (technologies, successes, failures and constraints) of the experiment. These can include field visits, discussions, training sessions and study trips. Make it clear whose experiences are being shared. Put the farmers' experiences in the forefront. Let the individual farmer (or the group) say "I have done it. It is mine". Ensure that experiences and views on what contributed to success (or caused a failure) are shared.

15. Recognize unique situations (such as land, climate, soils, socio-economic and political situations) which may exist, as these determine how a technology might be improved or modified.

On-farm technology testing

This extension approach involves farmers in testing and selecting technologies, such as varieties of a crop. This section describes how to do trials of crop varieties. A similar approach can be used for other types of trials, for example testing pest-control measures, fertilizer applications, or (as in one of the examples later in the section) dates to plant various crops.

On-farm trials may be conducted by researchers or extensionists, or by farmers:

- If they are conducted by outsiders, the farmers' involvement is small: it may be confined merely to providing land and labour.
- The trials can also be conducted by the farmers themselves, possibly with the assistance of an outside facilitator such as an extension worker or researcher. They can be part of a participatory technology development approach (see the section on *Participatory technology development* in this book). In such cases, the farmers take the initiative and responsibility for the trials: for example, they may decide that they wish to test varieties, select the varieties to test, design and implement the experiment, and evaluate the results. Outsiders can provide guidance in this process.

There are many gradations between these two extremes. The most appropriate approach will depend on the particular circumstances. This section describes an approach where the initiative for the tests comes from outsiders, but the farmers themselves have a high level of involvement and management.

Advantages

- The approach helps in developing and testing the most suitable technologies for the community. For this reason, these technologies are likely to be adopted quickly by other farmers.
- Farmer participation in on-farm trials enables them to be involved in evaluating and selecting farm technologies right from the beginning.
- It develops farmers' analytical skills. After conducting one such trial with the guidance of outsiders, they will be encouraged to do further tests on their own.
- It enables farmers to develop a sense of ownership of the technologies, since they choose which are to be promoted.

- It provides researchers with valuable information about farmers' preferences and the problems they face.

Disadvantages

- Farmers' organizations may find it difficult to get sufficient support from research stations and extension services to enable them to use this approach.
- On-farm trials require considerable organizational skills, and may require literacy and numeracy. The farmer groups may lack these. Considerable guidance from the outsiders may be needed.
- Planting material is sometimes not available on time.
- Trials may be disrupted by pests and unreliable weather.

Location

This approach is useful in almost all areas. However it may be difficult where the community has been used to handouts.

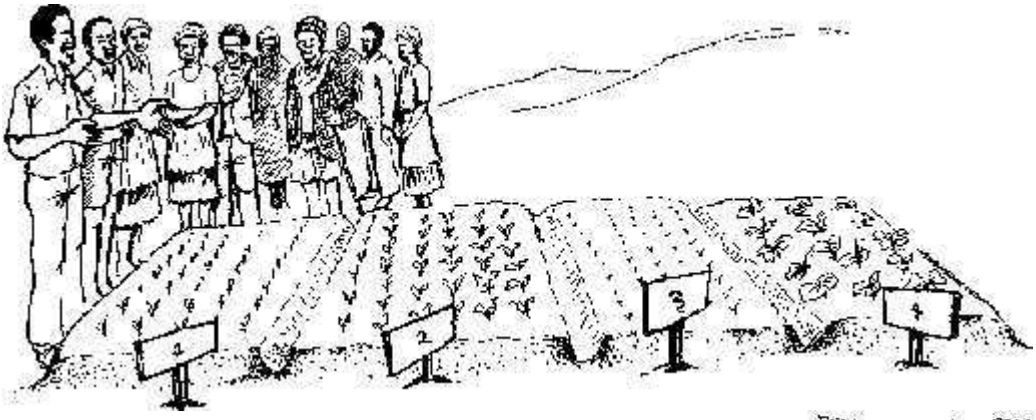
Procedure

This description assumes that the decision to test crop varieties has come from the outside organization such as a research institute or extension agency. But it may also be expressed by the farmers themselves through participatory appraisal methods, or during long-term work with the community.

1. Inform community members of the wish to test crop varieties, and seek their agreement and help in this.
2. Assess the local environment, farming systems, natural resources and the characteristics of the local crop varieties.
3. Decide which crop varieties to test. The local farmers may suggest the ones they are familiar with; the outsiders may suggest others. You should test at least two local varieties as well as the introduced ones.
4. Obtain seeds from research centres and the community. Avoid hybrid varieties of cross-pollinated crops, because after the first generation of seed, their performance goes down and they produce low yields.
5. Ask a group of farmers to volunteer to take part in the trials. Their plots should be representative of the local soils and land types on which you want to test the varieties.
6. Identify at least four separate sites for the trials, so you can replicate the trial four times. You need to do this to make sure that the results from one site are not because of chance (such as the soil in one plot being more fertile than the other plots, or the crop in one plot being destroyed by pests or a flood). An easy way to do this is to ask four different farmers to run the trials on their fields.

7. Lay out the trial plots. Each plots should each measure, say 10m x 10m **(Picture 1)**. At each of the four sites, you will need as many plots as there are varietiesto test. Plan to plant one variety in each plot. Extension workers should assist the farmers in laying out the plots.
8. Train the farmers how to manage the varieties: planting time, seeding rates, weeding, etc
9. Plant the copy varieties in the plots.
10. Maintain the plots according to plan. as far as possible, treat all the plots the same: the same amount of irrigation water, weeding pest contol, and so forth. This will mean that the results from the different plots can be compared directly with each other.
11. Together with the farmers, decide how to evaluate the varieties. The things to measure will depend on the type of crop being tested, but might include the germination percentage, vigour, resistance to drought and pests, flowering time, maturity, yield, theshability and harvestability. After harvest, they may include the cooking quality, taste, and quality of by-products. Note that the farmers may choose different criteria from the researchers, and they may put different weights on the same criteria. For example, the farmers may put more emphasis on drought-tolerance, while the researchers may stress total yield.

12. Monitor the varieties throughout the growing season. Both the outsiders and the farmers should do this. Organize field days at the different stages of crop growth so the farmers can see for themselves how the varieties are performing **(Picture 2)**.



13. Harvest the plots and weigh the yield.
14. After harvest, evaluate how the varieties have performed, using the criteria agreed on earlier. You can use participatory appraisal methods such as matrices to do this **(Picture 3)**.
15. On the basis of the evaluation, reach agreement with the farmers on which varieties should be promoted. You may decide to test some varieties further in the next season.

16. Organize seed-growers' groups of 10-15 farmers each. Train them how to manage the new varieties and grow seeds for distribution to their neighbours. Provide them with extension support so they can produce enough seeds to supply the local needs.
17. Report the results of the tests to the research institution. Make sure you report disappointments (such as crop failure) as well as positive results.

Testing sweet-potato varieties in Ethiopia

In 1996 and 1997, a local-level seed-production project was carried out in Kutcha and Baroda districts in southern Ethiopia by Agri-Service (a local NGO). The project's main aim was to ensure that drought-tolerant, disease-resistant, high-yielding varieties of sweet potatoes were available to overcome food shortages in the area.

Agri-Service held community meetings to discuss what resources and crop varieties were available. The community chose a group of representative farmers, who identified specific problems associated with the sweet potatoes varieties.

It was then decided to evaluate two local sweet-potato varieties and two improved varieties from the research station. The aim was to judge the performance of the improved varieties before they were released by the research station. Agri-Service bought improved planting materials from Nazret Research Station, while the farmers provided the local varieties.

After training, the target farmers planted the varieties at six sites. during field days organized during flowering and harvesting, farmers, extension workers and researchers monitored the crop performance. Of the varieites tested, Koka 6 (an improved varieity was chosen for its ease of harvesting, length of vine, stress tolerance and yield.

Agri-Service helped form and train 14 seed-growers' groups and organize their leaders into five committees. As a result, 800,000 cuttings of Koka 6 were distributed to 140 families, who planted them on a total of 14 ha of land. The crop yielded an average of about 2.1 t/ha (40% higher than the local varieties). The yield was so high that it was difficult to store the surplus.

Agri-Service learned that raising awareness and full community participation are crucial for the success of such efforts. This community work should be done during the off-season, when it does not interfere with normal farm work. Agri-Service also learned that farmers are good researchers, and their opinions should be taken into consideration when designing the trials.—*For more information, contact Asfaw Tulu, Agri-Service Ethiopia.*

Testing planting-dates in Kenya

In 1995, Intermediate Technoloty-Kenya identified late planting as one of the main reasons for low farm production in Maragwa, Tharaka Nithi, in Kenya. As a first step towards identifying the community's problems, IT-Kenya contacted the local development committee. It followed this with efforts to create rapport with the community and to gain local people's confidence. It conducted a participatory rural appraisal to get a better understanding of the existing knowledge and factors affecting crop yields. IT-Kenya and the local people analysed the problems jointly and developed plans for tackling them.

This resulted in an agreement to run a set of trials to test early planting for various crop species and varieties. The farmers set the plot sizes, which ranged from 0.2 to 0.4 ha (0.5-1 acre). Half of each plot was planted as close to the beginning of the rainy season as possible; the other half was planted about 10 days after the rains began. A total of 36 farmers were involved in the trials. Field days were organized regularly to share information on yields with the wider community.

Over 3 years, the project studied 20 varieties of the main short-season food crops: sorghum, millet, grams and cowpeas. The benefits of planting early were impressive: sorghum yielded an average of 42% more if planted early; millet yielded 30% more, grams 20% more, and cowpeas 18% more.

Farmers often do not plant early because of labour shortages, or lack of seed on the market in case the rains fail and replanting is necessary. The project recommended that sifficient seed be made available on the market in case the early rains fail, that ploughing groups be organized to provide ploughs and train oxen, that improved weeding tools be designed, and that further demostrations be conducted to convince farmers of the benefits of early planting.—*For more information, contact Eric Kisiangani, Intermediate Technology-Kenya.*

Research on agroforestry in Kenya

In 1984-85, CARE-Kenya began an agroforestry extension project in Siaya and South Nyanza districts. In its early phases, the project promoted tree-planting in schools and with women's groups, with CARE providing inputs for tree nurseries. The main technologies promoted were

hedgerow intercropping (mainly with *Leucaena leucocephala*), boundary planting and woodlots. The project extension workers designed the technologies with little regard for what the farmers already knew about agroforestry. The approach depended on heavy incentives in the form of farm and nursery inputs, which helped to ensure farmer participation, but undermined the long-term sustainability of the activities. The project tried to catalyse more intensive agroforesty practices. This involved changing farmers' attitudes, accelerating the rate of tree planting, and improving tree diversity. It did not use a farmer-to-farmer estension mechanism.

The latest phase of the project incorporates lessons from previous efforts. It includes three components; institutional capacity-building, extension and training, and adaptive research. The adaptive research dimension is described below.

Indigenous technical knowledge

The methodology begins with a survey of what farmers already know: their indigenous knowledge on land use and their production practices for crops, trees and animals. A cross-section of farmers are interviewed, especially the elderly.

Farmer selection and training

Using their own criteria, group members select "adaptive-research farmers" who are given an intensive 2-3-day hands-on training focusing on:

- The concept of adaptive research.
- The role of the adaptive research farmer.
- How to conduct a participatory research needs assessment.

- How to conduct farmer-managed trials
- How to analyse and comunicate the results to other farmers.

Needs assessment

The research and extension staff and the adaptive-research farmers work with the farmers' group to identify its needs, land-use problems, and possible solutions to these problems. Key

research topics are identified in each agro-ecological zone; the issues are then prioritized for action. Some of the research areas identified include:

- Sustainable methods of improving soil fertility.
- Effective control of striga weeds.
- Screening of crop varieties (such as maize).
- Screening of tree species for various uses.

Trial design and establishment

The adaptive-research farmers in each agro-ecological zone meet to discuss the design of the proposed technology trials and to decide what parameters to monitor. Project staff and research officers work with them to design the trials. The trial plots are then laid out on their farms. See the boxes below for examples of such trials.

Monitoring and data collection

The adaptive-research farmers are responsible for managing and monitoring the trials. The researchers help them keep records and collect data, and make sure that no data are lost. The group members contribute labour to maintain the trials. Materials for use in the trials can be contributed by the farmers or by the project. Commercial seed companies sometimes donate seeds for variety screening.

Trial 1: Species screening for border trees

The farmers screened several trees species to identify those appropriate for planting along farm borders. Though it was not the best in terms of either survival or growth rate, the farmers preferred *Grevillea robusta* for border planting. *Acacia mearnsii* grew fastest, but many seedlings died, so the farmers ranked it last. They ranked *Markhamia lutea* second because it tolerated both termitesand drought.

Tree species	**No. of farmers testing**	**No. of trees planted**	**Survival rate (%)**	**Average monthly growth (m)**	**Farmers' ranking**
Grevillea Robusta	9	180	53	0.09	1
Markhamia lutea	6	120	62	0.06	2
Casuarina equisetifolia	7	140	23	0.07	3
Acasia mearnsii	5	100	16	0.11	4

Trial 2: Maize variety screening

In almost all the trials during the 1997 long rains, several newly introduced varieties yielded better than the other (more commonly available) varieties. Field observations showed that Pioneer HB 3253 was very prone to *Striga*, so was suitable only where the weed is not a problem.

Average yielf (kg/ha)

Variety	No. of farmers testing	Yield (kg/ha)		Farmers' ranking
		High potential zone	Low potential zone	
Pioneer HB3253	17	4320	2940	1
Cargill 4141	17	4280	2400	2
Cargill 5222	17	3960	2640	3
Local white	17	4000	2200	4
HB 512	17	2920	2880	5
HB 511	17	2360	1400	6
Maseno DC	9	3040	—	—
HB 622	5	3800	—	—
Morogoro	2	2120	—	—

Data analysis and dissemination

The adaptive-research farmers and group members analyse the data from the trials. The researcher facilitates the discussion, with the farmer presenting the results. The results are also shared more widely with other researchers and institutions.

Using the results

After the trials are over, group members and the adaptive-research farmers are encouraged to compare their current production practices with the methods tested in the trials. They then make plans for the next season, modifying their practices based on what they have learned. In this way, farmers are encouraged to change their production system based on what they can use on their own farms, and as they gain new information from the trials.

Farmer visits

Farmer visits involve a group of farmers visiting other farmers within the same locality (or farther away) in order to share information about specific technologies or ideas. If done after a training course (as described below), the main aim of the visit may be to enable farmers see the items taught during the course actually being used. The method is particularly useful to build farmers' confidence and to establish farmer networks. The saying that "One who doesn't travel thinks his mother is the best cook" best captures the purpose.

Farmer visits are often part of a broader extension programme. They are useful in community-based extension efforts (see the sections on *Group extension and Participatory technology development*) or as part of regular extension activities. Farmer visits may be organized by an outside group such as the extension service or an NGO, or by the farmers themselves.

Advantages

- Farmers learn by seeing and doing. The farmers will see the technology being used, and may adopt it easily.
- Farmers tend to believe other farmers, so the spread of skills and ideas is much faster than through conventional extension.
- Seeing successful examples motivates the visiting farmers to try to do better themselves.
- Visits help build relationships and networking among farmers.
- The visits build the confidence of the farmers hosting the demonstration.
- The visitors can see and learn many things other than the specific technology they came to see.

Disadvantages

- The costs for training (training materials, resource persons and venue) and transport for the field visit may be high.
- Farmers may be unable to bear some of the costs.
- Farmers may hesitate to share their experiences with others.

Organizing a field visit

1. You may already be familiar with the specific socio-economic culture and environment where both communities live. If not, you can use participatory appraisal methods to study them. This helps to identify the farmers' needs, problems and resources in each area.

2. Plan a training course and develop training materials relevant to the needs identified.

3. Find out the farmers' opinion on when to carry out the course and visit. See the "Do's and Don'ts" box at the end of this section for some things to consider.

4. Invite farmers to participate in the course and the visit. As a way of showing their commitment, participants should be encouraged to contribute in kind or in cash. However, contributions should not be forced, and each case should be treated differently.

5. Carry out the training. This should be simple and short, and focus on the two or three main things that the visitors will see during the field visit.

6. Implement the visit. Ensure that the visit's objectives are clear to all concerned: both guests and hosts. As far as possible, the NGO staff member or extension worker should keep in the

background, allowing the host farmers to describe their experiences, and the visitors to ask questions about results and problems.

7. Immediately after the trip, get feedback on the visit from the participants: on both the logistics and what they have learned. Together with the participants, identify ideas or techniques they can try out. Where necessary, suggest modifications to the techniques to suit the local conditions. Encourage the participants to discuss the technology with others so as to avoid misunderstandings when trying to adopt the technology. For example, one farmer adopted agroforestry and mulching without

consulting her husband. He uprooted her trees because he wanted to grow vanilla instead.

8. Provide information and support to farmers as they try out the new techniques.

9. After some time, evaluate the results to find out whether the techniques have been adopted. If yes, which ones have they adopted? If not, why not?

Do's	**Don'ts**
o Avoid organizing visits during busy agricultural seasons. o Include both successful and not-so-successful farmers among those to be visited. Each situation contributes differently in terms of learning. o Make sure that the farmers being visited are willing and ready to receive the visitors and to explain what they are doing in their farms. o Make sure the timing of the visit suits both the hosts and the guests.	o Avoid organizing visits during busy agricultural seasons. o Do not organize visits if the techniques are complicated or require a lot of attention, time and labour. o Do not visit rich farmers. The visitors may think that their success is the result of their wealth; this may discourage them from adopting the technology.

Credit and marketing

Credit for farm activities

Credit is the provision of loans by a bank or other organization. The loans can be in cash or in kind (eg, seeds, livestock, fertilizer); they can be granted to individuals or to groups. This section describes cash on in-kind credit; the section on *Livestock micro-credit* describes a special form of credit used with animals.

In the group approach to credit, needy members of the community are identified and organized into groups. The groups help to ensure that loans are repaid, since the members press each other to honour their commitments to repay. This approach also eases the management of funds. Once the groups are organized and have legal status, they are trained on how to manage heir loans. Training may also be given on the activities the funds can be spent on. The loans are then given to the community, mostly in kind, though in some cases cash is given. The funds are given at a low interest rate which the farmers can easily pay. A brief period (called the "grace period") is then given before the farmers have to start repaying the loans. The group arrangement is used only for the purpose of accessing the credit; payment is done by the individuals rather than the group as a whole.

Credit enables poor members of society to acquire what they would not otherwise be able to with their limited resources. When properly done and successful, the community members are empowered because they have added to their assets and are able to manage other forms of credit. The process thus develops the community's capacity to organize itself for a particular activity.

Credit programmes can be run in any community where credit can help solve problems. Group-credit programmes work best where there is some level of cohesiveness within the community. The community should also be willing to undertake the project.

Procedure

1. Identify the area where the project will be implemented.

2. Identify project beneficiaries. This could be done using participatory methods such as wealth ranking (see the section on *Participatory agricultural extension*).

3. Create awareness on the kind of credit programme to be implemented.

4. Organize the target beneficiaries into groups and make sure they are registered with both the organization and the government. The purpose of this is to allow monitoring of the credit activities. In some countries registration with the government is required.

5. Conduct training on all aspects of the project.

6. Release the loans when you are sure the beneficiaries have been adequately prepared to receive them.

7. Conduct on-going training and extension to follow up the planned activities.

8. Start collecting the loan repayments after the grace period. Repayments can be made in kind or in cash. Depending on the agreement reached with the beneficiaries.

Credit for irrigation in Kenya

The Smallholder Irrigation Scheme Development Organization (SISDO) develops small-scale group-based irrigation infrastructure. It targets horticultural crops for both the local and international markets. SISDO provides credit without collateral to self-selecting groups. The groups co-guarantee the loans given to every member.

SISDO offers credit for various types of enterprises:

- Group-based gravity-fed irrigation infrastructure (developed with and managed by the farmers).
- Pump-fed irrigation systems for clusters of individual farmers.

- Farm inputs for groups of farmers with irrigation water so they can produce horticultural crops.
- Zero-grazing units for clusters of farmer groups.

The provision of credit starts with a request by the community to SISDO. Several meetings follow to explain SISDO's objectives and to train the farmers. Screening is also done at this time to determine the viability of the project, and to gauge the group's cohesiveness and eligibility.

Before farmers can get loans, they must be organized into groups and registered with the relevant ministry, be willing to meet every month, and agree to produce only horticultural products. Farmers applying for credit must reside on the farms to be irrigated. They are required to pay 15% of the project cost as a measure of their commitment.

Loan application forms are distributed at the group meeting for individuals to fill in. Once the groups have agreed to co-guarantee each other, the documents are signed by the group officials. SISDO then disburses the loan to the group. It is the task of the group to distribute the loan to its members. The loan is usually paid in kind. SISDO's role is to ensure that the rules and procedures are followed. The groups then ensure that the loans are repaid on time each month. *—For more information, contact Grace Njoka, SISDO, Kenya.*

Seed credit in Lesotho

In 1995, the Rural Self-help Development Association (RSDA) began promoting the Machobane farming system in Lesotho (see the section on *The Machobane farming system in Lesotho*). RSDA developed an approach to assist, train, and provide technical assistance to small farmers.

Community campaigns are conducted to promote the Machobane system. Farmers who are interested in trying it sign up with RSDA, and pay a small annual service fee (7.50 maloti). They then attend a training course which includes an orientation to the farming system, visits to farmers' fields, and demonstrations. Mr Machobane, the inventor of the farming system that bears his name, is involved in the orientation and demonstration activities. The farmers then measure and plough a 0.4 ha (1 acre) plot, and prepare organic fertilizer for incorporation into the soil.

RSDA makes the farmers an in-kind loan of the seeds to be planted. This includes: 5 kg of wheat, 5 kg of peas, 5 kg of maize, 5 kg of sorghum, 5 kg of beans, and 300 kg of seed potatoes. The farmers provide their own seeds for other crops, such as pumpkin and watermelon. This loan of seeds is given only once.

RSDA provides extension services to the farmers throughout the year, delivering seeds and offering further training on the Machobane farming system. RSDA plans to provide technical assistance for up to 5 years. Old and new farmers alike are required to pay the annual service fee, for which they receive the extension services and training.

After the harvest, RSDA assesses the production records with the farmers, who are then expected to repay their seed loan in kind. They must return the following seed amounts: 6 kg

of wheat, 6 kg of peas, 6 kg of maize, 6 kg of sorghum, 6 kg of beans, and 360 kg of seed potatoes. *—For more information, contact Tsepozi Mathamba, RSDA, Lesotho.*

Do's	Don'ts
o Give credit only to trained farmers who know the implications of accepting the credit. o Give credit at the right time. o Give credit only where lack of credit has been identified as a constraint to production. o Gauge the level of cohesiveness of the community before giving credit using the group approach.	o Don't give credit to groups before they are properly established. o Don't ask for a lot of collateral from farmers.

Livestock micro-credit

Livestock can be an important part of an integrated farming system, making important links with crops produced on the farm. They produce milk, meat, manure, draft power, hides, and income from milk and meat sales.

However, small-scale farmers in many areas lack livestock, or their animals are of poor quality and produce little meat and milk. Livestock micro-credit (sometimes called "livestock dispersal") is one way to introduce livestock in such areas. These schemes make animal "loans" to individuals, on the condition that the loan is repaid in the form of one of the animal's offspring. This animal is then passed on to another household under the same arrangement. Alternatively, the farmer can repay the loan in cash, which is then used to buy another animal to be loaned. The micro-credit arrangement may be part of a broader project that also provides veterinary and other services (see *Community-based veterinary services* and *Keeping male animals for breeding* in this manual).

These credit schemes help farmers to improve the quality of their livestock through introducing pure-bred or cross-bred animals. They also enable a larger number of farmers to keep and benefit from livestock.

Livestock micro-credit is applicable for a wide range of areas where animals are managed intensively, and where farmers can be organized in groups that manage the loan process. It is not suitable where it is not possible to grow sufficient forage (especially in the dry season) or where the animals may be harmful to the environment (for instance, by overgrazing or eroding the soil).

As shown in the example from Ethiopia below, this approach is particularly useful with goats. They are hardy, versatile animals and involve little investment and few risks for the farmers. They reproduce quickly, enabling other farmers to receive a young goat within a short time. In many cultures, women and children are responsible for keeping goats, so this is a way of increasing their income. Because goats can eat forage from roadsides and field edges, they are ideal for poor families who have little or no land.

Micro-credit can also be used with other species, including cattle, as shown in the description of the Kenya project later in this section.

Procedure

1. Approach the community and discuss the loan procedure and the requirements for farmers to participate.

2. Help the farmers decide if they want to participate in the micro-credit arrangement. Participants may volunteer or be nominated by a community organization according to certain criteria (such as priority being given to woman-headed households).

3. Help the participants organize themselves into credit groups.

4. Participants plant forage (doing this may be a requirement for participating in the project).

5. Train participants in how to manage the animals and grow forage.

6. Each participant receives one or two animals on credit.

7. The participants keep and feed the animals and allow them to breed.

8. Participants repay the loan in cash (which is then used to buy another animal), or in the form of one of the offspring from either the first or second pregnancy. The credit should be repaid within 2-3 years, otherwise the farmers may not take their responsibility to repay the loan seriously.

Dairy goat micro-credit in Ethiopia

The highlands of eastern and southern Ethiopia have a high population density, the land is eroded, and farms are small (less than 0.5 ha per family). Families often do not have enough food to eat, and local women are not able to get bank loans because they can not afford the collateral.

Since 1988, FARM Africa has been working with the Ethiopian Ministry of Agriculture and local NGOs to promote dairy goats in this area. The project identified women who owned less than 0.5 ha of land, had large families or no husbands. These women were

Training for livestock micro-credit

Various types of training may be necessary for the villagers receiving livestock micro-

credit.

- If they have not owned this type of livestock before, they may need training in basic husbandry and forage-growing techniques.
- Selected participants can be trained in simple veterinary techniques. They should be provided with drugs and equipment. They can buy new drugs and pay their expenses by charging other farmers for their services. (See the section on *Community-based veterinary services*).
- If pure-bred or cross-bred stock are introduced, participants may need training on these animals special requirements.
- Group leaders and members may need training and assistance in organizational development and simple record-keeping skills.

Credit repayment

Should farmers repay the credit in cash or in kind (as a young animal)? Each has advantages and disadvantages:

	Farmer repays the loan in cash	**Farmer returns a young animal to the group**
Pros	The farmer can make more profit from selling the animal Individuals have greater freedom to make decisions The group can raise funds from the sales	Little possibility for corruption Inflation-proof Book-keeping is simple Easily managed by community Few defaulters due to peer pressure
Cons	Book-keeping requires some literacy Possibility of corruption Unless interest rates are adjusted, there is a danger of losing capital to inflation	Farmers dislike parting with the animals they have raised When the arrangement is for the farmer to keep the first offspring and repay the loan with the second, other farmers must wait a long time before they benefit Risk of community intrusion into an individual farmer's affairs With cross-bred livestock, the animal to be repaid may be better quality than the one received

given a loan, and with the help of a project veterinarian, each bought two goats in the local market. The women were required to pay 5% of the price of the goat, plus 5% as insurance in case it died.

The beneficiaries were encouraged to form groups of 20-30 women. Each group elected a chair, secretary and treasurer, and met once a month to discuss results and problems. Project extensionists used this opportunity to provide advice to the group. Groups received training in goat husbandry and forage management, and were encouraged to save money in a group fund. Women who showed that they could manage the goats well, received cross-bred goats or an exotic male animal for breeding.

The beneficiaries had to repay their loans to the group within 2-3 years, including up to 10% interest. They could choose to pay in cash (in three instalments) or in kind (in the form of one weaned kid). The group then chose a new member of the group to be the next beneficiary to receive a loan in the form of a goat.

By June 1997, 1500 women, organized into 120 groups, owned more than 2000 local goats and nearly 900 cross-bred animals. They sell about 500 goats a year. About 100 women had been trained as community veterinarians.

The goats significantly increased family incomes. A fattened male goat fetched birr 210-560 (US$ 30-80) on the market. This is equivalent to the income from a 0.25-0.7 ha field of sorghum. A female local-breed goat gave an average of 55 litres of milk per lactation (130 days). A cross-bred animal gave 175-200 litres of milk in a lactation lasting 170 to 220 days.

Aside from increasing family incomes, the project has raised the status of women in the community. Its success has changed the attitudes of extension workers and banks towards providing credit and extension services to women. *—For more information, contact Kettema Yilma, FARM Africa-Ethiopia.*

Cattle loans in Kenya

Under the National Dairy Development Project, Heifer Project International (HPI) works with the Ministry of Agriculture to promote milk production in the Coast Region of Kenya. The average landholding for a household in this area is 1-1.5 ha (2-3 acres).

HPI works through community organizations which help manage village activities. It encourages community groups to write proposals for participation in the programme. It offers heifers to farmers through micro-loans. After receiving the heifer, the individual cares for the animal until it produces a female calf. Once this calf has reached weaning age (1 year), it is passed on to a group member who has not yet received an animal.

Each group sets its own rules on how to manage the programme. For example, if a male calf is born, some groups require that it be returned to the group for sale; the money then goes to buy a heifer for another member. Some groups allow the individual to keep the male calf and allow the cow to keep trying to have a heifer.

Before individuals can receive a heifer through the dispersal programme, they must:

- Attend training courses and participate in group activities.

- Plant at least 0.4 ha (1 acre) of quality forage. Several forage species are commonly used. These include grass species such as desmodium and Napier grass, and common tree forage species such as leucaena, gliricidia and sesbania.
- Build a zero-grazing shed (see the section on *Zero-grazing* in this book) so they can keep the animal without having it graze.

HPI support

HPI provides several types of support to the farmers and their organizations. First, it provides loans of cross-bred animals. These species are generally more resistant to pests and diseases, but sometimes loans of improved pure-bred animals are also made.

Although the animal is loaned to an individual, it is hoped that it will benefit the entire family and the larger community. HPI encourages the villagers to form groups to decide how the loans will be made, who should receive them, and how the recipients should be chosen. The groups can include either men or women, or both. However, most are women's groups; in this area, women are generally responsible for caring for livestock.

HPI and the Ministry of Agriculture train all members of a participating family to care for the animals. They also provide technical assistance before and after an animal is received. For example, if they plan to use artificial insemination, community members can receive training on this breeding method.

Lastly, HPI often helps with marketing livestock products such as milk. For example, one dairy group was provided with large-capacity (more than 1000 litres) milk coolers.

Christine Kashindo's gift

Christine is a housewife with seven children and is a member of Vitendo Women's Group. She one of the most successful farmers participating in the HPI programme.

Her group of 35 women applied to HPI for assistance through livestock and training. Christine attended seminars on how to take care of cattle, and then constructed a zero-grazing unit and planted Napier grass. She worked hard for 2 years to complete her unit so that she could qualify to receive a heifer. She worked as a labourer for other farmers so she could save money to buy materials for the unit. When the shipments of heifers arrived in July 1992, Christine was among the lucky ten that the group had selected to receive the first animals.

Christine named her cow Pato, which means "gift" in Swahili. Her first calf was a female, and Christine passed it on to another group member, thereby fulfilling her obligation to the group and repaying her loan. Pato had a second, third, and fourth calf—all females.

Every day, Christine receives lots of milk from her cows. She gives some to her children, who were rarely able to drink milk before. Some goes to feed the young calves. Each day, the money from 1 litre of milk goes back to the Vitendo Women's Group to purchase more heifers. The remaining milk—more than 30 litres—is taken to the new HPI milk-cooling plant and then sold. At the end of each month, Christine receives a cheque from the cooling plant.

Christine has used the money to build a larger house, and then added a new roof. She then rented 0.6 ha (1.5 acres) of land, hired a tractor to plough it, and paid workers to grow maize. She recently bought two goats.

Christine regularly attends training courses, group meetings and tours, sharing her experiences with others. These course have taken her to other parts of Kenya and abroad, offering her a chance to learning further new ideas and practices.

Christine is one of the few women in Kenya to own four dairy cows. How does this feel? "I am so proud and happy," is her response. **—For more information, see: Coleman, Amani Bedford. 1997.** ***The gift that keeps on giving*****. Heifer Project International.**

Kafedha Safari's four male calves

Kafedha is a member of the Mbarakachembe Women's Group, located in Malindi district, Kenya. Kafedha received a pregnant heifer from HPI in March 1994. She named the heifer Mvera, which means "I'm very thankful" in Swahili. The cow has calved four times—producing a male calf each time. So Kafedha has not yet been able to repay her loan to the group. She returned the the first three bull calves to the group, but the group allowed her to keep the fourth. She will continue to breed the cow, and hopes to be able to pass on a heifer in the future.

Although she has not yet been able to return a heifer to her group, she has benefited greatly from her cow. It gives milk each day, providing milk for the family as well as milk to sell. The animal also produces manure to be used to improve soil fertility.

The additional income has allowed Kafedha to improve the well-being of her family. She says that she is "employed by the cow," showing the importance of the income to her and the family. All of her children's school fees are paid, she is able to pay for medical expenses for the family, and she has been able to purchase a 0.6 ha (1.5 acre) plot

where she is planting coconuts and mangoes.

The additional income has also helped out in other ways. Kafedha feels that she has increased decision-making power within the family, as she can buy school supplies, medicines, etc, without asking for money from her husband. Also, her husband is very happy to know that Kadefha's efforts and the income from the cow are helping to share the burden of the family's expenses.

Dealing with problems

As with any project of this nature, the HPI programme has encountered difficulties. Some animals have died due to disease such as East Coast fever, or have fallen prey to parasites. The leadership of the community groups has also been a problem.

If a loaned animal dies, the group must determine the cause of death. Each group has it own rules. Generally, if the animal dies because of an accident, the recipient can be considered for another animal loan. But if the animal dies as a result of negligence, that person may not be eligible for another loan. *—For more information, contact Heifer Project International, Kenya*

Marketing produce as a group

Small-scale farmers grow a variety of crops individually on small farms for subsistence and for sale. They commonly market their produce individually, selling it to merchants at the farm gate or taking it to the nearest local market, where prices are low and may vary widely over time. In addition, transport is expensive, and the roads are few and in poor repair.

Farmers feel that marketing is a major problem. They feel that merchants control produce prices, or can buy produce at very low prices during the harvest season, transport it to another area and sell it at a large profit. Farmers can overcome this problem by marketing their produce as a group.

Advantages

- The group can sell directly to retailers at a higher price, bypassing the merchants altogether.
- They can provide a larger amount of produce and maintain a continuous supply.
- They are in a stronger bargaining position in relation to merchants and retailers.

Disadvantages

- Marketing requires skills that farmers may have to learn through trial-and-error. They should be ready to make mistakes and take on risks.

- Establishing a marketing system takes time. Farmers must be patient: they should not expect to become millionaires overnight.
- Setting up a marketing system may be difficult for a group of farmers to do on their own. An outside organization such as an NGO may be needed to provide the skills and make them with initial linkages with buyers.

Procedure

This section assumes that an outside organization such as an NGO is helping groups of farmers to identify opportunities and set up a marketing system for a crop. A similar approach can be used for other produce (milk, eggs, chickens, animals, flowers, honey). Many of the activities described below are continuous and happen at the same time.

1. Get to know the market for a particular type of produce, such as vegetables, that the farmers already grow, or could grow. See the box below for some questions to ask.

2. Alert the farmers to the market situation, and discuss with them their interest in supplying particular types of produce.

3. Select retailers (such as supermarkets or greengrocers) and explore their interest in trading with the farmer group.

4. Help the farmer group and the retailers reach an understanding on the type of produce to be delivered, the quantity, quality and timing of deliveries. Have the group and the buyers sign a written agreement detailing their responsibilities and what happens if, for example, the farmers cannot supply the produce because of bad weather.

5. Train the farmers in how to grow the crop, control pests and diseases, harvest the crop and handle it (for example, packing it into crates for shipment). This is particularly important if the crop is a new one. It is important to maintain good quality of the produce to assure a good price and the retailer's interest in the trade.

6. Also provide training to the farmers in group organization, crop planning, marketing and record-keeping.

7. Help the farmers plan the dates of planting and harvest so they can supply the produce at the right time. They may have to plant a small amount of the crop every two weeks throughout the season to make sure there is a continuous supply ready for harvesting and shipping to the town.

8. During the growing season, provide extension advice to the farmers and help them solve problems as they arise.

9. At harvest, the farmers collect their produce in one place, grade and weigh it, pack it into crates, and load it onto a lorry. Keep careful records of how much each farmer delivers.

10. Transport the produce to the retailer in town. Representatives of the group should travel with the lorry and receive the payment from the retailer.

Questions about the market

Below are some questions to ask when trying to find out about the market for a type of produce.

- **Where is the produce sold? Who sells it? Who buys it?**
- **What are the prices? Do they fluctuate during the year?**
- **Who already supplies the market?**
- **How much demand is there? Is it supplied already, or is there room for another producer?**
- **Can the market be supplied by the group of farmers? For example, is it possible to transport perishable produce to the town quickly enough so it arrives in good condition?**
- **Is the price you can get for the crop high enough to cover the farmers' costs and yield a profit?**

11. Have the payment deposited into the group's bank account.

12. Deduct a portion of the payment to cover the cost of the transport. A percentage can also go into the group's own fund, and to cover the NGO's costs. The remainder is divided among the group members according to the amount of produce they have delivered.

Issues

- **Corruption** may be a problem. Keep careful records of all transactions, and make sure that these are transparent (everyone knows and understands them). Keeping the records should be the responsibility of several people, rather than just one, and this responsibility can rotate among the members so they can all keep check on the funds. Different group members can accompany the produce into town each week; this means that they will all become familiar with how the transactions work.
- **Pests, diseases and bad weather** can disrupt the crop production. The group should take precautions to avoid as many such problems as possible (for instance by using integrated pest management or providing additional inputs such as organic matter and irrigation water). The agreement with the buyer should also take the possibility of such problems into account.
- Running a smooth marketing system requires **co-ordination and management skills**. The NGO should provide training and assistance to the group to ensure they have these abilities.

The two examples below describe the experiences of NGOs and groups of farmers in Kenya in marketing organically grown produce.

"Conservation Supreme" in Kenya

In April 1997, the Association for Better Land Husbandry began a pilot project called "Conservation Supreme", working with four smallholder farmer groups in Ndia division, Kirinyaga district. The 68 farmers in these groups produce 12 different crops and market them collectively in six Nairobi outlets. The crops include hot peppers, beetroots, brinjals, carrots, coriander, snow-peas, spring onions, sage and turnips. They sell these as ecologically sound produce, which commands higher price.

ABLH has trained the farmers in various aspects of crop husbandry, the safe use of pesticides, harvesting and handling, packaging, record-keeping, labelling and loading. Every week, the farmers harvest the crops, sort them, and take them to a group consolidation point. After grading and weighing, the farmers receive a receipt, and the produce is taken to a packaging shed for labelling, packing and sealing. An ABLH vehicle driven by a farmer takes it to Nairobi, and delivers it to the retailer. To begin with, an ABLH staff member accompanied the vehicle; later the farmers were able to handle the transactions themselves.

While it is still too early to know if this marketing system will be sustainable, the farmers are very interested in continuing it and learning further. The group is considering getting their produce certified as produced in an environmentally sound way, so it will fetch higher prices. *—For more information, contact the Marketing Project, ABLH, Kenya.*

Marketing vegetables by women's groups in Kenya

SACRED, the Sustainable Agriculture Centre for Research and Development in Africa, has helped women's groups in western Kenya to grow and market organic vegetables. SACRED distributed horticultural seeds to 22 groups of women; the seeds included beetroot, cabbage, carrot, Chinese cabbage, dania, eggplant, kale, lettuce, onion, radish, tomato and turnip. These vegetables were imported from America, but grew well in the local conditions. The farmers also grew several local types of indigenous vegetables, including black nightshade, crotalaria and chute plant.

SACRED and the women's groups have found that marketing these products requires training and careful preparation. The women were not confident in selling their products in the towns; they felt more comfortable in a rural setting. To begin with, they merely waited for SACRED to market the produce for them; despite training, they took a long time to understand that the project was theirs, and that they would have to take initiative in management and marketing.

The women found that each type of market has advantages and disadvantages.

- **Local markets**, such as sale to neighbours, avoided the cost of transport, but were viable only for those types of vegetables which have a local demand. Imported vegetables, such as many of those grown by the SACRED-supported groups, had to be transported to the towns in order to be sold.

- **Institutions**, such as schools, hospitals and prisons, were good outlets for some types of produce, but they bought on credit and took a long time to pay.
- **Open-air buyers** were exploitative in their prices. They bought produce by the bag rather than by weight, and squeezed as much as possible into each bag.
- **Supermarkets** have proved to be good customers, but they have stringent requirements that farmers find difficult to fulfil: high-quality, graded produce, pre-packaged in batches of 1 or 2 kg, and delivered on time and in the right quantities. The

farmers have sometimes failed to provide the right amount of produce; for instance they have over-supplied certain types, leading to wastage and losses. The groups may need to invest, for example in equipment to seal plastic packaging, in order to meet the supermarkets' needs. For some low-value crops, such as kale, the packaging was worth more than the crop being sold. It therefore made sense to sell only processed produce to supermarkets.

Careful management and planning have proven necessary. Certain quick-maturing types of crops must be planted every 2 weeks in order to keep up with market demand. Farmers must plan their planting and harvesting according to expected demand and purchasers' orders. For new crops, they must learn how to grow the crops and when to harvest them. They must keep careful records, and study the market in order to decide what to plant and where and when to sell it. *—For more information, contact SACRED, Kenya.*

Conserving soil and water

Soil erosion happens when particles of soil come loose and are carried away by water or the wind. When it rains so much that the water cannot seep into the soil fast enough, the extra water flows down the slope, carrying soil particles with it.

Many agricultural soils are easily eroded. The erosion problem is likely to be more severe on certain types of soils, on steep slopes, where there is intense rainfall, and where the vegetation is removed.

Soil conservation

Soil conservation means reducing the amount of soil erosion and maintaining soil fertility. It relies on increasing the amount of water seeping into the soil, reducing the speed

Common types of erosion

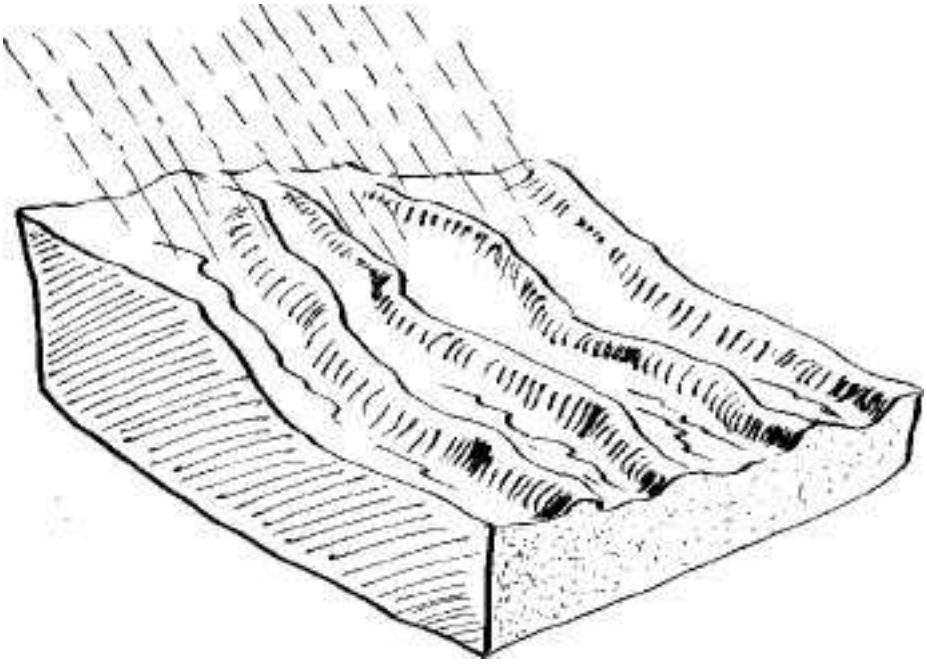
- **Rain-splash erosion** Occurs when raindrops fall on unprotected ground. The impact on the soil splashes away soil particles and digs a crater.

Rain-splash erosion

- **Sheet erosion**
  Occurs when thin layers of the topsoil are moved by the force of the runoff water, leaving the surface uniformly eroded.

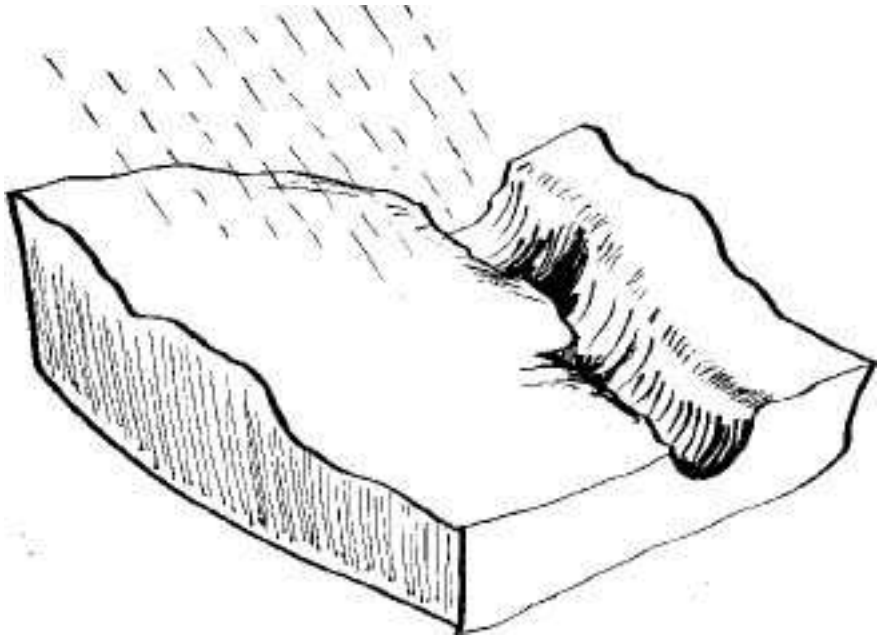
Sheet erosion

- **Rill erosion**
  Caused by runoff water when it creates small, linear depressions in the soil surface. These are easily removed during land tillage.



Rill erosion

- **Gully erosion**
  Unlike rill erosion, gullies are too deep to be removed during normal cultivation with ordinary farm implements. They are formed from small depressions, which concentrate water and enlarge until several join to form a channel. The deepening channel undermines the head wall, which retreats upslope. The gully then widens as the side-walls are worn back.



Gully erosion

and amount of water running off, and keeping enough vegetation to protect the soil surface and to bind the soil together.

For any form of land use to be sustainable, production must be combined with conservation of the resources it depends on. Soil conservation efforts should:

- Be able to control erosion sufficiently.
- Maintain the organic matter of the soil.
- Maintain soil physical properties.

- Maintain the appropriate level of nutrients in the soil.

Water conservation

Soil conservation is closely related to water conservation. In arid and semi-arid areas, rain falls only during a few months of the year, but is unreliable even during those months. It typically comes in a few, heavy storms, and much of the water runs off the surface, causing flooding and erosion.

Water conservation relies on trapping as much of this water as possible and storing it on the surface (in tanks or reservoirs) or allowing it to sink into the soil in order to raise the water-table and increase the soil-moisture level. More water can seep in if it is spread over a large area of soil rather than being concentrated into fast-running streams. So water-conservation efforts focus on stopping the water from becoming concentrated in the first place (by ensuring a protective cover of vegetation on the soil surface), slowing down the flow of running water (for example, with pits and dams), and spreading the water out over a large area (for example, with contour ditches).

Advantages

- Conserving water makes water available for crops, livestock and domestic use over a longer period.
- Controlling soil erosion improves crop or pasture yields.
- Conservation measures improve the supply of fuel and forest products.
- They increase the value of the land.
- Terraces make cultivating steep slopes easier.
- More and better livestock fodder is available, for example from grass strips, hedge barriers and terrace embankments.
- Employment opportunities in soil- and water-conservation work increase.

Disadvantages

- Fragmented land ownership makes it difficult for farmers to invest optimally in soil and water management systems.
- Conservation structures need a lot of labour to build and maintain.
- Crop production in semi-arid areas involves a lot of risks, including flooding. This makes it difficult for farmers to realize the full benefits of conservation

- Many farmers lack the skills to design and build conservation structures; sub-standard and poorly constructed structures often result.
- Land-tenure systems determine the ownership of the structures and influence farmers' interest in conservation and in maintaining the structures.
- Irregular rainfall reduces the effectiveness of vegetative erosion-control practices.

Agronomic/vegetative conservation measures

There are many ways of conserving the soil and water, some of which are described elsewhere in this book. They can be divided broadly into agronomic and physical conservation measures. Agronomic or vegetative measures (listed below) include the use of vegetation and soil tillage practices; physical measures (described later in this section) involve building permanent structures, usually of soil or stone, to control the flow of water.

Crop management

Good crop management reduces soil erosion by water and wind to tolerable levels and can improve soil fertility. Select appropriate crops for the soil and slope, plant early, and use suitable cropping systems and rotations to keep the soil covered.

Tillage methods

Tillage aims to optimize soil physical and biological conditions for crop production, and to ensure timely seedbed preparation, planting and weed control. Use a tillage method that does not make the surface soil too fine and powdery. Break up the hardpan if necessary (see the sections on *Deep soil preparation* and *Minimum tillage*).

Applying organic matter

Adding manure and fertilizers to the soil provides the required plant nutrients for vigorous crop growth. This covers the ground quickly (protecting it from erosion and allowing water to seep in) and produces higher yields. See Part 6 on *Soil fertility* in this book.

Agroforestry

Agroforestry involves planting trees or shrubs in the farm, or keeping those that are already there. Trees can conserve the soil in many ways. They cushion the impact of raindrops on the soil, so reducing the amount of rain-splash erosion. Their roots bind the soil. Planted along contours,

they can interrupt the flow of water running off the surface. They shade the soil, reducing the soil temperature and cutting the amount of water that evaporates into the air. They break the wind, reducing the amount of wind erosion. They recycle nutrients from deep in the soil, and leguminous trees fix nitrogen that can benefit food crops.

Apart from helping conserve soil, agroforestry can provide many other ecological, economic or social benefits: fodder, fuelwood and charcoal, timber and building poles, and fruit.

Contour farming

Contour farming involves ploughing, planting and weeding along the contour, ie, across the slope rather than up and down. Experiments show that contour farming alone can reduce soil

erosion by as much as 50% on moderate slopes. However, for slopes steeper than 10%, other measures should be combined with contour farming to enhance its effectiveness. See the sections on *Marking contours* and *Contour tree-planting* for more information.

- **Contour ridges** are used mainly in semi-arid areas to harvest water, and in higher rainfall areas for growing potatoes.
- **Trashlines** made by laying crop residues or "trash" in lines along the contour. They slow down runoff and trap eroded soil, eventually forming terraces. However, the contour line can be destroyed by termites eating the trash.
- **Grass barrier strips** planted along the contour. They are planted with fodder grass such as Napier, or are left with natural grass. They are effective soil conservation measures on soils that absorb water quickly, and on slopes as steep as 30%.

Physical soil conservation structures

Physical soil conservation structures are the permanent features made of earth, stones or masonry. They are designed to protect the soil from uncontrolled runoff or erosion, and to retain water where it is needed. They supplement agronomic or vegetative measures but do not substitute for them. The appropriate type of physical structure depends on:

- Climate and the need to retain or discharge the runoff.
- Farm sizes.

- Soil characteristics (texture, drainage, and depth).
- Availability of an outlet or waterway.
- Labour availability and cost.
- The adequacy of existing agronomic or vegetative conservation measures.

Below is a list of some common physical conservation structures.

Cutoff drains

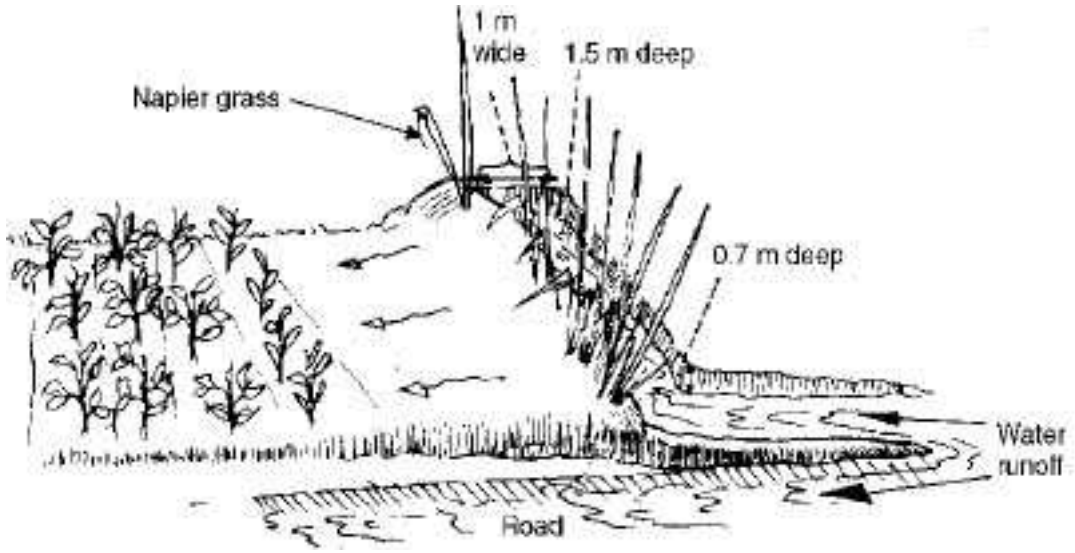
Cutoff drains are dug across a slope to intercept surface runoff and carry it safely to an outlet such as a canal or stream. They are used to protect cultivated land, compounds and roads from uncontrolled runoff, and to divert water from gully heads (see the section on *Gully reclamation*).

Retention ditches

These ditches are dug along the contour. They catch and retain incoming runoff and hold it until it seeps into the ground. They are an alternative to cutoff drains when there is no nearby waterway to discharge the runoff into. They are often used to harvest water in semi-arid areas.

Infiltration ditches

Infiltration ditches are one way of harvesting water from roads or other sources of runoff. They consist of a ditch, 0.7-1.5 m deep, dug along the contour, upslope from a crop field. Water is diverted from the roadside into the ditch, which is blocked at the other end. Water trapped in the ditch seeps into the soil. On soils with an impervious layer (such as a hardpan) below the surface, the water does not sink straight down into the soil. Instead, it moves downslope just below the surface, towards the crops in the field below.



Infiltration ditch spreading water from a road into a field. Make sure that the bank blocking the ditch at the far end is higher than the road so that in a big storm, excess water spills down the road and does not burst the bank.

Controlling mosquitoes in water-retaining pits and reservoirs

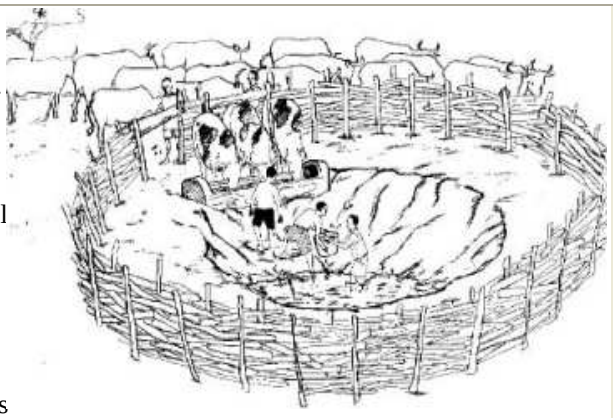
A common problem with pits and ponds is that they are transformed into mosquito breeding grounds during the rainy season. However, a farmer in Zimbabwe has a very simple solution. He pours a small amount of used motor-oil on the water surface. —*For more information, contact Phiri Maseko, Zimbabwe.*

Water-retaining pits

Water-retaining pits trap runoff and allow it to seep into the soil. A series of pits are dug into the ground where runoff normally occurs. The soil from the pits is used to make banks around the pits (keep the topsoil and put it on top of the banks). Furrows carry excess water from one pit to the next. The size of the pits depends on the amount of runoff: a typical size is 2 m square and 1 m deep. Plant bananas and other tree crops around the pits. Keep children and livestock away from the pits.

Water harvesting in Mooka village, Zambia

Villagers in Mooka, in Kalomo South, Zambia, have built a shallow well to harvest water. This has provided water for cattle in the dry season for more than 50 years.



The Mooka well is dug where two seasonal water courses meet. The well is about 7 m across and is surrounded by a fence to keep cattle out. There is a small drinking area with a drinking trough inside the fence.

The quality of the water in the well can become poor, making the animals sick, and the pool can become a breeding area for mosquitoes in the rainy season. Hauling water out of the well into the drinking troughs is a lot of work. But the well is only 0.5 km from the village, meaning that the farmers do not have to herd their cattle for watering to the Zambezi River, which is 24 km away. This method has since been copied in more than 50 villages.

The village headman organizes work-groups to maintain the well. They remove the silt which accumulates—as often as once a month during the dry season. A big clear-out of silt is needed after the rainy season.The fence also requires a lot of maintenance.

Soil conservation in Machakos district, Kenya

Machakos district, to the east and southeast of Nairobi, has an area of 6000 km^2 and a growing population of 1.2 million people. About three-quarters of the district is semi-arid, with the mean annual rainfall of 500-800 mm. More humid conditions are found in the hills, which have steep slopes, intensive cultivation and high population density. The soils have weak structures, and their surfaces tend to seal upon impact of raindrops, leading to rapid runoff and erosion.

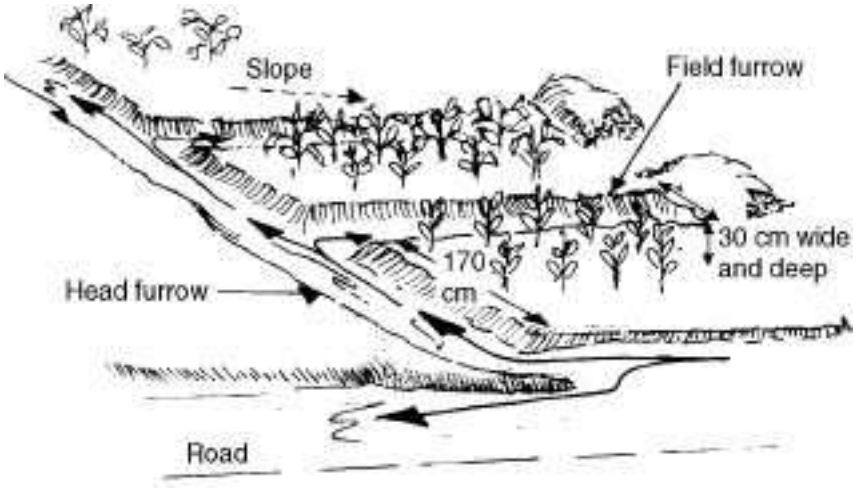
Massive land degradation caused by over-grazing and soil erosion were identified as problems in Machakos during the early 1900s. The colonial administration took measures to counteract this. The momentum slowed in the 1960s, but accelerated again in the mid 1970s with new awareness of the severity of the problem, coupled with moral, financial and technical support from the Kenyan government and donor agencies. Through intensive training, the farmers of Machakos have recognized the value of conservation, and they have slowly adopted conservation farming practices whenever possible. The most common practices include agronomic and vegetative measures and terracing.

Over the years, a soil conservation culture has evolved among the farmers. They see it as key to any crop production, and are ready to start conservation measures without technical advice from extension officers. In many places, farmers employ labourers to dig new *fanya juu* terraces or rehabilitate old ones. On some farms, maize yields are nearly 50% higher on terraced land than on non-terraced land.

Self-help groups (known locally as *mwethya* groups) have become a major force in terrace construction and are responsible for building them and controlling gullies on their members' farms. Soil and water conservation technologies—especially those applied through the farmers' own initiative—are a vital factor in the battle against land degradation and famine.

Broadbeds and furrows

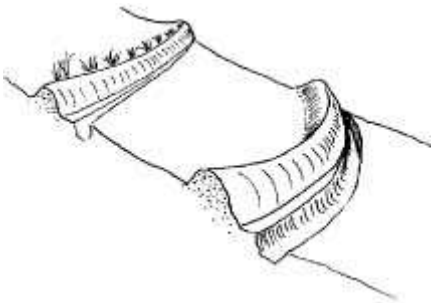
In a broadbed-and-furrow system, runoff water is diverted into field furrows (30 cm wide and 30 cm deep). The field furrows are blocked at the lower end. When one furrow is full, the water backs up into the head furrow and flows into the next field furrow. Between the field furrows are broad beds about 170 cm wide, where crops are grown.



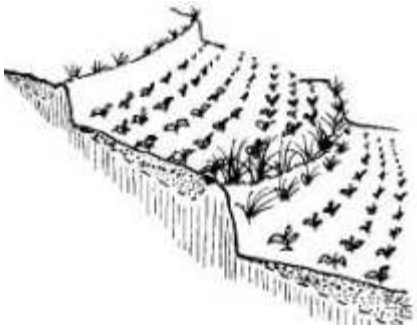
Broadbed-and-furrow system. Ensure that it is constructed so that excess water spills down the road.

Fanya juu

Fanya juu terraces are made by digging a trench along the contour and throwing the soil uphill to form an embankment. The embankments are stabilized with fodder grasses. The space between the embankments is cultivated. Over time, the *fanya juu* develop into bench terraces (see below). They are useful in semi-arid areas to harvest and conserve water.



New fanya juu *terrace*



Same terrace after 5 years

Fanya chini

A *fanya chini* is like a *fanya juu*, except that the soil is put on the lower side of the contour trench, not on the upslope side of it (as in a *fanya juu*). *Fanya chini* are used to conserve soil and divert water. The resulting embankment can be used to grow fodder. *Fanya chini* are easier to make than *fanya juu*, but they do not lead the formation of a bench terrace over time. They can be used on slopes up to 35%.

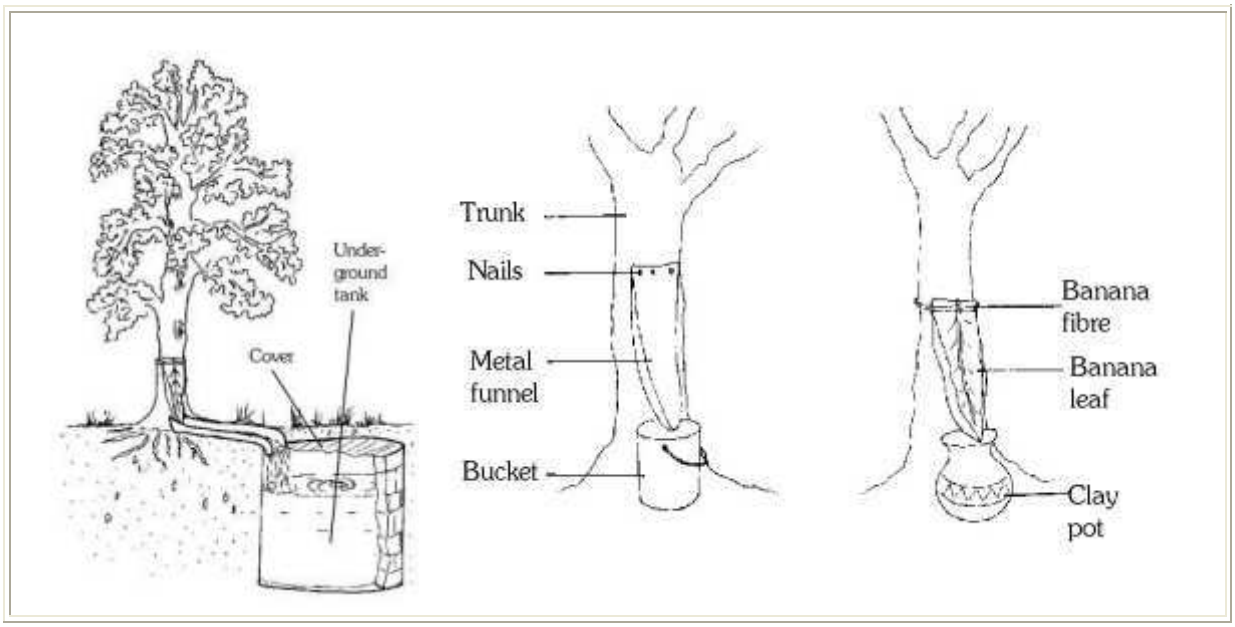
Bench terraces

Bench terraces are level (or nearly level) steps constructed on the contour, and separated by embankments (risers). They can be formed by excavation or may develop over time from a grass strip or *fanya juu*.

Do's	Don'ts
o Plant grass on the embankments of all physical conservation structures. Banana trees can be planted along channels. o Repair the structures promptly if they are damaged and at the end of the season. o Choose structures carefully to suit the soil type and slope.	o Don't graze livestock directly on grass planted on the embankments or terraces.

Harvesting rainwater from trees

This technology is useful for people cannot afford a metal roof and are not near other sources of “free” water like springs, wells or boreholes, but who have trees in their compounds. Rain falling on the foliage runs down the tree trunk, and is funnelled by a banana leaf or metal sheet attached to the trunk into a bucket, pot or storage tank. Rainwater can be harvested from trees anywhere: it is a question of finding out which trees are appropriate. The best ones have short, smooth trunks, thick crowns and heavy foliage. Jackfruit (Artocarpus heterophyllus) and wild fig (Ficus natalensis) are very suitable. This method is cheap and easy to set up. While the water collected is not as clean as that from a metal roof, it is cleaner than that collected from thatched roofs. It should be filtered and boiled if it is used for drinking. Mr Mukasa of Mpigi district in Uganda has two grass-thatched houses and a few trees on his compound. He harvests rainwater from one of the trees, a jackfruit. He uses banana leaves tied to the trunk with banana fibres, and collects the water in a clay pot. While the amount of water collected is not large, he says it helps his family a lot because the nearest well is about 1 km away.



Stones terraces

Stone terraces are useful in areas with steep slopes but a high population density and scarce land. The terrace risers are made of stones collected from the land. The terraces themselves can be sloping or level. In the Konso area in southern Ethiopia, farmers form the terrace steps into a series of shallow pits, in which they plant several different crops.

Marking contour lines

You may want to mark contour lines (level lines running across a slope) to decide where to dig contour canals, plant trees along the contour, and several other methods of controlling soil erosion.

This section describes two ways of doing this: using an A-frame, and a line level. Aside from marking contours, the A-frame and the line-level can be used to mark graded terraces or to measure the slope of a field.

Location

A-frames and line-levels are useful in hilly areas subject to erosion, or on gently sloping fields in which the farmer wishes to build ridges or dig ditches to allow water run-off to sink into the soil.

Advantages

- A-frames and line-levels are cheap and easy to make and use.
- They can be made from readily available materials.

Disadvantages

- A-frames are not practical for marking contours over large distances. Line-levels are better for this.

A-frame

An A-frame consists of three pieces of wood, fixed together in the shape of a capital letter "A". The A-frame is held upright, and a weight on a string hangs down from the top of the "A" to act as a plumb-line. If the A-frame is on perfectly level ground, the string crosses the horizontal bar of the "A" at a certain point. This point is marked during calibration.

To use the A-frame, it is "walked" across the slope, making sure that the two legs are level each time by checking if the string crosses the horizontal bar at the calibrated point. If not, the forward leg is moved until the string shows the frame is level. The position of the legs on the ground are marked with pegs, and then the frame is pivoted around to mark a new point on the slope.

Requirements

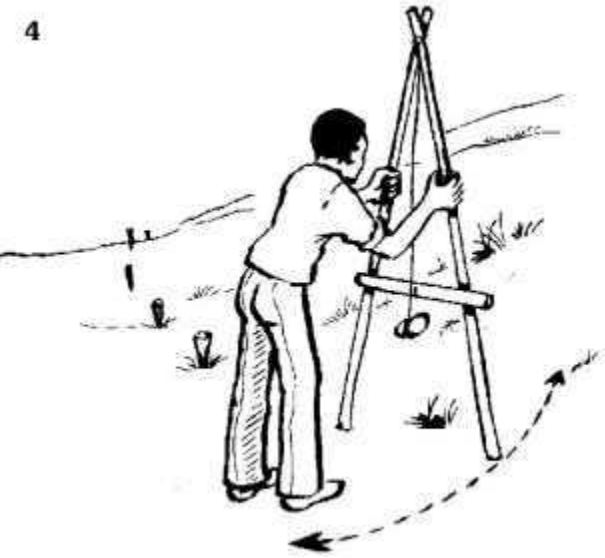
- Two straight wooden poles (1.5-2 m long), and one straight pole (1-1.5 m long).
- String, hammer, nails, pencil.
- A round stone.

Making the A-frame

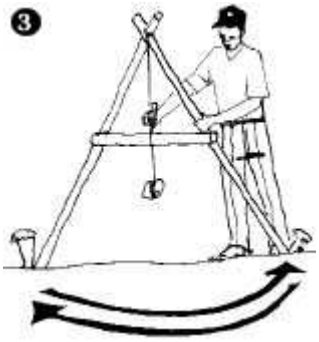
1. Use the poles and nails to make a frame in the shape of an "A" **(Picture 1)**.

2. Tie one end of the string to the top of the "A".

3. Tie the stone to the other end of the string, so it hangs down just below the horizontal crossbar of the "A".



Calibrating the A-frame



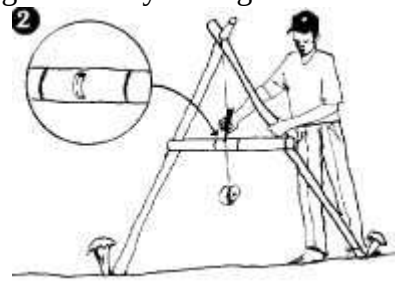
4. Stand the A-frame upright on reasonably level ground. Mark on the ground where the two legs stand.

5. Hold the A-frame still, and use the pencil to mark lightly on the crossbar where the string crosses it **(Picture 2)**.

6. Turn the A-frame round, so that each leg stands exactly where the other had stood.

7. Make a second light mark on the crossbar where the string crosses it.

8. The two marks on the crossbar should be fairly close together. Halfway between them shows where the string would cross if the A-frame were standing on exactly level ground. Make a heavy pencil mark or notch the bar with a knife at this point **(Picture 3)**.



Marking the contour

9. Choose a place on the slope to begin. Stand the A-frame up and mark where the first leg stands with a peg or large stone.

10. Keeping the A-frame upright, and without moving the first leg, swing the second leg up or down the slope until the string crosses the crossbar exactly at the heavy pencil mark **(Picture 4)**.

11. Mark where the second leg stands with another peg or stone.

12. Keeping the second leg in the same place, lift the first leg up and pivot it around. Move it up and down the slope until you find the place where the string crosses the crossbar at the heavy pencil mark.

13. Mark where the first leg is now standing with another peg or stone.

14. Continue in this manner to the end of the field.

15. The line of pegs or stones will mark a contour line: they will all be at the same height on the slope. The pegs are usually not in a straight line. If necessary, make a smooth curve by moving them a little up or down.

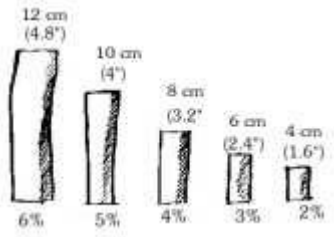
16. To mark another contour line, move up or down the slope a certain distance—usually about 20 m (20 paces) on a gentle slope, or a drop of 1.5 m on steeper slopes. Repeat the process from Step 9 above onwards.

17. You can then dig ditches, construct terraces or plant trees along the contour lines using the pegs or stones as a guide.

Using an A-frame to mark or “grade” the slope of a field

An A-frame can also be used to “grade” a field or a drainage canal to achieve a certain slope. This can be a useful as it allows a farmer to ensure proper drainage of a field.

5

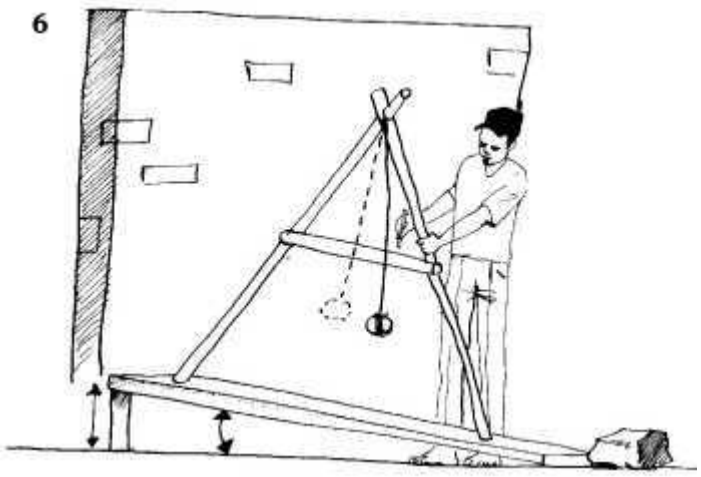


Once you have assembled the A-frame following the directions above, you need to calibrate it. However, if the A-frame is to be used to grade the slope, the calibration procedure is different.

1. Decide what percentage slope you want the field or drainage canal to have. For this example, let’s say you want a 6% slope.

2. Cut a small block of wood 12 cm high. The height of the block for other percentage slopes for other percentage slopes will be either more or less than this **(Picture 5).**

6



3. Place the block on level ground against a wall so that it does not move. Place a straight, 2-metre-long board or pole on top of the block, with the other end resting on the ground. Place a heavy stone against that end so that the board does not move. Do not stand on the board when marking the A-frame.
4. Place the A-frame on the board, and mark where the string passes on the crossbar of the A-frame. The A-frame is now calibrated; when the string aligns with the mark on the crossbar, this indicates a 6% slope **(Picture 6)**.
5. Use the A-frame to mark out the slope of a field or drainage ditch, following the same procedure as described above for marking a contour. Move one of the A-frame legs up and down the field until the string passes through the 6% mark on the crossbar.

Line-level

A line-level is another tool used to mark a contour or measure the slope of a field, as well as to lay out cut-off drains, retention ditches, terraces and other conservation structures. A line-level is easy to use and effective, and is more accurate than using an A-frame. However, three people are needed—as well as a spirit level, which may be difficult to find in the field.

Making a line-level

1. Cut two straight poles, 1.5 m long. Nail a small wooden base on the bottom of each pole to prevent them from sinking into the soil when you are using them.

2. Tie a string (preferably made of cotton) between the tops of the poles, so there is exactly 10 m between the poles when the string is taut. The loops around the poles should be a little loose so you can move the string up and down if you want.

3. Tie a spirit level to the middle of the string, so that when the string is held taut and exactly level, the bubble of the spirit level is in the middle of its run.

4. Starting near the top of the first pole, make notches down the pole every 5 cm. Mark the top notch with a “0 cm”, the first notch below it with a “5 cm”, the second with a “10 cm”, and so on. Do the same on the second pole at the same heights as on the first one.

Marking a contour

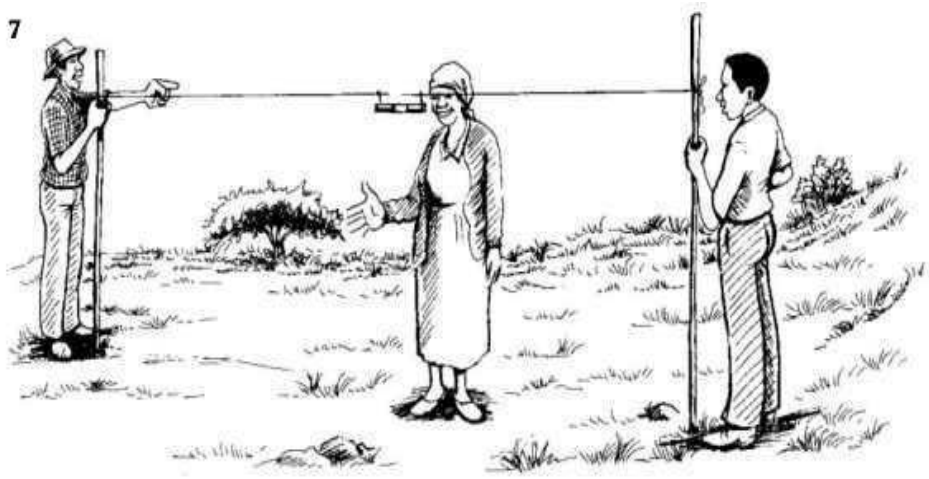
1. Make sure the string is at the “0 cm” notch on both poles.

2. Choose the place where you want to start marking the contour, and mark this place with a peg. Hold one pole upright next to the peg.

3. Making sure the string is taut and both poles are upright, move the other pole up or down the slope, until the bubble of the spirit level shows the string is level (Picture 7).

4. Mark with a peg where the second pole is standing.

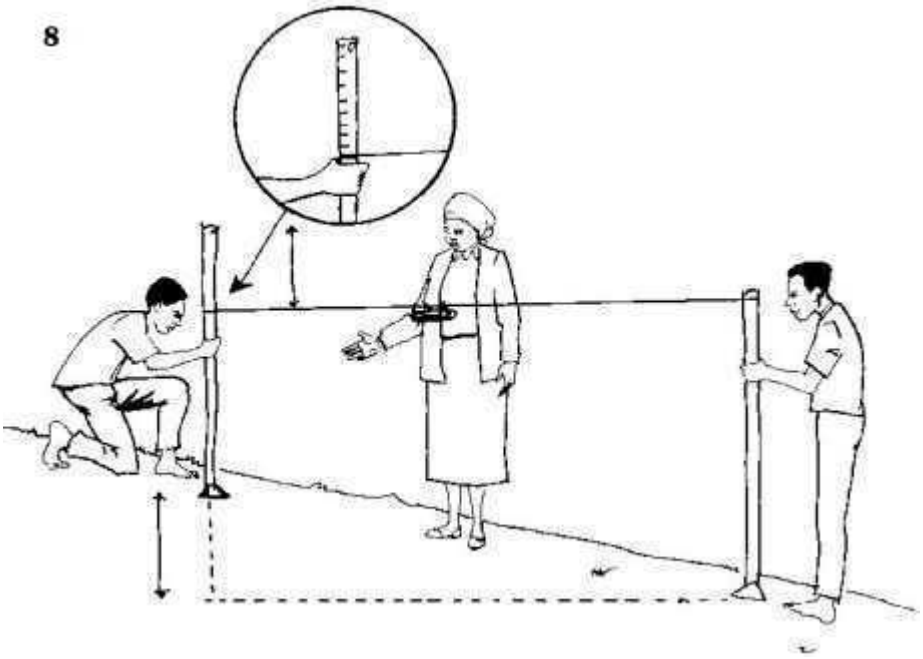
5. Repeat the procedure across the slope to mark out the contour line.



Measuring the percentage slope

1. Stand one pole at the top of the slope, and the other directly downslope from it. Be sure that the string is placed at the two notches marked “0 cm” (near the top of the poles).

2. Move the string on the up-slope pole down until the spirit level indicates that the string is level.



3. Record the number of 5 cm notches below the “0” mark. Each 5 cm notch indicates a 0.5% slope. For example, if you have moved the string moved down 10 notches, the slope is 5% (Picture 8).

Gully reclamation

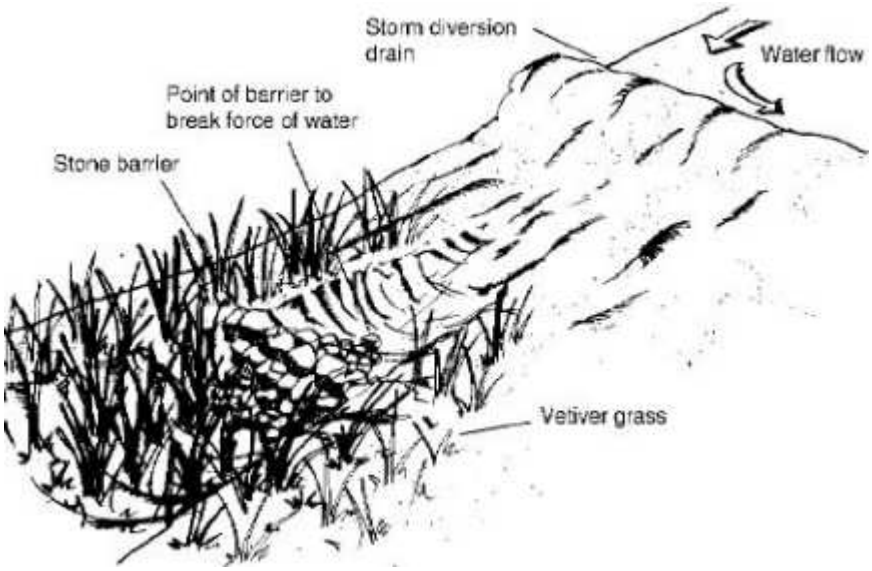
Once they start, gullies can rapidly erode valuable topsoil and expose the subsoil or bedrock, and making the land very infertile. It is important to halt the process of gully formation early, before they have had a chance to erode a large area. Reclaimed gullies can make valuable land for growing crops.

Location

This method has been used in Zvishivane District in Zimbabwe, a dry region that gets an average rainfall of 400-500 mm a year. Most of the soils are sandy. Due to a lack of ground cover, water runoff is a big problem and many gullies have formed.

Advantages

- Stopping gullies recharges the water-table and may make water available in the dry season.
- It reduces the amount of soil erosion downslope.
- It turns a totally unproductive area into productive land.



Work on reclaiming a gully starting at the top. The storm drain higher up diverts the bulk of the water. Build more stone barriers downslope.

Disadvantages

- Gully reclamation requires a lot of labour.
- It is treating a symptom. The real problem is higher in the watershed where the water is coming from.
- Sometimes it does not work if a very heavy storm comes at the beginning of the reclamation work.

Requirements

- Rocks, vetiver grass (or another tough bunch- or creeping grass).

- Wheelbarrows, picks, shovels, iron bar to dig out rocks.

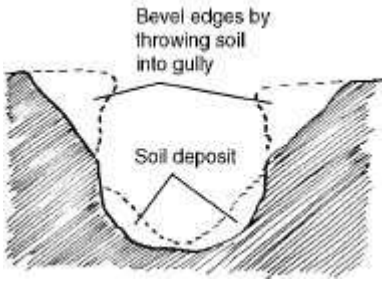
Procedure

1. Construct a storm drain above the gully to lead the water away from it. Do this in such a way that the water is well-managed and does not lead to erosion itself.

2. Start work at the top end of the gully. Throw the soil from both sides into the gully, down to where you want to build the first stone barrier. This soil will introduce grass seeds into the gully as well as flattening out the gully sides.

4. Construct the first stone barrier across the gully floor. Make the barrier widest in the middle, so that it has a point of stones facing upstream to break the force of the water. The barrier should be at least 1 m wide and 30 cm high. It should cut into the gully walls on each side.

5. Below the barrier put flat stones on the gully floor to break the force of water flowing over the barrier.



Working from the beginning of the gully downwards to where the first stone barrier will be built the steep sides of the gully are flattened with the soil being thrown into the gully.

6. Plant vetiver grass (or another strong bunch- or creeping grass) below the barrier, and on the banks that have been bevelled above the barrier.

7. Going downslope, build barriers roughy every 10 m across the gully.

8. During rains, soil will settle and gradually fill up the area behind the barriers. When it is full of soil, add more rocks on top of the barrier to trap more soil. Keep the wall 1 m thick.

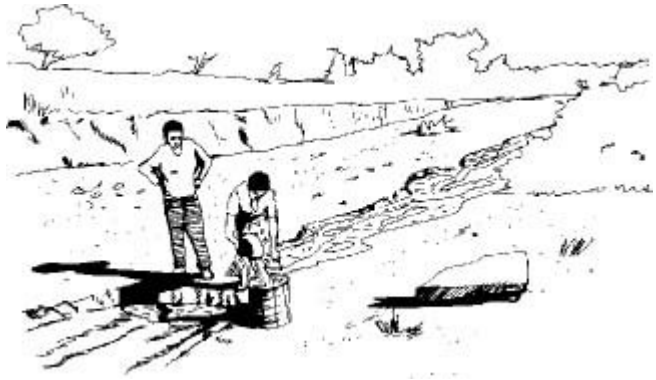
9. Plant trees and shrubs along the side of the gully. These should not cause too much shade, as this would not allow the grass to grow.

Gully reclamation in Mudenda, Zambia

A large gully had developed in the village of Mudenda, Kalomo West, Zambia. In October 1997, a team from CARE-Zambia's Livingstone Food Security Project and the Department of Agriculture conducted a participatory appraisal to understand the causes and consequences of this gully. This revealed that the community recognized that the catchment was not well taken care of as a result of bush fires, overgrazing, deforestation and inappropriate cultivation. The men of the village were afraid the gully would expand further and threaten other fields; but the women, who collected water from the gully and grew vegetables on its sides, wanted to develop a water-harvesting scheme for it. The community agreed to rehabilitate the gully and

to continue to harvest water from it.

Several visits to the village by project and department staff helped establish rapport and enabled the outsiders to understand the different perceptions of the men and women. These led to an agreement to conduct a second participatory rural appraisal, focusing on



the Mudenda gully. During the first day of this appraisal, the villagers mapped the community, its resources and social structures, listed the rainfall history of the area, and collected the yields of crops. This information helped the community and the staff to analyse the catchment-level issues surrounding the gully and how the community used it, and to understand the link between soil erosion in the catchment and low crop yields.

The second day of the appraisal consisted of a holistic planning exercise. The villagers were first asked to think about possible solutions to some of the issues identified the previous day. They then drew up plans to revegetate the upper portion of the gully, improve their land-husbandry practices (such as by using cover crops) around the gully (and especially upstream from it), build a fence around the gully, and build a drop-structure at the head of the gully to prevent it from eroding further upstream.

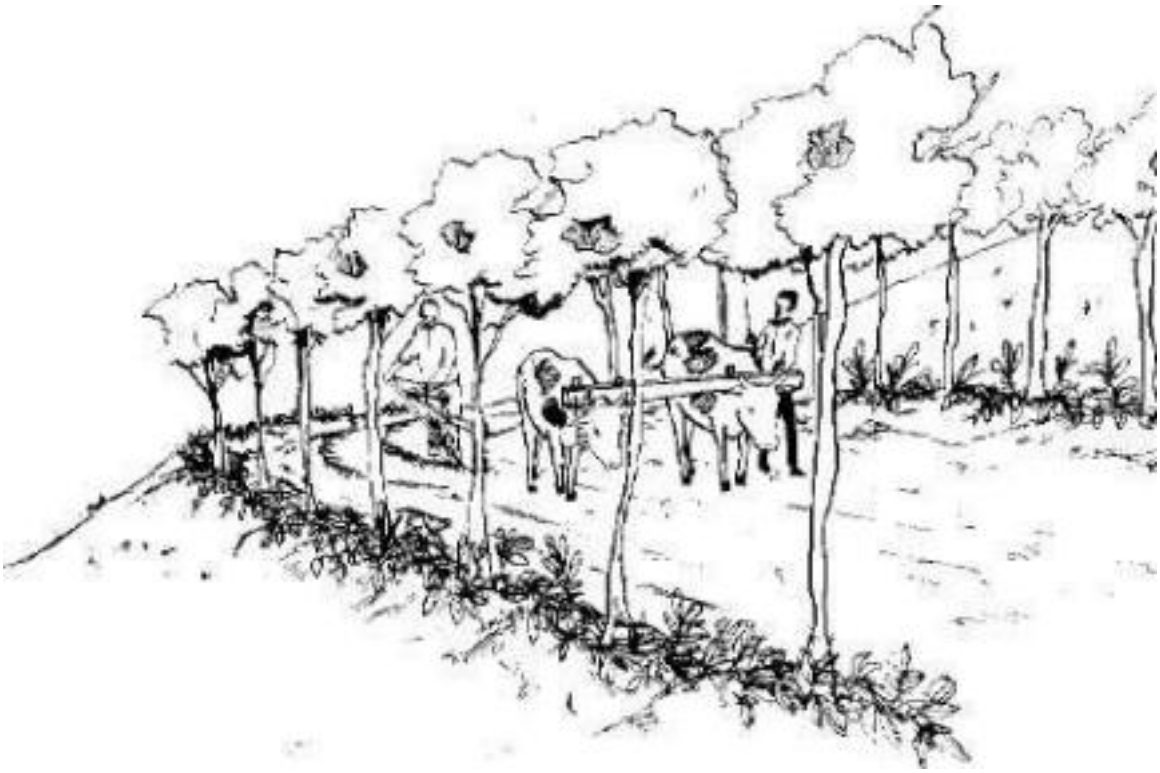
The villagers emphasized that their conservation efforts should have benefits in the short- as well as the long-term. It was important to analyse the views of different members of the community, as in this case, men and women saw the gully from very different perspectives. - *For more information, contact Robby Mwiinga, CARE-Zambia.*

In areas where it is difficult to find rocks, logs can be used. They should be pegged and tied in place. Another alternative is to use sacks filled with sand or soil. Make small holes in the sacks for grass to grow through.

Do's	**Don'ts**
o Keep livestock away from gully until it has been reclaimed. o Use other measures to control water runoff above the gully, such as harvesting water off paths and roads. o Repair and extend the walls if necessary, for instance if a flood washes away sides of the gully on one side of the wall.	o Don't create another gully with the storm drain. o Don't make the gap between the barriers too wide. o Don't build the barriers too high too quickly. A gully has to be healed gradually.

o Learn how to reclaim a small gully first, before trying to do the same on a larger one.	

Contour tree-planting



Farmers plant lines of closely spaced trees across a slope to slow down rainwater flowing down the slope. This reduces the amount of erosion. Over time, soil builds up on the up-slope side of the line of trees, forming a terrace. Farmers plant food crops in the rows between the trees.

A contour is a level line running across the slope. The trees growing along this line bind the soil and build up mounds around their trunks. If the trees are spaced closely, the mounds tend to join together over time, forming a small ridge or dam. When water reaches this ridge, it stops flowing, forms a puddle, and percolates into the soil. This increases the amount of moisture in the soil and raises the water-table.

The trees can also provide fuelwood, mulch or green manure, fodder or fruit.

Location

Contour tree-planting is useful in hilly areas with high rainfall and easily eroded soils.

Advantages

- The line of trees prevents rainwater from washing soil down the slope. It retains topsoil in the field and maintains soil fertility.
- The trees provide fodder for animals and fuel for domestic use.
- Tree leaves can be incorporated into the soil as a conditioner. Leguminous trees can be trimmed and the leaves used as mulch or green manure.
- The lines of trees encourage the farmer to plough across the slope instead of up-and-down. This further reduces erosion.
- Fodder grasses or legumes can be grown along the row of trees.

Disadvantages

- If they are not pruned regularly, the trees may shade the crops growing nearby.
- The tree roots can be a problem during ploughing.
- The trees may host pests of the crops.

Requirements

- Tree seedlings.
- Hoe; line-level or A-frame.

Procedure

Nursery

1. In a nursery, grow seedlings of the type of tree you want to plant. You can choose various types of tree:

- Leguminous trees such as leucaena and albizia for fodder, fuelwood and to get green manure from the prunings.
- Fruit trees for fruit.
- Other types of trees for building poles and fuelwood.

Laying out the contour

2. Choose a place on the slope where to start.

3. Using an A-frame or line-level, mark a contour line across the slope with sticks or stones. (See the section on *Marking contour lines*).

4. Dig a hole big enough to plant a tree seedling. Move one pace (about 1 m) along the contour line, and dig another hole. Repeat this until you reach the edge of the field.

5. Move about 10 m (30 feet) up or down the slope, mark another contour line, measure the spacing and dig holes. Do the same thing again until you have marked enough contours on the slope.

Do's	Don'ts
o If a seedling dies, plant a new one in its place. o Prune the trees regularly to prevent them from shading the crops in between the tree rows.	o Don't allow livestock to graze on the seedlings. Instead, prune the trees and carry the forage to the livestock in their sheds. o Don't over-harvest the contour-line vegetation, as this may break the continuous ridge line. Water can then begin to flow through the gap and create a gully.

Planting and cropping

6. Plant the seedlings in the holes, and water them if needed. Plant at the beginning of the wet season so the seedlings have time to become established.

7. Plough the soil between the lines of young trees, and plant food crops.

8. Weed the crop and care for the trees. You can leave a strip of grass, grow vegetables, or plant a mixture of fodder grasses and legumes, along the line of trees to help slow down the flow of water.

9. If you are growing leguminous trees, prune them regularly to reduce the amount of shade. Use the prunings as mulch or incorporate them into the soil as organic fertilizer.

Enset

Enset (*Ensete ventricosum*) is a multi-purpose crop grown in Ethiopia that is useful for contour planting and in sustaining soil fertility. It is sometimes called the "false banana" because it looks like a banana tree. Ethiopian farmers grow enset for various uses: it provides food, feed, fibre, fuel, medicine and construction materials; it also helps conserve soil and water, and provides shelter for coffee bushes. It is widely planted in Ethiopia, where the fleshy stem is processed into a staple food. It is thought that some 15 million people depend directly or indirectly on this crop. Outside Ethiopia, varieties of enset are planted in gardens as ornamentals.

Enset is grown as a pure stand, or can be intercropped with coffee, banana, fruit trees, timber trees or food crops. In the highlands of Gurage, in Hadiya and parts of Kambata zones in southern Ethiopia, where enset is mainly grown as a monocrop, farmers plant it in rows along the cont
slopes.

Enset has a strong, wide-spreading, deep roots which bind th
perennial plant, so is useful as a windbreak. The leaves are la
deep roots, it remains green throughout the dry season, and t
Farmers prune the leaves of younger plants and leave them o

To plant enset, farmers split the corm (the fleshy root) from
an enset plant into halves, and plant the pieces in a nursery

field in holes spaced 1-1.5 m apart. They apply manure, weed the field and cultivate it carefully to obtain as many suckers as possible. They then separate the suckers and transfer them to the permanent field. They apply manure, cultivate around the enset regularly to control weeds, and prune the younger enset leaves to control the growth of the plant. *—For more information, contact Kelsa Kena, Awasa Research Centre, Ethiopia.*

The water-harvesting innovations of Phiri Maseko, Zimbabwe

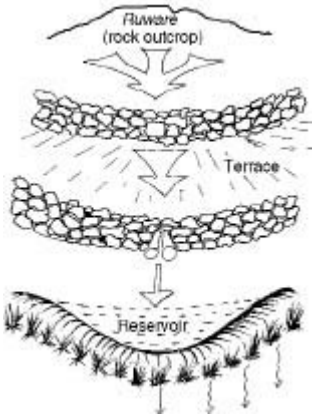
Every drop of rainwater is valuable in dry areas. But it is dry areas where a lot of soil erosion occurs and the water is lost. This happens more on steeper slopes. It is to address this problem that Mr Phiri Maseko, now in his seventies, has devoted his life. He has done this by developing many examples on his own small farm, as well as training many others in his methods.

The Phiri family lives on a 3-hectare plot in Runde communal area, Zvishavane, in Zimbabwe. This area is dry and prone to droughts: it has an average annual rainfall of 570 mm.

Soils

Phiri's plot is located on the slope of a hill and faces north-north-east. At the top of the hill is a bare rock outcrop, immediately below which is the homestead. The thin, grey soils are predominantly sand. Further down the slope through the yard and across the road into the cropping area, the soils become deeper, darker and less stony. Their clay content increases, especially towards the wetland in the north of the property. The wetland experiences seasonal waterlogging and is the source of a stream.

The *ruware*

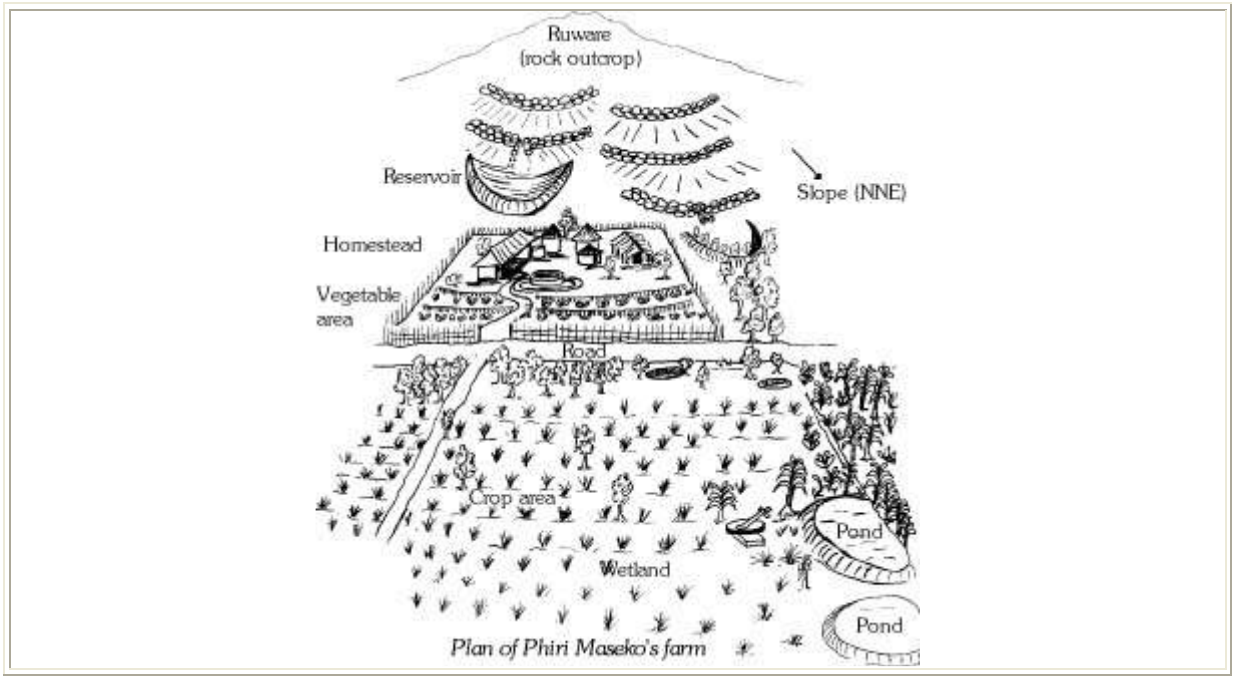


One of the most important resources (one that many would see as a disadvantage) is the large granite dome, or *ruware*, above the plot. In an uncontrolled situation this rock could cause severe erosion by channelling a lot of water onto the land below it where the Phiri family live and farm. Instead, however, the rock provides the main source of water for the trees, crops and household.

Tiers of stonewall terraces catch and direct the flow of water so that it can sink into the soil and replenish the underground store. The terraces trap grass seeds and create swathes of protective vegetation. Silt traps ensure that the terraces do not get choked with sand.

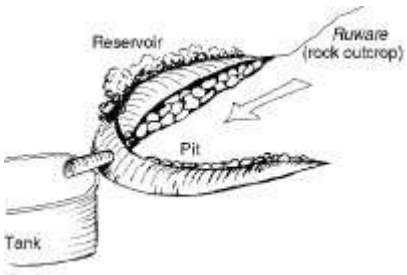
Most of the water is then channelled into a seasonal unsealed reservoir to encourage efficient infiltration of water into the soil rather than storing it on the surface. Some of the water can be siphoned into a storage tank made from bricks and plaster. Phiri knows that if a season is good enough to fill the reservoir three times then it will have sunk enough water underground

to last for two years. Harvesting water at the top of the slope recharges the groundwater so that crops, trees and natural vegetation will have moisture available to them in the soil.



Around the homestead

Below the *ruware* is the yard where the family lives. The terrain is quite steep, and it is extensively terraced with strong, stone structures built along the contours. The family grows a wide variety of fruits and vegetables, and keeps chickens, ducks and turkeys. The many trees around the homestead thrive on the water harvested higher up, which moves slowly downslope underground.



Some of the water harvested from the* ruware *can be stored in a tank made from bricks and plaster.

The road

Between the homestead garden and the cropping area is a dust road. Phiri has seen the need to control the runoff from this surface and take advantage of it by channelling the water and allowing it to seep into the soil above the fields. He has dug large pits into the soil at the side of the road. Around these pits the indigenous vegetation has visibly benefited. Thick shrubs and small trees are growing, and the grass is dense.

The cropping area

The Department of Agricultural and Technical Services pegged out contours in the cropping area (see the section on *Marking contour lines*). The Phiri family grows a variety of crops in between contour ridges here. Along these ridges Phiri has dug rectangular infiltration pits, 4 m long, 2 m wide and l m deep. The front end of the pit is bevelled to avoid undermining of the banks. The pits are covered with dense, tall grass, which stabilizes the structure.

Infiltration pits dug in existing contour pitches.

The pits measure 4 m by 2 m, and are 1 m deep.

Three wells in the cropping area are fed by the water that is harvested higher up. A network of irrigation pipes and ditches supplies crops with extra water during drought. Some vegetable gardens and a nursery are located close to two of the wells to take advantage of the extra water.

The wetland

In the north of the farm and at the lowest part is a natural wetland that Phiri has protected and harnessed for crop cultivation and water storage. He has dug two ponds there. The larger is higher up the slope and contains fish. This overflows into the smaller pond downhill. Reeds, sugarcane, bananas, Kikuyu and elephant grass are planted densely on the banks of the ponds to hold the soil. Phiri encourages all farmers he meets to grow reeds. They conserve the soil and are a valuable cash crop, as they are used in basket-weaving. Phiri gives free banana seedlings to the projects that he is involved with.

The main pond has a rope-and-washer pump and a tyre pump. Water from these seasonal ponds are used for irrigation via the ditches and pipes.

Benefits

Phiri's farm produces a crop in dry years when his neighbours do not get a harvest. Phiri is able to produce something all year round: crops in the rainy season, vegetables in the dry season, and bananas all year. The water harvested, conserved and used has a great value for food security and income. Nevertheless, Phiri feels he could make even more use of the water he harvests, for example by digging more ponds. *—For more information, contact Phiri Maseko, Zvishavane Water Project, Zimbabwe.*

Soil and water conservation by Shalawe Mwangi, Kenya

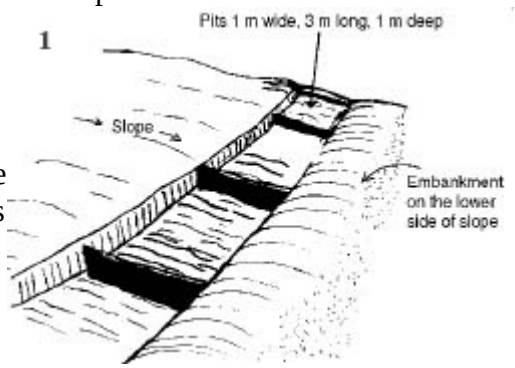
Since 1986, the Catholic Diocese of Nakuru, Kenya, assisted by Baraka Agricultural College, has been working with a network of more than 100 small-scale farmers practising sustainable agriculture. These farmers are particularly interested in conserving soil and water and improving their soil fertility. Over the past decade, the programme has conducted a number of workshops focusing on the concepts and practices of soil conservation, agroforestry, farm woodlots, integrated pest management, cropping systems, composting, and others.

Over the years, many of the practices were presented as a "package" of sustainable agriculture with the idea that participating farmers would adopt not only these practices, but that they would also disseminate the messages through a farmer-to-farmer approach. However, as the farmers tried innovations on their farms, they learned new things about how the various sustainable agriculture technologies did—or did not—fit their unique farm and community situations. Therefore, the programme staff began to work with the farmers to modify some of the practices using the participatory technology development process (see the section on *Participatory technology development*).

Shalawe Mwangi was chosen by his community to attend a 1-week workshop on sustainable agriculture at Baraka Agricultural College. After the course, he decided to conserve soil and water on his 0.8 ha (2 acre) farm. As he said to the programme extension staff: "I do not have compost and I do not intend to make it... I am not interested in double digging either... My problem is the lack of soil and water on my land."

Harvesting water

Shalawe had a unique problem. Excess water from a discharge drain was eroding the soil on his fields. So he wanted to be able to develop a way to intercept and harvest the water and prevent the soil from being washed away. This, he felt, would enable him to bring his land back into sustainable production.

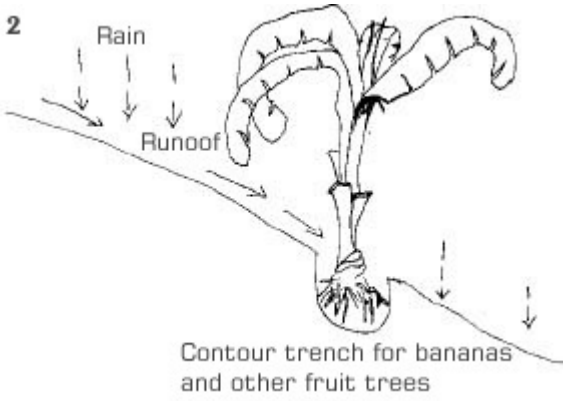


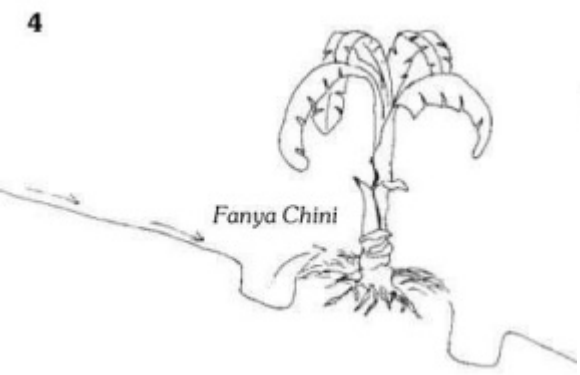
The law did not permit Shalawe to divert the discharge drain. So he decided to harvest the water for use on his farm. After examining his options, he dug 10 pits in the bottom of the drain to collect the water **(Picture 1)**. Each pit was 3 m (10 feet) long, 1 m (3 feet) wide, and 1 m (3 feet) deep. He laid the pits out in such a way that when the first pit was full, the water would flow into the next one, continuing until all 10 were full of water.

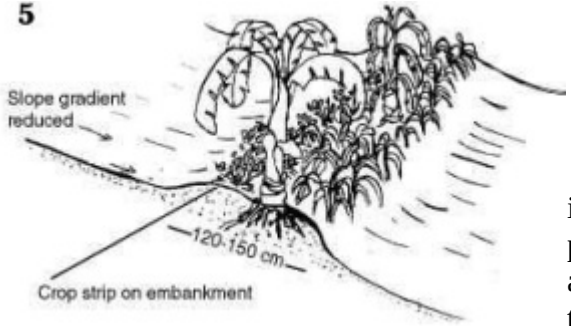
Shalawe discovered that usually the rains would stop before the tenth pit was completely full. This meant that the water was effectively intercepted for use on the farm. He was happy about this success and proud of his ability to solve the problem. Since the programme extension staff had trusted in his ability, he in turn developed trust in the staff and gained confidence.

Reducing soil erosion

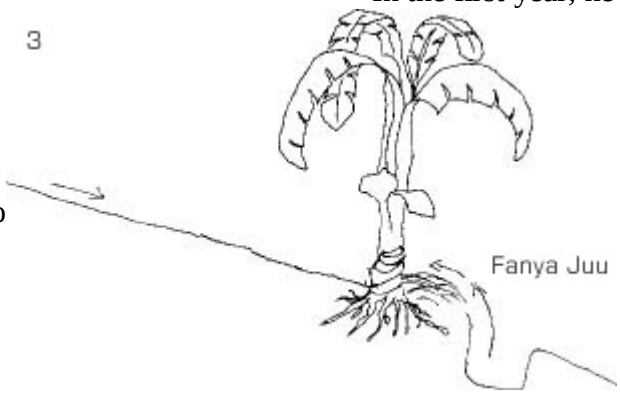
Shalawe thought that neither *fanya juu* nor *fanya chini* terracing (see the section on *Conserving soil and water*) would control runoff and help rebuild the soil on his sloping land. So he decided to use a combination of the two. He discussed the







idea with the programme staff, and decided to do the work in stages. In the first year, he built a shallow trench along the contour, 1 m (3 feet) wide. He planted banana trees in the trench **(Picture 2)**.



Below the trench, he dug a fanya juu terrace to catch soil that was washed downslope **(Picture 3)**.

In the second year, he constructed a fanya chini terrace above the line of bananas, sandwiching the line of bananas between the fanya juu and fanya chini terraces, and creating a strip 120–150 cm (4–5 feet) wide **(Picture 4)**.

On this strip he interplanted cassava, sugarcane, papaya trees, *Grevellea robusta* and other crops. The strip helped build a protective embankment, speeding up the development of bench terraces **(Picture 5)**.

Looking back

After five years of commitment, hard work, creativity and experimentation, Shalawe is proud of where he is today. The improvements have enabled his family to produce more food, and they have even been able to sell some produce. Shalawe has been able to improve his house and build a tank to collect water. He can confidently show visitors what he has done on his farm. As he puts it: “Before, I was regarded as unproductive and had nothing to contribute to the development of my family or my village… But now you can see for yourself.” *—For more information, contact William Keyah, Catholic Diocese of Kenya.*

The keyline water-harvesting system

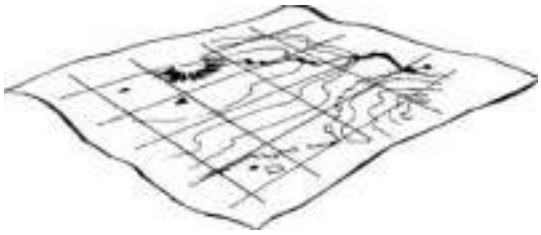
The keyline water-harvesting system spreads rainwater and allows it to seep into the soil through the careful design of a whole piece of land. Developed in Australia, this system works best where there are at least two stream lines or water courses, though aspects of it may be used where there is only one.

A keyline water-harvesting system carefully manages water runoff. The main aim is to capture rainfall and runoff, and allow it to sink into the ground. Any runoff that does occur is spread rather than being allowed to follow its natural course downslope.

It is essential that the piece of land is designed as a whole at the beginning of the exercise. It does not work to do things in an unplanned way.

Requirements

- A contour map of the area, at as large a scale as possible. This is not essential, but is very helpful. Aerial photographs are also very useful.



- An A-frame, spirit level or water pipes to measure contours (see the section on *Marking contour lines*).

- Various earth-moving tools: wheelbarrows, shovels and pickaxes. Oxen (or a tractor) and an earth scoop are very useful for building dams and roads. If you can, hire a bulldozer for major earth-moving work.

- The commitment and understanding of all involved are essential. This can be fostered using the process described in the section on *Integrated land-use design*. Considerable time and labour are usually needed to put the keyline system into practice.

Procedure

Observe the runoff

1. Follow the first two steps (observation and assessment, and holistic goal formation) in the section on *Integrated land-use design*. This should lead to an intimate understanding of the land in question by those involved.

2. Pay particular attention to assessing the nature of the runoff. Draw up a checklist of questions to help you do this, such as:

- What is the slope?

- What is the ground cover like?
- How easily will water percolate into the soil, and into the subsoil?
- How much runoff in a heavy rainstorm is there likely to be from different parts?

There are many more questions. Drawing up this list of questions is a useful exercise in itself.

3. Part of the observation should include marking contour lines using an A-frame or line-level, at regular intervals down the slope. While doing this, try to identify possible dam-sites. It may be necessary to call in an expert for this.

Design the water-harvesting system

4. With a thorough understanding of the piece of land and a common vision of what the various people working on it would like, the detailed siting can begin. In doing this, think "water flow" all the time. If there are enough people, have them work on ideas in separate groups. This will lead to many options being developed. It is at this stage that creativity is most called for. Consider the following in particular:

- **Runoff sources.** How can roads and paths be designed to carry runoff from above them (and off the road or path itself) to a dam, pond or field? Roads are a common cause of erosion if the runoff from them is not carefully controlled. But if they are well designed, they are a good potential source of water. Consider also roofs, sports fields, land higher up in the catchment, rocks, and land with poor ground cover. Where do water-harvesting ditches need to be sited to control the runoff they will produce?
- **Dams and ponds.** Where will they get their water from? How can their spillways be designed to spread water rather than just run it back into the same water course? Can spillways be designed to take water along the contour to the next water course?

5. When a lot of ideas have been generated, you need to start linking them together. The keyline system is a total water management plan for a piece of land. All aspects are interconnected to keep catching, spreading, sinking and storing water. The aim is to prevent the water from rushing downslope.

Principles of water harvesting

Top down. Start work at the highest point of the piece of land. Control water there first, and then work your way down the slope, putting your design into effect.

Spread and sink. Unless you are specifically carrying water to a dam, pond or tank, sinking water (allowing it to seep into the soil) is the aim of all water management. Remember that in the long term it will be much better if the dams are filled from underground water moving downslope, rather than from surface runoff.

Spillways. Pay special attention to all spillways. These are the weak links in any water-harvesting earthwork. You must design them to stand up to the worst storm. This includes spillways from a dam or pond, from ditches, or from a small pit catching water off a roof. Use the principle above on the spillways: spread and sink.

Ground cover. Always aim for maximum ground cover. In the end, ground cover is the best water-harvester of all. You can design sports fields so that they have banks all round to catch the water; but ensure also that the fields are as well covered by grass. In the long term, the grass will mean much more than the banks in terms of sinking water.

Implementation

6. Once everyone agrees to the design for the whole piece of land, you are ready to implement. The plan is the guide. It can, of course, be adapted as you go along. Many people forget this!

7. Follow the four principles of water harvesting (see the box above).

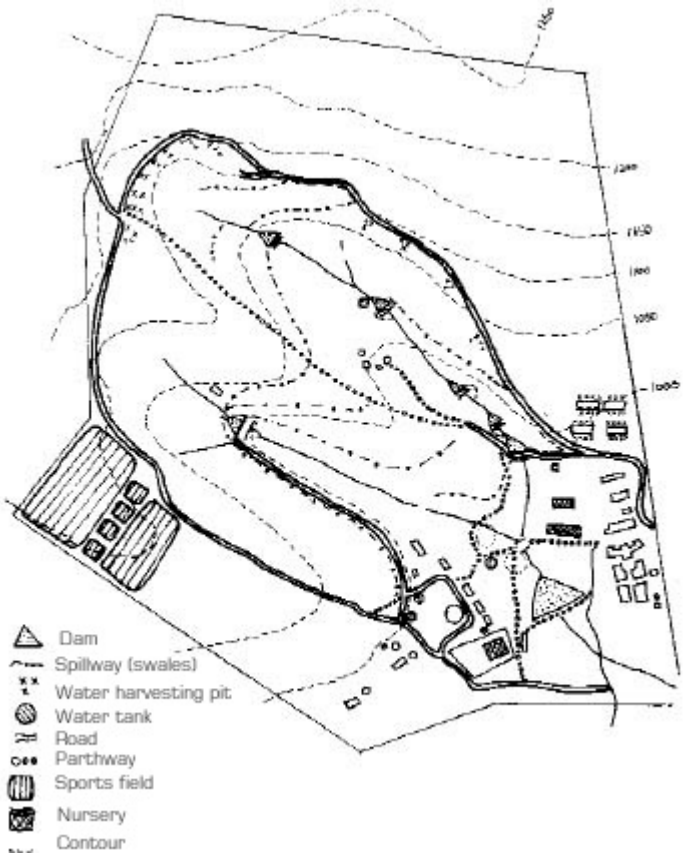
8. Learn and understand as many of the techniques for water harvesting as you can. There are many of them: pits, swales or *fanya chini*, contour ditches, bunds, *fanya juus*, infiltration pits, net and pan, tied ridges, stone contour barriers. Many of these are described in the section on *Conserving soil and water*.

NULC's keyline system

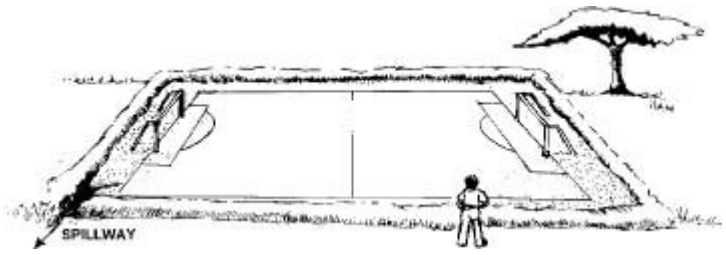
The Nyahode Union Learning Centre (NULC) in the eastern highlands of Zimbabwe has used the keyline system on its 42-ha piece of land. The Centre has a secondary school and technical college; most of the work has been done by teams of secondary students, who have worked during the school holidays. Many have paid their own way through school in this way.

Not only have the students put in hard work; they have also learned about dam-building and the keyline system. An important principle of the programme has been to develop a culture of discussion. Through discussion, the work teams have always known *why* they are doing what they are doing. They have contributed to decisions, have elected their own team leaders and have controlled their own work rate.

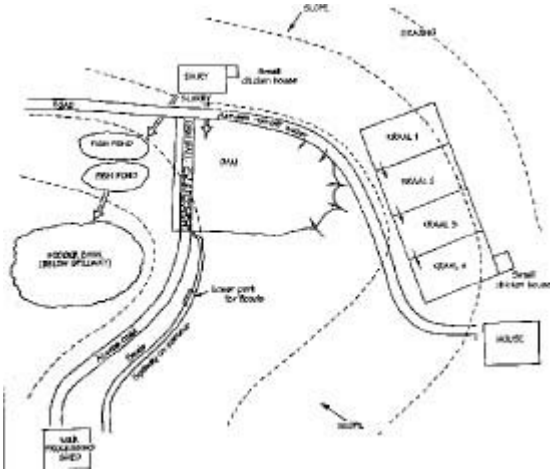
In the process of implementation, NULC has recognized that plans, no matter how good, are fallible. Reality always throws up surprises, plans can be mistaken, budgets may be out, and unexpected expenditure may raise its unwelcome head. NULC has learned, above all, the need for flexibility in implementation.



The design that NULC developed in 1990. All that is indicated has been implemented. Note the relationships between the roads and the water-harvesting structures, and the interconnections between the dams.



A football field, levelled and with banks all around, acts as a giant water harvester. If there is excess water in a heavy storm, the carefully placed and reinforced spillway carries it to the next level of the water-harvesting system.



A close-up of the plan around one of the dams. Notice the road, which is designed also to harvest water for the dam. The spillway carries water away on the contour around the ridge to the next water course. (The dotted lines indicate contours)

Technical features of the NULC system

- The sports fields (football/athletics and netball/volleyball) are sited at the top of NULC's land. They are themselves giant water-harvesters, encircled by large banks. Some of these banks are terraced as seating for spectators. NULC has made great efforts to ensure good ground cover using Kikuyu grass. Spillways have been carefully sited and constructed, as even with the good grass cover, the fields are unable to absorb all the water from a heavy downpour.
- Roof water from classrooms is harvested into 1-m circular pits.
- The spillway from the top dam snakes around along the contour to the neighbouring water course, carrying surplus water into the next highest dam. The spillway from this second dam in turn snakes back around the same ridge, carrying surplus water back to the first water course. The same happens with the third dam.
- The wetland below the second dam is constantly fed with water, ensuring a year-round supply of clear drinking water from the well next to it. There is water behind the dams all year round. This helps run extensive nurseries and gardens.

While this water-harvesting system needs a lot of monitoring and maintenance, it supplies a training and education institution with a population of 600 at any given time. This would not have been possible without this system. Furthermore, people in the community in the valley below talk of springs which were dry for many years now running again all year. —For more information, contact the Director, NULC, Zimbabwe.

Smallholder drip irrigation

Crop failure from poor rains is widespread and on the increase in the East African drylands, leading to increased food insecurity. In the arid and semi-arid areas of Kenya, some form of irrigation is necessary to meet water needs of horticultural crops. Large, capital-intensive irrigation projects tend to perform poorly compared to smallholder-irrigation schemes. Poor management results in the unfair distribution of water, and in soils becoming waterlogged and saline, leading to some schemes being abandoned.

Three types of irrigation systems are commonly used: surface, sprinkler and drip irrigation. Drip irrigation is the most efficient in terms of water use. It provides good water control by delivering water near the plant, enabling the farmer to grow crops with much less water than with other methods. In drip irrigation, water flows through a filter into special drip pipes, with emitters located at different spacings. Water is discharged through the emitters directly into the soil near the plants through a special slow-release technology.

Location

Drip irrigation is especially useful where rainfall is unreliable or water supplies are present but limited.

Advantages

- For a relatively low initial investment (US $15 to $85) a small-scale farmer can buy and set up a drip-irrigation system. If used to grow crops for market, this investment will pay itself within the first season and lead to increased household food production, especially during extended dry periods.
- Drip irrigation requires little water compared to other irrigation methods. About 40-80 litres per day are needed per 100-200 plants.
- The small amount of water reduces weed growth and limits the leaching of plant nutrients down in the soil.
- Inorganic fertilizer or manure tea can be applied efficiently to the plants through the drip system.

Disadvantages

- Most drip-irrigation equipment must be imported, so is not widely available.
- Most experience in using drip irrigation is confined to commercial farmers and research stations.
- Drip-irrigation systems are subject to clogging, especially if poor-quality water is used.
- Farmers require training to manage drip irrigation successfully.

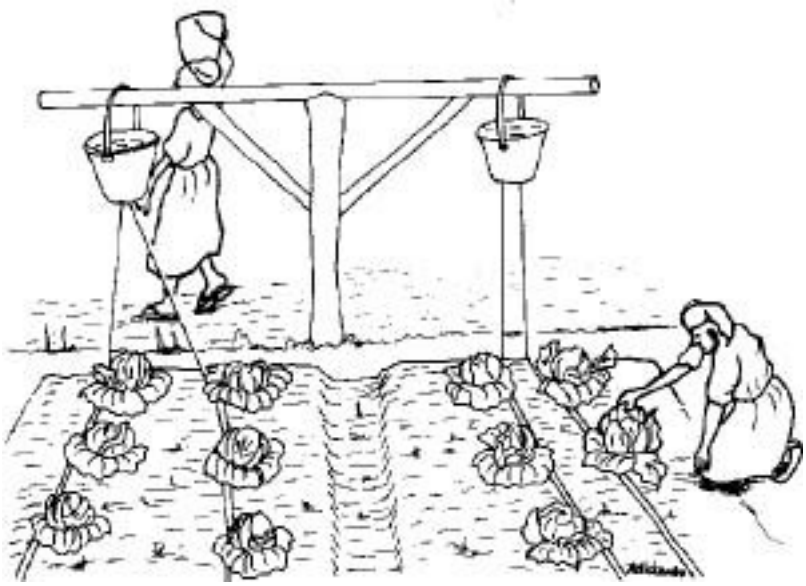
Requirements

- Filter, drip tape or polyethylene pipe and drip emitters, connectors.
- Water source (for direct-connected systems) or reservoir such as 20-litre bucket or 100-200-litre drum.
- Material for constructing bucket-stand or platform for drum or water tank.

Bucket system

The bucket system consists of two drip lines, each 15-30 m long, and a 20-litre bucket for holding water. Each of the drip lines is connected to a filter to remove any particles that may clog the drip nozzles. The bucket is supported on a bucket stand, with the bottom of the bucket at least 1 m above the planting surface. One bucket system requires 2-4 buckets of water per day and can irrigate 100-200 plants with a spacing of 30 cm between the rows. For

crops such as onions or carrots, the number of plants can be as many as the bed can accommodate. A bucket system currently costs about KSh 900 (US$ 15). A farmer growing for the market can usually recover this investment within the first crop season.



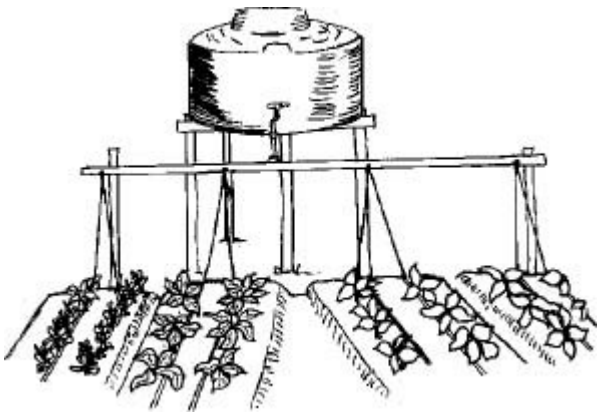
Bucket drip-irrigation system

Drum system

The drum system is a combination of several bucket systems but modified to use a water supply from a 100-200-litre drum instead of a 20-litre bucket. It consists of drip lines measuring 15-30 m long, a lateral line to which the driplines are connected (including a gate valve) and a drum or a small tank as the water reservoir, raised 1 m above the soil. The equivalent of five to ten bucket kits can be connected in this system. The lateral line is made of 2.5 cm (1-inch) diameter PVC, steel or polyethylene pipes. Connecting tees are used for each pair of drip lines.

A drum system equivalent to five bucket systems can irrigate 500-1000 plants planted with 30 cm between the rows. Such a system requires about 100-200 litres of water a day, depending on the environment and crop. It costs a total of KSh 5,000 (US$ 85). For comparison, a crop of cabbage yields a gross return of KSh 15,000 (US$ 250).

Bucket systems are produced by Chapin Watermatics Inc, 740 Water St, Watertown, NY 13601, USA, and are distributed at low cost. Bucket, drum, one-eighth-acre garden, and orchard kits are currently being promoted by the Kenya Agricultural Research Institute (KARI). For more information, contact Isaya Sijali, KARI.



Drum drip-irrigation system

Gender and development

Rural livelihoods in Africa depend heavily on natural resources. How well these natural resources are managed determines both the quality of life of the people and the sustainability of the production system.

In most countries in sub-Saharan Africa, agriculture is the lifeline of the economy. Women are key farmers, food producers and natural-resource managers. In the region, women produce 60-80% of domestically produced food, provide nearly half the farm labour, and shoulder over 90% of the domestic responsibilities. Women work almost twice as many hours as men. In Kenya, women form the core of the smallholder farm labour force. Nearly all rural women (96%) work on family farms, providing 75% of the farm labour and 60% of farm-derived income.

Despite these contributions, women face major constraints in terms of time, access to and control over resources, and the benefits they receive. Women typically have much less contact with extension agents, control very few agricultural technologies and farm inputs, and rarely take part in making decisions within the household or in institutions. Without this kind of support, their productivity and enthusiasm can be severely eroded.

Implications for sustainable development

Ignoring gender needs and interests reduces the level of participation of all segments of the community, thus jeorpadizing any development efforts. Some of the implications of this for development efforts are listed below.

Heavy workload for women

Time is a critical input in development work. Men and women tend to take on different tasks in the family and society. Because women spend the larger part of their day on "reproductive" work (see below for a definition of this), they are less able to take on the "productive" work tasks needed for development activities. There are several ways to address this division of labour. These include:

- Negotiating to ensure a better distribution of work among family members (for example to persuade men to take on some of the workload normally done by women).
- Providing basic services (such as a water supply) to reduce the amount of time needed for such tasks as fetching water.
- Introducing appropriate technologies (such as tools for weeding) to improve the efficiency of production.

Lack of necessary inputs and tools

The lack of necessary inputs (eg, improved seeds, fertilizers) and farm tools and implements (eg, weeders, seeders) can slow down farm operations. This can be attributed to poverty, but is also a result of lack of control over benefits from the farm. Because they are have different responsibilities, men and women might well decide to invest in different things: the man in fertilizer for "his" maize, for example; the woman in seeds for "her" plot of beans. But because the men make most of the investment decisions, the women's preferences may not get put into effect.

Extension services

Agricultural extension services are often directed to men, because it is men who are normally deemed to be the heads of households. The assumption is that once the information reaches the head of the household, it will automatically be shared with the rest of the household. However, this is not always true, and often women have little technical information necessary to improve their farm. For activities in which women are the key actors, information is a must if they are to participate.

Key ideas in gender analysis

The tools of gender analysis focus on:

- **The division of labour.** Who does what type of work? Work is divided into three broad types: reproductive, productive and community (described below).
- **Access to and control over resources.** Who can use the resources such as land, trees and water? Who controls what happens to them?

- **Benefits from the work done.** Who gets the income (in whatever form) from the resources and the work?
- **Constraints and opportunities.** How might appropriate interventions be targeted to overcome problems identified?

Gender

"Sex" refers to the biological differences between men and women. The word "gender" refers to their social and economic differences. This term is used to analyse the roles, responsibilities, constraints and opportunities of men and women in development. What men and women do in the family and society depends on society's expectations rather than on the biological differences between males and females. These expectations differ from place to place, and can change over time. For example, in many communities herding is the work of boys and men. But this has changed with the introduction of dairying and zero-grazing, where women play a key role. Because gender is specific to a given culture and time, gender analysis is necessary for every community and project.

Productive work

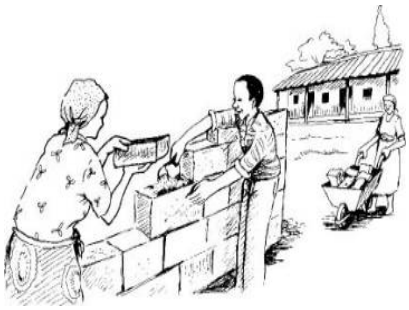
This is work which has monetary value. It covers a wide range of activities including farming and business enterprises **(Picture 1)**.

Reproductive work

This is work that supports the welfare and maintenance of the family. It includes child care, fetching water and fuelwood, cooking, washing, nursing, and other household tasks. Reproductive work has no monetary value and is difficult to measure. It is often not considered to be "work", yet it takes women many hours each day to do **(Picture 2)**.

Community work

This is work that goes towards the provision of community services and the maintenance of the social system. Activities under this category include building schools, maintaining roads, building soil-conservation structures, attending committee meetings, and providing support during bereavement **(Picture 3)**.



Access

"Access" means the ability of an individual to get to and use a particular resource. For example, women may have access to a forest (they can collect fuelwood there) even though they do not own it. The rights of the user are few, and are often limited only to improving the resource. If the user has only access to the resource but no control over it, he or she has little security, as the person controlling the resource may take it away at any time. The user therefore has no incentive to make long-term investments in it, like planting trees or growing cash crops such as coffee and tea. Access to resources without control over them can be a barrier to development.

Women may have access to some land on which they can grow crops, but it may be owned and controlled by their husbands.

Control

"Control" over resources means power that goes beyond simply use. It means power in both management and decision-making. Someone who controls a piece of land can rent it out to someone else, cut down the trees and plant crops on it, or even sell it. Control gives security to the user, so promotes long-term investment.

Integrating gender into development

Ignoring gender issues often leads to unwanted consequences (usually for women) and failed development efforts. Gender should therefore be considered in all aspects of development activities. By asking some simple but appropriate questions, it is possible to understand gender issues from the start.

Needs assessment (community diagnosis)

- Identify community activities and determine who does them: men, women, boys, girls (and older men and women). This helps to assess the possible participation of everyone.
- Establish the resources available within the community and who has access and control over them: men, women, boys, girls.
- Find out how decisions are made in the community and in households, and the roles of men, women, boys and girls in each.
- Articulate the development needs, constraints and opportunities for men, women and children.
- Assess the possible impact of the project on men, women and children.

Planning

- Ensure that the concerns and constraints recognized during the needs assessment are addressed, using stated criteria and procedures. Develop strategies that are responsive to the needs of both men and women.
- Develop projects that respond to the needs of men, women, boys and girls.

Implementation

- Ensure the participation of those with different types of workloads. Conduct a time-use analysis exercise to find out the best times and days for women, for instance, to participate in project activities such as training and meetings.
- Ensure the meaningful representation of both men and women in making decisions.

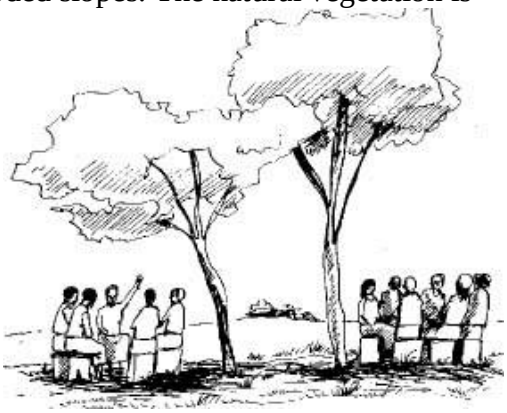
Monitoring and evaluation

- Develop indicators of the project performance for men, women, boys and girls. Adjust the project activities if necessary to ensure that the intended beneficiaries are reached, and to avoid unwanted effects on particular groups.
- Involve all stakeholders in monitoring the project performace, through record-keeping, review meetings, etc.

Gender and development in Kenya

This case study highlights the role of women in development and the gender-based barriers that frustrate sustainable development efforts.

Katheka is a semi-arid area about 85 km from Nairobi and 15 km from the market town of Tala. It has thin, sandy, fragile soils on steep, easily eroded slopes. The natural vegetation is scrub, with acacia and coarse grass. The area receives about 600-800 mm of rain per year. Drought is common, and the community sees water shortages as its number-one problem. Access to water is a gender issue because women alone are responsible for fetching water. During the dry season, it takes women no less than 5 hours to bring water home. A closer source of water would free up a lot of their time for other work.



The main crops are pigeonpeas, maize and beans. Coffee, the only cash crop, has not done well. Recently, attempts have been made to grow fruit for commercial purposes.

Despite great efforts to conserve natural resources, life is precarious, and Katheka's 2,800 people (1989 census) work hard to survive. Many men spend up to 7 months working away from home to earn money. Therefore, it is mainly the women who face the daily challenges of village life.

Gender study approach

Although poverty, poor infrastructure and low farm productivity had previously been identified as development challenges in Katheka, gender issues had not been studied in detail. A study was therefore undertaken in 1993 by a team who had previously worked in the area, so the area was not new to them. After the local chiefs had granted permission for the study, the team met with the villagers to explain the work process. They conducted a comprehensive needs assessment using participatory rural appraisal methods to highlight the gender aspects of the situation. The results of the analysis were presented to the community for discussion and endorsement. The final stage was to develop recommendations for action.

Study results

Similar to findings in Ghana, Tanzania and other parts of Africa, the study revealed that women are almost wholly responsible for "reproductive" work, are substantially involved in "productive" and "community" work, but have little control over the necessary resources (see the section on *Gender and development* for definitions of these terms). Similarly, women also have limited control over the benefits of their work. The disparity between their responsibilities and control frustrates individuals and slows down development efforts.

Although the study did not benefit the communities directly, it made them aware of the inequitable distribution of work and resources, and the impact this has on development. During the field work, it became clear that men were not consciously aware of women's heavy workload. Their realizing this was a first step toward bringing about social change.

Division of labour

Generally, women worked 13-16 hours a day, compared to about 6 hours for the men.

Reproductive work

Women are overwhelmingly responsible for this work, (cooking, fetching water, etc.). Boys between 5 and 17 years also contribute, as do men from wealthier households.

Productive work

Both men and women are heavily involved in productive work. Women undertake all agricultural tasks except spraying.

Community work

The Katheka community has a long history of community work, possibly because of the fragile environment and the high levels of poverty—both of which demand a supportive community. Both men and women are involved in community work, but women appear to be more committed and consistent than men.

Access and control

Both men and women have access to most of the resources in Katheka. Both have user rights, although the women's user rights are determined by men. Unlike the case with access, women have limited control over resources such as trees, money, skills and tools. They also have little control over benefits, as such decisions are made largely by men. Men control the sale and purchase of livestock and land, as well as deciding what to do with the proceeds from selling cash crops. They essentially control the equipment and farm implements.

Summary

The gender relations in Katheka are similar to those in many other villages. The women are overwhelmed with work, both productive and reproductive, but have little control over the resources to do the work, or the benefits of their efforts. In Katheka, as elsewhere, this

remains a development challenge. Lack of necessary inputs and tools leads to low productivity. Katheka's high levels of poverty— despite their hard work—may in part reflect this inequality.

The women's heavy workload and their limited control over productive resources and benefits limit their ability and interest in sustainable development. They spend a lot of time on reproductive activities such as fetching water, fuelwood, and health care. They could use this time more productively if these basic resources were readily available.

The gender study culminated in a set of recommendations and a loose community plan. The team used these recommendations to develop fund-raising proposals on behalf of the community. Unfortunately, none of these was successful. Nevertheless, the community has continued to mobilize local resources and is working with church organizations to build water systems to address their number one problem: water. *—For more information, contact Charity Kabutha, Winrock International, Kenya.*

Access to and control over resources and benefits in Zambia

CARE-Zambia is working with 10,000 farmers in the drought-prone areas of Livingstone and Kalomo districts in southern Zambia. In 1994, the Livingstone Food Security Project was started with a goal to reduce household vulnerability to drought. The project aims to achieve household food security, establish responsive sustainable farming and water-use systems, and promote income generating activities—all reinforced by strong community-based institutions.

Gender analysis study

Realizing the importance of gender issues within the project areas, the staff conducted an assessment study in 1997 to discover the gender roles among the project communities and households. This revealed two major gender-related constraints to improving households' farm production:

- Access to and control of productive resources (such as fertile land, cattle or oxen, ploughs and seeds for cash crops) used in farming.
- The use of income from selling produce surpluses.

The gender analysis also revealed that men and women prefer to plant different crops (see the table below). Married women said they had inadequate access to or control over productive resources such as land, cattle and ploughs. They also said they received few of the benefits: their husbands did not share the household's income, and they could not get seeds of cash crops from the project.

Number of farmers growing specific crops, 1995/97 season

	Maize	Sorghum	Cowpeas	Groundnuts
Men	580	465	309	216
Women	350	249	387	387

Access to and control over resources

Most of the project participants belong to a group called the Tonga, after the language they speak. Traditionally, when a Tonga woman marries, she goes to live in her husband's village. She is regarded as a temporary resident in both her parents' and her husband's village, meaning she has less access to productive resources. Under traditional law, the village headman cannot allocate land to a married woman; rather, it must be allocated by the husband. Women cannot own oxen or land because they are believed to be too weak to do so. Men pay a large dowry when they get married, so many people see a wife as her husband's property, or as his labourer who will help him get rich.

Land ownership and use

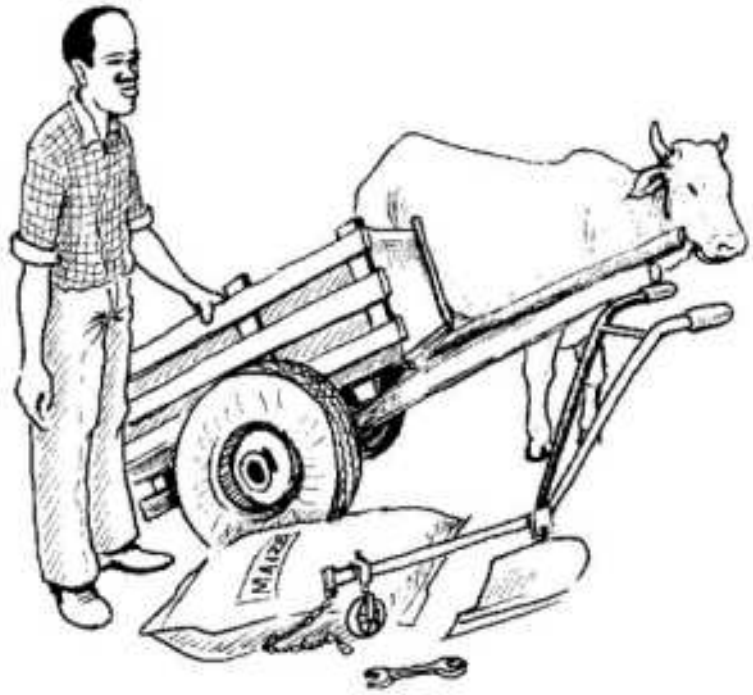
Tonga households traditionally grow crops in two separate sets of fields—those managed by the husband, and those managed by the wife. Because the husband owns the land, he decides what to plant, how much to plant, where to plant it. Each year, he will also allocate fields to his wife, based on the performance of the previous year's crop. Usually, he reserves the more fertile and productive fields for himself so he can grow maize and cash crops. His fields are also known as the "family fields", since this is where maize (the main staple) is produced. The crop is stored for use by the family, but any surplus can be sold by the husband.

The husband allocates his wife the rest of the fields—mostly infertile land. She has no choice but to accept the land she is given. She usually uses it to grow groundnuts, but sometimes she plants cowpeas or other crops. The area of groundnuts is limited, the average being about 0.4 ha. Groundnuts are grown for food, but she can sell any surplus to buy items for the household or herself. The husband has no control over this income, except by controlling the area under cultivation and the timing of planting.

Control and ownership of other productive assets

Cattle are important among the Tonga, who see them as a source of wealth and as a form of savings and security. However, the only person in the household who can own cattle

is the husband. This includes any cattle purchased using family earnings. The use and



control of the cattle (and the plough) by the husband can be seen clearly during land preparation and planting. Men do the ploughing, and women do the planting (this is true for both maize and groundnuts). Work starts in the husband's fields and then moves to the wife's fields. The wife's crops often end up being planted late, sometimes resulting in poor yields.

The table below shows that female-headed households are particularly affected. The woman in such a household may own land and usually grows both maize and groundnuts, but has to rely on family labour.

Access to seeds of cash-crops

Due to a series of droughts (1991–92, and 1994–95), the Livingstone Food Security Project identified the need for a source of quality seeds through a participatory appraisal. In response, the project began a seed multiplication and distribution programme. Since the 1994/95 season, it has distributed seeds of drought-tolerant varieties of the most important crops in the area: maize, cowpeas, sorghum, millet, groundnuts and green gram. These varieties require few external inputs, thus helping to ensure that all farmers can benefit.

Yield of maize and groundnuts
(average over two seasons: 1995/96 and 1996/97)

	Maize (kg/ha)	Groundnuts (kg/ha)
Households with both husband and wife (husband)	1059	129
(wife)	-	406
Female-headed households	829	104

Note: Yields may vary considerably from year to year.

Although the seed is available to both men and women on an equal basis, women tend to want groundnuts, while men choose maize. Relatively few women have access to maize seed, the main crop for both food and cash. Husbands do not like their wives to grow maize in the wife's fields because they fear she might neglect the family fields.

Household income

The household earns most of its money by selling surplus maize and other cash crops. This money is controlled by the husband, while the women control any income from selling groundnuts. The husband buys productive assets such as ploughs and oxen, while the wife buys non-productive assets, such as poultry and kitchen utensils.

Consequences

There are various consequences of the inequitable access and control between men and women.

- Women are generally not involved in making decisions about money from the surplus maize produced from the family fields (those managed by the husband). The husband usually spends this money without it sharing with his wife (or wives). This is particularly a problem if the man has more than one wife; he may prefer to spend the money himself rather than sharing it among many wives. It is also a problem in areas with higher production, and when farmers are paid in a lump sum.
- Men may control the productive resources of the household as a way to keep production of groundnuts down, so reducing his wife's ability to earn money that she will control herself.
- Households headed by women get poor yields because they are forced by lack of labour to plough and plant late, and because they are allocated infertile land.
- During the 1996/97 season, 126 men grew seeds as part of the project's on-farm seed-growing scheme, but only 16 women did so. Because the seeds are supposed to be sold (or exchanged) within the community, a husband may argue with his wife over the money if she grows and sells seeds.
- Wives work less on the maize in the family fields to concentrate on their own groundnuts; this may lower yields of the family's main food crop.
- Women "steal" maize from their husbands' fields because they know they will not benefit from the income generated. This may affect the household's food security.

Project interventions

To address these problems, the Livingstone project and local communities planned and embarked on the following activities.

- Distribution of seed loans to individuals (both men and women), as opposed to households. This has given women more access to seed to grow their own crops for food and income. Some have brewed sorghum and sold beer to earn money.
- Broadening the range of seeds distributed to include crops that women want.
- Through a savings and credit scheme, some women are currently saving part of their income to buy productive assets of their own. This is followed with counselling on joint decision-making between husbands and wives over the use of family income.
- Gender-awareness training has been conducted for community leaders (mostly men), who go on to train others. The trained leaders have helped negotiate with other men on increasing the participation of women in all development issues.

- Women have conducted experiments on ways to improve soil fertility using green manure crops. These methods are being tested with a view to improving the productivity of the women's fields.
- The project has stimulated representative community-based organizations to embrace the concerns expressed by both men and women. These organizations are known as "village management committees" (covering one village) and "area management committees" (covering two or more villages). These committees are responsible for initiating, planning and maintaining their own development activities. The project trains their leaders in group management, gender and development, land husbandry, and marketing. The organizations distribute seeds loaned to farmers, collect the loan payments, administer a rotating savings scheme, and provide agricultural extension services to other farmers.

For more information, contact Emma Sitambuli, CARE–Zambia.

Soil fertility

Using organic matter

Maintaining soil fertility is one of the most important things farmers can do. Here are some questions about the soil and the types of organic fertilizer they use. The answers will help determine how best they can maintain and increase the soil fertility.

What do you know about the soil?

You should know the characteristics of your soil and its problems. Is it short of nitrogen? Is it low in phosphorus? Does it have enough organic material?

If possible, get a soil test done by a laboratory or extension agent. The test will tell you if the soil is lacking essential nutrients and what you can do about it.

You can also use the following simple rules of thumb:

- If the crops have yellow leaves, the soil may be short of nitrogen. You may need to add nitrogen in the form of organic material or artificial fertilizer.
- If the crop leaves are purple, the soil may be low in phosphorus. You should add phosphorus-rich organic material (such as tithonia leaves and stems), and preferably artificial fertilizer that contains phosphorus (such as di-ammonium phosphate, DAP).

Note that the crop leaves may become yellow or purple because of waterlogging, competition with weeds, diseases, or other reasons. So these rules of thumb are not a certain guide. If in doubt, check with an extension agent.

Types of organic material

Type of organic material	Constraints to using this material
Crop residues	Recycles nutrients, but does not add extra nutrients to the soil
Root residues, eg crop stubble	Hard to manage
Weed residues	Danger of the weeds growing and competing with crops
Tree prunings	Trees take land that could be used for crops
Green manure, cover crops, eg sunn hemp	Take land that could be used for food crops
Farmyard manure	Livestock and fodder may be unavailable
Kitchen waste	—
Urban or industrial waste, eg sludge from beer brewing	May be contaminated with heavy metals
Purchased organic inputs, eg manure bought from other farmers	Cost

What types of organic material do you have?

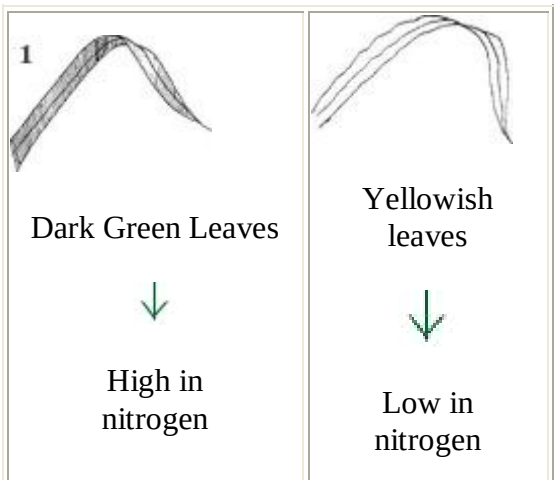
Farmers have many different sources of organic material they can use to keep their soil fertile. Some comes from the crops they grow. Some comes in the form of animal manure. And some is in full view in hedges, roadsides and field edges: weeds and wild plants that farmers often do not recognize as a valuable source of organic material.

Look at the types of organic materials you use, or could use. The table on the previous page shows the types of organic material that may be available, as well as some of the constraints or problems you may face when using them.

Plants

How best to use plant organic material depends on the types of substances it contains. Plants contain three main substances that may make them good organic fertilizer—or not-so-good. These substances are nitrogen, lignin and phenols.

Nitrogen. All plants need nitrogen to grow. They get it from the soil, and they store it in their leaves, stems and roots. Some types of plants are good at getting nitrogen either from the soil or from the air, and others are not so good. Tithonia, for example, is very good at taking up nitrogen

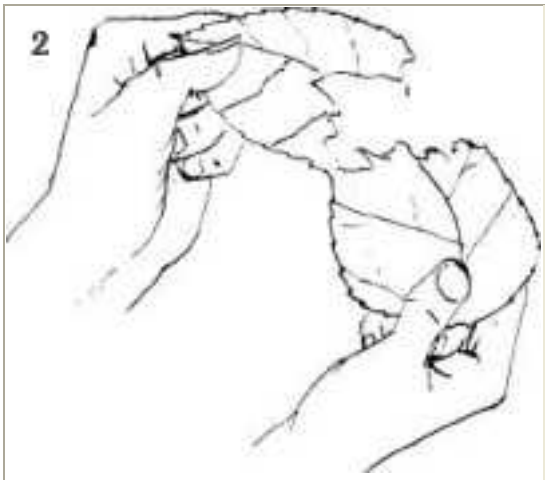


Good organic ferilizer	Poor organic fertilizer

from the soil, while maize is less good.

Some plants, called legumes, even fix their own nitrogen from the air. Legumes (beans, chickpeas, sesbania, leucaena and many others) are very valuable organic material or intercrops as they actually increase the amount of nitrogen in the soil as well as storing it in their stems and leaves (see the sections on *Green manuring* and *Inoculating legume seeds*).

In general, you can tell if a plant contains a lot of nitrogen from the colour of its leaves. If it has dark green leaves, it probably contains a lot of nitrogen (so makes good organic fertilizer). If the leaves are yellowish, it contains little nitrogen (so is less useful) **(Picture 1)**.



Can tear leaves easily

↓

Low in lignin

↓

Good organic fertlizer

Lignin. When they die, some plants rot quickly and release the nutrients they contain into the soil within only a few days. Other plants decompose more slowly, so their nutrients are released only gradually. In general, plants that rot quickly make better organic fertilizer, as the crop can use their nutrients sooner.

Plants that are woody contain a substance called lignin. In fact, all plants contain lignin, but in different amounts. Plants that contain a lot of lignin rot more slowly, so do not make very good organic fertilizer. Older plants tend to contain more lignin than younger ones.

You can tell if a leaf contains a lot of lignin by tearing it with your fingers. If it tears easily, it does not have very much lignin (making it good for use as fertilizer). If it is hard to tear, it has a lot of lignin and will not make good fertilizer **(Picture 2)**.

Astringent taste

↓

High in phenols

↓

Poor organic fertilizer

Manure kept covered
and out of the rain
↓
Good organic fertilizer

Phenols. Phenols are substances in the plant that also make it rot slowly. A plant with a lot of phenols will make low-quality organic fertilizer. You can tell if a plant has a lot of phenols by tasting it: if it is astringent (it makes your tongue curl up), it probably has a lot of phenols and will make poor organic fertilizer **(Picture 3)**.

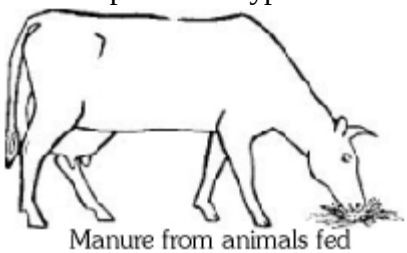
Different parts of plants may contain different amounts of these substances. For example, the stems may contain a lot of lignin, but the leaves may have very little (so it may be best to use only the leaves as fertilizer).

Wavy leaves
↓
Decompose slowly
↓
Poor organic fertilizer

The amount of these substances also depends on where the plants grow. A plant growing in a warm, rainy place on good soils may contain different amounts of the substances from the same type of plant growing in a dry, poor soil.

Other things can also influence whether the plant will make good organic fertilizer. For example, if the leaves are waxy, they will decompose slowly, so make poor fertilizer **(Picture 4)**.

All this makes it difficult to say for certain what the best way to use a particular type of organic material will be. It is best to try out various things to find the one that best suits your farm.



Manure from animals fed
with good fodder
↓
Good organic fertilizer

Animal manure

The quality of manure depends on what the animals have eaten. If they have been fed with poor-quality forage or grazed on poor soils, their manure will be of poor quality. If they have been fed good-quality feed, the manure will be rich in nutrients **(Picture 5)**.

Manure needs to mature for several weeks or months before it can be used as fertilizer. But the amount of nitrogen it contains falls over time, because nitrogen escapes into the air or is washed away by rainwater. To prevent this, keep it in a covered pit or drum before spreading it on the field **(Picture 6)**.

Manure with urine (for instance, if it is collected in a lined slurry-pit) contains more nitrogen than manure without urine. But the nitrogen in urine is lost easily. Cover the slurry-pit to prevent this (*see the sections on Zero-grazing and Urine–manure slurry as fertilizer*).

Even if manure is of poor quality, it still makes useful fertilizer, so you should use it anyway on your soil.

The type of manure also influences its quality, because different species of animals eat different things. In general, manure from pigs and poultry is of better quality than manure

from goats and cattle. You can enrich cattle manure by mixing it with manure from other types of animals.

How good is animal manure as organic fertilizer?

If...		It is probably...
The manure came from animals that have been fed with poor-quality grasses or on natural rangeland...	➔	Low in nitrogen
The manure has been allowed to stand for more than 6 months and has been exposed to the sun and rain...	➔	Low in nitrogen
The animals have been fed with high-quality feed, such as legumes, concentrates and improved pasture...	➔	High in nitrogen

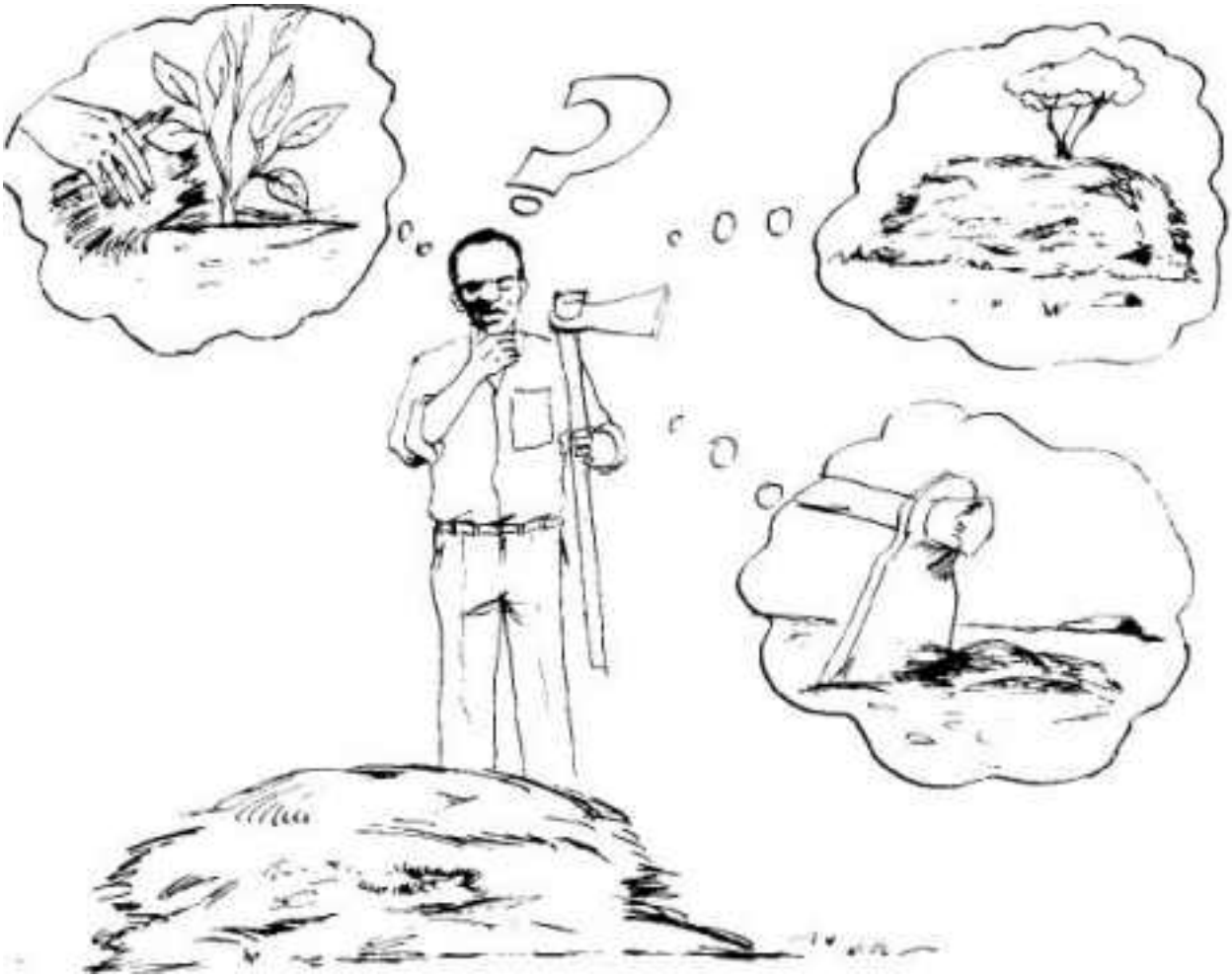
How should you use organic material?

Many farmers do not use the organic resources they have available wisely. Up to 40% of the nitrogen in manure is washed away by rain or disappears into the air before the manure is used as fertilizer. In western Kenya, only 10–20% of farmers use plants from hedges to help improve their soil. Farmers face many choices in deciding how to use organic material. They can:

- Choose among different plant types (trees, cover crops, crop residues, etc).
- Select organic material from different places (on-farm or off-farm).
- Pre-treat the material in different ways (apply it directly, make compost, etc).
- Mix different types of organic material, or use a combination of organic and artificial fertilizer.
- Spread it on the surface as mulch, or work it into the soil.
- Apply the organic material before ploughing or afterwards.
- Use the organic material to fertilize high-value crops such as vegetables, or on staple crops such as maize.

Once you have found out the quality of the organic material you want to use, you must decide how best to use it. Depending on the type of plant material or manure, it may be best to incorporate it into the soil, use it as compost, or leave it on the field as mulch.

It is best to use high-quality organic material directly as fertilizer on the soil. For other types of organic material, such as maize stalks, it is probably better to compost them first



How to use different types of organic matter

Types of organic material (examples)	Quality	What it contains	How to use it
Tithonia Gliricidia Leucaena High-quality animal manure	High	High in nitrogen Low in lignin Low in phenols	Incorporate directly into the soil to fertilize annual crops
Calliandra	Fairly high	High in nitrogen High in lignin or phenols	Mix with fertilizer, or with high-quality organic material (such as tithonia) before incorporating in the soil
Maize stalks Low-quality animal manure	Medium	Low in nitrogen Low in lignin	Mix with fertilizer or add to compost
Twigs	Low	Low in nitrogen High in lignin	Leave on the field to help control erosion and to retain water

(see the section on *Composting*), or mix them with inorganic fertilizer before incorporating them into the soil. Some types of organic material, such as stems and twigs do not make good compost because they contain too much woody lignin. It may be best to leave these on the soil to control erosion and help retain moisture. The table above has guidelines on how to use different types of organic matter.

If you have both high- and low-quality organic materials, mix them together before applying them on the field. Mix together plant and animal wastes to enrich poor-quality manures.

In general, it is better to use a mixture of organic and artificial fertilizers than either organic or artificial fertilizers by themselves. If you use high-quality organic material, you probably have enough nitrogen but not enough phosphorus—so fertilizers that contain phosphorus should be your priority, especially if you know your soil is low in phosphorus. Choose an artificial fertilizer that contains both nitrogen and phosphorus rather than one that has nitrogen only (see the table below).

Artificial fertilizers that contain nitrogen and phosphorus

Nitrogen	Nitrogen and phosphorus	Phosphorus
Urea Calcium ammonium nitrate (CAN) Ammonium nitrate	Di-ammonium phosphate (DAP)	Triple superphosphate Rock phosphate

Tithonia

Tithonia, or false sunflower, is a plant common in hedgerows throughout Kenya and other countries in eastern and southern Africa. It has yellow flowers that look like a daisy. Farmers are very familiar with it, but many do not realize that it makes a very good organic fertilizer.

Although it is not a legume, tithonia accumulates large amounts of nitrogen and phosphorus from the soil. When it is cut and incorporated into the soil, it rots quickly, releasing nearly all its nitrogen into the soil within just 2 weeks. This means that the nitrogen is available very quickly for the growing crop to take up. By comparison, leaves of Senna (Cassia), a leguminous tree species commonly used as organic fertilizer, take 4–8 weeks to release all their nitrogen.

Tithonia also acts as a natural pesticide: it is effective against nematodes and may be effective in controlling striga.

See the section on Manure tea for information on how to make a manure tea from tithonia.

For more information on the approaches to using organic matter described in this section, contact Michael Swift, Tropical Soil Biology and Fertility Programme (TSBF), Kenya. Please also send comments on these approaches to Dr Swift.

Minimum tillage

Minimum tillage is a tillage method that does not turn the soil over. There are various kinds of minimum tillage. The one described here uses two oxen-drawn pieces of equipment: a subsoiler and a ripper.

On many soils, conventional ploughing compresses a layer of soil at a depth of about 15 cm (6 inches). Over several seasons of ploughing, this compressed layer can form a hardpan. This prevents water from percolating down, decreasing the soil's moisture-holding ability and increasing the amount of water that runs off the surface.

The hardpan also stops plant roots from penetrating deep into the soil. The shallow roots of crops cannot reach nutrients below the hardpan, and the plants tend to fall over easily.

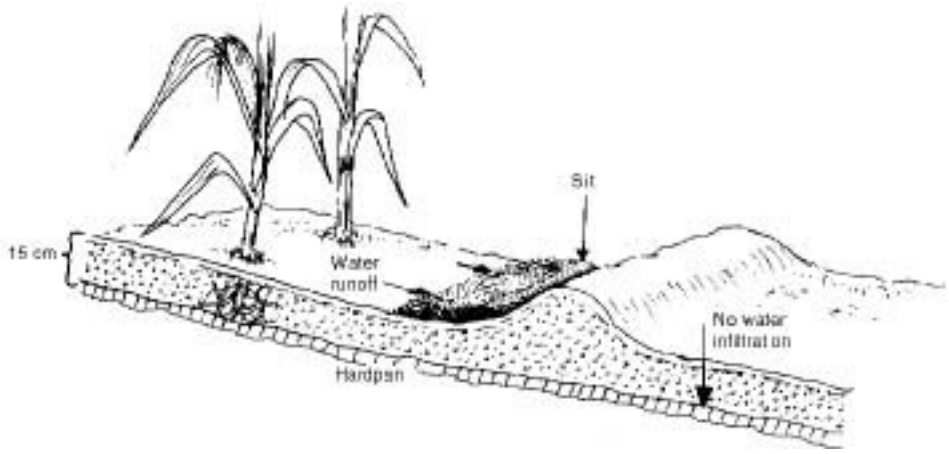
The subsoiler used in this minimum tillage method penetrates deep into the soil, breaking up the hardpan and allowing water and roots to pass through. The ripper breaks up the soil further and makes planting-furrows at the same time.

Location

This technology is applicable where hardpans exist. This is usually on light sandy loams, loams, and clay loams. It is not used in sandy or clay soils.

Advantages

- Subsoiling allows water to percolate more easily and evenly into the soil. This means that the soil can be tilled earlier after the first rains, and the soil stays moist longer.
- Using a ripper allows planting to be done earlier and faster than with conventional furrow planting.
- Crop roots can penetrate deeper into the soil, and crops produce higher yields.



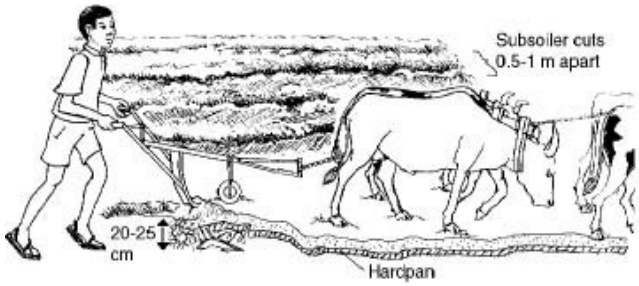
A hardpan stops water from seeping into the soil, resulting in erosion and dry soils. It also prevents crop roots from reaching down deep. Where conventional ploughs have been used, the hardpan forms at a depth of about 15 cm.

Disadvantages

- At least four strong oxen are needed to pull the sub-soiler. (Only two are needed for the ripper.)
- In some situations, minimum tillage can promote the growth of weeds.

Requirements

- Healthy oxen.
- Sub-soiler.
- Ripper.



Subsoiling is done on the contour at 0.5 to 1-metre intervals. Four oxen are needed for subsoiling.

Procedure

1. In the dry season, plough the land using the subsoiler, drawn by four oxen. Plough along the contour (across the

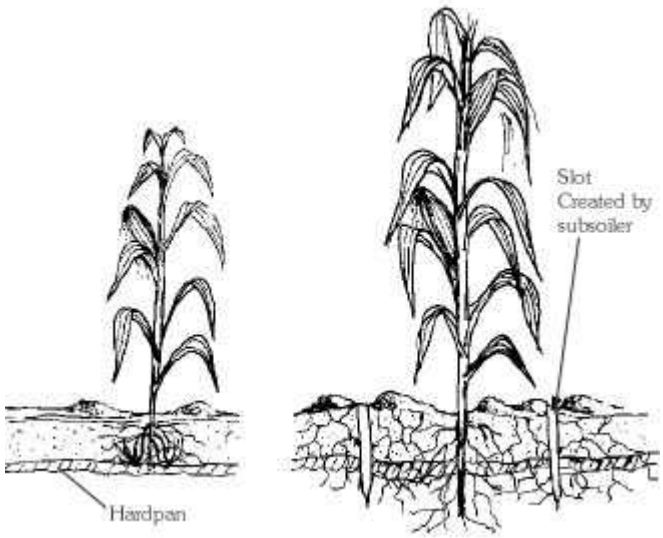
slope, not up-and-down), leaving 1 m (3 feet) between the rows. On steeper slopes, leave 0.5 m (18 inches) between rows.

2. After the first rains, use the ripper to break up the soil and prepare furrows for planting.

3. Plant the crop.

4. Begin weeding the crop early, and weed regularly.

5. Plough with the subsoiler again after 1-2 years.



Maize grows better where subsoiling and ripping have broken the hardpan (right) than previously (left)

Do's	**Don'ts**
o Use the subsoiler when the ground is dry. This will allow the hardpan to crack and shatter. o Follow the contour when subsoiling or	o Don't use the subsoiler when the soil is wet. o Don't allow continuous grazing of

ripping.	cropping areas.

Promoting minimum tillage in Tanzania

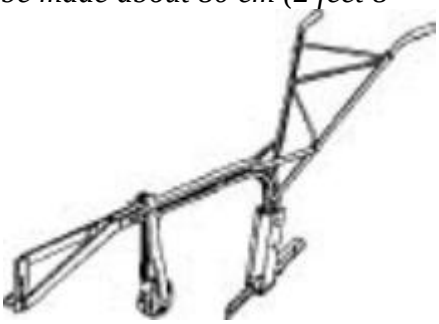
The Agricultural Mechanism Management (AMM) project is promoting minimum tillage in the Arusha region in northern Tanzania. The project is working with farmers on the use of the sub-soiler and ripper in areas with 400-1200 mm of rainfall a year.

The project first visits farmers and carries out an appraisal exercise to find out if they are aware of the hardpan problem. About 20 farmers are then chosen to carry out demonstrations comparing minimum tillage with conventional ploughing. The farmers use their oxen for around 6 hours per day (in the mornings and evenings) and are able to till about 2 acres (just under 1 ha) in this time.

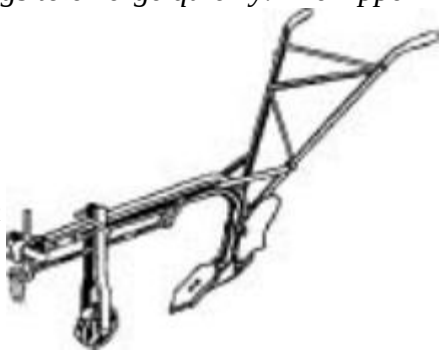
The farmers apply the same crop management on the minimum-till and conventionally ploughed fields. This means they can compare the results directly. The project helps organize field days so that other farmers can see and discuss the results.

The ploughs can be made locally from old implements, car chassis, and materials bought from equipment dealers. AMM can provide spare parts such as shanks, sweeps and points. By demonstrating the benefits of the technology and fostering the business infrastructure supporting it, AMM hopes that the technology will begin to spread among farmers by itself. *—For more information, contact Agricultural Mechanism*

The subsoiler being used by AMM in Arusha. This digs 25-30 cm into the soil, breaking the plough hardpan. The hitch extension can be adjusted to ensure deep penetration, even in the dry season. The subsoiler attachment can also be fitted to other plough frames. The furrows should be made about 80 cm (2 feet 8 inches) apart



The Magoye-type ripper used by AMM in Arusha. It allows planting to be done at shallower depths than with conventional furrows, enabling the seedlings to emerge quickly. The ripper is especially siutable for planting maize.



Deep soil preparation (double digging)

Double digging is a method of deep soil preparation in which the soil is fertilized with organic matter and is loosened to a depth of 60 cm (2

feet).

This technology, coupled with composting or manuring, is used to improve soil fertility and structure. It is recommended for use in compacted, heavy, or rocky soils, and soils whose structure has been degraded by chemicals and frequent ploughing.

Location

In areas with high population density, where the average farm size is shrinking, food production must become more intensive and efficient. Double digging allows farmers with very small farms to produce more food on less land. It is not suitable for use on larger pieces of land.

Advantages

- It increases the amount of space in the soil for air and water, which in turn improves crops growth.
- It improves the soil structure, especially when compost or manure are added.
- It promotes earthworms and the activities of soil microbes.
- It breaks up soil crusts and hard pans, and increases the speed that water that can seep into the soil.
- Used with enough organic fertilizer, it helps the soil retain water, allowing crops to survive longer in dry situations.
- It allows crops to planted close together, which can result in yields four times the conventional average.
- If the crops are planted close together in a diagonal pattern, their canopy suppresses weeds and acts as a living mulch, further decreasing the amount of moisture lost through evaporation.

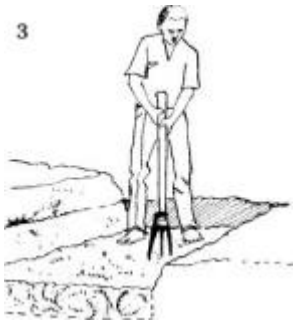
Disadvantages

- Double digging is labour intensive, but usually needs to be done only once.
- It may damage the soil structure if not done properly or if the beds are not adequately fertilized with compost or manure.

Requirements

- Hoe or digging fork, rake, digging spade.
- Wheelbarrow or big buckets.
- Digging board (a plank of wood to stand on while you are digging, so you do not compress the soil).
- An area of at least 1.5 m x 6 m (5 feet x 20 feet) for each bed.

Procedure



1. Measure the area you want to double-dig, marking the corners with pegs. The beds should be 1.5 m wide, and can be as long as you want.

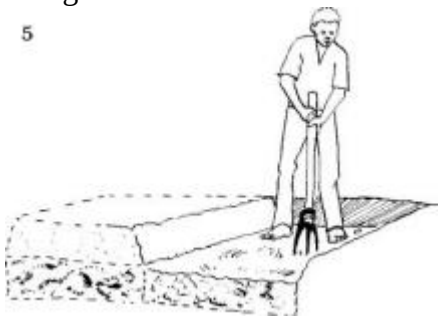
Lay out beds across (perpendicular to) the slope if the ground is not level.

2. Spread several wheelbarrows of compost or animal manure on the area you have measured out. Cover the soil completely with a layer at least 5-8 cm (2-3 inches) deep **(Picture 1)**.

3. Dig a narrow trench, about 30 cm (1 foot) wide, and about 30 cm (1 foot) deep (generally until you can see the subsoil). Set aside the topsoil you have dug out; you will need it later **(Picture 2)**.

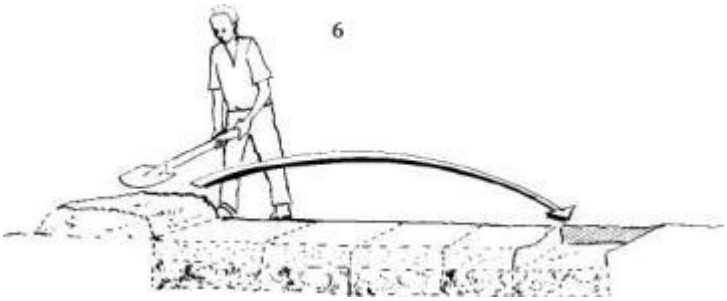
4. Using the digging fork, loosen the subsoil along the bottom of your first trench to a depth of another 30 cm (1 foot) **(Picture 3)**.

5. Now turn a strip of topsoil 30 cm (1 foot) wide and deep into the first trench, mixing in the compost or manure, filling the first trench completely and forming a second trench next to it **(Picture 4)**.



6. Loosen the subsoil below the second trench, as in step 4 **(Picture 5)**.

7. Repeat this process until you reach to the end of your measured bed. You will notice that the level of the topsoil has been raised up from all the organic material being incorporated, as well as through breaking up the subsoil.



8. You will have an empty trench at the end of the bed. Bring the topsoil you set aside in step 1, and put it into this trench **(Picture 6)**.

9. Shape the bed so it has a flat top and gently sloping edges.

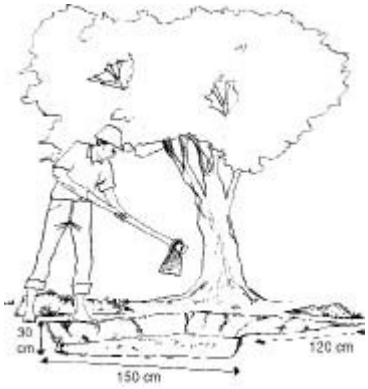
10. Plant immediately. Plant the crops at a close spacing in a diagonal pattern so they cover the soil quickly and protect the bed **(Picture 7)**.

11. If you are not yet ready to plant, mulch the bed **(Picture 8)**.

Do's	**Don'ts**
o Double-dig at the beginning of the growing season.	o Avoid compacting the soil on the bed; never step on it. Do all the work (soil

o If the soil is particularly compacted or especially infertile, a second round of double digging may be necessary. Otherwise, it is sufficient to repeat the double digging after 3 years. o At the beginning of each new season, merely turn the topsoil of the bed using a fork, adding a new layer of compost. o Fertilize the bed well with old manure or compost, depending on the type of crop to be planted. For instance cabbages may require a lot of compost, while carrots may need none. o Rotate crops strictly. For example, follow deep-rooted crops with shallow rooted ones, and heavy feeders with light feeders.	preparation, planting and weeding) from one side or the other. The beds are made narrow so it is easy to do this. o Don't double-dig unless you are applying compost or manure. o Don't mix the topsoil and subsoil. o Don't double-dig on steep hills or sloping land without using conservation measures.

Composting



Composting means piling up crop and other farm wastes in layers to make them decompose quickly.

Composting is done to produce an organic fertilizer that is balanced in plant nutrients. This organic fertilizer, known as humus, improves soil fertility, moisture retention and soil aeration.

Location

Compost can be used in all soils with low fertility. It is especially good in areas that have low rainfall, where artificial fertilizers cannot be used effectively because of lack of moisture. It is also useful in sandy soils which have poor water-holding capacity. Compost improves the structure and drainage of all soils.

Advantages

- Large amounts of vegetation, such as crop remains, garden weeds, kitchen and household wastes, hedge cuttings, garbage, etc, are put to use.
- When properly made, compost becomes immediately available as plant food without the need to be first broken down by soil microorganisms.
- Compost does not cause excessive weed growth, as is the case with ordinary farm manure.
- Good crops can be obtained without the need for extra chemical inputs.
- All farmers, regardless of their financial abilities, can make and use compost.

Disadvantages

- Compost requires a lot of labour to prepare and spread it over the farm.
- The nutrient composition of the compost varies a great deal. It depends on the materials used and the preparation methods (see *Using organic matter*).
- Not enough vegetation to make compost may be available in drier areas.

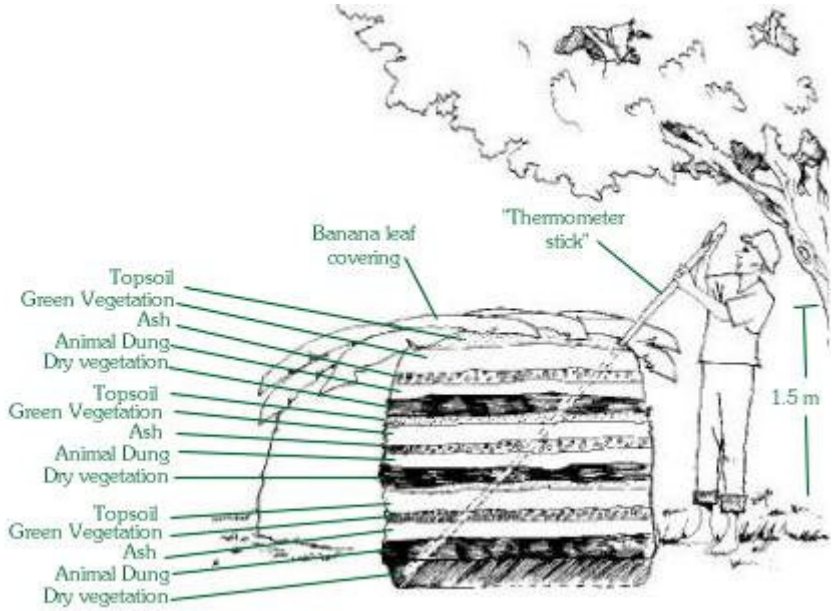
Requirements

- Various types of vegetative materials.
- Topsoil.
- Animal manure or biogas slurry.
- Wood ash.
- Water.
- A long, sharp, pointed stick.
- Wheelbarrow, watering can, hoe, machete.

Pile method

This method is suitable for areas with higher rainfall. For low-rainfall areas, use the pit method (described later in this section).

1. Select a location close to where you want to use the compost. The place should be sheltered from the wind, rain, sun and runoff. A compost pile must not get either very dry or very wet.
2. Measure a rectangle 120 cm (4 feet) wide and 150 cm (5 feet) or more long (the length depends on how much composting material you have). Do not make the rectangle wider than 120 cm, as you must be able to work on the compost without stepping on it. In rainy places, it is best to make compost in a pile above the ground. In drier areas, use the pit method described later in this section.
3. Dig a shallow pit about 30 cm (1 foot) deep. Put the soil on one side (you will need it later).
4. Begin building a compost pile by putting a bottom layer of rough materials such as maize stalks and hedge cuttings in the pit. This layer should be about 30 cm thick. Chop up any materials which are too long to improve the air circulation in the pile. Sprinkle some water on this layer.
5. Add a second layer of dry vegetation, hedge cuttings or grass. This layer should be about 15 cm (6 inches) thick. Sprinkle water on this layer, too. You should sprinkle water on each layer as you add it. The pile should be moist throughout.
6. Put on a third layer of animal manure or biogas slurry. The manure contains micro-organisms which are vital for decomposition.
7. Sprinkle some ash or dust on this layer. The ashes contain valuable mineral including potassium, phosphorus, calcium and magnesium. The ashes also neutralize the acids produced during decomposition, especially by the animal manure.
8. The next layer should be of green materials about 15-20 cm (6-8 inches) thick. Use green leaves from high-protein leguminous trees like calliandra, leucaena and sesbania. You can also use hedge cuttings of plants like tithonia.
9. Sprinkle on a little topsoil or old compost. The topsoil contains bacteria which are



useful in the decomposition process.

10. Add more layers in turn, starting with dry vegetative materials, then animal manure or biogas slurry, followed by wood ash, green vegetation and topsoil. Remember to sprinkle water on every layer. Build the pile up to 1.5 m (5 feet) high. A well-made pile has almost vertical sides and a flat top.

11. To complete the pile, cover it all over with a layer of topsoil about 10 cm (4 inches) thick. This layer prevents plant nutrients from escaping from the compost pile. Lastly, cover the whole with dry vegetation such as banana leaves to reduce moisture loss through evaporation.

12. Take a long, sharp, pointed stick and drive it in at an angle so that it passes through the pile from top to bottom. This stick will act as your "thermometer". After three days, decomposition will have started in the pile, and the stick will be warm when you pull it out.

13. Pull the "thermometer" out from time to time to check the progress of the pile. You can also tell from the thermometer how dry or wet the pile is: it should be moist but not wet.

14. Sprinkle water on the pile occasionally (about every 3 days, depending on the weather). If it has been raining, you may not need to water the pile.

Turn the pile after 2 weeks

15. After 2-3 weeks, turn the pile over. Do not add any fresh materials except water. You must turn the pile if the "thermometer" is cold when you pull it out, or if it has a white substance on it, as this shows that decomposition has stopped. Turning the pile is important because it mixes the different layers, making the decomposition faster and more complete.

16. The compost should be ready after 4 weeks. Check the temperature of the pile to make sure. If the stick feels warm when you pull it out, the pile is still decomposing and the compost is not ready. Finished compost should have a fresh, earthy smell and contain no grass, leaves, or animal manure.

17. You can store compost by covering it with a layer of banana leaves or polythene.

Do's	**Don'ts**
o Choose a sheltered site for the compost pile. o Chop up long stems and big leaves. o Sprinkle some water on every layer, and ensure that the compost is moist all the time. o Turn the pile every 3 weeks. o Protect the finished compost from sun, wind and rain.	o Don't use materials that might contaminate the soil. o Don't step on the pile. o Don't use waxy leaves (such as eucalyptus leaves). o Don't over-water the compost pile. o Don't compact the layers. o Don't use materials that do not decompose.

Pit method

The pit method of making compost conserves moisture, so it is useful in areas with low rainfall and a long dry season. Do not use it in wet areas, as the compost may become waterlogged.

1. Dig a pit 1.2 m (4 feet) wide and 0.6 m (2 feet) deep, and as long as you need for the amount of materials you have.

2. Build a pile in the pit, using the same method as in the pile method (see above).

3. Add water if necessary.

4. Push long poles into the pile to allow air to get into the layers beneath.

5. Turn the pile every 2 weeks.

You can produce a regular supply of compost by digging three pits side by side. Every 2 weeks, turn the compost from one pit into the next one, and start a new compost pile with fresh vegetation in the empty pit.

Using compost

Well-decomposed compost should be applied at the rate of 20 t/ha (8 t/acre): about two large hoefuls per square meter, or enough to barely cover the ground with a layer 1 cm (0.4 inch) thick. For potatoes, use 1 tin (about 20 kg) for about 2 m (6 feet) of furrow. In double-dug beds (see the section on *Deep soil preparation*), apply 3 wheelbarrows of compost on 10 m^2 (100 square feet) of beds.

Mulching

Mulch is dry, vegetative material used to cover the soil. It helps reduce evaporation and retain moisture, reduce soil erosion, and provide plant nutrients as the material decomposes.

Location

Mulch can be used in fields before and after planting, as well as around young crop plants. It is especially useful for high-valuable vegetable crops, and for for growing crops in dry areas, during dry-season cropping, and in places where the soil is easily eroded by heavy rains.

Advantages

- Mulch keeps the soil underneath moist longer than bare soil.
- It controls soil erosion by cushioning the impact of raindrops and by slowing runoff.
- It suppresses weeds by shading them out.
- It leads to healthy crop growth.

Disadvantages

- Mulching is labour-intensive.
- It can introduce new pests and diseases into a field.
- Dead plants for use as mulch may not be available.

Requirements

- Dry plant materials you can find nearby, such as grass, maize or sorghum stalks, maize husks, wheat straw.

Procedure

1. Carry to the field the material you want to spread as mulch.

2. Spread it on the soil using your hands or a rake. Put a layer of mulch 7-15 cm (3-6 inches) deep all over the bed, or around the growing plants. Do not put on so much mulch that you bury the plants or shade them out.

Do's	**Dont's**
o Use dry plant material that does not rot quickly.	o Don't use wet or green material as mulch.

Green manuring

Green manures are fast-growing plants (legumes and non-legumes) planted on a piece of land to improve soil fertility and protect the soil from erosion. They are normally low, spreading plants that grow fast and cover the soil surface quickly after planting. During or after the growing season, the green-manure plants are slashed and incorporated into the soil, where they decompose, releasing nutrients and improving the soil structure.

Green manures conserve and improve the soil in several ways:

- Legumes such as soybeans, green gram, groundnuts and pigeonpeas take nitrogen from the air and fix it in a form they can use. This nitrogen-fixing is done by tiny micro-organisms called bacteria living in the lumps (called nodules) on the roots of the legumes. The roots of other plants (such as maize) growing close by can also absorb some of the nitrogen. When the legume dies and rots, the nitrogen in its leaves, stem and roots is released into the soil, where other plants can absorb it. The rotting plants also increase the amount of organic matter in the soil.
- Green-manure crops prevent the soil from being washed away by rainwater. If a raindrop hits bare soil, the splash dislodges tiny soil particles, which can be washed away easily. The impact of the raindrop also compacts the surface, making it harder for the rainwater to seep into the soil. Instead of seeping in, the water runs off the surface, carrying with it the dislodged particles. On even gentle slopes, this can cause gullying. The green manure acts as a cover crop: it breaks the fall of raindrops, so

preventing compaction and helping the water seep in rather than running off. Its roots bind the soil and stop running water from eroding it.

Examples of green-manure crops

Food legumes	**Fodder legumes**	**Others**
Bambara groundnut (*Voandzeia subterranea*)	Clover (*Trifolium* sp.)	Pumpkins (*Cucurbita* sp.)
Chickpea (*Cicer arietinum*)	Lablab bean (*Dolichos lablab*)	Sweet potato (*Ipomoea batatas*)
Cowpea (*Vigna sinensis*)	Lucerne (alfalfa, *Medicago sativa*)	Kikuyu grass (*Pennisetum clandestinum*)
Green gram (*Phaseolus aureus*)	Lupin (*Lupinus* sp.)	
Groundnut (*Arachis hypogaea*)	Seratro	
Lablab bean (*Dolichos lablab*)	Stylo (*Stylothanses* sp.)	
Pigeonpea (*Cajanus cajan*)	Sunn hemp (*Crotalaria juncea*) (fibre)	
	Velvetbean (*Mucuna deeringiana*)	
	Vetch (*Vicia* sp.)	

- The green-manure crop protects the soil from the direct heat of the sun, helping it retain moisture. It breaks the wind and stops soil particles from being blown away.

The green-manure crop can be grown as a pure stand, so it enriches the soil for a cereal crop grown in the next season. It can also be grown as an intercrop between rows of another main crop, such as maize, sorghum and millet, or beneath fruit trees.

Location

Green manuring can be used in various types of soils. It is especially appropriate for infertile soils and areas with low rainfall, where artificial fertilizer cannot be used effectively because of the lack of moisture. It is useful on sandy soils, as deep-rooted legumes help recycle nutrients. It also helps improve the structure of heavy soils. It can help control erosion in hilly areas or places with strong winds.

Green manuring in Rachuonyo District, Kenya

In 1994, the NGO Community Mobilization Against Desertification (C-MAD) and Loyce Tula, a farmer in Rachuonyo District in western Kenya, decided to test green manuring on Loyce's farm. That year, Loyce used compost to fertilize her fields, but harvested a somewhat disappointing yield of only 2.5 sacks of maize from a plot measuring 16 x 30 m (a yield of 4.5t/ha).

In 1995, Loyce inter-cropped her maize with double rows of beans. The plot yielded 4.5 sacks (8.4 t/ha) of maize, and 2 sacks (3.7 t/ha) of beans. The following year, she planted a pure stand of maize, and harvested 5 sacks (9 t/ha). That year, C-MAD arranged a field day on Loyce's farm so her neighbours could see the yield for themselves. They were impressed, and all farmers in the village now intercrop legumes with their maize, sorghum and millet. They have also started planting stylo in cassava fields to control weeds, improve soil fertility and produce fodder.

Local farmers also are intercropping legumes with Napier grass to control striga weeds. A mixture of Napier with stylo, lablab bean, velvetbean or seratro makes good fodder. They do not use sunn hemp as a fodder intercrop as it does not make good forage. —*For more information, contact Community Mobilization Against Desertification, Kenya.*

Advantages

- Some types of green manure provide food or fodder as well as conserving and improving the soil.
- Lupin (a fodder legume) is good at recycling phosphorus as well as nitrogen.
- Green manures suppress weeds by shading them out. Some legumes reduce the number of striga weeds in the field. Sunn hemp is especially good at this.
- Relatively little labour is needed, compared to other ways of adding organic matter.
- Green manures are cheap to plant and easy to manage.
- Seeds of green-manure crops are easily available.

Disadvantages

- The benefits of green manures may be long-term rather than immediate.
- It can be difficult to incorporate green manures into an existing cropping system.
- Some green-manure crops such as velvetbean and lablab bean may compete with the main crop for light and nutrients. It is important to select green manures carefully so they do not interfere with the main crop.
- Some green manures may attract new pests and diseases which attack the crops.
- Some green-manure crops may become weeds by seeding and growing in the crop field in the next season.
- Green manures may not be successful in the dry season, especially in drier areas.

- If a green-manure legume has not been grown in the field before, the soil may not contain the bacteria it needs to fix nitrogen (see the section on *Inoculating legume seeds*).

Requirements

- Green-manure crop seeds.
- Inoculant (for some types of legumes).
- Hoe.
- Sand (for small seeds).

Planting as a pure stand

If you are planting the green manure as a pure stand, follow the steps below:

1. Prepare a seedbed by digging the soil and removing the weeds.

2. Water the seedbed, and plant the seeds or cuttings of the green-manure crop. Space the plants closely so they cover the ground quickly when they start growing.

3. If necessary, weed the plot regularly to reduce weeds and pests.

4. While it grows and flowers, a green-manure legume fixes nitrogen in the nodules onits roots. After flowering, the legume leaves fall off, increasing the amount of organic matter in the soil. With sunn hemp, turn the legume into the soil just after it has flowered.

5. Cut the leaves and stems for fodder if necessary, but do not remove the entire plant or expose the soil surface.

6. Harvest the green-manure crop (eg, the pods).

7. Slash the remaining stalks and leaves and, if possible on the same day, turn them into the soil. You can leave fodder legumes, such as velvetbean and lablab bean, to grow for up to 2 years before slashing them.

8. Leave at least 7 days before planting the next crop to allow the stalks and leaves to decompose.

9. Plant the next crop as a pure stand of cereal, or intercrop again with legumes.

Do's

- Choose the right type of green manure for your needs.
- Make sure the planting materials do not contain seeds of weeds.
- If legume seeds are hard to find, grow a small plot to produce your own.
- Use normal spacing for the cereal even if you are intercropping it with a legume.

- Mix small legume seeds, such as sunn hemp and stylo, with about the same amount of sand before broadcasting the seeds. This helps give an even stand of the legume in the field.
- Use inoculant with soybean seeds to ensure they form large numbers of nodules. Use inoculant with other legumes species if possible (each species of legume needs a different type of inoculant, so make sure you get the right one). See the section on *Inoculating legume seeds* for details.
- Weed the green-manure crop.
- Reduce the canopy (for example to prevent an intercropped green manure from interfering with the main crop) by harvesting the crop for fodder.

Don'ts

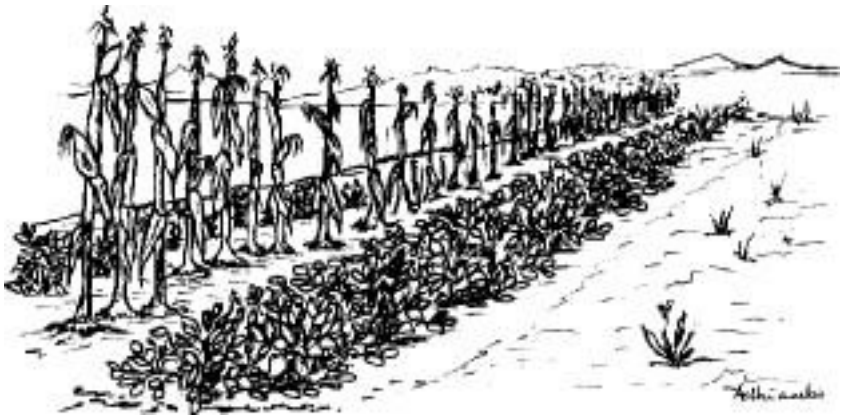
- Don't plant if the soil is so dry or so wet that the crop will not germinate.
- Don't allow livestock to graze directly on the green manure. Instead, cut the green-manure crop and carry it to the animals.
- Don't harvest large amounts of the legumes as vegetables or fodder.

Planting green manures as an intercrop

You can also plant a green-manure legume as an intercrop between the rows of the main crop. Choose the type of green manure and planting times carefully so it will not grow taller than the main crop and shade it out.

1. Choose a legume species that grows well in your area, and obtain enough seed.

2. For most legume species, plant at the same time as the cereal crop, so the crops can germinate before the heavy rains. Broadcast small-seeded legumes, such as sunn hemp, stylo, red gram and seratro. Plant larger seeds



For legumes such as cowpea that form vines, plant one row of the legume between the rows of cereal.

in rows between the rows of cereal. Plant velvetbean and lablab bean about 2 weeks after the cereal, as they grow fast and would shade out the cereal if planted earlier.

For smaller legumes such as gram, plant two rows of the legume between the rows of the cereal.

3. Continue with steps 3-9 above.

Inoculating legume seeds

Legume inoculation means mixing legume seeds (soybeans, green gram, etc) with a powder containing a special type of bacteria. This is done before planting the seeds, to make nodules form on the roots of the legumes.

The inoculant increases the amount of nitrogen fixed by the legume. This increases the yield of the legume and other crops intercropped with it, or crops grown in the same field afterwards.

The bacteria in the lumps (or "nodules") on the roots of legumes naturally fix nitrogen in a form that plants can use (see the section on *Green manuring*). These bacteria normally live in the soil, waiting for a legume to grow near them before they can start their nitrogen-fixing work. But if there are not enough bacteria in the soil, very little nitrogen can get fixed by the legumes growing there. The nodules stay small, and so does the legume plant.

Mixing bacteria inoculant powder with the legume seeds before planting them makes sure there will be enough bacteria to produce a lot of large nodules. This will help produce healthy, vigorous legume plants, and will mean a lot of nitrogen is fixed in the soil for another crop to use.

Location

Inoculants are useful for all types of soils. They should be used in fields where the legume has not been grown before, since there may be very few of the right kind of bacteria in the soil there. They should be used especially with soybeans and for green manures: in many situations, velvetbeans and sunn hemp will not fix nitrogen unless they are inoculated.

Advantages

- Inoculating legume seeds raises the yield of the legume and the fertility of the soil in which it grows.

Disadvantages

- Inoculants can be expensive and hard to obtain.
- Each species of legume needs a different type of inoculant.

Requirements

- Legume seeds.
- Inoculant (of the right type for the legume species).
- A bowl and a little water.
- For silver-leaf desmodium (a type of fodder legume), you also need a little sugar to mix with the inoculant.

Procedure

1. Obtain the right type of inoculant for the legume you want to plant. You can get inoculant from seed companies, universities and government research institutes.

2. On the day you want to plant the legume, put the legume seed into a bowl **(Picture 1)**.

3. Sprinkle the inoculant over the seed. You need only a small amount of inoculant: about 5 g (1 teaspoonful) for every 100 g of seed. See the instructions on the packet for how much inoculant to use **(Picture 2)**.

4. Sprinkle a little water over the seeds, enough to make the powder stick to the seeds, but not enough to make them wet **(Picture 3)**.

5. Carefully mix the powder with the seeds until all the seeds are evenly covered **(Picture 4)**.

6. Plant the legume seed on the same day by broadcasting or dibbling it in rows **(Picture 5)**.

Using soil as inoculant

Since the nitrogen-fixing bacteria live in the soil, you can use soil instead of inoculant.

1. Find a field where the same legume as you want to plant is growing and where the plants are flowering. Make sure the plants are healthy.

2. Pull up several plants from different places in the field, and break open the nodules on the roots with your fingers. If the nodules are pink inside, there are bacteria inside them that are fixing nitrogen. If there no nodules on the roots, or the nodules are not pink inside, there are no nitrogen-fixing bacteria, and you need to find another legume field.

3. Take a small amount of soil from this field (about the same amount as the seed you want to plant).

4. Mix this soil with your seeds before planting them.

You may be able to get soil from neighbours who have inoculated their legume seeds in a previous season.

Do's	**Don'ts**
o Before you go to the expense of buying inoculant for a large amount of seed, obtain a small amount to test. Plant a plot of treated legume seeds next to another plot of untreated seeds. Measure the amount yielded by each plot. You will then be able to tell whether the inoculant has improved the yield, and you can use inoculant for a larger area in the next season. o Make sure you get the right inoculant for your legume species. If you are not sure, ask an experienced farmer or an extension worker. You can also ask to your neighbours if they have had experience with inoculant. o Follow the instructions on the inoculant package carefully. o Before using it, keep the inoculant in a cool, dark, dry place, away from children. o Wash your hands after handling the inoculant, as it is poisonous.	o Don't use too much water to moisten the seeds. o Don't use inoculant with crops that are not legumes (such as maize or other cereals), as it will not work. o You do not need to use inoculant year after year for the same legume crop in the same field. Once you have grown this crop in a field, the soil will contain the bacteria, so it is not necessary to inoculate the seeds again.

Cattle-manure ash

Cattle-manure ash is an indigenous technology used in vegetable gardens to enhance the availability of plant nutrients. Cattle manure is either burnt directly on beds (with heavy clay soil types) or elsewhere if the soils are sandy or loamy.

The ash also improves soil pH and the soil's ability to hold moisture. It repels pests found in the soil, and lowers the cost of weeding by destroying weed seeds. It is used for vegetables in both nurseries and the main beds.

Advantages

- Uniform, rapid germination of vegetable seeds due to improved soil moisture management and enhanced release of nutrients (the effect can last for a season). This in turn helps farmers establish their vegetable gardens quickly, leading to quicker cash returns.
- Improved soil moisture retention. The ash reduces waterlogging and helps conserve soil moisture by acting as a mulch.
- Control of pests of both leaf and root crops, such as nematodes.
- Weed control: weed seeds in the manure are killed by burning.
- Cattle manure is readily available and light, so transport is not a problem.
- Vegetables grown with cattle-ash manure taste sweeter than ones where chemical fertilizer has been used.

Requirements

- Hoe.
- An adequate amount of dry, loose cattle manure, at least 1 month old. The manure must not go through a rainy season as it tends to harden, making it difficult to burn.

Cattle-manure ash in Zambia

Farmers in the Livingstone Food Security Project, Zambia, depend on vegetable gardening for most of their livelihoods. Returns of over 1,000,000 kwacha (US$ 700) have been realized by households within a period of 3 months. However, chemical fertilizer and irrigation costs account for 45% of the total production cost.

The use of cattle-manure ash has reduced these fertilizer and irrigation costs by as much as 50%. These savings are because cattle-manure ash releases nutrients quickly (enabling vegetables to mature fast), helps control pests and weeds, and improves soil moisture management. — *For more information, contact Robby Mwiinga, CARE-Zambia.*

Procedure

1. If your soil is a heavy clay, pile the manure in heaps in the seedling bed or main beds: about 5-10 kg of manure per square metre. Set fire to the manure in the evening, and leave it to burn overnight.

On sandy and loamy soils, burn the manure on a separate piece of land, then carry the ash to the vegetable beds.

2. In the morning, spread the ash evenly and incorporate it into the soil using a hoe. Keep the ash close to the surface—less than 5 cm (2 inches) deep. Leave some on top, so that when you water the beds, a crust of ash forms to help retain soil moisture.

3. Lightly water the bed.

4. Plant vegetable seeds either in lines or by broadcasting.

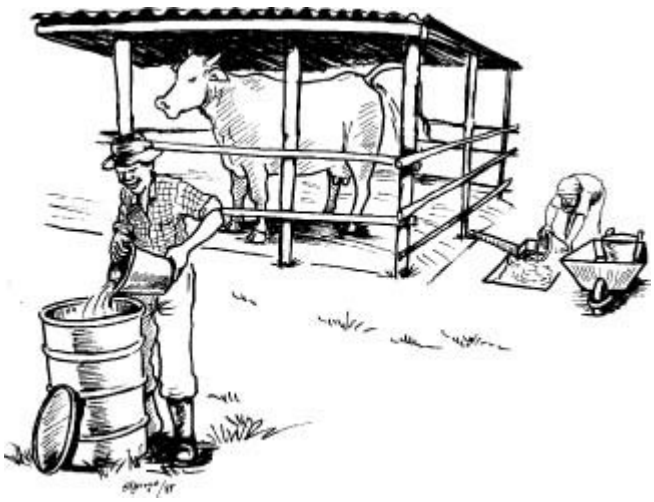
5. To kill aphids, sprinkle ash on the leaves of already established vegetables.

Alternative method: burn the manure somewhere else, then put the ash in small planting holes after mixing with the soil.

Do's	**Don'ts**
o Ensure that the ash is on the surface and within the top 5 cm of soil. This maximizes the availability of nutrients in the root zone of vegetables, and conserves soil moisture. o On heavy clays, leave the burnt areas fallow for one season in every three.	o Don't use cattle manure which has been exposed to a rainy season. o Don't burn during the day because the ash may be blown away by wind (it is usually less windy at night). o Don't burn the manure on sandy or loamy soils. This tends to destroy the soil's ability to hold water. Instead, burn the manure somewhere else, then carry the ash to the vegetable garden. o Don't burn cattle manure on the same piece of land too often, as this may damage the topsoil.

Urine-manure slurry as fertilizer

A slurry (a thick, liquid mixture) of animal manure and urine from a livestock shed makes good organic fertilizer, as it is rich in nitrogen and organic matter. The slurry must be kept for some time before it can be used to fertilize crops.



Location

Urine-manure slurry is useful in areas where livestock are kept in sheds in a zero-grazing system, where the manure and urine can be collected easily (see the section on *Zero grazing*).

Advantages

- The slurry is ready for use as manure after a short time.
- It makes an ideal fertilizer for leafy vegetables and other crops.
- It makes use of manure, which might otherwise be seen as a waste product.

Disadvantages

- If fresh slurry is used, it can scorch or burn the crop leaves.
- It is costly to build a concrete floor and slurry pit.

Requirements

- Animal shed with concrete floor and drainage channel running to a pit.
- Drum or pit to store slurry.
- Bucket, broom, shovel.

Procedure

1. Build an animal shed with a slanting roof, so rainwater runs off outside (see the diagram in the section on *Zero-grazing*). The floor must be made of concrete and have a drainage channel sloping towards a lined manure pit outside the shed.

2. Wash and sweep the manure and urine into the pit every day.

3. When the pit is full, transfer the urine-manure slurry into another pit or drum, and keep it covered for 2 weeks.

4. After 2 weeks, dilute the slurry with twice the amount of water.

5. Pour the mixture around the roots of crops. Do this every 2 weeks during the growing season.

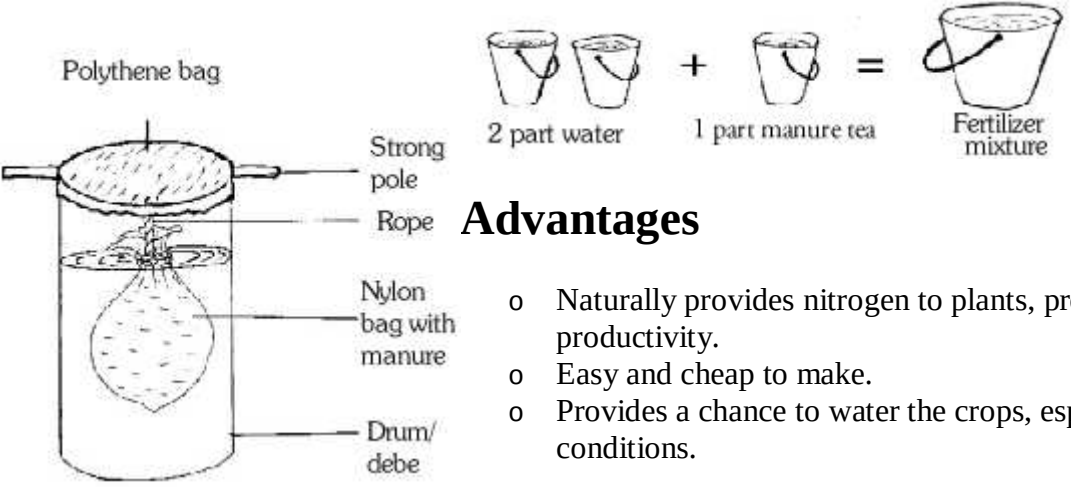
Using fresh slurry

Instead of storing the slurry for 2 weeks, you can use it fresh. Dig a furrow alongside the row of crops and pour the fresh slurry into it. Cover it with soil to prevent the nitrogen from escaping into the air. Take care not to allow the fresh slurry to touch the plants directly.

Do's	**Don'ts**
o Cover the pit and storage drum to stop the nitrogen in the slurry from escaping into the air. o Allow the slurry to mature for 2 weeks before using it (or see the note on *Using fresh slurry* above).	o Don't handle donkey manure, as it contains the germs that cause tetanus. o Don't use fresh urine or put the slurry on the plants themselves, as it may scorch the leaves.

Manure tea

Liquid manure, or "manure tea", is a source of natural plant food which can quickly provide crops with nutrients during the growing season. When applied properly, liquid manure is a very effective natural fertilizer that can be used for top-dressing. Manure tea promotes vegetative growth and fruiting by providing nitrogen to the crops. It is most commonly used on vegetables, but can also be used for maize and other grain crops. It is safe to handle and will cause no harm to humans or animals.



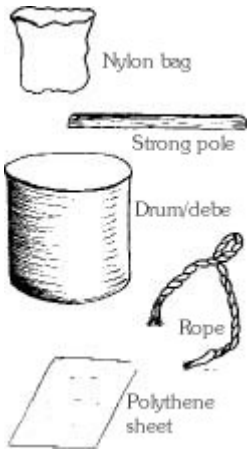
Advantages

- Naturally provides nitrogen to plants, promoting crop health and productivity.
- Easy and cheap to make.
- Provides a chance to water the crops, especially in dry weather conditions.

Disadvantages

- May be difficult to prepare and apply for large plots of land.
- Poorest farmers may not be able to afford containers.

Requirements



You can use fresh manure from cattle, chickens, goats, rabbits or sheep, or a mixture of any of these. The quality of the manure depends on how well the animals have been fed (see *Using organic matter*).

You will also need the following:

- Drum or *debe*, about 200 litres (40 gallons) capacity.
- Strong sack or gunny bag (a porous nylon bag is best).
- Strong pole.
- Rope.
- Small plastic (polythene) sheet to cover the drum.

Preparation

1. Place the manure in the sack: 50 kg of manure for each drum. Fill the bag so that you can tie the bag securely with the rope.

2. Fill the drum three-quarters full of water, and hang the bag in the water from a strong pole placed across the top of the drum.

3. Cover the drum to prevent nitrogen from escaping. Let it stand for 14–21 days.

4. Stir the mixture in the drum every 3–5 days by partially lifting the bag in and out of the water several times using the pole.

5. After 2–3 weeks the water will have turned dark, and most of the nutrients will have been dissolved into the water. The darker the colour, the more concentrated is the mixture. It is then ready for use.

6. Remove the bag from the drum.

Application

1. Dilute the manure tea with 2 parts of water for every 1 part of tea. However, if the manure tea is very dark, use 3 parts of water for every 1 part of tea.

2. Water the crop using the mixture, giving between 250 ml to 500 ml (half to 1 pint) per plant. Apply the liquid around the stem, not on the leaves, 2–3 times a week for 3–4 weeks.

Any plant showing nitrogen deficiency (ie, drooping or stunted plants, yellowish leaves, or plants with poorly formed leaves) will benefit from the manure tea. Leguminous plants, tubers, bulb and root crops do not normally require any such top-dressing.

Do's	**Don'ts**
o Use the liquid manure when the crop requires a top-dressing, especially if the plants show nitrogen deficiency.	o Don't splash the liquid manure on the plant leaves. ¡ Don't use undiluted liquid manure.

Manure tea from tithonia or comfrey

False sunflower (*Tithonia diversifolia*) is a volunteer species that grows almost everywhere—along roadsides and riverbanks, in marginal lands, or even in gardens (see also the section on *Using organic matter*). It is a tall plant with several stems from the base to the crown. In fertile soil it can grow to a height of 4 m (13 feet).

Tithonia

Tea made from this plant has proven a good top-dressing that improves the quality of home-grown vegetables, especially cabbages and kale (*Brassica* species), and tomato, capsicum and eggplant (Solonaceae family).

The entire tithonia plant is used to make the tea. The health and growth stage of the plant affects the quality of the tea. The best stage is when the plant is dark green and 60-120 cm (2-4 feet) in height. If the plant is already flowering it is not good to use because most of the nitrogen previously available in the plant has been used to make flowers and seeds.

Russian comfrey

Make the tea following the same steps as described above, except instead of using animal manure, cut the tithonia into pieces and use it to fill the sack.

You can also use leaves of Russian comfrey (*Symphytum officinale*) instead of tithonia to make the tea. Other plants with fleshy stems and leaves can also be used to make

Cropping systems

Multiple cropping

Multiple cropping is the practice of planting several different crops on the same plot of land at the same time. It is common among small-scale farmers in Africa. Crops, livestock and trees can all be integrated into a small farm, making it much more productive. Such integrated farming is particularly relevant for small farms or fields.

The integration of many farm enterprises gives farm families several advantages. More crops can be planted in a small space. For example, intercropping and relay cropping can allow a farmer to plant two crops—maize and beans, for example—in the field at the same time. The production of crops is

usually spread over a longer period of the year, allowing for better vegetative cover to protect the soil, but also spreading out the harvest throughout the year.

The appropriate crops, crop combinations, planting times and planting patterns will vary from place to place, depending on the local climate, soils, topography, water availability, pests and diseases, socio-economic conditions, and other factors.

Advantages

- Multiple cropping reduces the risk of total loss from drought, pests and diseases. Usually at least some of the crops can escape disaster and produce a yield.
- It optimizes production from small plots, so can help farmers cope with land shortages.
- Including legumes in the cropping pattern helps maintain soil fertility by fixing nitrogen in the soil.
- Multiple cropping yields different types of produce, resulting in a balanced diet for the family.
- It suppresses weeds. As the planting density is high, weeds cannot compete with the crops.
- Different types of crops can be planted to take advantage of different seasons. For example, crops that require a lot of water can be grown in the wet season, intercropped with drought-resistant crops that can be harvested in the following dry season.

Disadvantages

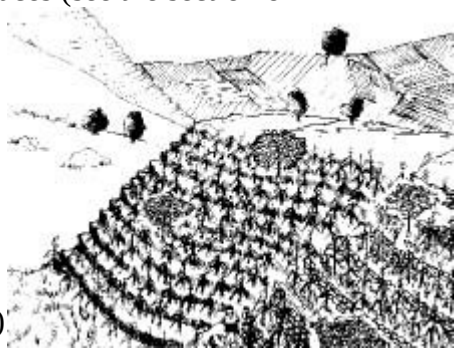
- The presence of crops in the field throughout the year allows crop pests to survive more easily. Some pests can shift from one crop to another: for example, aphids can move to cotton plants during the dry season.
- The large number of different crops in the field makes it difficult to weed.
- It may be difficult to introduce new technologies such as row planting, modern weeding tools, and improved varieties.

Multiple cropping in Konso, Ethiopia

Konso district in southern Ethiopia suffers from erratic rainfall and repeated droughts. Farmers in mid-altitude areas (1500-1600 m above sea level) have developed many indigenous technologies to deal with this risk. On an average land holding of less than 1 ha, they typically grow a combination of five to twelve different crops:

- **Cereals:** sorghum, maize, wheat or barley.
- **Legumes:** beans, pigeonpeas and cowpeas.
- **Root crops:** cassava, potatoes, *kolso* (a wild, bitter, survival food).
- **Trees for forage and construction:** *Terminalia* sp., or the horseradish tree (*Moringa oleifera*) for its edible leaves.
- **Cash crops:** coffee, cotton.

The Konso farmers grow these crops in shallow pits on stone terraces (see the section on *Conserving soil and water* for a description of these). They prepare the soil in January and early February, before the start of the long rainy season. Because of the hilly topography and the presence of perennial crops such as coffee and cotton, they prepare the land manually with hoes. The main crops are grown during the long rainy season (normally from early March to mid-May, though this varies from year to year). The short rainy season (late October to early December) is too brief and too light to support new crops, but can be used for ratooning (re-sprouting) of sorghum.



Words relating to multiple cropping

Agroforestry	Growing trees along with annual crops and livestock.
Alley cropping	Growing annual crops between rows of (often leguminous) trees or shrubs. Prunings from the trees or shrubs can be used as fertilizer, mulch or livestock fodder (see the section on *Contour tree-planting*).
Cropping pattern	The yearly sequence and spatial arrangement of crops, or of crops and fallow, on a given area.
Cropping system	The cropping patterns used on a farm and their interaction with farm resources, other farm enterprises and available technology which determine their make-up.
Farming system	All the elements of a farm which interact as a system, including people, crops, livestock, other vegetation, wildlife, the environment and the social, economic and ecological actions between them.
Intercropping	Planting two or more crops in the same field at the same time. Crops can be planted in rows (row intercropping), or the seed can be dibbled at random or broadcast (mixed intercropping). Planting in rows makes applying fertilizer, weeding and harvesting easier.
Monoculture	Growing the same crop year after year on the same piece of land.
Multiple cropping	Growing two or more crops in the same field in one year at the same time, or one after the other. Multiple cropping can be done with annual food crops, perennial crops (such as cotton), fodder crops, and tree crops.
Relay cropping	Growing two or more crops in a field with their growing seasons overlapping: eg, planting a second crop in the field where another is already growing. After the harvest of the first crop, the second (often drought-resistant) crop continues to grow, and is harvested later.
Rotation	Changing the crops grown on a particular piece of land from season to season (or changing from crops to fallow).
Sequential cropping	Growing two or more crops in sequence in the same field in the same year. The second crop is planted after the first one is harvested.
Sole cropping	One crop variety grown alone in a pure stand.
Strip cropping	Planting of alternate strips of grasses or grains with other crops along the contour in order to conserve moisture and decrease erosion.

he Machobane farming system in Lesotho

The Machobane farming system is an intensive cropping system, using crop rotation, relay cropping, and intercropping practices. It was developed by James Machobane during the 1950s. Although he had no formal agricultural training, Mr Machobane developed a very complex, integrated farming system designed to improve the productivity of small-scale farmers in Lesotho. The Rural Self-help Development Association, a local NGO, is promoting the Machobane system (see Credit for farm activities).

Key features of the Machobane system

The Machobane system includes at least seven basic crops commonly grown in Lesotho: maize, potatoes, sorghum, wheat, peas, beans and curcubits (pumpkins and melons). These crops are relay-intercropped in a 1-acre (0.4 ha) plot. The cropping pattern allows food crops to be produced almost all the year round. It reduces the likelihood of total crop failure because of pests or bad weather. The Machobane farming system takes these basic principles into account:

- The use of organic fertilizers.
- Perennial vegetation cover.
- Cropping pattern adequate to the varying climate.
- Natural pest control.
- Relay harvesting allowing for almost year-round harvest.

Although the specifics of this farming system may be appropriate only in the temperate climate of Lesotho, many of the principles outlined here are also applicable to smallholder farming areas in tropical Africa.

Use of organic fertilizers

Many farmers in Lesotho have aimed to maximize their profits by using inorganic fertilizers. However, this can result in short and long-term environmental degradation. Inorganic fertilizers can disrupt the natural plant growth and development and reduce the natural protection mechanisms against pests and diseases.

Use of organic fertilizers in the Machobane system

Soil type	Animal manure	Wood ash
Heavy soils	40	80
Light sandy soils	60	60
Coarse sandy soils	80	40

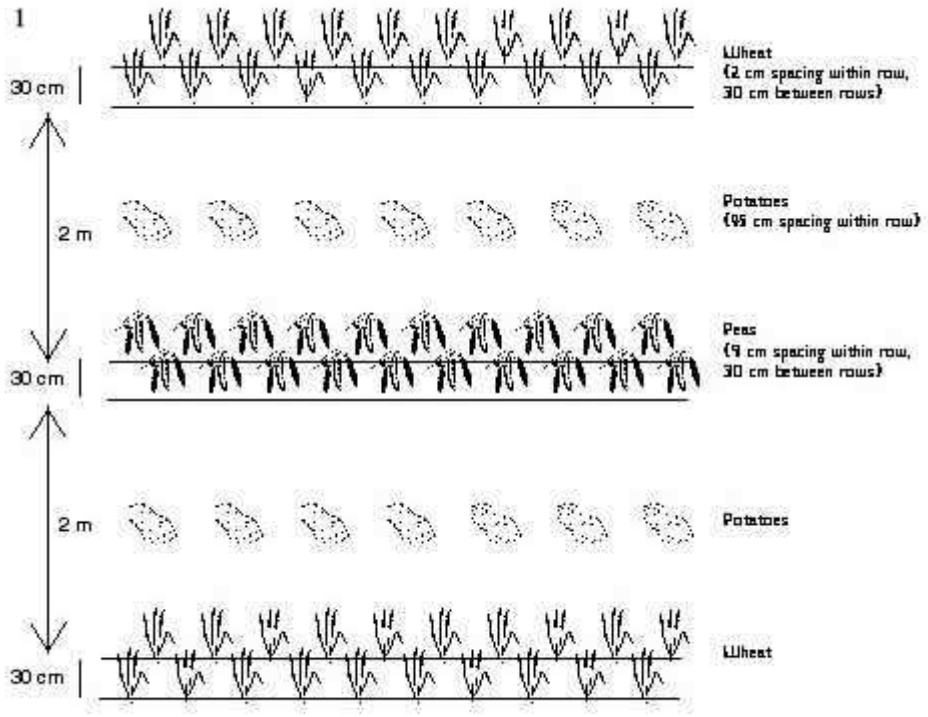
Figures are wheelbarrows per acre (1 acre = 0.4 hectare)

The Machobane system uses animal manure and wood ash as fertilizer. For the initial land preparation, approximately 300 wheelbarrowfuls are used per hectare (120 per acre; 1 wheelbarrow contains about 25 kg). Depending upon the type of soil, different mixtures of organic material are applied, as shown in the table on the previous page.

About the same amount of organic matter is applied to the field before each cropping season. By the fourth year, the fertility of the soil will have improved, and less organic fertilizer will be needed each cropping season.

Perennial vegetative cover

The Machobane system ensures complete crop cover throughout the year, because winter crops (eg, wheat and peas) are planted in April–May (for harvest in January–March), and summer crops (eg, maize, beans and sorghum) are planted in August–October (for harvest in November–December). Because the system uses minimum tillage (complete ploughing of the field is only done once every 5 years), soil movement is minimized. Crop residues are left in the field, allowing humus to build up. Because there are always crops in the field, grazing of livestock is not possible.



Cropping pattern in August. Wheat and peas are planted in April–May, and the potatoes are added in August.

Cropping pattern adapted to varying climate

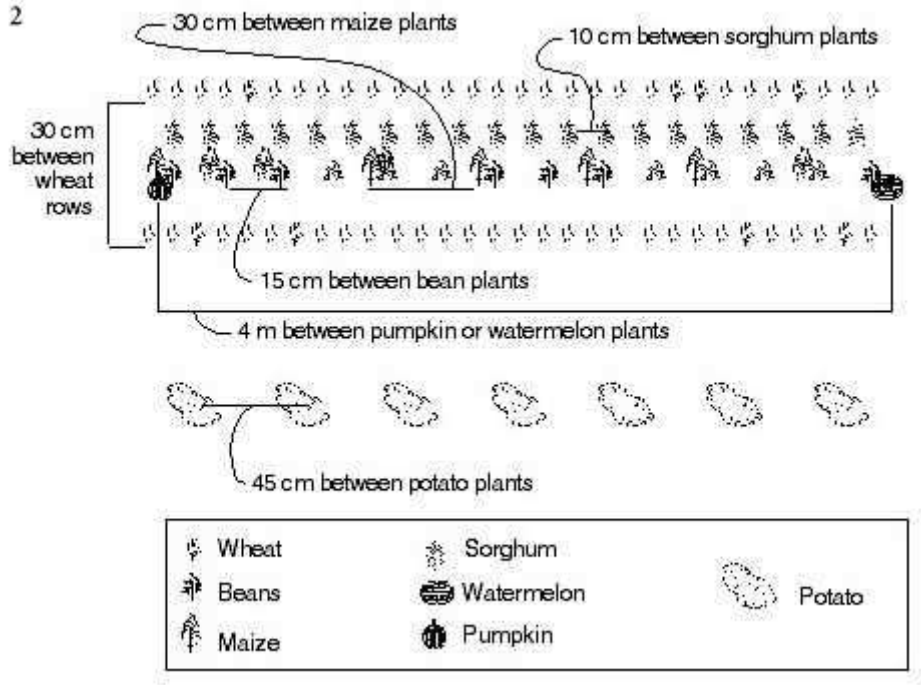
Lesotho's climate is temperate, with a warm summer and a cool winter. Late or early frosts, hail and seasonal drought are not uncommon. The Machobane system allows for the planting of cool-weather crops, such as peas, wheat and potatoes, which perform well in the winter conditions. In the summer months, maize, beans, pumpkins and other crops are intercropped. However, because Lesotho can experience drought in the summer, drought-resistant crops like sorghum (aptly known as the "camel of the plant kingdom") are also planted to reduce the risk of crop failure.

Seedbed preparation and planting

In the first planting season, the 0.4 ha (1 acre) field is ploughed. The plot is then harrowed or disked to prepare the soil completely. A spade or hoe can be used to make the furrows or rows where the seed is to be planted. In April, the winter crops (wheat and peas) are planted. A double row of wheat is planted, with 30 cm between the two rows. Then a gap of 2 m is left, and a double row of peas is planted, again with 30 cm between the rows. Then comes another

gap of 2 m, followed by a double row of wheat, a 2-m gap, another of peas, and so on **(Picture 1)**.

In August, the first batch of potatoes is planted in the 2-m gaps between the rows of



Cropping pattern in October. Maize, beans and sorghum are planted in between the maturing rows of wheat (or peas). Every 4 m, pumpkin or watermelon is planted.

Crop planting details

Crop	Distance between rows	Space between plants	Seed depth	Seeding rate per acre (0.4 ha)	Planting date
Wheat	30 cm between double lines	2 cm	25 cm	5 kg	April to May
Peas	30 cm between double lines	2-9 cm	25 cm	5 kg	April
Potatoes	2 m	45 cm	20-30 cm	300 kg	mid-July-Aug (1st batch) Nov-Dec (2nd batch)
Maize*	2 m	30 cm	25 cm	5 kg	October
Beans*	2 m	15 cm	25 cm	5 kg	October
Sorghum*	2 m	10 cm	25 cm	5 kg	October
Pumpkin*	2 m	4 m	25 cm	0.5 kg	October
Watermelon*	2 m	4 m	25 cm	0.5 kg	October
Vegetables (rape, cabbage, spinach)	Varies	Varies	Varies	Varies	December (after harvest of 1st batch of potatoes)

* Maize, beans, sorghum, pumpkin and watermelon are all grown simultaneously in the same row at different plant spacings (see Picture 2).

wheat and peas; only half of the field is planted at this time. Starting in November, the rest of the field is planted with a second batch of potatoes.

In October, the summer crops are planted in a complex intercropping pattern of maize, beans, sorghum, pumpkin and watermelon. In the 30-cm spaces between the double rows of wheat and peas, a single furrow is dug. Maize and beans are planted in this furrow, with 30 cm between the maize plants, and 15 cm between the beans.

Every 4 m, two pumpkin seeds are added to the maize and bean hill. In every other row, watermelon is planted rather than pumpkin. Finally, sorghum is sown along the entire furrow **(Picture 2).** After the first batch of potatoes are harvested in December, vegetables such as rape, cabbage, and spinach can be planted.

Crop management practices

Tillage

Number of seeds per hole for the

summer crops	
Maize	1 seed per hill
Beans	1 seed per hill
Pumpkin	1 seed per hill
Watermelon	1 seed per hill

Once the crops are in the field, minimum tillage is done using a spade or a hoe. A hand-pushed ripper **(Picture 3)** can also be used to open the furrow to plant the summer and winter crops. New crops can then be planted without harming the standing crops.

Weeding

Weeds in the field should be controlled as they can harbour insects and pests, and can also compete with plants for moisture, light and nutrients. The first weeding is done with a hoe immediately after crop emergence to break up and aerate the soil around the crops and to kill the weeds. The second weeding is done when the crops are about 1 month old.

Crop residues are left in the field, helping to improve soil fertility and hindering weed growth.

3

Hand-pushed ripper ussed for minimum-tillage cultivation

Earthing the potatoes

The first earthing is done when the potatoes are at their first stage of flowering. A very small quantity of soil is gathered around the plant at this time. The second earthing is done at the second budding: a little more soil is ridged around the plant. The third earthing is done at the third budding, and ridging is done to cover half the plant with soil. With the fourth earthing, two-thirds of the plant is covered with the soil.

Natural pest control

Natural pest control is encouraged in the system, while chemical pesticides are discouraged. Since some crops act as natural repellents to certain insects, the intercropping practice contributes to pest control. The deliberate crop rotation helps to break the life-cycle of insect pests. Regular weeding throughout the year helps to control pests and diseases. Also, some plants can create an unsuitable environment for insects; for example, the pumpkin plant has hair which is irritating. Pest-control home remedies may also be used.

Relay intercropping

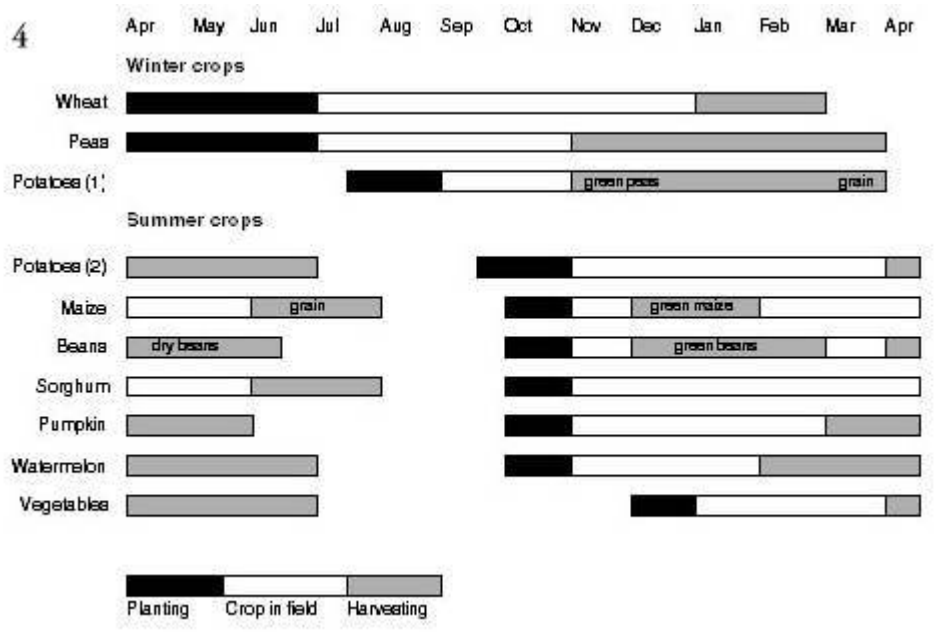
The relay intercropping practice offers many advantages. For example, because the crops are sown at different times there is little competition during the growing period. Time spent weeding one crop helps prepare the soil for the crop that will follow. Available land is maximized with the production of several species.

Relay harvesting

The relay intercropping system allows for staggered harvesting of crops throughout the year (Picture 4). The winter crop of peas can be harvested in November (as green peas) and in March (as grains). Wheat is harvested starting in January. The first batch of potatoes is harvested from late November to March; the second batch is harvested starting in April. The potatoes are harvested as soon as the leaves and stems have become dry.

Harvesting the large number of summer crops begins late in the year. Green maize can be harvested in December–January, and green beans in December–February. Watermelons can be harvested starting in February. From March to May, pumpkins should be harvested. Beans in grain form are harvested from April to the end of June; rape, cabbage, and spinach can be harvested during the same period. Grain or dry maize and sorghum are harvested in June–July.

No machinery is used for harvesting. Potatoes are harvested with a spade or a digging fork. All other crops are harvested by hand. —For more information, contact Tsepozi Mathamba, RSDA, Lesotho.



Crop calender for the Machobane farming system

Controlling crop pests and diseases

Methods of controlling pests and diseases in sustainable agriculture are sometimes very different from conventional measures. In many cases, our knowledge of natural pest control has been handed down in the form of old farming traditions whose value is no longer recognized. One of the aims of sustainable agriculture is to rediscover and further develop this knowledge and to give the farmers the opportunity to fall back on methods whose cost and ecological side-effects are minimal.

Sustainable agriculture aims to reduce the incidence of pests and diseases to such a degree that they do not seriously damage the farmer's crops—but without upsetting the balance of nature. Use cultural control methods to prevent pest and disease attack. If these do not work, there are several natural pesticides that can be used to control an outbreak.

Preventing pest and disease outbreaks

Plough after harvest

Many pests breed or develop in the residue of the previous crop. If you plough the stubble under after harvesting, you can control these pests.

Choose resistant varieties

Select crop varieties that are resistant to the main pests and diseases in your area. Scientists have developed high-yielding varieties that are resistant to important pests and diseases, though many local varieties are more resistant than modern varieties.

Plant several different crops and varieties

If you plant all one crop or variety, it may be completely wiped out by a pest attack. But if you have planted several crops, or several varieties of the same crop, chances are that at least some will survive an attack.

Rotate crops

If you plant the same crop on the same piece of land year after year, the pests, diseases and weeds that attack that crop may multiply. Instead, try to grow a different crop each season: for example, plant beans in a field where you planted maize the previous season. This will reduce the number of pests and diseases, since most do not attack different types of crops.

Use healthy seeds

Some diseases can be carried by the seeds. Choose seed only from healthy plants, or buy seed from a trusted source.

Plant at the right time

Often this means planting early, to avoid the time when there are most pests and diseases.

Minimize water stress

Water stress weakens a plant's ability to resist attacks by pests. Cultural methods that minimize loss of water from soil and the crop include establishing windbreaks, adding sufficient organic material to the soil, mulching (where practical and where this will not attract termites), and planting at the appropriate time. If possible, provide irrigation water, especially for high-value crops.

Maintain beneficial insects and insect-eating birds

Keep a variety of plants around the farm as habitat for insect-eating birds and beneficial insects (insects such as ladybirds and wasps that feed on pests like aphids and cabbage worms). Avoid using synthetic chemical pesticides, because these kill off these beneficial insects.

Plant trees or hedges as windbreaks

Apart from breaking the wind, trees and shrubs moderate the temperature, reduce evaporation, and provide a habitat and food for useful insects. Tall trees, such as *Grevillea robusta*, and trees of medium height, such as sesbania (*Sesbania sesban*) or leucaena (*Leucaena leucocephala*) provide good habitat and wind protection. Include plants such as tithonia (*Tithonia diversifolia*) in the hedge. It has not yet been scientifically proven that tithonia repels pests, but very clear positive effects have been observed. Tithonia can also be used as green manure and to produce liquid fertilizer (see the sections on *Using organic matter* and *Manure tea*).

Plant diversion crops

Such crops as sunflowers and finger millet, and also local plants which bloom and bear fruit, attract birds and insects. You can take advantage of this by growing such plants at the edge of your fields. These "diversion crops" attract the pests away from the main crop.

Plant insect-repellent crops

Plant flowers like marigold and certain kinds of vegetables which help to control pests in or around the main crop. This is sometimes called "companion planting". Plants with strong smells, such as French marigold and coriander, act as repellents and can protect the crops nearby.

Apply organic matter

The use of compost, mulch, and green manure crops can have a very positive effect against the development or pests and disease.

Controlling pest outbreaks

Sometimes an outbreak of a pest cannot be avoided. At these times the farmer may be forced to interfere in the natural cycle to prevent crops from being destroyed. This can be done in various ways.

Hand-picking

Large insects should be collected by hand. Of course, this is possible only if the number of pests is not yet too great, and they have not become too widespread on the crops. If the danger is recognized early enough, extensive pest damage can be avoided through simple hand-picking.

Synthetic pesticides

If hand-picking is not sufficient or practical, it becomes necessary to resort to some kind of chemical control—using botanical or synthetic pesticides. Many synthetic pesticides are very difficult for nature to break down and have negative side-effects on human health when improperly handled. Only in rare cases are they selective in their effects. They should only be used as a last resort when a pest outbreak threatens to wipe out a farmer's entire crop, or for selective spot-control of difficult pests or diseases, to keep them from spreading.

Botanical insect repellents

Among these are Mexican marigold (*Tagetes minuta*), chilli (*Capsicum annuum*) and *Ocimum suave*. Made into solutions that can be sprayed or watered with, these can prevent or reduce the attacks of various insects and diseases. Repellents also play an important role in storing crops after the harvest. Ashes, sawdust and the leaves or fruit of many different plants can be mixed with the produce (see the section below on neem) and protect it from disease and pests during storage.

Moderate killers

Pyrethrum and chinaberry (*Melia azederach*) are among the moderate killers, a group of botanical pesticides whose level of effectiveness is relatively low.

Preparing botanical pesticides

All of the pesticides mentioned below should always only be used alone and only when the plants show the symptoms of an attack. Do not use them as a preventive measure (the cultural control measures described above should be used for this).

Repellents

Fill 2/3 of a small container with the cut-up leaves and flowers of Mexican marigolds and *Ocimum suave*, or the fruit of chilli peppers. Then fill the rest of the container with clean water. Cover the mixture and let it stand for 5-7 days. Then filter the contents and add 30 g of soft soap for every 5 litres of water. Use diluted. For young plants, you can dilute one part of the solution with five parts of water. For older plants, dilute one part of solution with an equal amount of water.

Mexican marigolds generally work as a repellent for smaller insects and nematodes. Chillies offer

very effective protection from the common cutworm and larger insects. *Ocimum suave* can be used against all insects.

Pyrethrum

Boil two cups of pyrethrum flowers in 5 litres of water. Allow to cool, then filter the liquid and dilute it with twice to five times as much clean water. Add 30 g of soft soap in every 5 litres, then spray the liquid.

Tobacco

Boil a cup of cigarette butts (or 250 g of tobacco) in 4 litres of water. Allow the liquid to cool, filter it, and dilute it with the same quantity of clean water. Then mix with 30 g of soft soap in every 5 litres of liquid before spraying it. This tobacco solution is very toxic and should be used only in an emergency. It is effective against maize stalkborers, lice, mites, worms, caterpillars and many other pests.

Neem


Neen Leaves

The neem tree (*Azadirachta indica*) is widely distributed in coastal regions of East Africa and the eastern drylands of Ethiopia. It was introduced from its home in South Asia, where it highly appreciated for its medicinal and pest-repelling properties.

The neem tree is often confused with the chinaberry (*Melia azaderach*), a closely related species with very similar leaves. But there are two easy ways to distinguish the two. First, the fruits of neem drop off when they are ripe, but the fruits of chinaberry remain on the tree. Second, neem bark is rough, but that of chinaberry is smooth, and of a darker colour.

Insect pests which neem will control		
Brown planthoppers	Leaf-eating beetles	Young scale insects
Cabbage caterpillars	Leaf-miners	Whitefly
Adult grasshoppers	Mealy-bugs	
Greenfly (aphids)	Onion thrips	
Neem repels termites and most species of ants for over 1 month		

How to make neem powder

1. Collect only ripe neem fruits (or berries), which are yellow, not green. Collecting a good quantity of berries is easy, as a mature tree (10 years old) will produce 30-50 kg of berries each season. Remove the outer layer of pulp if birds have not already done this.

2. After cleaning the seeds, spread them out in the shade on mats to dry for a few days. Make sure

they are not exposed to rain or direct sunshine. The active ingredients in the seeds (the main one is called "azadirachtin", after the Latin name for the tree) will lose strength when exposed to high heat and sunlight. An open, breezy place in the shade of a tree or house is best for drying. *Attention!* The seeds must be well dried before storing them to avoid the growth of moulds which will quickly spoil the seeds, and your efforts!

3. Store the seeds in well-aerated baskets or jute gunny sacks. Do not put them in plastic bags. These will keep moisture inside and make the seeds rot.

4. Remove the seed coat. For this you need a large mortar, which you do not use for grinding other cereals. Neem is very bitter, and will give an unpleasant flavour to anything else you grind in the mortar. Place about 0.5 kg of the seed in the mortar and pound it very gently—not hard enough to crush the seeds, just enough to break off the seed coat, exposing the kernel inside.

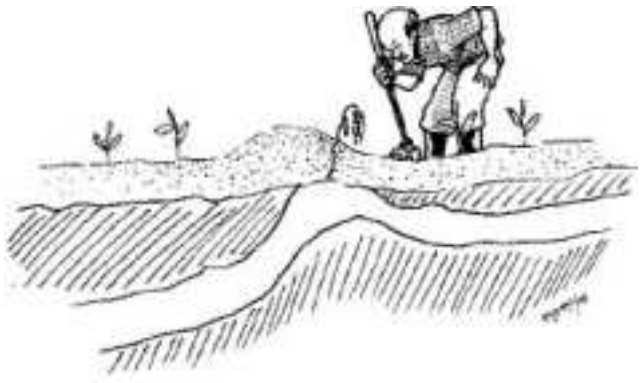
5. Next, separate the broken seed coats from the kernel by winnowing them in a light wind.

6. Put a few handfuls of clean neem kernels into the mortar and—this time—pound vigorously until you produce a fine powder. Make only as much powder as you will use in a few weeks, since the insect-repelling properties will not last as long once you make a powder, especially if it is exposed to light or heat.

Controlling moles with stinging nettles

Not only insects can be controlled with plant-based methods. Moles are a serious pest in many areas, particularly those with higher rainfall. They can be controlled with various poisons and synthetic chemicals, but these are costly and can be dangerous to handle. A farmer in Kenya has found a way to control moles using the leaves of the stinging nettle plant (*Obetia radula*), known in some areas as *hila hila* or *thabai.* Other plants with spiny leaves or stems can also be used. Moles do not like the nettles as they irritate their sensitive skin. They move somewhere else, where they may be eaten by predators.

Dig out a molehill so you can see the tunnels leading to it on both sides. Use a cloth or gloves, push pieces of stinging nettle as far as you can into the tunnels. Cover the tunnel with soil. Repeat for as many tunnels as you can find.



How to use neem powder

Neem powder is very effective for protecting crops from a wide range of pests. *Note:* neem does not kill pests immediately, as do many synthetic pesticides. Do not expect to see insects fall dead when using neem! When bugs feed on plants with a coating of neem solution, they will quickly stop eating, and will also stop growing and reproducing.

On vegetable crops. Mix 500 g (3 handfuls) of neem powder with 10 litres of soapy water. The soap helps dissolve active substances in the neem powder, and makes them stick to the plant. Allow this mixture to sit overnight. After stirring it well, spray the solution onto the plants, or sprinkle it onto them with a grass broom. If you use a sprayer, be sure to sieve the solution first using a fine cloth to avoid clogging the spray nozzle. When applying the solution, take care to cover the leaves of the plant completely, especially the undersides, where the pests like to hide. If pest infestation is heavy, apply twice in one week. Otherwise, one treatment every 7 to 10 days will do. Stop using the neem solution 3-4 days before harvest to keep your cabbages from having a neem flavour (washing the produce well will remove this taste, but takes more water and time).

On cereal crops (maize, sorghum, millet). One particular pest—the stalk borer—can be readily controlled using neem powder. Mix equal parts of the powder with sawdust or termite clay. Put a pinch of this mixture into the funnel formed by the young leaves. When it rains, the active

substance will be carried down to where the borer hides and will stop it from doing any damage. Apply the

powder every 8 days during the critical early growth period. Normally three treatments will be enough to protect your crops from attack.

As a control for root-knot nematodes. Neem powder can also be used as a soil amendment for controlling nematodes, especially in nurseries. Mix about two kg of powder (8 handfuls) with 10 litres of water and leave it overnight (there is no need to add soap to the water). The next day, stir up the mixture and apply it directly to the soil using a watering can with the nozzle taken off **(Picture 1)**. This amount is enough to cover an area of about 8 m^2 (2 m x 4 m). After applying, stir the surface of the soil with a rake to improve contact with the neem solution **(Picture 2)**. It is best to treat the soil this way 10-15 days before planting seeds or transplanting seedlings.

Against ticks and internal parasites in livestock. You can spray neem extract (at a higher concentration) on livestock to control ticks and lice. Feeding neem leaves to your animals will control intestinal parasites.

Controlling maize stalkborer

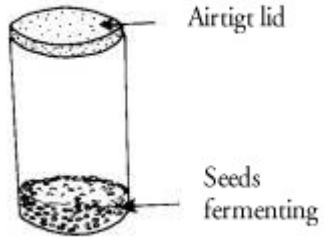
Maize stalkborers are insects which burrow in the stem of maize or sorghum. Sometimes they are found in the maize cobs of young maize plants. This burrowing and eating of the inside if the plants severely reduces the yield of maize and sorghum.

You can use neem powder to control stalkborers, as described earlier in this section. Or you can use wood ash or soil, or a mixture of both. Sieve the ash or soil to remove any big particles which may damage the leaves. Take about 1 teaspoonful of the soil or ash (or a mixture of the two) and put it into the funnel made by the new leaves when the maize plants are between 45 and 90 cm (1.5-3 feet) high. It is best to apply the ash or soil before the plants show any signs of stalkborer attack. Do not apply too much soil or ash, as this may damage the leaves.

Storing vegetable seeds

Vegetables provide valuable vitamins and minerals in the diet, and they can also be important cash

1



crops. By storing their own seeds, farmers can save money and ensure a reliable supply of quality seeds of their local vegetable varieties.

Advantages

- Correct processing and storage of seeds ensures high germination rates.
- It cuts the cost of buying seeds and increases profits.
- It guarantees seeds are available when needed.

Disadvantages

- If diseased plants are used, the seeds may be poor quality and spread disease.
- Farmers cannot process and store seeds from hybrid plants.

Requirements

- Equipment: knife, watertight containers, bucket, sieve, pieces of polythene bag or cloth, airtight bottles or cans, water.
- Ripe (or dry) fruits or pods containing seeds. These should be from non-hybrid varieties. If not sure, check with someone who knows. Hybrid seeds are usually clearly marked as such and are much more expensive.

2

Processing seeds

Fleshy fruits with wet seeds

The description below is for tomatoes. Use a similar method for other fleshy fruits with wet seeds (eggplant, cucumber, gourds, squash)

1. Select very ripe fruits from healthy plants (without disease)

2. Cut and squeeze all the seeds and juice into a container. Close the lid tightly. Leave for 4–7 days. The mixture will begin to ferment a little **(Picture 1).**

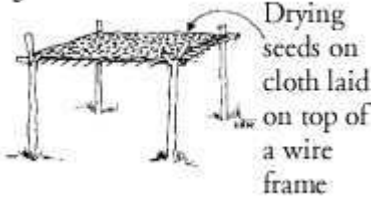
3. Shake the fermented juice gently and then pour it into a bucket.

4. Add clean water. The viable seeds will sink to the bottom and non-viable seeds will float **(Picture 2)**.

5. Carefully pour off the water and non-viable seeds so that you are left only with the good seeds.

6. Wash the good seeds and put them on a sack or cloth to dry for 2–4 days **(Picture 3).**

3



Fleshy fruits with dry seeds

Use this method for vegetables that have fleshy fruits with dry seeds inside (chilli, ladyfinger).

1. Put the whole fruits on a sack or cloth to dry.

2. Extract the seeds in the same way as for dry seeds (see below).

Dry seeds

Use this method for vegetables that have dry fruits or pods (various types of beans, cabbage, cauliflower, mustard, lettuce, onions and peas).

1. Put the pods or fruits in a sack or bag and pound them to release the seeds.

2. Separate the seeds and put them on a sack or mat to dry for 2–3 days.

3. Winnow the seeds to remove chaff, weed seeds and other contaminants.

Seed storage

For all types of seeds:

1. Store the dried seeds in an airtight tin or bottle, in a cool, dry place. Label the bottle with the type of plant and the date of harvest.

2. To keep seeds dry, mix them with cooled ash from the fireplace or stove (0.5 kg of ash for every 1 kg of seed). Sun-dry the seeds from time to time to keep their moisture content low.

3. To protect stored seeds from insects, mix 3–4 teaspoons (15–20 g) of neem powder with 1 kg of stored seed (see the section on *Controlling crop pests and diseases* for how to make neem powder). Instead of neem powder, you can use 4–6 teaspoons (20–30 g) of chilli powder.

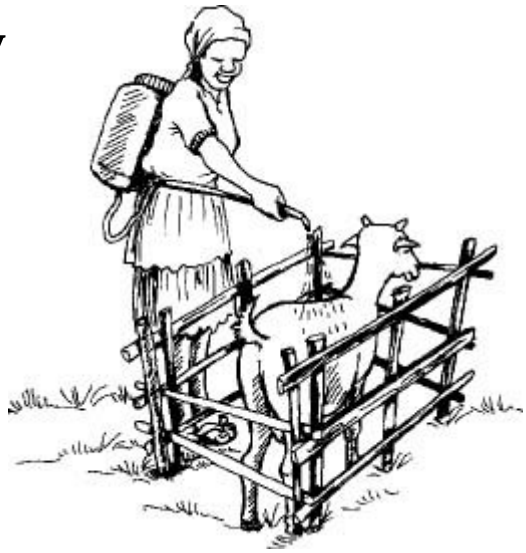
Do's	**Don'ts**
o Use only healthy, very ripe fruits or dried pods for seed. o Use clean water to wash the seeds (for wet seeds from fleshy fruits). o Dry the seeds in the shade if possible. Avoid putting them in the direct sun around midday, as this will lower the germination rate. o Treat the seeds with a chemical dressing if you think that they may be diseased. o Save seeds regularly so that you have a constant supply. o Sow seeds when they have been kept for 3–	o Never dry seeds over a fire. o Don't process the seeds in the rainy season, as it is impossible to get them dry enough for storage. o Don't keep your seeds for a long time (over 2 years), as they will not germinate. o Don't let the seed to touch the soil before storage. Soil contains many micro-organisms that can carry diseases.

6 months.	

Part 8

Livestock extension

Community-based veterinary services



Livestock health is a major problem facing farmers and herders throughout Africa. But there are few veterinarians in remote rural areas. By the time a veterinarian is able to see a sick animal, it may be too late. Modern treatments may be expensive, inappropriate and unsustainable in remote areas. Cutbacks in government services in many countries mean that farmers cannot rely on them for treatments.

However, many of the most common livestock diseases and other problems can be treated by local people using a small

range of simple equipment and drugs. Local people can be trained in applying these methods to treat sick animals. This reduces both the running costs and the cost to each livestock owner.

In addition, farmers have a rich store of knowledge on herbal medicines that they have found effective over the years. Much of this valuable "ethnoveterinary" knowledge is being lost or is being replaced by modern techniques, and younger people often look down on it as a form of witchcraft. Sharing this knowledge is vital to ensure that it is used and is preserved for the future.

Providing community-based veterinary services involves much more than training local people to treat diseases and supplying them with drugs and equipment. Organization is key. There must be sufficient people in the local community who keep livestock and are interested in improving their animals' health. This ensures a high level of community involvement and improves chances of cost-recovery and financial sustainability. Local groups providing the veterinary services must be strong, independent and able to make decisions on how to manage them. These local groups should be linked with government veterinary services and policy-makers for technical support and planning.

This section gives examples of various approaches to providing community-based veterinary services. These include the training of paraveterinarians in Ethiopia, the organization of livestock holders to implement a pest-control programme in Ethiopia, training in traditional practices in Kenya, and the use of traditional herbal medicines.

Advantages

- Community-based approaches enable livestock health services to be provided to a large number of farmers in remote areas.
- Because they live and work in the villages, local paraveterinarians and traditional healers are able to respond quickly to problems that arise.
- Community-based approaches improve the access of smallholder farmers to essential veterinary drugs and services, thereby improving the health of their stock.
- The nearest professional veterinarian can supervise the paravets and support them if necessary. The paravets in turn can refer problems to the veterinarian for further treatment.
- The paravets and community workers can monitor disease outbreaks and report them to the authorities quickly.
- The paravets charge a small amount for their services and for the drugs and supplies they use. By requiring some payment, they can replenish their supplies and cover their expenses, so can continue providing the services in the future. This means that the community's animal health-care services can become sustainable and self-financing.

Disadvantages

- Paravets' knowledge and skills may be limited and insufficient to deal with serious problems.
- People may have limited confidence in paravets.
- The paravets, local people, the project management and the government may have different expectations of the paravets, for example in the need for their services, the types of services provided, and payment for them.
- Professional veterinarians may be opposed to the introduction of paravets.
- It may be difficult to maintain an adequate stock of drugs and supplies (especially after outside funding has ceased).

Training paravets for dairy goats in Ethiopia

FARM Africa's dairy-goat project in the highlands of Ethiopia offered to train as paraveterinarians people who were chosen by the women's groups participating in the project. Each group chose two people, usually one of the members and the husband of another member.

FARM Africa gave the nominees 5-7 days of training in the village. The course content focused on the major diseases in the area. It covered internal parasites such as worms, external parasites (ticks and mange), treating and dressing wounds, hoof-trimming, castration and eye treatments. It also covered how to diagnose common diseases and what diseases to report to the authorities.

Local farmers were invited to bring in their sick animals for treatment during the course, so the trainees got to see a wide range of cases and diseases, and

were able to learn practical treatments on the spot. The trainees were invited to identify each disease and explain how they would normally deal with it. The instructor then helped them identify the most typical or prominent symptoms, explained how to distinguish one disease from another, outlined the options for treatment, guided the trainees in treating the disease, and discussed what follow-up measures were necessary.

At the end of the course, the trainees were each given a knapsack sprayer, castration equipment, hoof shears and other basic equipment, as well as a supply of drugs and dressings as initial capital.

Every 6 months, the trainees receive training to refresh their knowledge and upgrade it, for instance in identifying infectious diseases (such as pneumonia), injecting drugs, and treating mastitis. The project also replenishes the paravets' drug supplies.

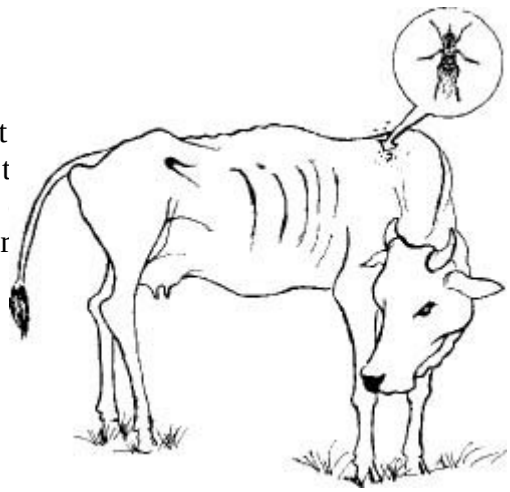
The paravets charge clients for the price of the drugs they use, plus a mark-up of 10-20% so they can cover their expenses and buy more supplies. For procedures that do not require supplies, such as castration, they charge a set rate: for example, birr 1 per animal castrated.

Paravets are required to keep records. Literacy is not a requirement, as the record sheets are specially designed to be used by people who cannot read and write.

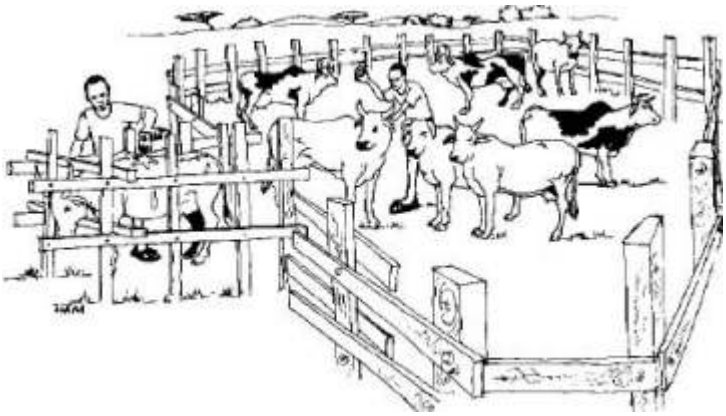
The project has trained 100 paravets in this way. They currently provide services to the villages in their area, including the 1500 women members of the 120 goat-keeping groups affiliated with the project. *—For more information, contact Kettema Yilma, FARM Africa, Ethiopia.*

Tsetse control in southern Ethiopia

About 10 million km^2 of sub-Saharan Africa is unable to exploit
of tsetse flies. The flies carry trypanosomosis, a serious disease t
kills many animals. In Konso district in southern Ethiopia, 16%
abort, and more than half the calves die. Many of these deaths ar



Agriculture and local veterinarians have worked with local people to control tsetse flies. In an initial survey on livestock diseases, local farmers identified trypanosomosis as their main problem. The farmers and a team of specialists then made an in-depth study of the problem, and shared their findings with the community, local decision-makers, and potential donors. In 1995, the project arranged



Treating cattle against tsetse flies

for 24 cattle-owners and elders to visit Ghibe, where the International Livestock Research Institute studies tsetse control methods. The researchers demonstrated various control techniques, and discussed the advantages and disadvantages of each.

After the visit, the community decided to test one of the methods: the insecticide Deltamethrin, which is poured onto the animal's back. FARM Africa provided funds, and the community agreed to take over the costs after one year if the results were positive.

At the end of the one-year pilot phase, veterinarians, policy-makers, community members and donors held a workshop to evaluate the results and to plan for the future. The evaluation showed that the pilot project was successful, and the workshop participants decided to expand it to cover the entire area. They chose a community-based approach to minimize the need for trained workers, keep running costs low, and to recover the costs in order to ensure sustainability.

The project decided to work with traditional, livestock-oriented community organizations called "fora-men associations". These associations each have about 3-7 members, who herd their livestock jointly. The fora-men associations are responsible for using the insecticide to control the flies, developing new ideas on implementation, and contributing funds to pay for the insecticide.

For ease of management and co-ordination, the fora-men associations are grouped into larger "fora-men peasant associations". A total of 1130 livestock holders are organized into 10 of these larger associations, which liase with and co-ordinate the various fora-men associations and manage the funds.

The 10 peasant associations in turn are represented on the Woreda Tsetse Control Committee. Other members of the committee are Bureau of Agriculture staff, the Konso local government, and local NGOs. District veterinary office staff provide technical support, training and supervision.

Farmer-technicians from ten peasant associations were trained on how the tsetse flies live on the cattle and transmit the trypanosomosis disease, how the insecticide controls the flies, and how to use the

insecticide. The trainees treated nearly 3000 cattle, closely supervised by the veterinary staff. This ensured that they were using the insecticide correctly, and could run the project with minimal help or outside inputs. Cattle owners were required to pay birr 5.40 (US$ 0.80) for treating each of their animals.

The veterinary staff recommended treating the animals seven times a year, but the farmers suggested treating them only when there were many flies. This meant the number of treatments could be reduced to five, saving more than one-quarter of the costs. The community collected birr 18,000 to buy insecticide, and the United Nations Development Programme donated an additional birr 50,000 to use as a revolving fund.

The project seems to have had a major impact on the health and productivity of cattle in the area. Since the insecticide treatments began the number of cattle infected by trypanosomiasis fell from 16% to zero and the number of flies caught in traps fell by 100-fold from 3.25 flies per trap each day to 0.03. The number of cattle deaths has fallen from 16% to 5% each year; the number of abortions from 20% to 2%, and the number of calves dying has dropped from 58% to only 8%.

However, this success has caused a new problem: fewer cattle dying means a rising population. It is estimated that the number of cattle will double in 12 years, resulting in a lack of forage and soil erosion. Possible solutions include intensifying forage production through planting fodder trees, improved livestock marketing, and encouraging cattle-owners to focus on the quality of their stock rather than the sheer numbers.

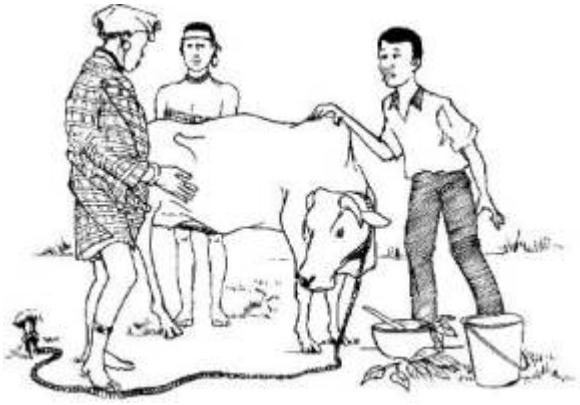
FARM Africa and ministry officials have learned that development projects can be much easier and more sustainable when based on traditional, local organizations. They also discovered that with proper training and supervision, farmers are able to handle complex technologies. Because of the project's success in controlling the flies, it became possible for livestock owners to herd their animals on valley land that had previously been infested by tsetse. But this meant there was the possibility of conflicts with other people interested in using the same land. To avoid such conflicts, it was important to involve all the people who shared the valley in making decisions about how to use it *—For more information, contact Tibebu Habtewold, FARM Africa, Ethiopia.*

Training in ethnoveterinary medicine in Kenya

Intermediate Technology-Kenya staff identified local traditional healers in Tharaka, in eastern Kenya, and asked them to identify traditional remedies that they found useful. The healers were asked to say which treatments they knew were effective, and which they had less confidence in.

IT-Kenya then invited two of the most respected traditional healers (a man and a woman) to join a 10-day training course for a group of 15 paravets at Marimanti. The course covered both modern and traditional remedies. As part of the course, the healers trained the paravets in how to collect, prepare and administer traditional remedies for various problems. *—For more information, contact Orito Mageka, IT-Kenya.*

Examples of local treatments for animal diseases



Farmers use a wide range of medicines to treat problems in their livestock. Many of these medicines are based on herbs growing wild nearby. There are thousands of such treatments, used by livestock holders and traditional healers. Below are four examples used by farmers in Zambia and Zimbabwe.

Chest congestion in cattle

Farmers in Kalomo South, Zambia, use the root of a plant (called *simatindi* in the Tonga language) to treat cattle that have pneumonia. They dig up the large, pumpkin-like root of the plant, cut it in half and pound it into a paste. They mix about 2 kg of the paste with 3 litres of water, and boil it for at least 10 minutes. They allow the mixture to cool, then force the sick animal to drink about 750 ml of it. They use about half this dosage for calves less than 2.5 years of age. They treat all animals (both sick and healthy) in a herd at the same time. If the animals do not recover in 4 days, the farmers repeat the treatment. They are careful not to overdose, as this can harm the animal. The farmers find that this mixture is also good for deworming the cattle.

Deworming cattle

Farmers in Kalomo use red mahogany (*Khaya myasica,* or *mululu* in Tonga) to deworm their cattle and to treat diarrhoea. They cut about 1 kg of mahogany roots into pieces, boil them in 2 litres of water for 15 minutes, and allow the mixture to cool. They make adult cattle drink about 350 ml of the liquid. For calves between 1 week and 2.5 years old, they use 125 ml. They make sure the cattle have plenty of water to drink in the days after administering the medicine. They do not repeat the treatment until at least a week later. While the same medicine can be used to cure stomach pains in people, pregnant women should not drink it as it can cause a miscarriage. *—Brian Mooka, Zambia.*

Wound treatment

Farmers in Zimbabwe use the leaves of the *muvengahonye* plant to treat septic wounds in their cattle. They crush the leaves, add some drops of water, and put the paste on the wound. They repeat this after 2 days if the wound has not yet healed. The *muvengahonye* paste helps the wound heal.

Eye treatment

Farmers in the same area use the milky sap from *chisvosve* plant to treat pink-eye infections in their animals. They do not put the sap directly into the eye, but rub it above the animal's eyelid. This normally cures the diseases within 3 days *—Zephaniah Phiri, Zimbabwe*

For many more cures used by farmers in Kenya, see: ITDG and IIRR. 1996. Ethnoveterinary medicine in Kenya: A field manual of traditional animal health care practices. *Nairobi.*

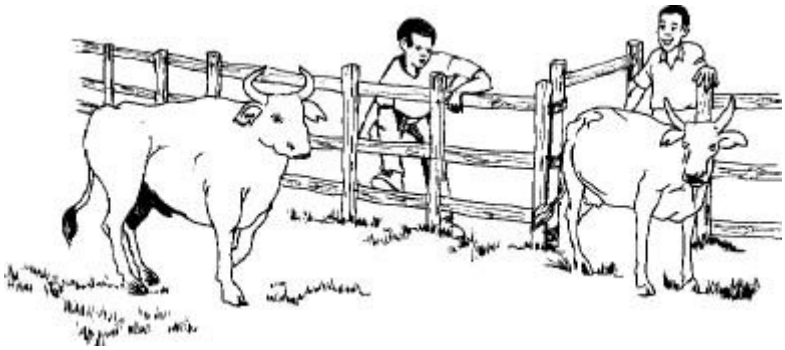
Keeping male animals for breeding

Many farmers are reluctant to keep male animals (bulls, he-goats, rams or cockerels), as they are costly and difficult to keep, and do not produce milk or offspring. The farmers prefer to sell or slaughter the male animals, and keep only the females. But this may make it difficult to find a male for breeding. The few males that are in the village mate with all the females, causing problems of inbreeding.

Governments often keep male animals of improved breeds at breeding stations, and use the semen to provide artificial insemination services. But there are few such stations, and the nearest may be a long way away. By the time the farmer is able to call an inseminator, the female animal may be no longer on heat.

Groups of farmers can overcome this problem in various ways. The group may decide to buy an animal and give it to one of the group members to look after. Or an individual farmer can own the male, and lend it to other farmers for a fee.

The approaches described in this section are useful where there are few male animals, or where it is difficult to access the services of a breeding station. They can also be used to improve the quality of the local breed of livestock by crossbreeding the females with a male of an improved breed. The description below is for cattle, but the approach can be used with all types of livestock, as shown by the examples later in this section.



Procedure

1. The farmers' group buys a bull (possibly one of an improved breed).

2. One of the group members feeds the bull and looks after it.

3. When a cow comes on heat, its owner brings it to the bull for breeding.
4. The cow-owner pays the bull-keeper for the service in cash or in the form of feed.

5. Every 2 years, the group sells the bull and buys another one. This is to prevent inbreeding.

Issues

Issues and problems encountered in this type of approach include:

- **Should the male be a local or an improved breed?** Local breeds may be more resistant to diseases, but improved breeds often produce more meat and milk.
- **Who should own the male?** Alternatives include ownership by the group (with some payment to the person keeping the animal), or ownership by an individual (who charges others for the breeding services of the male).
- **Who should keep the male?** Keeping a male animal involves quite a lot of work and responsibility: providing feed and water (more for a male than a female), keeping the animal healthy, and dealing with the females which come to be bred.
- **How is the male animal to be fed?** Some communities bring feed for the male, or set aside community land to grow fodder grass.
- **How is payment for the male's service made?** Payments can be made in cash or in kind (in the form of fodder, feed supplements, milk, or another animal).
- **When should payment be made?** Alternatives include on service (each time a female is served), on result (when the female successfully gives birth), or continuous (eg, villagers take turns in bringing feed to the male).
- **What is the level of payment?** How much should the keeper get for caring for the male animal? In general, the benefits (in terms of cash, in-kind payments or prestige) should be high enough to be attractive for the keeper, but low enough for the group to want to contribute.
- **Are the animals healthy?** The group should make sure that both the male and the females are healthy, to avoid spreading diseases and pests.

There are many different ways of resolving these issues. The examples below illustrate some of these.

Dairy goats in Ethiopia

As part of its work to promote dairy goats with women in Ethiopia (see the section on *Community-based veterinary services*), FARM Africa established 15 community goat-breeding stations in the highlands of eastern and southern Ethiopia. At each station, a village woman keeps an exotic-breed he-goat for mating with the female animals belonging to group members. The group decided who should look after the he-goat and how to pay for the breeding service. Payments included providing feed for the male, paying when they bring a female for mating, or working on the keeper's farm.

This arrangement began to have problems: some farmers failed to bring feed for the he-goat, as they scarcely had enough for their own animals. They also

said they were too busy to work on the keeper's farm. The keepers started to complain about their extra work and the lack of reward from looking after the he-goat. At this stage, FARM Africa decided to pay the keepers birr 10 (US$ 1.30) for every crossbred kid born. It said it would make such payments for no more than 2 years—the time it would take for the crossbred kids to grow and start to produce milk.

After seeing the quality of the offspring, women's groups in Eastern Harange decided to buy their own exotic he-goats for birr 1200 (US$ 170) each. They pay birr 5 for every successful kid sired by the male. Moreover, the keeper receives 25% of the price of the male when it is sold.

Not all the breeding stations have been successful. In Konso and Wolaita in southern Ethiopia, the

project ended before farmers were convinced of the benefits of improving their goats breeds in this way. *—For more information contact Kettema Yilma, FARM Africa-Ethiopia.*

Breeding-bulls in Zimbabwe

Villagers in Mujimba, Zvishavane district, Zimbabwe, lacked a good-quality bull. They asked Lutheran World Federation for help, and were given a bull of an improved breed. They agreed that the village councillor would keep the bull and would graze it on common land along with other farmers' cows. If a cow belonging to a farmer living far away comes into heat, its owner borrows the bull and takes care of it while it is on his or her farm. After the service, the bull is returned to the councillor's house.

The bull has improved the quality of the animals in the village. The group now plans to plant improved fodder crops such as Napier grass and Kikuyu grass on community land. *—For more information contact Zephaniah Phiri, Zvishavane Water Project, Zimbabwe.*

Cockerels in Kenya

The Kenyan Ministry of Agriculture has given groups of women in Naitiri each a cockerel of an improved breed. The women chose one of the group members to keep the cock. Each of the members has about five hens; she can borrow the cock from the manager for about a week. In return, she has to give the manager a 2-month-old chick. The manager can then do what she wants with this bird: sell it, slaughter it, or add it to her flock.

This scheme works well, though there have been problems. There is a danger that the cock contracts diseases, and moving the cock around may stress it. Local cocks are also still being used, diluting the effect of the improved cock on the quality of the local poultry. *—For more information contact Eric Kisiangani, ITDG Kenya.*

Bulls in Kenya

A group of farmers in Taita, Kenya, received a bull from the government. One member of the group keeps the bull, and the other members bring their cows to it for service.

They must spray the cow against ticks before bringing it to the bull; to make sure, the bull-keeper sprays it again before the service.

Each time a cow is served, the cow owner must pay the keeper KSh 100 (about US$2) and bring a load of Napier grass as feed. Out of the payment of KSh 100, the bull-keeper can pocket KSh 90, but must set aside KSh 10 for maintaining the bull and for medicine and other supplies. Every 2 years, the group sells the bull and buys another one to avoid inbreeding. *—For more information contact Ruth Masha, HPI-Kenya.*

Payment with milk in Kenya

A farmers' group in Matunda, Kitale, Kenya, pays the bull-keeper in the form of a dairy cow. The keeper can keep 2 litres of milk each day in payment for looking after the bull. The rest of the milk is sold, and the money goes into the group's fund. *—For more information, contact Dorcas Nekesa*

Wangila, Kenya.

Avoiding inbreeding in goats in Kenya

A farmers' group in Mangu, Kenya, avoids the problem of inbreeding by keeping two male goats. A farmer is not allowed to bring a female goat to mate with its own sire. Farmers pay KSh 30-50 (US$ 0.50-0.83) per service, but if a female does not become pregnant, it can be mated again without payment. The group also buys feed concentrates to feed the males. *—For more information, contact Peter Njenga Ndung'i, Kenya.*

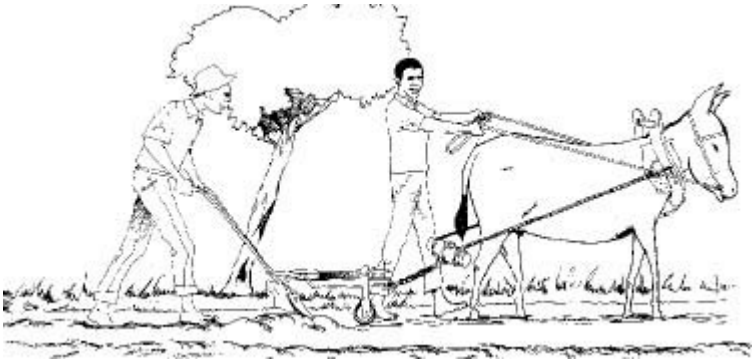
Part 9 

Livestock technologies

Animal draught power

Animal draught power is useful for small- and medium-scale farmers with limited income: those who cannot afford to buy or hire tractors. Draught animals can be used for many purposes: mowing, ploughing, weeding, harvesting, transportation and pumping water. Many types of animals have been used as draught animals, including cattle (or oxen), donkeys, mules, camels and horses.

Animal draught power is particularly useful for smallholder farmers who practise sustainable agriculture. The animals provide a good source of organic manure, and grass and tree fodder can be used to feed them. Using animal traction to prepare the land, and for weeding and other field work helps to avoid the compaction and physical destruction of the soil that can be caused by tractors.



Advantages

- Draught animals reduce the amount of physical labour and makes farming a more appealing occupation. It thus encourages farmers to stay on the farm and not to migrate to the towns.
- Replacing hoes with draught animals and equipment increases productivity. Farmers can double or triple the area cultivated, thereby increasing crop output at low cost.
- Animal draught power is not expensive. The animals and equipment are cheap compared to tractors. The investment can pay for itself in a few years.
- Animals compact the soil less than do tractors.

- The animals and equipment can be supplied locally, thereby creating less dependence on external resources.
- Draught animals do not require radical changes in cropping patterns or labour. Although they reduce labour needs in some field operations, the savings are not drastic, and labour can shift to other activities, such as planting, harvesting and caring for animals and harnesses.
- The use of animal draught-power can create work opportunities by stimulating the development of artisans, increasing jobs for local blacksmiths, carpenters and leather-makers who produce the equipment needed.
- Farmers can hire out their teams and equipment for transport, water-pumping and tillage.

Disadvantages

- Using draught animals is more labour-intensive than tractors.
- Although they are cheaper than tractors, the equipment and materials can still be too

expensive for small-scale farmers.

Using donkeys for draught power in Kenya

Manor House Agriculture Centre, located in the Rift Valley province of Kenya, uses donkeys for animal power. It chose to work with donkeys for several reasons:

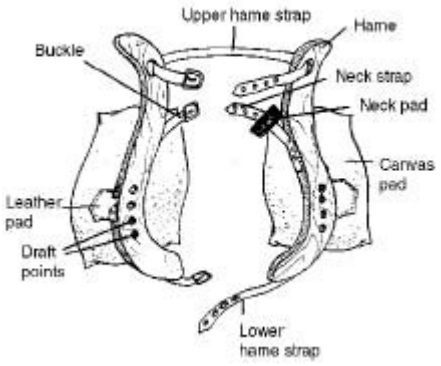
- Donkeys are more resistant than other species to many tropical diseases, such as those carried by ticks.
- Donkeys do not eat as much as ruminant species.
- Donkeys learn quickly; they can be trained in about 3–4 weeks.
- Both sexes of donkeys deliver equal amounts of power (females need a 6-month work rest during and after a pregnancy).
- A donkey can pull 25% of its body weight for 4 hours in the morning and 3 hours in the afternoon, for a total of 7 hours per day. Oxen can only pull 18% of their body-weight, and only for 4– 4.5 hours per day. Oxen need more time for chewing the cud to allow for proper digestion. So donkeys take less time to convert food into power.

6. In arid and semi-arid areas, the cost of keeping oxen is often too high to make them a feasible source of farm power; donkeys are less costly to keep.
7. Donkeys can work for as many as 30 years; oxen can work for only about 15. Since donkey meat is not valuable, there is no reason to slaughter them, so they live for a long time.
8. Donkeys can usually be acquired from local markets at a lower cost than oxen and horses.

Manor House provides training and technical assistance to farmers on how to use collar harnesses to improve performance and how to avoid injuries to the animals.

Requirements for a donkey harness

- Leather: for harness straps.
- Canvas cloth: for canvas pads. Since donkeys do not have natural padding to absorb the pressure of the equipment, yokes are not used. Rather, a collar harness is used to enable them to pull loads more comfortably and efficiently.
- Wood: for harness frames and hames.
- Ropes or chains: for the link between the animal and the load.



Training donkeys to work as draught animals

Young animals (about 2.5–3 years old) of either sex are the best age for easy training. Although they are more difficult to train and it takes longer, mature donkeys can also be trained to provide draught power. A young animal can be trained in 3–4 weeks; it takes 6 weeks to train a mature animal.

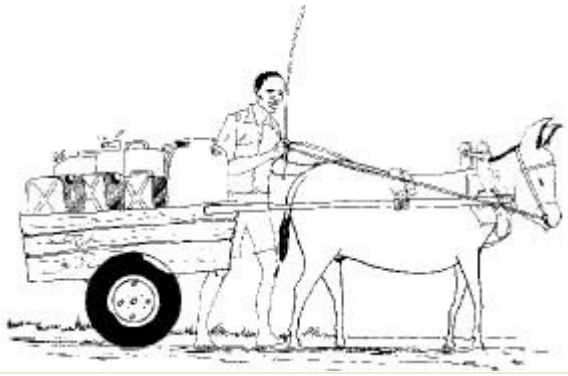
1. Over a period of a month or more, the owner should aim to develop friendship and a good working relationship with the animal. This would include feeding and providing water to the donkey, grooming it, leading the animal to shelter or to pasture, and other general care.
2. The training starts by having the animal wear a light harness and bridle for 2 hours in the

morning and 2 hours in the afternoon. The farmer can train the donkey to take the bridle by opening its mouth with his fingers. The bridle has reins which allows the farmer to train the animal to obey commands: steer, turn, stop, and move backwards. This training will take about 3 weeks, depending upon the trainer.

3. When the donkey reaches the age of 4 years, the animal can take on light duties, such as mowing and transporting light loads. Once the animal has reached the age of 5, the work can be gradually increased: for example, ploughing for 2 hours in the morning and 2 hours in the afternoon. Young draught animals should only do light duties because the animal's body tissues are still growing and developing.

Do's

- Provide adequate feed for the animal, especially grass, grains and grain by-products.
- Provide adequate water and salt to the animal. Draught animals need to replace water and minerals lost through sweating during work.
- Deworm the animal regularly, about every 3 months.
- Allow the animal adequate rest. Work the animal in the morning, then let it rest at least 4 hours during midday (you can give it feed during midday). You can work again in the afternoon for 3 more hours.
- Train the animal in the language that will be used by the owner.
- Provide adequate shelter for the animals.
- Trim the hooves regularly. Trim them at least twice during the rainy season. Do not trim them during the dry season as they may crack.
- Ensure proper harnessing to avoid health problems such as galls, wounds and burns which can reduce the animal's performance.
- Although donkeys are hardy, they still require general grooming and should be kept in a clean environment. Treat diseases and wounds promptly.
- Use a cart rather than transporting loads on the animal's back, as this can harm the animal.



Don'ts

- Don't overwork the animal, as it may kick or become stubborn.
- Don't work pregnant female donkeys for 3 months before and for 3 months after they give birth. This allows proper nutrition for the foal.
- Don't mistreat the donkeys when harnessing, so that the animals begin to feel comfortable when performing their duties.

—For more information, contact Alfred Mayende, Manor House Agriculture Centre, Kenya

Zero-grazing

Zero-grazing means keeping animals in a stall, and bringing fodder to them instead of allowing them to graze outside. It is also sometimes called "cut-and-carry". The description below is about how to keep dairy cattle using zero-grazing. It is an intensive system that produces a lot of milk from a small amount of land.

Zero-grazing can also be used with goats and sheep. They can be kept in a shed with a slatted wood or bamboo floor, raised about 1 m above the ground. The droppings fall through the slats into a pit beneath the shed. They can then be carried away to be used as fertilizer.

Location

Zero-grazing is especially useful in areas where land is scarce. It requires a reliable source of feed, and sufficient labour to cut and carry the feed.

Advantages

- Zero-grazing reduces the number of pests (especially ticks and intestinal worms), since the animals do not graze on infested pastures.
- It allows the intensive use of land for growing fodder, and maximizes the use of the available land.
- It reduces damage to crops caused by grazing cattle.

Disadvantages

- This method requires labour to cut and carry the feed and to fetch water.
- Building and maintaining the shed and pit take money and labour.

Requirements

- Building materials for the cattle shed (wood, cement, sand, gravel, posts, roofing).
- Field to grow fodder.

Shed construction

1. Choose where to build the cattle shed. This should be close to a reliable source of clean water, as cattle can drink up to 100 litres of water a day. If possible, build the shed near a field where you can grow fodder.

2. Build the shed (see the diagrams for a suggested design). The roof can cover the whole pen, or just the animal cubicles. It should slope away from the pen so rainwater does not fall into the pen. The roof can be made of metal or thatch; thatch is cooler but must be repaired regularly and can catch fire. The roof should slope from a height of about 2.7 m (9 feet) at one side, down to about 2 m (7 feet, high enough for a person to stand up in).

3. The walking area should have a floor made of concrete or hard-packed soil. Concrete is better, as this is where the animals will spend most of their time, and concrete is easy to clean. The floor should slope gently (2 cm drop in every 1 m distance, or 2.5 inches in 10 feet) towards a channel leading to a manure pit outside the pen. The concrete can be made from a mix of 1 part of cement, 2 parts of gravel and 3 parts of sand. The floor should not be made too smooth, otherwise the cattle may slip on it.

4. Dig a manure pit, large enough to hold the manure produced in 2-3 days. Dig a channel leading from the walking area to the pit, and line the channel and pit with concrete. If you cannot afford concrete, make a paste of red soil, cow dung and ash. Smear this paste on the sides and bottom of the pit. Allow it to dry, then smear on another layer. Repeat this five times to build up a leak-proof layer.

5. Cover the pit with a plastic sheet or banana leaves to reduce the amount of sunlight hitting the manure. Sunlight causes the nitrogen in the manure to escape into the air, so reduces the value of the manure as fertilizer.

6. Make individual cubicles 120 cm wide x 210 cm long (4 feet x 7 feet), one for each cow. The cubicle floors should be made of dry soil, as cattle prefer to lie on soil rather than on cold concrete. The cubicle floors should be higher than the concrete floor of the walking area and should slope slightly toward the concrete. The cubicles should be just large enough so the urine and dung should drop onto the concrete area; this keeps the cubicles clean.

7. For calves, you can put in temporary barriers of wood to make the pens smaller: about 120 cm wide x 150 cm long (4 feet x 5 feet). The floor of the calf pens should be raised about 4 cm (1.5 inches) and should be made of slatted wood. This helps keep the floor clean, and protects the calf from diseases.

8. Set aside parts of the stall for a milking area and as a store for feed.

9. Provide troughs for water and feed in the walking area and the calf pen. Provide a feed trough in the milking area so the cows can feed during milking.

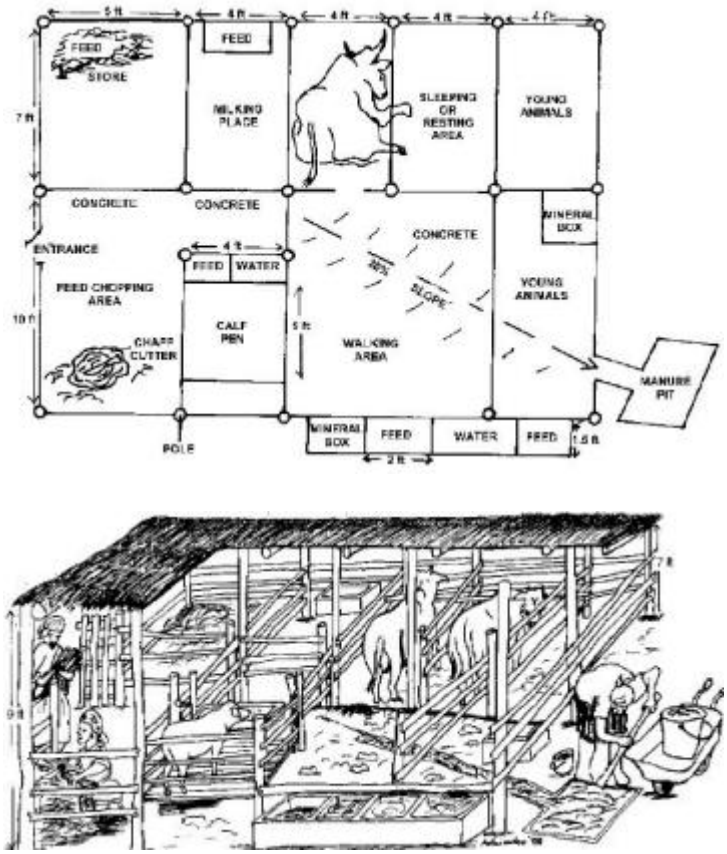


Diagram of a shed for two cows. The roof should cover the whole shed; part has been cut away to show the inside of the shed.

Fodder

1. Plant fodder crops near to the shed so you do not have to carry the feed too far. About 0.4 ha (1 acre) of Napier grass is enough for each graded dairy cow. If the Napier grass is intercropped with desmodium or other legumes, 0.3 ha (0.75 acre) is enough for one cow; 0.4 ha of Napier and desmodium is enough to feed a cow and a calf. See the section on *Growing Napier grass for fodder* for more information.

2. Plant the fodder grass in rows, and dig a shallow trench in between each row. You can put the manure slurry into these trenches to fertilize the grass.

Feeding and management

1. Every day, cut fresh grass and feed to the cattle. Make sure the feed troughs are never empty.

2. Provide as much water as the animals want to drink.

3. Hang solid mineral blocks (you can get these from feed stores) for the animals to lick. Or you can put powder minerals in a wooden box with an open top, and fix the box in the pen for the animals to lick.

4. Clean the walking area every morning. Pour water on the concrete and sweep all the manure

towards the manure pit. Every 2-3 days, remove the manure slurry from the pit and use it to fertilize the fodder grass. You can also use the manure to fertilize other crops (see the section on *Urine-manure slurry as fertilizer*).

Do's

- Protect the stall from predators such as hyenas and jackals.
- If the area is very hot, you can roof the walking area as well as the shed. Otherwise, you can leave the walking area open.
- If necessary, put straw in the pens as bedding for the animals.
- Make sure the animals have enough space to be comfortable. Keep the stall clean.
- Watch carefully for pests and diseases, and treat them early.
- Keep the bull separate from the cows. Watch the cows carefully for signs of heat so you know when to breed them.

Don'ts

- Don't use roadside grasses as feed, as they can spread pests such as ticks, and diseases such as foot-and-mouth disease.

Planting Napier grass for fodder

Napier grass is an improved fodder grass that produces a lot of high-protein forage. It is also known as "elephant grass", "Sudan grass" or "king grass". Its scientific name is *Pennisetum purpureum*.

Location

Napier grass is best suited to high rainfall areas, but it is drought-tolerant and can also grow well in drier areas. It does not grow well in waterlogged areas. It can be grown along with fodder trees along field boundaries or along contour lines or terrace risers to help control erosion. It can be intercropped with crops such as legumes and fodder trees, or as a pure stand.

Advantages

- Napier grass is propagated easily.
- It has a soft stem that is easy to cut.
- It has deep roots, so is fairly drought-resistant.
- The tender, young leaves and stems are very palatable for livestock.
- Napier grass grows very fast.

Disadvantages

- Napier grass is an aggressive plant that spreads through rhizomes under the ground. If it is not controlled, it can invade crop fields and become a weed.
- The older stems and leaves are less palatable for livestock.

Requirements

- Planting materials.
- Rope, hoe, wheelbarrow, tape-measure or measuring stick with marks at 60 cm and 90 cm (2 feet and 3 feet).
- Manure.

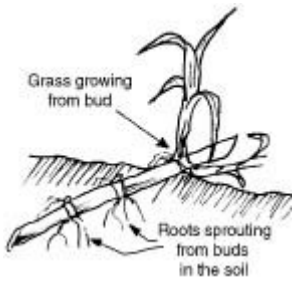
Procedure

Napier grass can be planted using three different methods: by cuttings, "slips" or whole stems.

Planting cuttings

1. At the beginning of the rains, collect the planting materials. With a sharp knife, cut the bottom part of young Napier grass stems into pieces. Each piece should have at least three nodes (the knobs or swellings on the stem).

2. Stretch out a rope across the plot to make sure you have a straight line. Using the hoe and measuring stick, plant the pieces of stem at 60 cm intervals along the line. Plant them angled into the ground at about 30 degrees, so two of the nodes are buried in the soil and one is above the ground.



3. Plant more rows with a spacing of about 90 cm (3 feet) between the rows.

Planting "slips" or "splits"

If you planting "slips" or "splits", you do not have to wait a long time for the grass to grow before you can multiply it. Seedlings from the slips become established more quickly than those grown from cuttings.

1. Cut Napier grass stems at ground level to remove all the green material.

2. Dig up the clump of roots and shoots growing under the ground.

3. Separate each seedling from the clump. Each seedling must have both roots and a shoot.

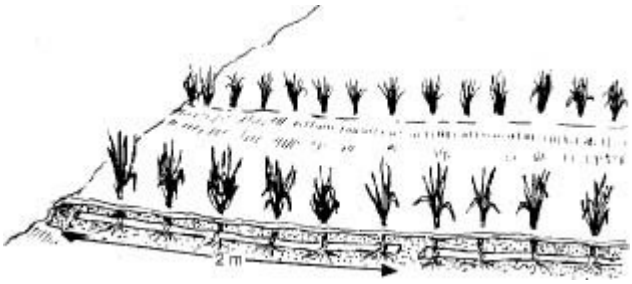
4. Trim the roots to about 5 cm (2 inches) long.

5. Plant the seedlings in small holes or a furrow.

6. Cover the roots with soil, but leave the shoots open to the air.

Planting whole stems

Planting whole stems is useful during the heavy rains, and in hilly areas where you need the grass to sprout quickly to cover the ground. Plant them along the contour to control erosion.



1. Cut whole young stems of Napier grass, about 2 m (6 feet) long.

2. Put the stems end-to-end in a furrow, and cover them with soil.

Maintenance and harvesting

1. Water immediately after planting.

2. Weed the Napier grass plot regularly.

3. If any of the cuttings die, fill in the gaps with new ones.

4. Harvest the grass when it is 90_120 cm (3_4 feet) high. Harvest the grass following a pattern. Beginning at one end of the row, cut enough grass to feed your animals for 1 day. The next day, cut the next grass along in the row. Carry on until you reach the end of the row. In this way, you will always be able to cut fodder for your livestock.

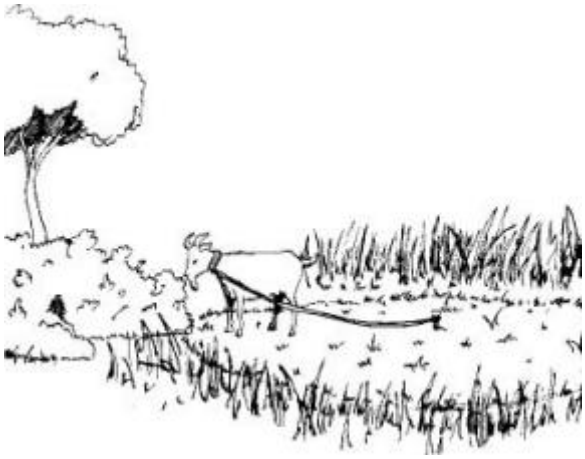
5. Apply liquid manure by digging trenches in between the rows of grass. Pour liquid manure into the trenches (see the section on *Urine_manure slurry as fertilizer* for details).

6. If the livestock do not eat all the grass, use the remainder as mulch or compost.

Do's	**Don'ts**
o Cut the grass 15_25 cm (6_10 inches) above the ground. Some farmers have found it is better to cut at ground level, though this may damage the plant too much. o Fill in any gaps in the rows with fresh cuttings.	o Don't use older stems as planting materials, as they will not germinate well. o Don't intercrop with cereals, as the grass will compete with the crop for nutrients and light. o Don't allow animals to graze on the Napier grass, as they may damage or kill the plants. o Don't allow the grass to overgrow, as it

	may become a weed. o Don't allow the grass to grow too high (more than 120 cm or 4 feet), as livestock will not eat it.

Tethering



Tethering involves tying animals by a rope to a peg driven into the ground so they can graze only in the circle around the peg. Tethering uses pasture land efficiently and stops animals from straying. It can be used with any livestock species (including cattle, goats, sheep and chickens).

Location

Tethering is useful where land is in short supply, or it is not possible to build fences for paddocks because of the cost or the lack of fencing materials. You can tether animals around the edges of a field where crops are growing. After the harvest, you can release the animals in the field to graze on the crop residue, or you can tether them in the field to prevent them from straying.

Advantages

- A full-time herder is not needed.
- Tethering is a very flexible method that can be used in many different circumstances.
- It does not require fencing or other expensive inputs.

Disadvantages

- The animal cannot run away from predators.
- The animal may be strangled by the rope if it is tied to a tree.
- The animal must be moved frequently to make sure it has enough feed and shade.

Tethering in the highlands of Ethiopia

There is a serious shortage of grazing land in the highlands of Ethiopia. Farmers keep a small number of livestock (usually a pair of oxen, a cow and a few goats and sheep), which they tether around the homestead, on the edges of crop fields, and along roadsides. It is a good way of using land that would otherwise be unused. In areas with intensive cash crops, such as coffee, qat (*Catha edulis*) and vegetables are grown, farmers tether their animals all year round. In places where annual food crops are grown, farmers tether the animals only in the wet season, and in marshy bottom land in the dry season. They give the tethered animals additional feed such as crop thinnings, weeds and

hay. — *For more information, contact Kettema Yilma, FARM Africa-Ethiopia.*

Requirements

- Pegs.
- Rope.

Procedure

1. Tether each animal separately to a peg using a rope. Make the rope long enough so the animal can reach sufficient forage, but not so long that the rope will become tangled in bushes. For cattle, you can tie the rope around the animal's neck or one of its front legs. It is best not to tie a goat or sheep by the leg as it may break its leg if it is startled.

2. Move the animal at least three times a day.

3. Provide water to the animal, or bring it to a watering point, at least twice a day.

4. At night, bring the animals into the kraal.

Do's	**Don'ts**
o Use a strong rope, preferably made of sisal.	o Don't tether animals to a tree, as they can go round and round the tree and strangle themselves on the rope.

Poultry manure as a cattle-feed supplement

Poultry manure makes an excellent feed supplement for cattle, goats and sheep. It is high in urea, a source of nitrogen, which improves the environment in the animal's rumen (stomach). This helps use the feed more efficiently and easily, making the animal better nourished with whatever feed is available.

Location

Feeding poultry manure is useful where large numbers of poultry are kept in houses. Cattle-raisers can use the droppings from their own poultry, or get manure from chicken farms.

Advantages

- The urea in the manure makes the animals healthy and fat.
- Poultry manure is readily available.

Disadvantages

- Poultry manure can carry bacteria that cause salmonella and coccidiosis disease. Animals that eat it may become ill if the manure is not sun-dried well enough.

Requirements

- Bag or container for manure.
- Sieve, shovel.

Procedure

1. Remove the manure from the poultry house and dry it in the sun. Important: it must be dried well to kill any bacteria in the manure and to prevent mould.

2. Break up lumps in the dried manure and sieve it to remove wood, stones and nails that can harm the cattle.

3. Mix the powder with other feed supplements such as bran, maize and the powder left over from milling grain. You need to mix the manure with other feeds because otherwise the cattle may refuse to eat it.

4. Feed this mixture to the cattle. The manure from 100 chickens is enough for 1-4 cattle.

5. You can keep the dried manure in bags for up to 2 months in a dry, airy place (such as under the roof).

Do's	**Don'ts**
- Dry the manure properly in the sun to kill any bacteria. - Feed dairy cows with the manure-concentrate mixture once a day. You can feed	- Don't give the manure mixture to young cattle less than 5 months old, or to sheep and goats less than 3 months old. They can catch salmonella and coccidiosis easily, and their rumens have not yet developed enough to be able to digest the manure

non-dairy animals with the mixture twice a day. o If you store the manure, keep it dry.	properly. o Don't feed wet manure.

Poultry manure as a cattle-feed supplement

Poultry manure makes an excellent feed supplement for cattle, goats and sheep. It is high in urea, a source of nitrogen, which improves the environment in the animal's rumen (stomach). This helps use the feed more efficiently and easily, making the animal better nourished with whatever feed is available.

Location

Feeding poultry manure is useful where large numbers of poultry are kept in houses. Cattle-raisers can use the droppings from their own poultry, or get manure from chicken farms.

Advantages

- The urea in the manure makes the animals healthy and fat.
- Poultry manure is readily available.

Disadvantages

- Poultry manure can carry bacteria that cause salmonella and coccidiosis disease. Animals that eat it may become ill if the manure is not sun-dried well enough.

Requirements

- Bag or container for manure.
- Sieve, shovel.

Procedure

1. Remove the manure from the poultry house and dry it in the sun. Important: it must be dried well to kill any bacteria in the manure and to prevent mould.

2. Break up lumps in the dried manure and sieve it to remove wood, stones and nails that can harm the cattle.

3. Mix the powder with other feed supplements such as bran, maize and the powder left over from milling grain. You need to mix the manure with other feeds because otherwise the cattle may refuse to eat it.

4. Feed this mixture to the cattle. The manure from 100 chickens is enough for 1-4 cattle.

5. You can keep the dried manure in bags for up to 2 months in a dry, airy place (such as under the roof).

Do's	**Don'ts**
o Dry the manure properly in the sun to kill any bacteria. o Feed dairy cows with the manure-concentrate mixture once a day. You can feed non-dairy animals with the mixture twice a day. o If you store the manure, keep it dry.	o Don't give the manure mixture to young cattle less than 5 months old, or to sheep and goats less than 3 months old. They can catch salmonella and coccidiosis easily, and their rumens have not yet developed enough to be able to digest the manure properly. o Don't feed wet manure.

Leucaena tea as a feed supplement

Leucaena leaves can be used to prepare a "tea" mixture which can be used as a daily feed supplement for cattle, or as a treatment to strengthen weak animals. This practice has been used for 5 years by the Baraka Farm in Molo, Kenya with mature cattle (not calves), but could probably also be used with goats and sheep. The tea mixture is especially effective for weak or sick animals.

Because leucaena leaves contain mimosine (a substance that can be toxic in large doses), the animal should not be given too much of the tea, or it can become ill.

Advantages

- The animals benefit faster from the nutrients in the leucaena than if they eat the leaves.
- The tea can be used as a daily supplement to improve the nutrition of ruminants.

Disadvantages

- This practice has not been systematically tested and assessed. Further research needs to be done.

Requirements

- Leucaena leaves (about 30 kg of green material).
- Large drum (eg, a 44-gallon drum).
- Sack made of porous material such as sisal (eg, a fertilizer bag).
- Pole, rope
- Plastic sheet to cover the drum.

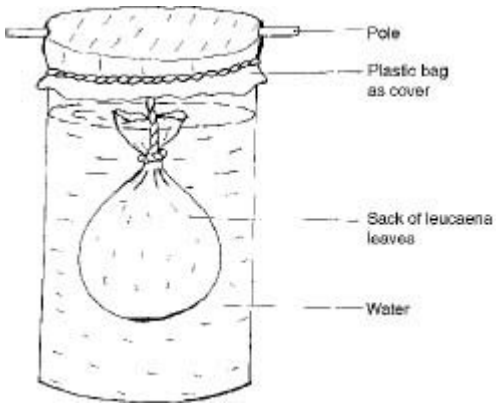
Procedure

1. Chop 30 kg of leucaena leaves into small pieces.

2. Put the chopped material in the sack.

3. Fill the drum three-quarters full of water (about 120 litres, or 33 gallons).

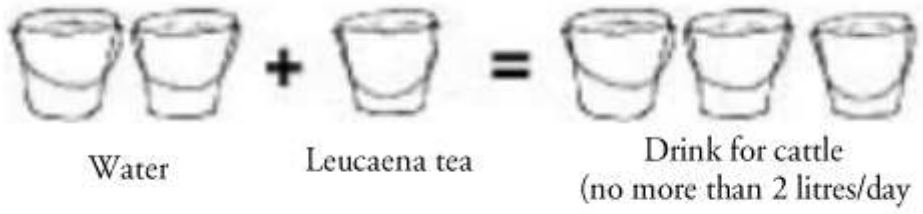
4. Tie the sack of leucaena leaves to the pole, and suspend it in the drum. Cover the drum with a plastic sheet and tie it tightly to prevent nitrogen from escaping.



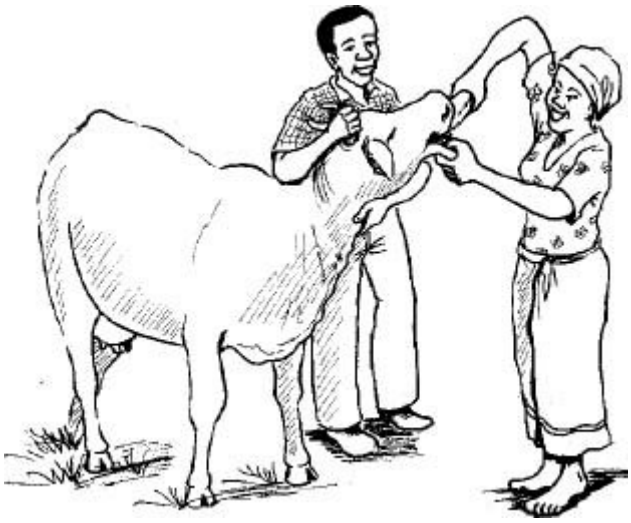
5. Leave the sack in the water for 14 days to ferment. Stir it every 3 days.

6. After 14 days, remove the sack from the water. The tea should be used within 5 days of removing the sack.

7. Dilute the tea with two parts of water for each part of tea.

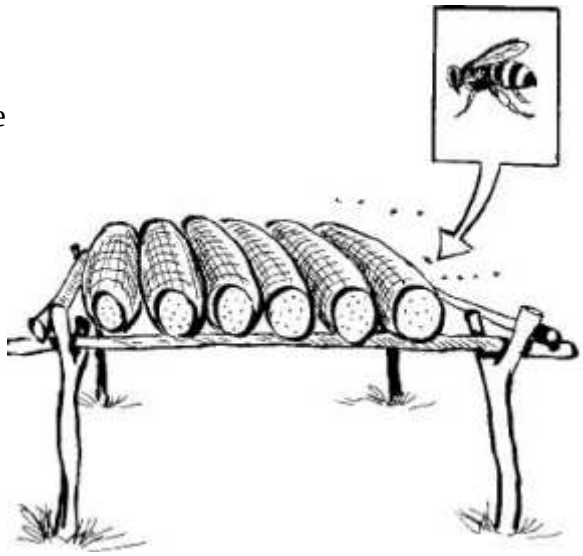


8. For a mature cow (350-450 kg), give no more than 2 litres of diluted tea per day. Offer the diluted tea to the animal to drink. If it will not drink, put the liquid in a bottle and force the animal to swallow it.



Do's	**Don'ts**
o As a feed supplement, give the tea to the animal every day. As a supportive treatment, give the tea to a sick animal each day for 3 days.	o Don't overdose the animal. Give only the recommended dosage.

Bee-keeping



Bees are traditionally an important part of small-scale integrated farming systems. They are vital contributors to pollination and crop production, and they produce honey, beeswax and other products.

Location

Bees thrive in a wide range of warm, tropical climates and topography. They do well near natural forests and on integrated farms with abundant water and flowers.They do not survive in excessively cold, hot or dry locations.

Advantages

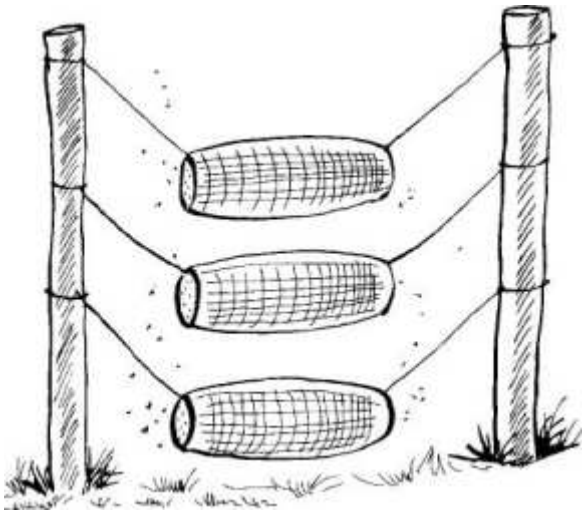
- Bee-keeping does not require a large piece of land or a land title.
- Bee products provide farmers with an additional source of income. Both local and international markets are readily available.
- Bee-keeping requires a minimal amount of labour and no external inputs such as fertilizers or pesticides.
- Bee-keeping skills are simple and easy to learn. Parents normally pass these skills on to their children.
- Planting various flowers to attract bees helps maintain a range of insect life, maintaining the biological balance and controlling insect pests.
- Bee-keeping encourages minimum tillage in the acre (0.4 ha) around the hive, since oxen or noisy equipment may disturb the bees.
- Honey has many uses. It is used as a medicine for humans and livestock. It is a symbol of social prestige and is used to pay bridal dowries. In some cultures, an exchange of honey symbolizes the settling of major conflicts. Honey is also used as a food-preservative.

Disadvantages

- Bees may be killed by chemicals such as insecticides and pesticides.
- Bees may sting the careless. They can become aggressive if they are not handled correctly, or if they are disturbed by children or animals.
- Bees may not survive prolonged rain or drought.

Protecting bees from predators and poisoning

Ants and birds (bee-eaters) are the main predators of bees. Below are some ways of protecting bees from these predators and from chemical poisoning.



Ants

- Hang the hives from ropes and smear the ropes with grease or other substances to prevent ants from reaching the hive.
- Sprinkle wood-ash around the hive-poles to hinder ants.
- Keep the surroundings free of tall grass and weeds, so you can spot ants from a distance.
- Smoke ants away from the hive by setting fire to an old cloth on the ant path.

Bee-eaters

- Use a scarecrow to deter bee-eating birds.
- To deprive the birds of perches, do not grow tall, branching trees near beehives, or keep the branches trimmed.

Chemicals

- Weed manually or with a machine, rather than using herbicides that may harm bees.
- If it is necessary to use chemical insect control, seal beehives temporarily with cow dung or mud until the insecticide has dissipated. Find out when nearby farmers plant to use chemical insecticides so that you can protect the bees by sealing the hives.
- Grow flower-bearing crops, vegetables, shrubs and trees to keep bees around the homestead. This will protect them from the danger of being poisoned by pesticides used by distant farmers.
- Avoid any form of chemical spray around the hives.