In partnership with the
UNITED NATIONS DEVELOPMENT PROGRAMME – LESOTHO

Sustainable Land Management Toolkit

MINISTRY OF FORESTRY AND LAND RECLAMATION – GOVERNMENT OF LESOTHO

[December 2014]

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Foreword by the Technical Advisor

The production of this toolkit has been a long journey in the dark without a compass for orientation and consists of several phases:

Phase 1: Review of Existing Departmental Operations manuals.

The Toolkit Development Inception meeting was held in the boardroom of DRRM in May 2012. It was agreed that all the existing operations manuals in the three departments of the MFLR should be reviewed and harmonized into a single document to make operational the SLM techniques component of SLM Model for upscaling. To accomplish this, a team consisting of three representatives from each department to be lead by the SLM Technical Advisor was established. No clear terms of reference were stipulated, but it was agreed that all operations manuals should be provided to the team. The provided documents and any other materials that the team might find relevant should be used to produce the Toolkit (not manual). The team initially consisted of one member from each of the Forestry, Soil and Water Conservation Departments and three members from Range Resource Management. At its first meeting, attended by these six officers, the SLM techniques as presented in the **SLM Model Document were reviewed**, and the following outline was adopted for the Toolkit Document:

1. Overview of the background of SLM Techniques within integrated watershed management
2. Forestry Techniques
3. Range Land Management Techniques, including protection of the wetlands
4. Soil and Water Conservation Techniques, including agronomic techniques

Phase 2: Transformation and harmonization of the departmental operations manuals into SLM Toolkit document.

The purpose in this phase was to produce a simple document for use by field staff to train each other and the communities (user groups) in the basic principles and practices of sustainable natural resource management. For each of the techniques stipulated in the SLM Model, a single power point slide was to be produced to include the following basic aspects of the technique: **definition** of the technique (what it is); **implementation/operation/construction** of the technique (how it is done); **benefits** of the technique (why it is necessary to adopt the technique); and **sustainability** aspects of the technique (what is required to ensure that the practice is sustained and its benefits last). In each of the slides, two additional pieces of information are provided: images to illustrate the technique as applied in Lesotho (or elsewhere) and a provision of elaboration of the slide text and images in the note section of the slide.

Acknowledgements

Fig. 1 Boreipala School

The production of this document would not have been completed without the assistance of several people and institutions: the Ministry of Forestry and Land Reclamation, UNDP Lesotho Country Office and GEF Regional Office bore the burden of costs developing this document through their financial and logistic support.

The SLM Project Manager guided the initiation of the document production, MFLR Technical team supported the teams assigned in this task to the best of their ability amid other commitments of the team members. The SLM Finance Officer is thanked for his facilitation of the meetings of the team and making arrangements for the success of the Validations Report. Without him and his team of dedicated drivers and the assistance of SLM Project Officer, the task would not have been brought to the success it had.

Last but not least, the Technical Advisor sends a vote of thanks to the team members who often had to work at abnormal hours and under pressure without any support in the form of food or transport. The Principal Secretary and the Directors of the three departments of the Ministry made all this possible by assigning to the task a hard working and dedicated team. Thanks goes to the rest of the staff of the Department of Range Resources Management who often had to be interrupted in their normal duties to cater for the unscheduled meetings of the team. The DCs' offices greatly contributed by supporting the team and making it possible for the participants of the validation workshop. The contribution of this group has been highly appreciated and has made the document more inclusive in its scope.

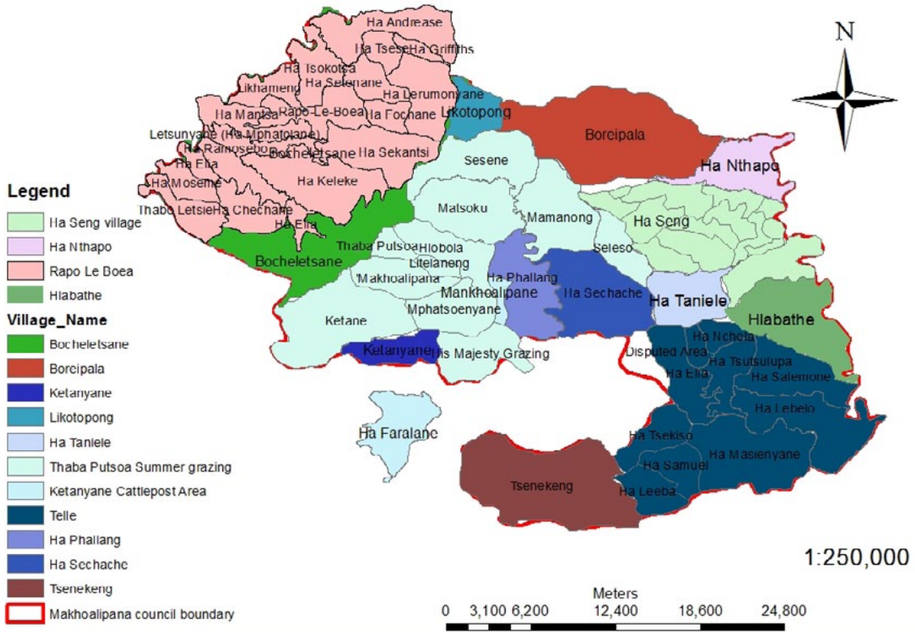

Fig. 2 Makhoalipana Council, Maseru District Map

SLM Pilot Area: Makhoalipana Council, Maseru District

Ideally, the techniques presented here should be the outcome of the tested practices within the pilot project area (Makhoalipana Community Council) at Semongkong in Maseru District. But, the coverage has been very limited in terms of what is available for practice. Because of these limitations, this toolkit is a generic presentation of what has been and is being implemented and tested in various areas of Lesotho. The techniques that have been in practice for over 60 years are the physical land protection techniques. They originally started as measures to address critical depletion of indigenous forest because of over harvesting for fuel and construction purposes, as well as a loss of agricultural productivity because of high rates of soil loss due to rain and wind erosion. Initially, these conservation measures were heavily structural, but over time biological measures and management practices have been introduced. The management of other natural resources and the general environment only started to be considered seriously in 1972. The major criticism of the SLM practices in Lesotho is lack of a unified, holistic framework which maximizes the benefits of the practices. They are implemented in "silos" with heavy sectorial bias even in the same ministry.

The Ministry of Forestry and Land Reclamation houses the departments that have tested and implemented various approaches that have the elements that can be incorporated into a coherent SLM Model to address problems of natural resources management. Therefore, the SLM Model developed within the Ministry has listed SLM techniques that can be used for upscaling of the project. This document is derived from harmonization of the current departmental operational manuals into a generic tool for the delivery of SLM and supports Lesotho SLWM-SIP which is developed to spear-head SLM Practices in the country.

Fig. 3 Thaba-Putsoa Landscape. The horizon rises to heights at about 2900 m. and the foreground, with a high density of shrubs, lies at 2600 m and houses the wetlands which store water from the steep slope above

The main purpose of the document is to assist the MFLR field staff to address the problems of **natural resources management** within the framework of **integrated watershed management**. As such, the field staff need to approach the problem in a holistic, non-departmentalized form.

1. Integrated Sustainable Watershed Management (IWM)
2. Approach
3. Land Management Techniques:
   - **a)** Forestry and Agro Forestry Techniques
   - **b)** Range Resources Management Techniques
   - **c)** Agronomic Techniques
   - **d)** Soil and Water Conservation Techniques

Document Outline Continued

The document layout is as outlined on the previous page. The first section introduces the concepts and definitions relating to **natural land resources management** models and approaches. It opens with the introduction of the SLM techniques as suggested by the model development in Lesotho whereby the techniques are described under the following headings:

Forestry and Agro-forestry Techniques » This session describes several approaches to forestry-related problems and techniques practiced in Lesotho; it deals with the management of indigenous and exotic forest resources to ensure their sustainability as well as the enhancement of community livelihoods from forest-related products. The description is illustrated by examples from Lesotho and outside of Lesotho.

Range Resources Management Techniques » These techniques address the main constraints in the management of range resources for livestock production and to maintain and enhance the biodiversity of the rangelands of the country. This also includes the importance of vegetation in climate change adaptation, improvement of the water resources base and protection of the soil in the rugged terrain of the highlands of Lesotho.

Soil and Water Conservation Techniques » The techniques are treated under two main categories; namely, agronomic and structural and techniques including water harvesting. The technique further describes how soil and water resources can be utilized in a sustainable manner.

Introduction to IWM Approach

SLM techniques include best practices that allow land-use systems to adapt to anticipated land degradation problems. Because solutions to the problems of land degradation and low productivity are many and complex, they can only be addressed within a holistic framework (Integrated Watershed Management/Integrated Catchment Management). The techniques needed are either mechanical, structural or biological in nature. SLWM addresses land degradation, loss of biodiversity and livelihood needs of the local communities.

Integrated Watershed Management (IWM) framework

The IWM is the framework to integrate resource management within the communities in a sustainable way. The programme tackles degradation problems of the natural resources that result in land degradation, low productivity and poverty.

Impacts of Land Degradation:

- Soil erosion
- Loss of biodiversity
- Shortage of fuel wood
- Climatic shocks (floods, frequent droughts, landslides)
- Desertification,
- Low agricultural production
- Inadequate water quantity and quality
- Poor access to land resources

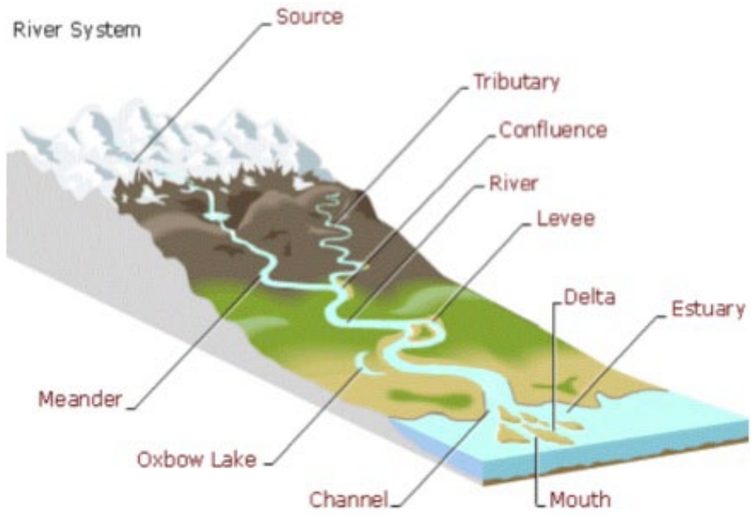

Fig. 4 *The Drainage Basin System.*

Integrated Catchment Approach

The integrated catchment approach is based on the unity of a drainage basin as a **process-response system** in which the morphological components are described in terms of the topographic characteristics of the system, namely:

Topographic characteristics » Relief, length, size, and slope.
Rock and sediment characteristics » Bedrock geology, regolith, and soils.
Land cover (vegetation and land use characteristics) » Biome and human uses of land for various purposes (cropland, pasture, recreation, settlements).

These characteristics then interact with the hydrological system described in terms of:

Inputs » Precipitation from the atmosphere into the watershed.
Throughputs/transfers » Runoff, infiltration, percolation interflow, through-flow, groundwater flow, evapotranspiration, and sediment transport.
Storages » Interception storage, surface storage, soil moisture, groundwater storage, and sediment storage.
Outputs » Water and sediment discharge, evaporation, and transpiration.

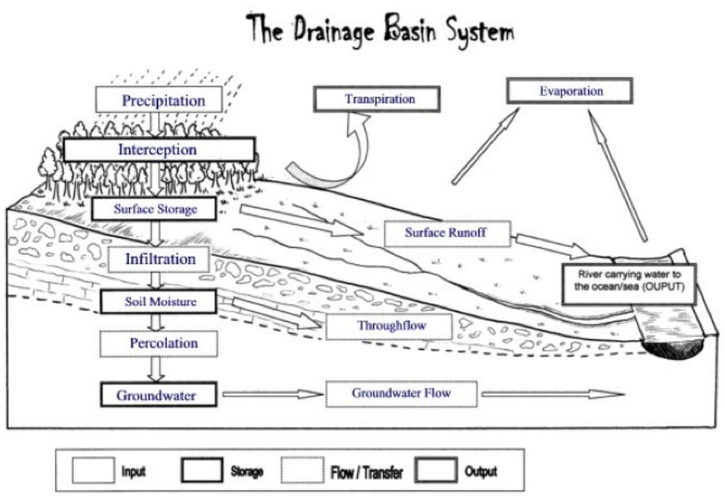

Fig. 5 This cross-sectional view of the drainage basin is provided here to simplify the conceptualization of the watershed functions processes

Definition of Concepts & Rationale for the Approach

Sustainable land management is defined as, "the use of land resources holistically for the production of goods and services to meet changing human needs, assuring long term maintenance of its productivity".

Efforts required to attain sustainable land management:

» Reduction of land degradation
» Improvement of productivity
» Maintenance of resources base for the benefits of present and future generations

The nature of the appropriate approach:

» Participatory, collaborative and integrated planning
» Application of appropriate and acceptable practices
» Avoidance of inappropriate land management
» Avoidance of exploitation of the natural resources

Means to achieve these goals:

» Capacitating and empowering the communities
» Strengthening the capacity of watershed managers (field services, user groups)
» Implementation of techniques with available local resources
» Dissemination and sharing of information through a strengthened information network (visits, manuals, posters, articles, newsletters, internet)
» Building integrated watershed management practices into government strategies and policies

Approach Effectiveness & Sustainability

The approach uses methods and techniques that aim to **reduce land degradation and improve productivity** without depleting the resources to benefit the present and future generations. The techniques will, therefore, aim to address environmental, economic and social demands. The integrated approach is likely to meet these challenges more holistically.

The question of approach to the programme is whether the programme can be sustained or be a sustainable programme. While SLM is intended to target the landscape, socioeconomic priorities should also get attention.

A more participatory, collaborative and integrated planning is needed to sustain the programme. The essential components of the model should apply appropriate and acceptable practices and avoid inappropriate practices and exploitation of the resources. In order to achieve this, we need to enhance and empower communities through training and promote implementation of the techniques that rely on available local resources and knowledge. Dissemination and sharing of information through exposure visits, network manuals, posters, articles and news letters where feasible need to be strengthened.

To be effective, the integrated watershed management practices should be built into the government strategies or policies, especially among the mountain communities. Capacity of the watershed managers should be strengthened in order to upscale the interventions.

Generic Grouping of SLM Techniques

Grouping is based on the type of land use and divides the techniques into **cultivated** and **non-cultivated**:

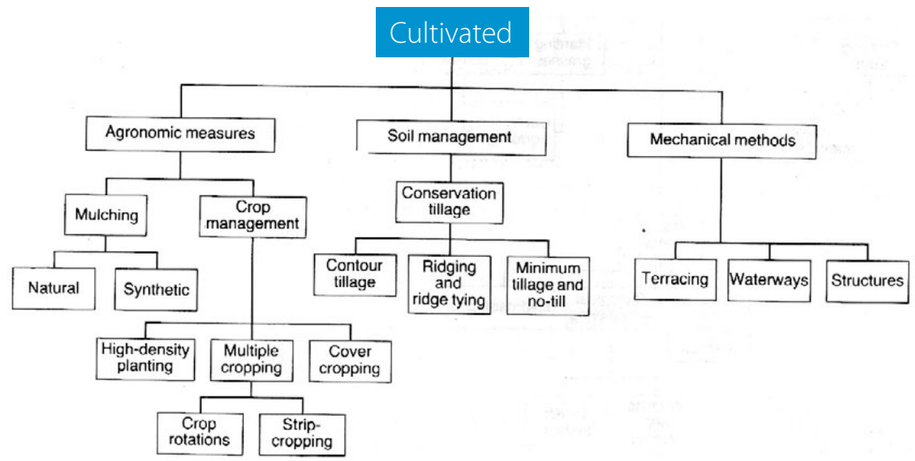

Fig. 6 Cultivated Techniques

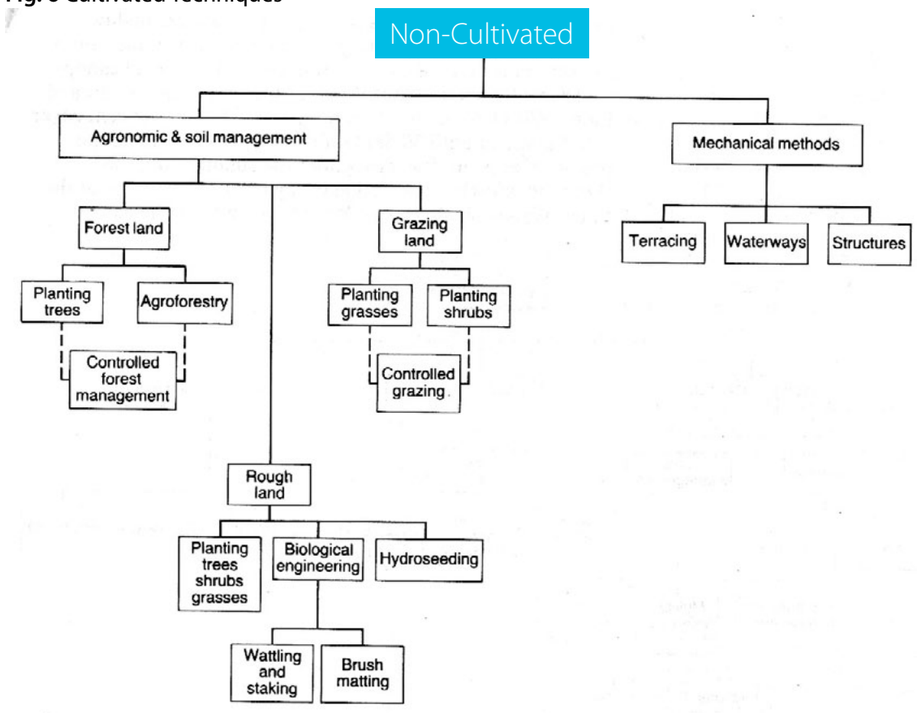

Fig. 7 Non-Cultivated Techniques

There are several approaches of integrating these techniques within the drainage basin (watershed) or landscape. **The most efficient and comprehensive way** of dealing with this is portrayed in the diagram below (Morgan 1986:167):

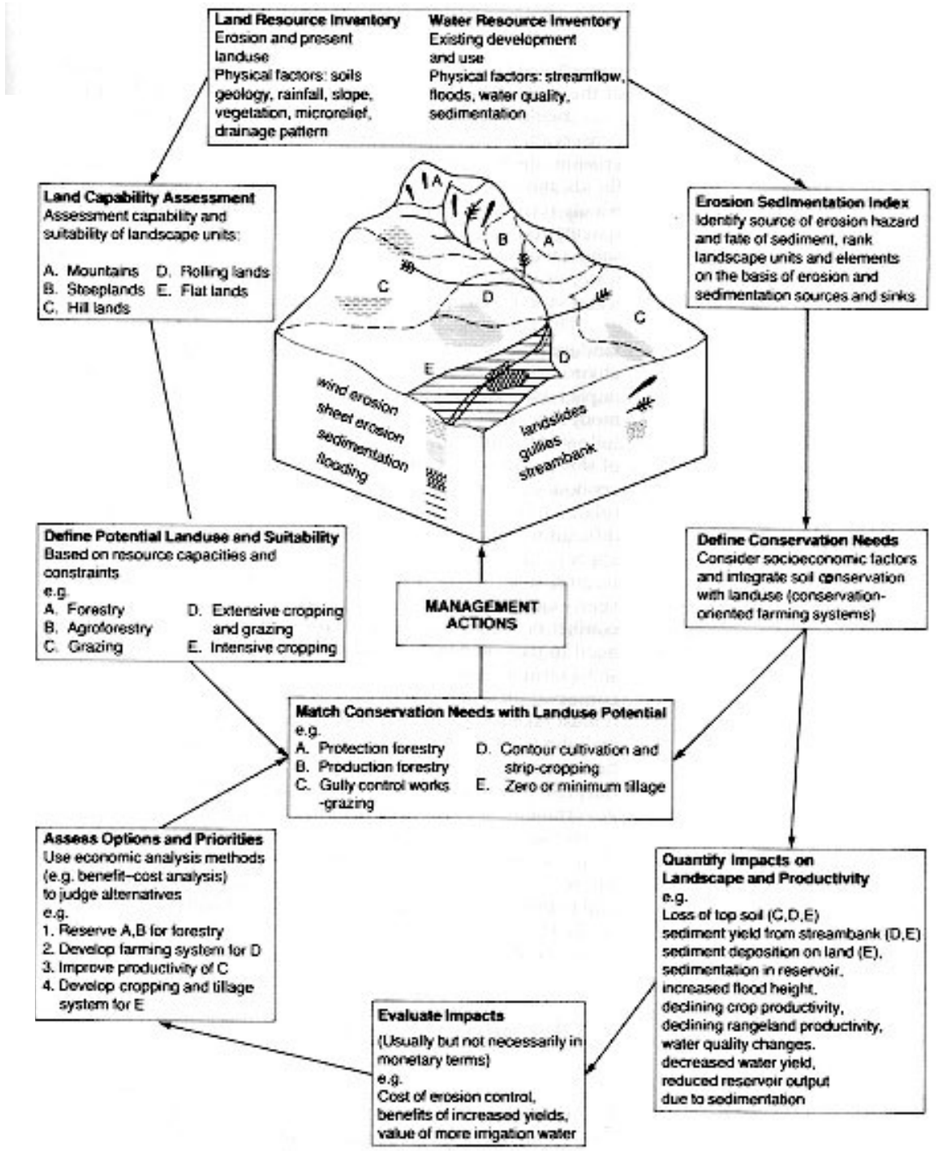

Fig.'s 8a & 8b This diagram was originally intended to guide the logical sequence of the design of soil conservation strategies

Generic Grouping Strategies

This strategy is normally made operational by use of strategies appropriate to each of the major land use categories: **cultivated or non-cultivated (rangeland complex, including forestry)**

Suggested steps for soil conservation:

1. Land and water resources inventory
2. Production of a sound land use plan
3. Management actions
4. Quantification of impacts and benefits of the proposed (implemented) strategy
5. Economic evaluation programme (several levels)
   - a) House-hold level
   - b) Community level
   - c) National level
   - d) Global level

Grouping adopted in this toolkit is slightly different and is aligned with the operations manuals from which they are gleaned.

The nature of the appropriate approach:

- » Forestry and agroforestry techniques
- » Rangeland management techniques
- » Soil and water conservation techniques

SLM Techniques in the Drainage Basin Context

The main tasks of the SLM techniques in environmental protection is to reduce the impact of the erosive power of raindrops and overland flow, and to create surface conditions that will improve surface storage, infiltration capacity, and sub-surface water storage. These conditions will in turn increase the residence time of water within the watershed, fuelling overall ecosystem health. The major objective therefore is to improve land cover. The logical steps in the application of SLM techniques will differ depending on the dominant agricultural practices in the region, the environmental impact of which is the main issue.

Range complex practices follow the logical frame presented below. The dominant SLM practices in this case are agronomic and soil management techniques applied on forest and grazing land. These practices are supported by mechanical methods: terracing, waterways and structures to control or reduce the effects of overland flow.

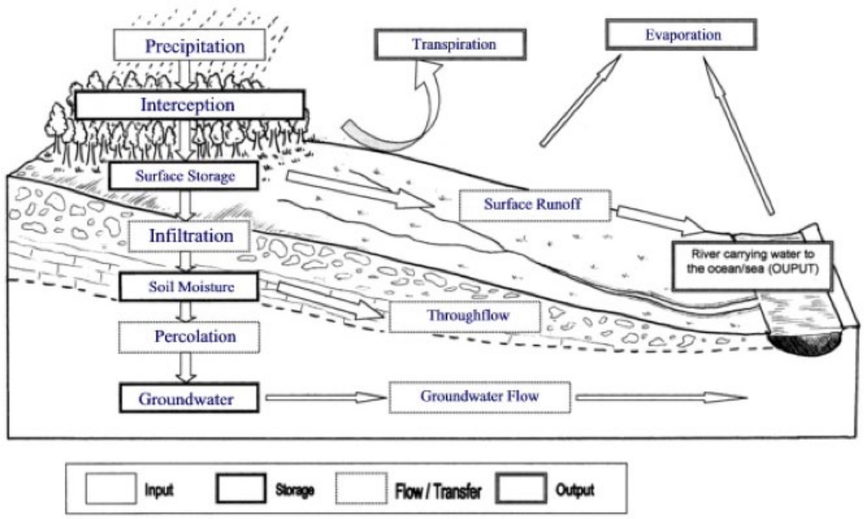

Fig. 9 The Drainage Basin System

The Drainage Basin System

The diagram at the bottom depicts a 3D view of the drainage basin. Like the blood vessels of a human body, the stream channels form the major conduits of the flow of water within a watershed (drainage basin). The form and material properties of the drainage basin control and modify the movement of water through the landscape and, as such, determine the biological quality of the ecosystems within the basin, which are driven by the climate system as the overall controller of avail heat and moisture condition over the watershed.

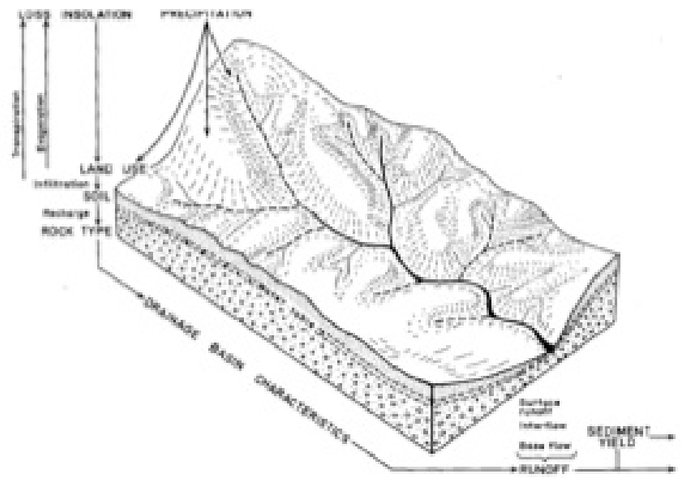

Fig. 10 3D Dissection of the Drainage Basin

SLM Techniques | Section 1

Forestry Techniques

Preface: Forestry Techniques

Fig. 11 A Natural Forest Meets Grassland

Most forestry interventions, since 1973 to date, have viewed the biomass problem as a simple requirement for wood for both cooking and space heating, simply because people were extracting more biomass than the environment could produce in a sustainable manner. Viewed from this perspective, the solution was self evident – if projected biomass demands exceeded supplies, one either planted more trees to shift the supply curve upwards or devised policies to reduce demand and shift the demand curve downward. As a result, foresters have tried to increase tree supplies with various large scale approaches such as monoculture plantations, peri-urban woodlots and community woodlots.

Unfortunately, in this race against time foresters often become technically myopic. They fail to put enough effort into exposing other stakeholders such as forest rangers, farmers, associations, institutions and organizations to basic technical requirements for better seedling survival. Often they are also not able to provide these stakeholders with basic forest management skills for ensuring sustenance and optimal production. Quite simply, before engaging in an afforestation programme, foresters must start with the people that will sustain them. They should not begin by asking how much land is available for planting but how many people are available to plant. They should also establish whether these stakeholders are technically equipped with the required skills to effectively and efficiently engage in the afforestation programme. If not, logic dictates that they will be expected to ensure that there is enough supervision.

1. Afforestation: The Planting Process

Definition: the establishment of a tree crop on an area from which it has always or very long been absent in an effort to protect and rehabilitate the land so as to enhance the ecological and socioeconomic functions.

Fig. 12 Afforestation

Fig. 13 Inappropriate Match

At a glance:
- » Land use
- » Soil type
- » Topography
- » Vegetation cover
- » Ecological status
- » Matching species to site

Site Selection / Matching Species to Site » Forest trees are planted on non-arable lands and areas which are not suitable for range practices. In most cases, the target areas are the ones which are degraded or susceptible to degradation. The site is chosen in such a way that the species to be planted are capable to minimize the erosion and improve the land. The aim is to restore the native vegetation to benefit the ecosystem. Planting trees which are shallow rooted on shallow soils and sloppy areas increases susceptibility of the area to erosion (see **Fig.'s 13 & 14**).

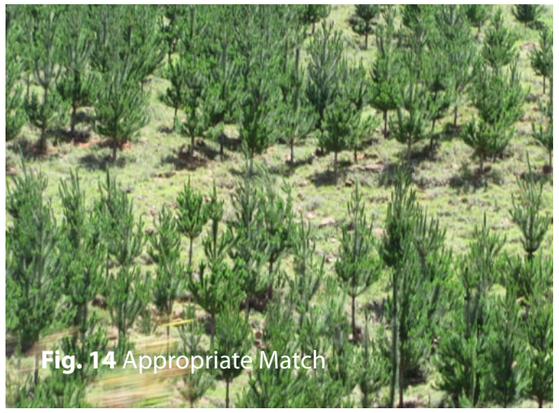

Fig. 14 Appropriate Match

Fig. 15 Pitting

Fig. 16 Thinning & Brushing

Pitting and Planting » Pitting is nothing but creating holes on a chosen site for a tree seedling to be planted (**Fig. 15**). The pits are normally man-made. The spacing is of different specifications based on the desired end product. The end product is determined mostly by the space between plants and rows. The smaller the space between the rows and the lines, the taller and thinner the plants will become; hence for pole production, the spacing is 1.5 m between rows and trees and 25-30 cm in depth. When planting trees for conservation purposes, the spacing is 3 m between rows and tress and 25 cm – 30 cm in depth in order to allow for an open canopy that will allow the growth and survival of surrounding plants. The size of the pit should be 60 cm x 60 cm x 30 cm.

Fig. 17 Fire Belts

At a glance:
- » Spacing between plants
- » Spacing between rows
- » Pit size

Forest Management and Protection (Indigenous and Exotics) » The management of trees depends mostly on what you want to achieve as the end product. The management practices are known as *silviculture* practices. They include, among other practices, thinning, brushing and pruning. Heavy thinning, brushing and pruning are essential in timber production to encourage the growth of stem (volume). The brushes are removed from time to time to avoid knots (**Fig. 16**). In pole production, thinning and brushing are done when necessary.

At a glance:
- » Silviculture practices (pruning, brushing, thinning)
- » Forest protection (fire, encroachment)
- » Fire belts
- » Forest guards
- » By-laws

Protection » Fire belts are constructed to prevent fire from the veld from entering the forests. Forest guards protect the forest from damage by men and/or animals (**Fig. 17**).

1. Afforestation: Benefits & Sustainability


Fig. 18 Afforestation


Fig. 19 Timber Products


Fig. 20 Honey Collection

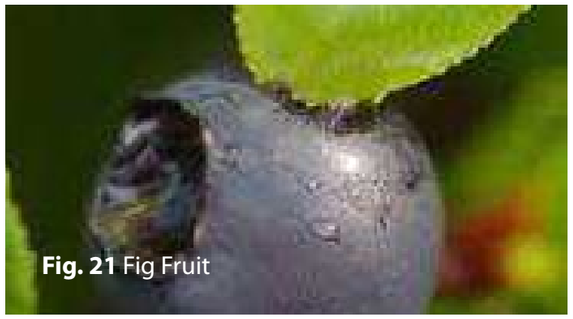
Fig. 21 Fig Fruit

Ecological Benefits

Carbon sequestration helps in the logging of carbon dioxide from the atmosphere that could lead to global warming, resulting in the diversification of flora and fauna. Protected environments enhance water infiltration, thus reducing runoff, an agent of land degradation. Therefore, the ecological benefits of afforestation can be summarized as: **carbon sequestration, biodiversity enhancement, land rehabilitation and habitat generation for flora and fauna.**

Socioeconomic Benefits

Timber Products:

» Timber (sawn wood)
» Fuel wood (head load, truck load)
» Pole production (treated and untreated, **Fig. 19**)

Non-timber Products:

» Mushrooms
» Fruits
» Apian (bee and bee hive) products
» Fodder

Sustainable Practices

The involvement and participation of all stake holders (administrative and traditional leaders, communities, groups and individuals) in tree planting activities is likely to ensure sustainability of forest resources. The provision of timely and good technical assistance from relevant departments is also essential for sustainable management of forestry resources.

2. Fruit Tree Production: The Planting Process

Definition & Requirements: fruit tree production refers to the planting of trees that bear edible fruits, e.g., peaches, apricots, quince, and so on. In most cases, fruit trees are the product of fruit tree seedlings that are raised and tendered in a nursery until they are ready for planting. It is necessary to have a permanent water supply near the nursery as well as the orchard (**Fig. 22**). Allow other vegetation to grow by hoeing around plants only. Budding is one of the operations that is carried out on the trees of peaches, apricots, apples, pears, plums and other fruit trees while grafting is done mostly on vines. All these operations are carried out in an effort to improve the quality of the product. Big trees that bear fruits of desired quality must also be available nearby to provide buds whenever needed.

Site Selection » Fruit tree plantations (orchards) should be placed on a bit of a slope – not on flat surfaces – and face North-East to avoid early and late frost attacks. Sandy loam soil is the best for its ability to absorb water. The site should also be near a permanent water supply and be protected from livestock. The enforcement of the by-laws, their application and the involvement of the community will play a big role in the proper protection of the orchard. Trees can also be planted along contours to protect the soil and to maximise the land's profitability (**Fig. 26, Pg. 22**).


Fig. 22 Orchard & Vineyard Near Water

At a glance:

» Topography
» Ecological status
» Soil Type
» Vegetation cover
» Proximity to water source

Matching Species to Site » Most of peaches do well at lowlands while apples are good on high lands.


Fig. 23 Nursery with Trees to Provide Buds

Fig. 24 Good Spacing

Pitting » Each pit should be spaced 1 m between plants and 1 m between rows. Pit dimensions are 1 m in length by 1 m in width at 0.6 m deep.

At a glance:

» Spacing between plants
» Spacing between rows
» Pit size

Planting » The steps are as follows: place the seedling on the middle of the pit with the root well spread; put back the soil from the pit starting with the top soil; gently step around the pit to firm the soil and water; 20 L of water in the morning and evening during summer and 20 L during the day in winter will suffice for watering the new seedlings.

Fruit Tree Management and Protection » During winter, prune the trees to give them a good shape and to allow for air movement. Start by removing dead, diseased and broken branches and shape the tree. When trees are heavily fruited, remove some fruits starting with bad, small ones to avoid the breakage of leafs. Construct a fire belt to prevent fire from entering the orchard and or vineyard. Apply the by-laws when necessary.

At a glance:

» Tendering operations (weeding, pruning, culling and selection)
» Fruit tree protection (from fires and livestock)
» By-laws

Fig. 25 Orchard

Fig. 26 Planting Along Contours to Maximize Profitability

Fig. 27 Beautification of the Environment & Enhancement of Biodiversity

2. Fruit Tree Production: Benefits & Sustainability

Ecological Benefits

Carbon sequestration helps in the logging of carbon dioxide from the atmosphere that could lead to global warming. Global warming leads to severe droughts and floods and this is likely to affect diversification of flora and fauna. A protected environment provides a good and healthy living space for all living creatures as well as man. Where the environment is not well cared for, there are a lot of different disease outbreaks resulting in high mortality rates. In these environments, there is also a high risk of soil erosion due to poor water infiltration that leads to severe surface runoff which is an agent of land degradation. Therefore, the ecological benefits of afforestation – in this case, of fruit trees – can be summarized as: **carbon sequestration, biodiversity enhancement, land rehabilitation (contour planting), shelter belt creation and habitat generation for flora and fauna**.

Socioeconomic Benefits

When trees are big enough to be pruned, the branches and twigs gathered during the pruning process will provide fuel wood that will be used for cooking food and heating homes during cold days. If the fuel wood obtained is more than enough, it can also be sold in order to generate income. Furthermore, when fruits are ripe and ready, they can be sold either fresh or dry to generate income. Fruits also provide nutrition to the body. When trees are properly planted and well cared for (well pruned), the added greenery will improve the natural aesthetic value of the area. The life standards of rural people can also be improved through sustained employment opportunities. Therefore, the socioeconomic benefits of afforestation – in this case, of fruit trees – can be summarized as: **fuel wood provision (brushes), increased greenery and scenic beauty of the area, production of nutrition-rich food products, and opportunities for income generation in the local community.**

Sustainable Practices

In order to ensure sustainability in fruit production, all stakeholders (administrative and traditional leaders, communities, groups and individuals) should be involved in all activities. The provision of technical assistance from relevant departments is essential. Where the orchard belongs to a society, proper documents specifying the agreement of land tenure, the terms and conditions should be made available.

3. **Agroforestry:** The Planting Process

Definition: land practice in which woody plants are integrated with crops and/or livestock on the same piece of land for ecological and economical benefits in order to minimize the negative outcomes of land degradation.

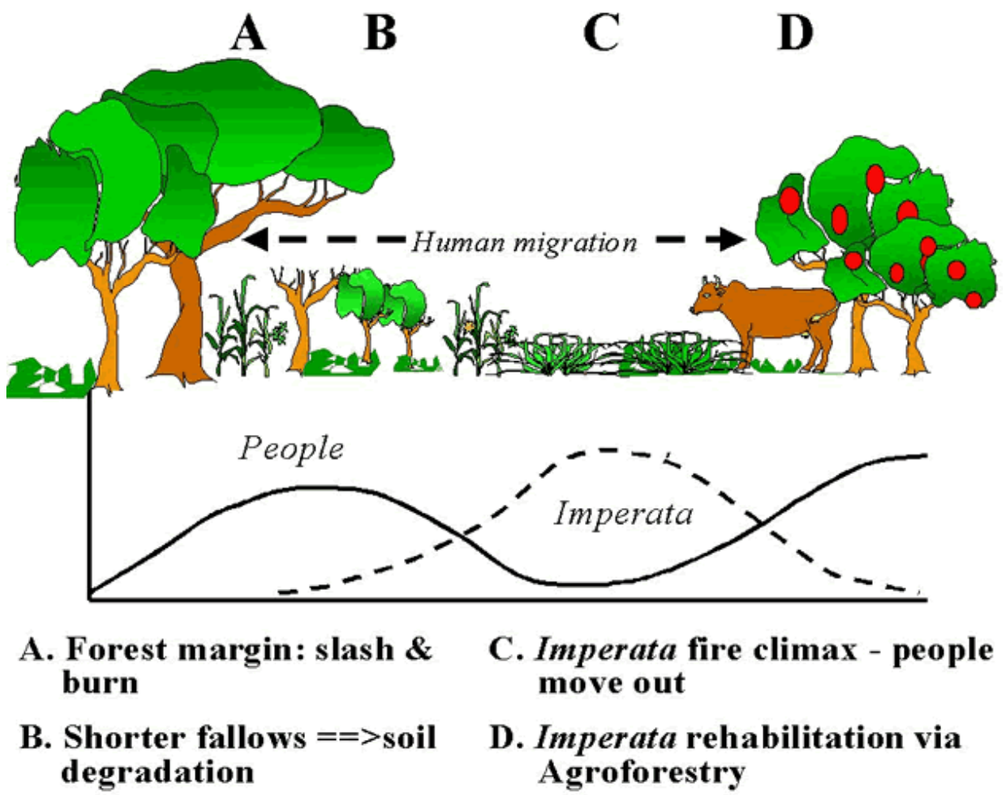

Fig. 28 Agroforestry

Site Selection at a glance::

» Soil type
» Topography
» Vegetation cover
» Ecological status
» Matching species to site

Ploughing and Pitting » Ploughing is done in the normal way. The spacing is 4 m between the lines and 4 m between plants, while the size of the pit should be 1 m x 1 m x 60 cm (depth). The prescribed spacing will allow enough space to plant other crops in between.

3. **Agroforestry:** Ecological Benefits

Trees, plants and animals depend on each other for a living and this interdependence is known as **the life cycle**.

Fig. 29 Planting Crops Amongst the Trees

Ecological Benefits

Crops provide food and shelter for humans and animals. In winter, most of the plants and animals lose their leaves and undergo their dormant stage, while others die completely. When the leaves of such plants, together with some crop residues, undergo the decomposition process they become potential contributors to soil quality in terms of fertility, improvement of texture and structure. Fertile soils will bring about healthy crop trees and grasses. Land covered in crops creates a good habitat for various living creatures. Hence, agroforestry systems are ideal protection for ecological systems.

Furthermore, agroforestry enhances carbon sequestration processes that help in the logging of carbon dioxide from the atmosphere to reduce the risk of global warming, ultimately resulting in diversification of flora and fauna and protection of the environment. Environments with good vegetation cover also enhance proper water infiltration through the reduction of surface runoff and improvement of subsurface storage (soil moisture and ground water). Agroforestry also reduces pressure on natural forests and improves the efficiency of the recycling of nutrients by deep-rooted trees on the site. Finally, it improves the microclimate by lowering soil surface temperature and reducing the evaporation of soil moisture through the combination of mulching and shading. Therefore, the ecological benefits of agroforestry can be summarized as: **carbon sequestration, biodiversity enhancement, improved soil fertility, shelter belt creation and habitat generation for flora and fauna**.

Fig. 30 Livestock Agroforestry

3. Agroforestry: Socioeconomic Benefits & Sustainability

Fig. 31 Increased Quality Food Output

Socioeconomic Benefits

The fertile soils created through agroforestry will produce a high yield of crops that will improve rural living standards through sustained employment and higher income. For instance, it increases income due to improved and sustained productivity in pole production (treated and untreated) for fencing.

Fig. 32 Fuel Wood

Fig. 33 Increased Quality Food Outputs

When agroforestry is practiced on a larger scale, people will be employed permanently since harvesting and selling will be carried out throughout the year because different types of crops are gown together.

An improvement in community nutrition and health will be seen due to increased quality of food outputs (**Fig. 33**) and decreased incidences of total crop failure, which are common to single cropping or monoculture systems. The standardization and improvement of communities will also be seen through the elimination of shift sites of farm activities. This practice also helps in the increment of outputs such as food, fuel wood, fodder, fertilizer and timber (**Fig. 32**). Agroforestry leads to an increase in overall food security (consistent crop yields) and a healthier nation.

Sustainable Practices

It is advised to involve all relevant stakeholders (administrative and traditional leaders, communities, groups and individuals). Assist them with technical knowledge from relevant departments.

4. Bee Keeping: Benefits & Sustainability

Fig. 34 Bee Keepers & Hive Setting

Definition: the rearing of bees for the production of hive products (honey, bee's wax, propolis, bee venom, etc.).

Site Selection » Choose a site with vegetation that can provide flowers throughout the year. The site must be away or at the very least be protected from animals and people. Clean water must be nearby.

Protection: Hive Setting and Management » Wear a proper outfit for bee keeping (**Fig. 34**). The bee hive must face the North-East to allow for longer days. Never open a bee hive before applying smoke when it is windy, during the winter, when it is raining or when temperatures are not conducive.

Fig. 35 Honey Comb Harvesting

Ecological & Socioeconomic Benefits

Bee keeping conserves flora and plays a major role in cross pollination; hence, supporting higher crop yields and consequently increased food security and income generation. Bee products such as sting, honey, royal jelly, pollen and propolis have medicinal value.

Fig. 36 Cross Pollination Supports Higher Crop Yields

Sustainable Practices

In order to ensure sustainability in bee keeping, all stake holders should be involved in all activities. Relevant departments should provide skill when needed.

SLM Techniques | Section 2

Range Resources Management Techniques

Preface: Range Resources Management Techniques

Fig. 37 Mountainous Rangeland

Range management is a discipline and an art that skilfully applies an organized body of knowledge accumulated by range science and practical experience for two purposes: (1) protection, improvement, and continued welfare of the basic resources, which in many situations include soils, vegetation, endangered plants and animals, wilderness, water, and historical sites; and (2) optimum production of goods and services in combinations needed by society. The management of rangeland requires selection of alternative techniques for the optimum production of goods and services with no resource damage. While emphasis is often placed on effects and management of domestic animals, the overriding goal is rangeland resource rehabilitation, protection, and management for multiple objectives including biological diversity, preservation and sustainable development for people.

Fig. 38 Rangeland

1. Grazing Associations: Formation

Definition: a community-based group of natural resource users who collectively have the same objectives for the management of natural resources and livestock improvement on an area declared as a Range Management Area (RMA). It is a community based approach to strategically manage the communal rangeland through the community user groups.

Fig. 39 Steps in Forming a Grazing Association

Grazing Associations (GA's) formed include Village Grazing Schemes (VGS's) and Herders Associations (HA's).

Range Management Areas (RMA's)/Grazing Associations (GAs) are specially designated management units intended to promote sustainable use of rangelands. The diagram above shows the steps followed in the establishment and formation of grazing associations.

First, the community is sensitized on the importance of grazing associations through public gatherings (*lipitso*) as shown in **Fig. 37**. Interested community members are then mobilized to form the association through meetings and public gatherings (**Fig. 38**).

Fig. 40 Community Gathering

Fig. 41 Public Gathering (*Lipitso*)

This step is followed by the election of management and executive committees by members of the association (**Fig. 39**). The committees are then trained on the management skills and general rangeland management issues such as the use of grazing permits, fines and penalties for trespassing on areas closed for grazing, proper stocking rates and the use of grazing management plans (**Fig. 40**). During training sessions, a questionnaire is administered to gather information from association members on their ideas and interests. This feedback is then compiled to form the first draft of the association constitution.

The draft is then presented to the members and other stakeholders for final validation through *lipitso* in preparation for the final document. Once the final document of the constitution is completed, it is immediately presented to the members and then registered with the Law Office. The declaration of the association then follows whereby the Principal Chief declares the association and the range management area as legally constituted with working units.

Fig. 42 Executive Committee

Fig. 43 Association Members

1. Grazing Associations: Benefits & Sustainability

Benefits (GA's/RMA's/VG's/HA's)

A community-based approach is thought to be user-friendly to all range users because its constitution is formulated taking into account all members' ideas. The approach ensures good management of rangelands, that all the rangeland resource users are involved in decision making and that each one is accountable to the consitution. Under user-group management, sustainability is ascertained by the community members' active involvement. **Fig. 41** is an example of a rangeland under good management by grazing association members.

At a glance:

» Community-based approach user friendly to all range users
» Ensures good management of rangelands, ownership, and sustainability

Sustainable Practices

Grazing associations can be sustained through regular attendance of meetings by range management staff to assist the association in the smooth running of their plans and to identify problems that need to be solved. Committee members should continuously be trained to equip them with the necessary skills required to run the association: keeping financial records, and managing conflicts among members of the association and on any other issues of interest. Range resources management staff should collaborate with the relevant ministries/departments to co-ordinate the marketing channels for livestock to enhance off-take from the rangelands.

Fig. 44 Well-managed Rangeland

At a glance:

» Conduction of workshops/trainings
» Monitoring and evaluation
» Collaborate with relevant ministries/departments

2. Range Inventory: The Collection Process

Fig. 45 Inventory Site Mapping

Definition: the process of gathering data on rangeland resources to inform decision making necessary for objective management and monitoring purposes. Range inventory can be carried out either **qualitatively** or **quantitatively** depending on the purpose of the inventory.

Qualitative Vegetation Survey

A detailed method of assessing rangeland health status. Data collected includes both biophysical and geographical information about the area.

Quantitative Vegetation Survey

A simplified estimation of veld condition using Rangeland Inspection data collection forms. The site where inventory is done is mapped and marked on the ground so that it can be easily located during monitoring as in **Fig. 42**, because the assessment has to be done at the same place. **Fig.'s 43 & 44** show range management technical staff carrying out qualitative vegetation survey. The remaining images show plant identification and cover observation (**Fig. 43**), clipping for determination of forage (**Fig. 44**), and the weighing of the clipped sample to enable expression of forage in kg/ha (**Fig. 45**).

Fig. 46 Qualitative Vegetation Survey Taking Place

Quantitative Data Collection

Data collection is done using standard forms for each assessment; however, similar indicators are used to assess the rangeland health, the following of which are:

1. Degree of soil stability and watershed function » assessed from bare soil patch and presence of soil erosion indicators such as rills and gullies, sheet erosion and sedimentation.

2. Nutrient cycling and energy flow » assessed by plant composition, distribution of plant species and litter. **Fig. 43** shows technical officers carrying out plant identification exercises on the line transect.

3. Presence and functioning of rangeland recovery mechanisms » assessed by plant vigour and presence of seedlings and grass tufts.

From these measured indicators, the rangeland condition is evaluated and the grazing capacity is determined.

Fig. 47 A Quartet Assesses Rangeland Vegetation

2. Range Inventory: Benefits & Sustainability

Benefits

Rangeland inventory is an evaluation tool used to assess the status of rangeland vegetation. For example; **Fig. 44** shows a quadrat being used to assess rangeland vegetation. The assessments are used to track changes or rangeland trends through constant monitoring.

At a glance:

» Provides information on the status of rangeland resources for proper planning
» Allows for the regular assessment of degradation statuses
» Enables monitoring of impacts of management interventions
» Allows for identification of remedial measures

Sustainable Practices

Competent technical staff are needed for plant identification, soil stability and watershed functioning determination. Local authorities should be informed. The presence of trained range riders is important as they assist the technical staff in carrying out the assessments and enhance ownership of inventory work by the communities.

Necessities:

» Competent technical staff
» Participation of relevant stakeholders
» Existence of trained range riders

Fig. 48 A Clipped Sample is Weighed to Determine Forage

3. Grazing Plans: Development

Definition: a schedule for proper use of rangeland resources to suit community needs and to sustain ecosystem services. The objective of the use of a grazing plan is to improve or maintain rangeland health as well as forage production while optimizing plant and animal performance. The plan can be presented either as a map or a time-table (**Figs. 46 & 47**). For efficiency these two should be used together.

The development of a grazing plan involves determining the following:

1. Type and number of livestock being grazed » This process involves determining carrying capacity and establishing seasons of use based on rangeland condition.

2. Number of grazing units required and establishing boundaries for each unit » This is done based on the forage yield available and the type and number of animals to be grazed. **Fig. 46** is a map showing the grazing units established and their boundaries as well as time (in months) for use.

Fig. 49 Grazing Units & Their Monthly Usage

3. Period of use for each unit » Grazing schedules should provide periodic rest from grazing during critical growth periods. Rest times should match the ability of the plant species to recover from grazing. This time promotes plant vigour, reproduction, and productivity. **Fig. 47** also shows a grazing plan in a table form and shows clearly the time in months of user (depicted in different colours) and the period of rest for each grazing unit.

4. Availability of water for livestock

Sustainable Practices

Competent technical staff are needed for plant identification and soil stability and watershed functions determination. Local authorities and the community should be involved throughout all steps to ensure ownership.

Fig. 50 Rotational Grazing Chart

Grazing Area	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
Nkholi												
Thaba-Chitja												
Khohlong ha motsu												
Cattle Post												

Development of a grazing plan » analysis is conducted of rangeland inventory, livestock registration and livelihood mapping. Suitable times and duration of grazing for each grazing unit are allocated.

4. Grazing Plan Management

Implementation Steps

1) Rotational grazing
2) Review and updating of the current grazing plan
3) Allocation of permits to access rangeland resources

1. Rotational Grazing

The rangeland is divided into sections or units and a certain number of animals (depending on the grazing capacity of the rangeland) is rotated between grazing areas within specified periods of time as shown in **Fig. 48**.

2. Review and Updating of the Current Grazing Plan

Following every annual rangeland inventory or inspection a grazing plan is reviewed and updated.

3. Allocation of Permits to Access Rangeland Resources

Permits are official documents that rangeland resource users need to access rangeland resources in a particular grazing area at a given time (Grazing permits, Traditional Healer's Licence).

Rules for Governing the Use of Grazing Units

1. The grazing permit should at all times be available for inspection where animals graze to verify that livestock on grazing land correspond to what is in the permit.

2. The grazing area where the animals are found grazing should be the same as indicated on the grazing permit.

3. The owners of livestock who fail to abide by the rules are liable to pay fines as indicated by the Range Management and Grazing Control Regulations of 1980 and the subsequent amendments of 1986,1992, 1993,1995 and 1996. An official receipt should be issued for that payment.

4. Grazing Plan Management: Benefits & Sustainability

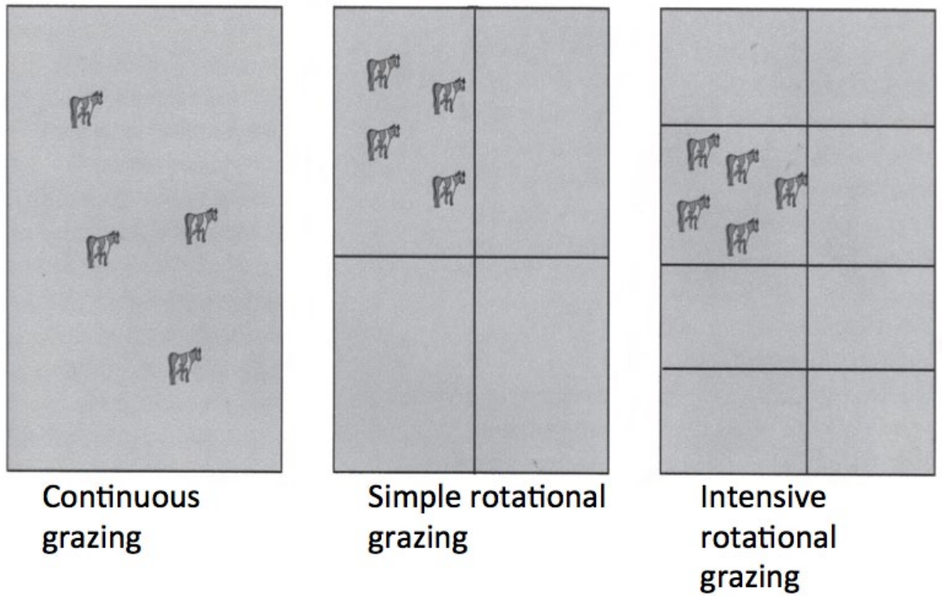

Fig. 51 Rangeland Division Patterns

Benefits

The monitoring and evaluation of the grazing plans helps in determining degradation at early stage and thereby counteracting when necessary.

At a glance:

- Reduced frequency, intensity and extent to which plants are grazed
- Improved ecosystem functions of the area
- Increased forage production
- Improved water availability and quality
- Reduced soil erosion and enhanced water infiltration
- Enhanced organic matter content.

Sustainable Practices

At a glance:

- Issuing of permits and ensuring proper use of rangeland resources
- Competent technical assistance from the relevant section
- Participation of relevant stakeholders
- Active involvement of trained range riders
- Rules governing the use of permits are strictly followed

Definition: management practices aimed at restoring degraded rangeland areas, which include **pasture rest, re-seeding and brush control**.

Fig. 52 Over-Grazed Rangeland

5. Rehabilitation of Rangelands

Pasture Rest

Definition: the withdrawal of an area from grazing by livestock for the period of one or more years.

Rangeland inspection is carried out to identify areas with unpalatable grass species and shrubs (Fig. **50**), bare patches (**Fig.'s 49 & 51**) and burned areas (**Fig. 51**). Such areas are delineated by beaconing or fencing them off to protect them from grazing. The proper rest period depends on the condition of the area, but it is usually a year or more. The areas are then declared as protected through public gatherings. Finally, the public is made aware of the boundaries and the actual closing date of the areas.

Steps Involved:

1. Identification of denuded and/or burned areas (**Fig.'s 13,14 & 15**)
2. Delineation of such areas
3. Determination of rest period
4. Closing an area from grazing

Benefits

Allows the forage to regain vigour and reproduce, which in turn helps to improve rangeland health. Pasture rest also provides opportunities to implement relatively long-term rangeland improvement practices (e.g. reseeding and brush control).

Sustainable Practices

Use prescribed grazing as part of an integrated management approach needs to be followed following the advise of competent technical assistance from the relevant section of the Ministry. The community and local authorities should be involved through all the stages of the setting aside an area from grazing and use of grazing permits should be adhered to.

Fig. 53 Sehalahala

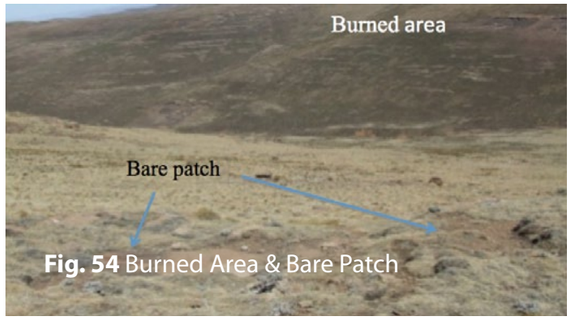

Fig. 54 Burned Area & Bare Patch

Fig. 55 Shrub Control

Fig. 56 Micro Pitting & Re-seeding

Fig. 57 Shrub Control

Shrub Control

Definition: the removal of invasive and undesirable shrubs from the rangelands. This process involves manual pulling or hand removal using simple hand tools such as a hoe or pick axe (**Fig. 52**).

Bush control changes rangeland vegetation from dominance by woody vegetation to dominance by herbaceous vegetation as forage production increases with reduction in woody species. Invasive shrubs impose competition for light, soil moisture and soil nutrients. Most shrubs outcompete the grasses because they have deeper root systems and produce a large number of seeds which are dispersed faster and have shorter dormant times for germination. Manual and mechanical techniques such as hand pulling and cutting are used in controlling bush encroachment (**Fig.'s 52 & 54**). This method targets unwanted woody plants and creates a competitive space for desired herbaceous plants; thus, improving productivity and biodiversity in rangelands.

Reseeding/ Re-vegetation of Rangeland

Reseeding can be done post-fire, after brush control or where bare patches exist. This process rapidly establishes a desired plant community thereby reducing the likelihood of infestation by invasive plants. Broadcasting and micro pitting (**Fig. 53 & 55**) are two main methods used. **Broadcasting** is the scattering of seeds using a hand or grass seeder. It is done in larger areas with minimum slope (less than 60%) and rougher terrain where natural sloughing and settling will cover the seeds. **Micro pitting** seeds are put below the soil surface where soil moisture and temperature are favourable for germination and seedling establishment.

Fig. 58 Planted *Eragrostis carvular*

5. Rehabilitation of Rangelands: Benefits & Sustainability

Ecological Benefits

Increases vegetative cover on denuded and bare areas thereby increasing biodiversity and soil moisture retention. It helps increase the availability and quantity of range forage for both wildlife and livestock and helps control the spread of invasive plants on rangelands. Reseeded plants can rapidly stabilize soils and promote water infiltration. Furthermore, rehabilitation practices enhance vegetation cover on bare areas and therefore can better control erosion and prevent loss of topsoil. **Fig. 56** shows an area infested by *Chrysocoma spp.* while **Fig. 57** shows the same area after removal of the *Chrysocoma spp*. Therefore, the ecological benefits of rehabilitation can be summarized as: **improvement of rangeland health through the allowance of forage to regain vigour for reproduction, implementation of relatively long-term rangeland improvement practices (e.g. reseeding, brush control), improved growth of grazable plants, enhanced vegetation cover on denuded and bare areas and increased biodiversity and soil moisture retention.**

Fig. 59 Before Rehabilitation

Sustainable Practices

Proper timing is required for reseeding (e.g. seeds germinate best when soil is moist and temperatures are warm). Use of seeds that are obtained locally for reseeding is recommended as they will be used in their natural environment and so will not temper with the ecosystem functions of the natural community. They are also cost efficient. When doing brush control, ensure total removal of the whole root mass to prevent resprouting. Excessive land disturbance should be minimised to avoid soil erosion risk. Competent technical assistance from the relevant section is needed. Involve the community and local authorities through all steps of the process to instill a feeling of collective ownership. Finally, grazing permits should be issued in time to an area where vegetation inspection has been done.

Fig. 60 After Rehabilitation

6. Fire Management: Fire Control

Definition: a set of techniques used to prevent and control destructive fires on rangelands. Fire management involves the establishment of barriers, referred to as **fire belts**, which are used to control the spread of fire on prime land (**Fig. 58**) and the dimensions of which will vary depending on rangeland conditions. There are two types of fire belts currently in use: **clean/cultivated fire belts and burned fire belts.**

Fig. 61 Fire Belt

1. Clean / Cultivated Fire Belts

These comprise destroying and removing the ground layer of vegetation either manually or mechanically. Examples include graded, mowed and ploughed belts (**Fig. 59**)

2. Burned Fire Belts

These comprise burning a strip of vegetation around the perimeter with the aid of fire controlling equipment (**Fig.'s 60 & 61**).

Fig. 62 Mowed Fire Belt

6. Fire Management: Benefits & Sustainability


Fig. 63 Burned Fire Belt

Ecological Benefits

Global warming is minimized as the fire is prevented from spreading all over the rangeland, ultimately leading to less carbon gas emissions. The rangelands act as a habitat for species of flora and fauna, so fire belts help to protect biodiversity and other ecological benefits of the rangelands. Therefore, the ecological benefits of rehabilitation can be summarized as: **minimizes global warming and protects biodiversity as well as wetlands and water sources.**

Sustainable Practices

To ensure sustainability and safety, fire belts must be constantly monitored to ensure that they are in good condition, which requires the availability of technical assistance and other stakeholder cooperation.


Fig. 64 Controlling a Burned Fire Belt

7. Wetlands: Identification


Fig. 65 Healthy Wetland

Definition: the promotion of management activities that will ensure the sustainable functioning of wetlands.

Wetland Identification

The parameters used in identifying wetlands involves the identification of hydrological processes and dominant plant species. The hydrological parameters are further divided into **primary and secondary indicators**:

Primary hydrological indicators of wetlands include: degree of inundation, soil moisture saturation, water marks, drift lines, sediments deposits and drainage patterns within the wetland.

Secondary hydrological indicators consist of the following: presence of oxidized root channels (rhizospheres), water stained leaves, local soil hydrology, bare soil areas and morphological plant adaptations.
In regard to **plant species dominance**, an area is characterized as a wetland if it has a high frequency of occurrence of plants rated as hydrophytes. They include the following broad groups: *Algae, Pteridophytes* and *Angiosperms*. The presence of the following hydric soils and soil characteristics are further indicators of wetlands: Histosolls (organic soils) Histic epipedons, sulfidic materials, aquic or peraquic moisture regimes, reducind soil conditions, soil colour (gleyey, bright mottles and low matrix chroma) and the presence of iron manganese concretions.


Fig. 66 Degrading Wetland


Fig. 67 Wetland Damaged by Rodents


Fig. 68 Fully Degraded Wetland

7. **Wetlands:** Maintenance, Protection & Rehabilitation

Fig. 69 Silt Traps

Maintenance

Proper maintenance is achieved through the development of a wetland resources management plan, the development of a grazing plan for wetland catchment areas (refer to Technique 3 in the same section), and the enforcement of legal protection.

At a glance:

- » Implement wetland resources management plan
- » Implement grazing plan for wetland catchment areas (refer to Technique 3 in the same section)
- » Enforcement of rules governing use of wetlands

Fig. 70 Gabion Structures

Fig. 71 Re-vegetation

Protection & Rehabilitation

These processes are done through the implementation of grazing control measures, rangeland rehabilitation measures (refer to sections 4 and 5) and the use of erosion control structures: beaconing, re-vegetation, gabion structures, silt traps, and legal protection (**Fig.'s 66 to 68**).

Fig. 72 A Healthy Riparian Area

7. **Wetlands:** Benefits & Sustainability

Ecological Benefits

Proper wetlands management promotes healthy riparian areas (**Fig.'s 69 & 71**) and increases sediment entrapment, improving water quality. Extensive riparian vegetation increases cover and shading of the streams resulting in cooler water temperatures, which benefit other wildlife such as fish (**Fig. 70**).

At a glance:

- » Improved water quality
- » Provision of water
- » Carbon sequestration
- » Control of floods
- » Conserved biodiversity and rare ecological habitats

Fig. 73 Wildlife Benefit from Improved Water Quality

Fig. 74 A Healthy Riparian Area

Sustainable Practices

These processes can be effected through the proper care and maintenance of the constructed structures. The involvement of the local authority in the development of the resource management plan is also important.

At a glance:

- » Maintenance of restoration and rehabilitation structures is vital
- » Involvement of the community and local authorities

8. Income Generating Activities: Alternative Livelihoods

Definition: the income generating activities which do not necessarily rely on rangeland resources.

Fig. 75 Piggery

Fig. 76 Vegetable Production

Alternative Livelihoods

The income generating activities discussed here are those activities which do not necessarily rely on rangeland resources for production. However, there are other sources of livelihood that can bring relief to rangeland resources. They include live-stock production such as piggery (**Fig. 72**), poultry (**Fig. 74**), rabbitry (**Fig. 76**), aquaculture, beekeeping, and vegetable production (**Fig. 73**).

Activities at a glance:

- Livestock production (poultry piggery, rabbits, aquaculture and beekeeping)
- Stall feeding
- Vegetable production
- Use of improved breeds, small and large stock
- Improvement of markets for livestock products

Fig. 77 Poultry

8. Income Generating Activities: Benefits & Sustainability

Benefits

These alternative livelihood activities help improve food production and also increase household income largely without compromising rangeland resources.

At a glance:

- Reduced pressure on rangelands
- Improved food production
- Increased household income

Fig. 79 Rabbitry

Sustainable Practices

Competent technical assistance is required at all times from all stakeholders, such as government departments and NGO's. Community members and local authorities are also required in decision making to install a feeling of ownership. Workshops and trainings should be conducted frequently to equip community members with relevant skills and necessary changes.

At a glance:

- Availability of competent technical assistance from relevant ministries and NGO's
- Involvement of the community and local authority in decision making
- Workshops/trainings to equip communities with necessary skills

Fig. 78 Sheep

SLM Techniques | Section 3

Soil & Water Conservation Techniques

Preface: Soil & Water Conservation Techniques

Fig. 80 Body of Water Resting in a Valley

The history of soil conservation in Lesotho is a long and active one which dates back to the1930's. In spite of the interventions, land degradation continues to seriously affect the livelihood and food security of Basotho. It is estimated that 0.25% of the total arable land is lost through soil erosion each year (Poverty Reduction Strategic Paper, 2004/2005 – 2006/2007). This prevailing land degradation results from unsustainable land management practices, erratic rainfall with resultant drought and floods, overgrazing and mismanagement of natural resources.

The Sustainable Land and Water Management Toolkit section on Soil and Water Conservation presents the techniques applicable in a simple format to be readily understood and applied by the target groups – extension agents and farming communities. These techniques address the holistic approach within the framework of integrated watershed management, with the ultimate objective of achieving sustainable land management. The Soil and Water Conservation techniques that are presented in this toolkit address agronomic, biological and structural measures in realizing the objectives of reversing the current trend in land degradation. The techniques are designed to be implemented in concert with the techniques of Forestry and Rangeland Resources Management that are part of this SLM toolkit.

1. Agronomic Practices: Cover Crops

Fig. 81 Cover Crops Protect the Soil Surface

Definition: a crop (usually a leguminous crop like beans and peas) planted immediately after harvesting the principal crop to provide ground cover and is often planted in between fruit tree rows.

Seeding & Seeding Rate

The seeding and seeding rate must be appropriate for the specific cover crop.

Benefits

Cover crops provide ground cover after the harvest of the principal crop to minimize soil erosion caused by rain drop splash, overland flow and wind. A grass or forage cover crop provides more protection of the soil surface than row crops (**Fig.78**). Organic matter from the cover crop litter increases soil fertility as the litter breaks down into nutrients by termites and soil fauna, and through nitrogen fixation by leguminous cover crops planted between rows of trees (**Fig. 79**). A cover crop further inhibits weed growth by covering the weeds and denying them access to sunlight; thus, it is a means of weed control in a rotation system and in orchards. Finally, cover crops provide fodder/forage for livestock production and mulch material for moisture conservation.

At a glance:

- Soil erosion control
- Soil structure improvement
- Increased soil fertility
- Weed control
- Soil moisture conservation
- Fodder and mulch provision

Fig. 82 Increased Soil Fertility

Sustainable Practices

This technique can be sustained through the implementation of a crop rotation system where a cover crop is incorporated, and through the technical assistance of land users to ensure the appreciation of the benefits and subsequent adoption of the practice by the farming community.

2. Crop Residue: Management

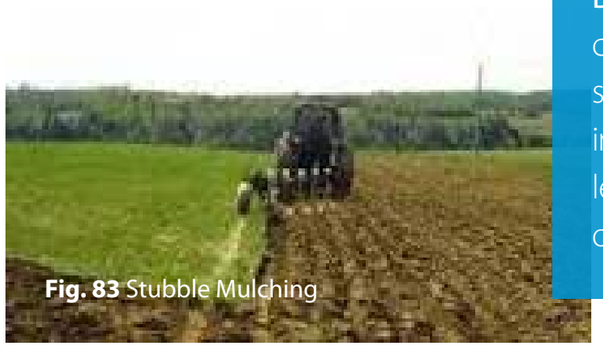

Fig. 83 Stubble Mulching

Definition: the practice of minimum cultivation be-tween harvest and seedbed preparation using tillage implements that destroy weeds but leave **at least 30%** of the crop stubble on the surface after planting.

Field Residue Management

This technique is achieved through stubble mulching, which is a technique of chopping the crop residues and spreading them on the soil surface, then tilling the soil without inverting the residues, using a chisel plough instead of a mould board plough, in order to control weeds if weeds are a problem (**Fig. 80**). In crop residue management, a minimum tillage system is engaged and control of weeds is done by hoeing or chemical herbicides or both. At least 30% of the crop residue must be left on the soil surface (**Fig. 81**).

At a glance:

- Avoid use of mould board plow, use a chisel plow only if weeds are a problem
- Control weeds by hoeing or chemical herbicides or both
- Leave at least 30% of residue on the soil surface

Benefits

By reducing rain drop splash erosion and run-off, infiltration into the soil is improved and consequently soil erosion is minimized. In addition, crop residue provides a rough soil surface that inhibits wind erosion. Bulky organic material from the previous crop that is incorporated into the soil improves soil structure, soil manageability and tilling operations. Crop residue management also improves soil moisture conservation by minimizing moisture evaporation from the soil surface, and by increasing the infiltration capacity of the soil. As a result of the above benefits, farming operations' economic viability is enhanced.

Fig. 84 Minimum Tillage System

At a glance:

- Improved rain water infiltration
- Soil erosion control
- Soil structure improvement
- Soil moisture conservation

Sustainable Practices

Sustainability of this practice is achieved through information dissemination through extension services for full adoption among the farming communities.

3. Fodder Production: Planting & Management

Definition: a system in which pasture, hay and grass silage are grown for livestock, especially on marginal lands.

Fig. 85 Sorghum Fodder Feed

Planting & Management

The first step in this practice is creating a seedbed that is properly prepared and then seed sowing should be done carefully to enhance proper germination. A nurse crop, such as teff, is needed as a first crop to prepare the land and should be properly planted through broadcasting, followed by adequate fertilization (**Fig. 82**). To enhance fodder growth and efficient cover, it is recommended that the crop should be cut once or twice in the first year of production. The common types of fodder crops include: cover (legumes), sorghum and banner grass (**Fig.'s 82, 83, 84 & 85**).

At a glance:

- » Proper seedbed preparation must be done
- » A nurse crop (teff) must be appropriately planted through broadcasting, and adequately fertilized
- » Proper weeding by clipping must be done once or twice in the first year

Fig. 86 Clover Cover Crop

Fig. 87 Fodder

3. Fodder Production: Benefits & Sustainability

Benefits

Fodder crop production on marginal lands provides control of soil erosion by protecting the soil surface from the erosive power of water and wind. Fodder crops, like cover crops, provide a more effective ground cover compared to row crops (**Fig. 83**). In addition, fodder production on marginal fields results in the conversion of degraded land into quality forage (fodder) production fields as well as an increase in the prospects for their rehabilitation into viable crop production units.

Fodder dry matter (litter) improves soil structure through the incorporation of organic matter into the soil. The break-down of organic matter into plant nutrients by soil fauna restores the soil fertility of degraded lands. Leguminous fodder crops, such as clover, restore nitrogen into the soil through their ability to fix atmospheric nitrogen (**Fig. 83**). These benefits convert marginal field into economically viable units for animal production through increased forage and conversion into fertile production units.

At a glance:

- » Soil erosion control
- » Converts fields that are not suitable for cultivation to quality forage for grazing
- » Improved soil structure
- » Improved soil fertility

Fig. 88 Sorghum

Sustainable Practices

For sustainable fodder production, grazing should not be allowed in the first year of fodder production and stall feeding with cut fodder should be encouraged all the time. This will minimize trampling by livestock that might cause compaction and initiation of soil erosion on the fodder production units. Grass-crop rotation system should be practiced after rehabilitation to ensure their long-term use.

At a glance:

- » Maintain grass – crop rotations after rehabilitation of the marginal fields
- » Grazing by livestock must not be allowed in the first year, fodder must be cut for livestock feeding

4. Contour Farming

Fig. 89 Contour Cropping

Definition: farming on sloping land along the contour, parallel to grass strips, terraces and diversions.

Contour Cropping » The management practice that reduces erosion by tilling and planting across (i.e. following the curvature of the land), rather than up and down the hill as shown in **Fig. 86**. In Lesotho, this is normally done parallel to the buffer strips (**Fig.'s 87 & 88**). This is achieved through throwing up small ridges while cultivating along the contour. Planting is done along the contours.


Fig. 90 Planting Parallel to Buffer Strips

Benefits

Cultivating and planting along the contour reduces water erosion by enhancing water infiltration. Infiltration is enhanced because the contour planting is perpendicular to the slope, thus slowing water velocity and allowing more of the water to soak into the ground. If the contour is perpendicular to the prevailing wind, wind erosion is also reduced.

Furthermore, by allowing infiltration into the soil, contour cropping enhances soil moisture conservation. The practice of ploughing , planting and tilling on the contour is generally done, but its effectiveness varies with slope steepness; slopes of moderate steepness are most effective, while steeper and flatter slopes are less effective.

Sustainable Practices

Contour farming is sustained by maintaining their alignment along the grass strips and terraces within the fields (**Fig. 88**). Sustaining this practice is achieved through the enhancement and improvement of technical assistance to farmers so that they realize the benefits and adopt this tillage method.


Fig. 91 Alignment Along Grass Strips

5. Contour Grass/ Cross Strip Cropping

Definition: the planting of alternating strips of close growing crops (wheat, or grass) with row crops (maize or sorghum) on the contour.

Fig. 93 Alternating Strips

Planting & Management

The management practice of growing two or more crops in alternating strips along the contour of the land. In this system, a row of crop that is more susceptible to erosion – like corn (maize) – is planted alternately with a cover crop that is less susceptible to erosion – like grass, meadow, clover, or oats. Crops are planted perpendicular to the wind and water flow (**Fig.'s 89 & 91**) and must be laid out and maintained on the contour.

Benefits

Contour grass/crop strip cropping helps in soil erosion control through sifting and trapping the soil detached from the row crops by the forces of wind or water. In addition, this practice increases soil moisture conservation by slowing down the velocity of runoff and encourages infiltration and moisture retention.

Sustainable Practices

This practice is sustained by maintaining alternating strips of a crop with a grass or a crop, maintaining correct strip widths for effective functioning and improving extension service among farmers for acceptance.

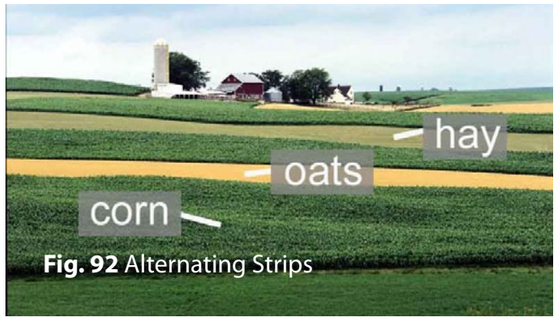

Fig. 92 Alternating Strips


Fig. 94 Crops Planted Perpendicular to Wind & Water Flow

6. Grass (Buffer) Strips

Fig. 95 Upslope to the Right

Definition: narrow strips of grass alternated with strips of clean tilled crop or small grain.

Fig. 96 Strips Are at Least 3 m in Width

Planting & Management

Grass strips are applied on slopes of farmland that are **more than 10%** and staked out on a contour in order to have the effect of contour farming. For effectiveness, the strips must not be less than 3 meters in width (**Fig.'s 92 & 93**). Note that on **Fig. 92** upslope is to the right.

At a glance:

- » Grass strips are applied on slopes of farmland that are in excess of 10%, and should be staked on a contour
- » They should be appropriately spaced with widths that are not less than 3 m

Ecological Benefits

Grass (buffer) strips assist in the conservation of the soil by filtering sediment in runoff water through the grass strips. As in contour farming, the strips are perpendicular to the slope and therefore slow down the velocity of water flowing on the slope to induce moisture retention. The continued trapping of runoff sediment and maintenance of contour farming tillage, result in ridges that resemble bench terraces on very steep slopes.

At a glance:

- » Sediment in runoff is filtered
- » Support and encouragement of contour farming
- » Facilitation of bench terrace development
- » Soil erosion control

Sustainable Practices

This practice is sustained by the strips' establishment on permeable soils where runoff can more easily infiltrate into the soil and not cause erosion hazard. To ensure continued effectiveness, farming operations should be maintained on contours to help the process of bench terrace development. The grass strips should be fully maintained through re-grassing or sodding along the strips and should be protected from upslope excessive runoff by the construction of diversion furrows.

7. Diversion Furrows: Construction & Management

Fig. 97 The Construction of a Diversion Furrow

Definition: channels with a specified gradient, constructed either manually or mechanically to lead flowing water (overland run-off water) away from sensitive areas to a desired outlet.

Planting & Management

Construction of diversion furrows is done using either through intensive labour or the use of construction equipment, such as bulldozers (**Fig.'s 94 & 95**, where labour is used). Diversion furrows are constructed according to design in terms of alignment, grade and cross section to avoid scouring within channels and to allow the maximum capacity that will prevent overtopping of diverted runoff. The length of the diversion furrow is dictated by the availability of a stable and good outlet for runoff where there will be no damage due to erosion of the soil. The entire channel and embankment must be grassed to guard against scouring and to stabilize the bank of the diversion furrow.

At a glance:

- » Constructed according to designed alignment, grade and cross section
- » Constructed given proper length, governed by the availability of a good outlet
- » Entire channel and embankment should be vegetated
- » Labour force or heavy equipment, such as bulldozers, used for construction

7. Diversion Furrows: Benefits & Sustainability

Fig. 98 Digging a Diversion Furrow

Ecological Benefits

Diversion furrows protect lower lying sensitive areas, such as buildings and cropland, from excessive hillside runoff by safely diverting the runoff to properly designated disposal areas. These furrows help to reduce hillslope erosion by dissipating the erosive power of the runoff through the reduction of the hillside slope. In addition, diversion furrows protect gullied areas from further damage as well as reclaimed areas below the diversions.

At a glance:

- Protection of sensitive bottomland from hillside runoff
- Diversion of excess water from sensitive areas to safe areas for disposal
- Reduction/prevention of continued gully erosion

Sustainable Practices

In order to ensure their sustained effectiveness, diversion furrows should maintain their design storage capacity, embankment height and outlets through proper maintenance, repairs of broken embankments and clearing of sediments accumulated after heavy rains to maintain the design storage capacity of the diversion furrows and stop the risk of overtopping. Grass (vegetation) established in the channel and embankment should be protected from damage by livestock by prohibiting grazing and trampling.

At a glance:

- Repairs broken embankments
- Clears channels of debris after heavy rains
- Protects the established vegetation from livestock

8. Slope Modification Structures

Definition: the use of stone lines and brush bundles on contours to micro-terrace steep slopes on rangelands. Two categories of these mounds are implemented in Lesotho: **stone lines and brush wood bundles**.

Fig. 99 Stone Lines

Planting & Management

Slope modification structures are stone lines (micro stone walls about 30 cm high) and brush bundles used to micro-terrace, on contour steep slopes of degraded rangelands and within the integrated watershed management program. Community labour is engaged to build optimal walls of stone lines at intervals, on contour across slopes of degraded rangelands as shown in **Fig. 96**. Alternatively, brush bundles from brush control activity in the Range Resources Management Technique are used to build the optimal walls in the fashion of stone lines, as shown in **Fig. 97**.

Fig. 100 Brush Bundle Walls

Ecological Benefits

Slope modification structures reduce soil erosion on steep slopes of degraded rangeland areas by reducing the length of slopes at intervals and velocity of overland flow run. Grass re-establishment is facilitated by the sediment sifted and trapped by the structures from sediment-laden overland flow. Soil medium build-up across the degraded rangelands, as a result of stone lines/brush bundle lines, facilitates grass seeding efforts of the Range Resources Management Program.

At a glance:

- Reduces soil erosion on degraded landscapes
- facilitates grass growth by trapping soil in the overland run-off flow above
- Provides soil medium to facilitate grass seeding in degraded areas

Sustainable Practices

Stone modification structures of stone lines and brush bundles should be checked on a regular basis to make repairs where the walls are broken and to ensure their proper functioning. In addition, livestock should be kept out of the area and pasture rest enforced for the period of grass re-seeding efforts on degraded rangelands.

9. **Terraces:** Construction & Management

Definition: graded or ungraded channels constructed either manually or mechanically to lead run-off to safe outlets or to retain it on the surface . There are three types of terraces: **graded, level, and bench terraces**.

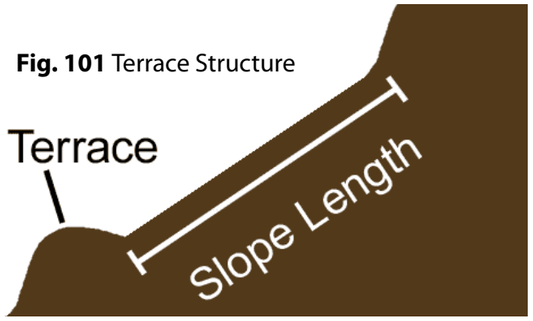

Fig. 101 Terrace Structure

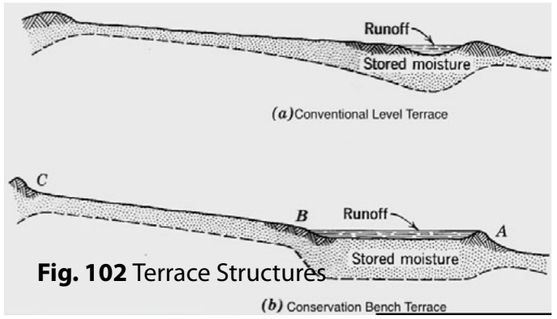

Fig. 102 Terrace Structures

Terraces can also be benches developed over time through tillage on the contour on very steep slopes or following the establishment of buffer strips. Most of what appears to be terraces in the Lesotho landscape are actually forms that have developed since the 1950's following the establishment of buffer stripping (makorota) throughout most of the country especially on cropland.

Types & Their Construction

1. Graded Terraces are constructed according to specified dimensions in terms of gradient and cross-section to allow movement of excess runoff to a safe outlet, such as a waterway. Graded terraces may be **broad based terraces** or **steep back slope terraces**:

» **Broad based terraces** have flatter back slopes and shallower channels suitable for cultivation and operations with machinery.
» **Steep back-slope terraces** have narrower and deeper channels, and are suitable on steep farm slopes.

They are designed, and then constructed either manually or by machinery in such a way that proper gradient and spacing is achieved. They have to have a maximum length of 500 m in order to avoid erosion within the channel due to excessive grade, and channel and ridges must be planted with grass.

2. Level Terraces lack any gradient and are constructed to be level without channel grade in order to retain runoff within the channel.

3. Bench Terraces are steep like benches constructed on very steep slopes (**Fig.'s 100 &101**) where construction of other types of terraces would be impossible due to excessive steepness. Some terrace-like forms have developed in some areas as a result of continuous cultivation on contours. The construction of bench terraces using heavy machinery is costly.

9. **Terraces:** Benefits & Sustainability

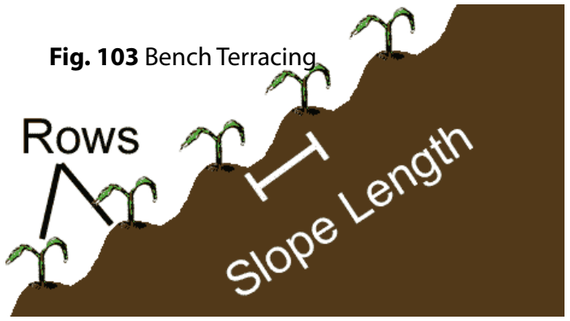

Fig. 103 Bench Terracing

Fig. 104 Bench Terraces

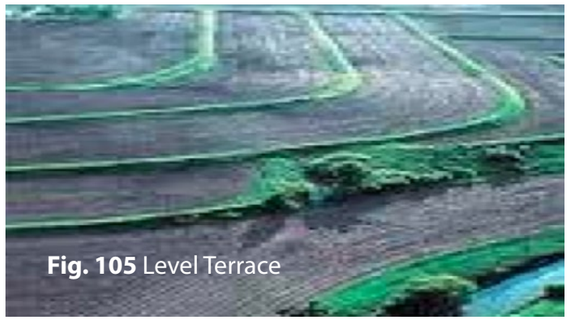

Fig. 105 Level Terrace

Fig. 106 Broad-based Terrace

Ecological Benefits

Terraces reduce soil erosion on farmlands by reducing land slopes (**Fig. 104**) and thus the erosive power of runoff. Level terraces help conserve moisture within fields, facilitating retention and infiltration of runoff into the soil. Bench terraces facilitate safe cropping on very steep slopes by diminishing runoff and soil erosion. (**Fig.'s 101 &104**). Broad-based terraces allow cultivation on the terraces (**Fig. 103**).

Sustainable Practices

In order to maintain sustainable efficiency of terraces, the following measures have to be undertaken: Terraces should be checked annually or after every rainy season to identify areas that might need repair and realignment; grass on terraces must be protected from grazing and trampling by livestock in order to protect the embankment; and finally, terraces must be protected against use as routes across the slope by vehicles, livestock and footpaths as these are likely to impair the efficiency of the terraces.

Fig. 107 Terraces Reduce Soil Erosion

10. Gully Control Structures

Fig. 108 Loose Rock Structures

Definition: structures fabricated to reclaim gullied areas, or stop further development of gullies laterally and headward.

Types & Their Construction

The method of constructing the gully structures varies with the type of structure and the properties of the gully to be reclaimed/protected.

1. Gully head and gully side protection (loose rock) structures are constructed using loose rocks with or without reinforcement (mortar) and at gully heads, within gullies as check dams and on the gully sides to prevent further gully extension (**Fig. 105**).

2. Brush wood and debris basins/mounds are constructed of wood woven together or tied with wire or plant stalks to form check dams within gullies in order to trap sediment. The construction of gully control structures in general proceeds from downslope within the gully upwards in order to maintain structural effectiveness as construction proceeds upslope. Construction must be completed before the onset of the rainy season.

3. Gabions are constructed by filling rectangular basket units of galvanized steel with stones. These basket units are then tied together with galvanized wire and assembled in a desired configuration, in a building fashion.

Ecological Benefits

Gully structures help improve water quality in streams and reservoirs through sediment trapping action.

At a glance:

- Controls erosion
- Improves water quality
- Improves vegetation cover
- Reclaims gullied areas

Sustainable Practices

Gully structures should be inspected at least once a year and their maintenance done on a regular basis. Trees and grasses established within treated gullies must be protected from fire, illegal cutting, grazing and encroachment.

Fig. 109 Gully Head Structure

11. Grassed Waterways

Definition: natural or artificial water channels, shaped, graded and seeded or sodded to grass for safe disposal of runoff from either terraces or diversions.

Fig. 110 Grassed Waterways Provide Safe Disposal Areas for Runoff

Construction & Management

Waterways are constructed by shaping and grading the runoff channel according to specified dimensions and stabilized by encouraging grass growth.

Ecological Benefits

Waterways provide safe disposal areas for runoff from terraces and diversions (**Fig.'s 108 & 109**). They also provide fodder for livestock from grass that is frequently cut as part of waterway maintenance.

Fig. 111 Healthy Waterway

Sustainable Practices

Waterways are sustained through protection from any disturbance, such as path and track development and livestock grazing. **Fig. 109** shows a degraded waterway that resulted from allowing path and tracks on the waterway, as well as grazing by livestock. Therefore, repairs of damaged grass areas must be done promptly and rat burrows must be treated to kill off the rodents. To avoid damage to the waterways, forage for animal feed must be cut instead of grazing. Finally, community extension services must be enhanced for awareness raising among communities to protect these and other conservation structures.

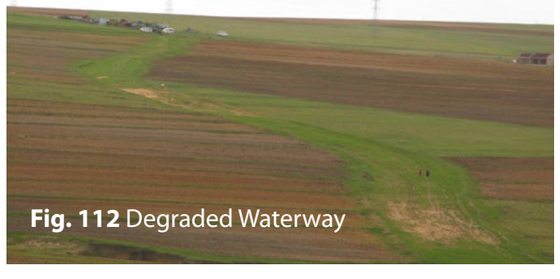

Fig. 112 Degraded Waterway

12. Water Storage & Harvesting: Construction & Management

Definition: a water impoundment made by constructing a dam or an embankment pond, by excavating a pit or dugout (**Fig.'s 110 &111**), or by the collection of spring overflow, roof and surface runoff into man-made water storage tanks.

Fig. 113 Embankment Pond

Construction & Management

Semi-impermeable embankments are built using either intensive labour or machinery. A durable dam lining with plastic material may be used . The pond is usually provided with an adequate spillway built to safely dispose of storm overflow. Grass should be planted on exposed embankment surfaces, including the spillway. Construction of the embankment must be done during the dry season and completed before rainy season. Grass seeding of the embankment is done at the start of rainy season to allow for proper grass establishment.

Fig. 114 This reservoir serves both as a water storage and gully reclamation structure

Requirements for harvesting tanks:

» House foundations with impervious roofing material such as corrugated roofing, tiled roofing and gutter fittings (**Fig. 113**). Storage tanks should also be in the vicinity of a crop production site, such as a garden or field

» Availability and accessability of nearby perennial spring water sources (**Fig. 112**)

» Availability of tank building materials – rocks, sands, cement, PVC pipes, reinforced building material, and valves

» Availability of skilled, local masons

Steps in constructing water tanks:

1. Build a semi-impermeable embankment
2. Build adequate emergency spillway to safely dispose storm overflow
3. Plant grass on exposed soil surfaces, on the earth embankment, and in the spillway
4. Construct the embankment during the dry season and complete before the rainy season, manually or by machine
5. Seed grass on the embankment at the start of the rainy season to allow for proper grass establishment
6. Construct the tanks through prefabricated containers or masonry as well as cement containers

12. Water Storage & Harvesting: Benefits & Sustainability

Fig. 115 Tanks Must be Stationed Near Perennial Spring Water Sources

Socioeconomic & Ecological Benefits

The water impounded through water harvesting dams and water tanks provides water for household use and livestock. Rural impoundment ponds facilitate the development of commercially irrigated agricultural production and provide water for forestry development. These ponds also enable irrigated gardening and the development of various income generating activities for households and communities, such as aquaculture. They also control silting in rivers, large impoundment reservoirs and other development facilities such as bridges and impede gully formation by impounding concentrated flows. Finally, these water sources provide recreation areas for water sports and fishing, as well as sociocultural spaces for baptisms..

At a glance:

» Waters livestock

» Provides irrigation to support agricultural, production and forestry plantations

» Aquaculture

» Controls floods and gullies

» Creates spaces of recreation

» Produces garden irrigation

» Provides potable water

» Controls dam and river siltation

Sustainable Practices

Embankment vegetation must be protected from the trampling and grazing of livestock and the catchment area for the reservoir must be protected, all to avoid soil erosion. Integrated catchment management programs must be done in the catchments drained by streams that feed into the reservoirs so as to minimize sedimentation. Rescue teams must be trained and set up in villages where embankment ponds are located to ensure the rescue of victims of drowning and to prevent the possibility of the cutting of embankments. Proper maintenance of the tanks by each individual owner and community must be ensured; this includes repairs from impacts by animals and machinery, the insulation of PVC pipes to protect against low temperature bursts, and protection from pollution.

Fig. 116 Corrugated Roofing & Gutter Fittings properly Direct Water to Tanks

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The Ministry of Forestry and Land Reclamation is committed to protecting and rehabilitating the physical environment through afforestation, range resource management, soil erosion control and water harvesting in order to enhance the means of livelihoods for all.

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