GREEN VILLAGE: COMMUNITY-BASED CATCHMENT MANAGEMENT GUIDELINES, AND LEARNING

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WATER RESEARCH COMMISSION

TT 793/2/19

WRC Green Village: Community-Based Catchment Management Guidelines

Report to the

WATER RESEARCH COMMISSION

by

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ABBREVIATIONS

BBCs	Buy Back Centres
BRC	British Reinforced Concrete
CA	Conservation Agriculture
CASL	Community Adaptation and Sustainable Livelihoods
CM	Catchment Management
CMS	Catchment Management Strategy
DBSA	Development Bank of Southern Africa
DEA	Department of Environmental Affairs
DLA	Department of Land Affairs
DLG	Department of Local Government
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization of the United Nations
GEEF	Green Energy Efficiency Fund
GIS	Geographical Information System
GPS	Global Positioning Systems
IAPs	Interested and Affected Parties
ICM	Integrated Catchment Management
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IDC	Industrial Development Corporation
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
LACES	Lookouts, Awareness, Communications, Escape routes, Safety zones
LCE	Low Carbon Economy
M&E	Monitoring and Evaluation
NDP	National Development Plan
NEMA	National Environmental Management Act, Act 107 of 1998
NEM:BA	National Environmental Management: Biodiversity Act, Act 10 of 2004
NRM	Natural Resource Management
NWA	National Water Act, Act 36 of 1998
ORS	Oral Rehydration Solution
PtO	Permission to Occupy
PRA	Participatory Rural Appraisal
PVC	Polyvinylchloride
SWOT	Strengths, Weaknesses, Opportunities and Threats
TLB	Tractor-Loader-Backhoe
VIP	Ventilated Improved Pit
VCP	Village Catchment Plan
WALA	Wellness and Agriculture for Life Advancement program
WRC	Water Research Commission
WWTP	Wastewater Treatment Plants

GLOSSARY OF TERMS

Adaptation: to adjust to new conditions and continue functioning.

Agroforestry: the deliberate combination of woody and non-woody species – most commonly trees with crops or grass – for multiple benefits.

Aquifer: a body of permeable or porous rock that can hold water or allow flow of water underground.

Attenuation: to reduce the force or energy of something, e.g. reduce the rate of flow of stormwater runoff.

Augmentation: to increase the available volume of something, e.g. increase the amount of available water.

Baseline (Base Scenario): the current status of a catchment or ecosystem. Usually measured at the start of an activity to monitor for improvement or degradation.

Biodiversity: the range of different types and species of living organisms within a given area.

Blackwater: wastewater containing faeces, urine and flush water from toilets.

Carrying Capacity: the maximum number of individuals (or animals) that can be sustainably supported, fed or are able to survive in any specific habitat or ecosystem without causing the habitat or ecosystem to breakdown or degrade.

Catchment: the area of land from which any rain falling on it will drain into a watercourse through surface flow to a common point (NWA 36 of 1998): sometimes referred to as a watershed. All land falls into a catchment. (See also **Micro-Catchment**; **Sub-Catchment**; **River Basin**)

Catchment Management Plan: a plan of action of sustainable resource management to achieve the **catchment vision**.

Catchment Vision: the future that a group want to see in their catchment – their overall goal.

Cattle paths: The pathway or walking route used by cattle or livestock.

Climate Change: the variation in the global or regional climate or average weather patterns, over a time scale of decades to centuries.

Climate Change Adaptation: measures taken to adapt to the impacts of climate change by lessening their impacts and/or reducing risks of extreme events.

Climate Change Mitigation: measures to decrease the reduction of greenhouse gasses in the atmosphere through reduced emissions, or by carbon storage (sequestration).

Climate Resilience: the ability of a living system to adapt itself to keep functioning after being exposed to shocks or disturbance caused by changes in climate.

Compacted soils: soils that have been trampled repeatedly by cattle, vehicles or farming equipment can become compressed or hardened. This reduces the ability of water to soak into the soil and results in runoff over the soil and erosion.

Conservation Agriculture (CA): an approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. CA is characterized by three linked principles, namely: 1. Reduced tillage especially minimum mechanical soil disturbance; 2. Permanent organic soil cover; 3. Diversification of crop species grown in sequences and/ or associations.

Conservation tillage – any form of reduced tillage techniques. (see **Conservation Agriculture, Minimum Tillage**, **Tillage** and **Zero-till**)

Consumption smoothing: keeping your usage (or consumption) of goods and services regular and consistent. So even when you are not earning an income, you are able to afford your day-to-day expenses.

Dam: a barrier, usually a concrete or earth wall, constructed to hold back water and raise its level, used to store water and augment water availability. (See **Augmentation** and **Reservoir**)

Decision Support System: a process that helps guide people to make choices from a ‘menu’ of activities based on specific needs and situations.

Deforestation: the partial or complete loss of trees within a landscape or forest (natural or plantation) and the associated loss of the forest’s ecosystem function and services.

Degradation: the condition or process of breaking down, destroying, or collapse of a system.

Erodible soil: refers to the ability of soil particles to dislodge or detach and be transported away e.g. by runoff or wind. Highly erosive soils are prone to erosion: (a) Soils high in clay content restrict infiltration and are of low erosive nature; (b) whilst sandy soils allow for more infiltration and thus more erosive; (c) soils with high silt content are the most erodible. (See **Erosion** and **Soil Erosion**)

Erosion: the process of eroding or being eroded, i.e. breaking down, by wind, water, or other process. (See **Soil Erosion**)

Eutrophication: the enrichment or build-up of nutrients, mostly nitrates and phosphates, in aquatic (water) systems, which stimulates growth of algae and depletes oxygen, killing local plants and fish and thus damaging and degrading the indigenous aquatic ecosystem. (See **Degradation**)

Failure point: A weak point that is deliberately built into a structure or a fence. This will allow the fence to break at a specific place if, for example, severe flooding occurs. The rest of the fence will remain intact and the failure point can be easily repaired.

Geotextile: Strong fabrics that are used to stabilise soil and prevent the loss of soil, e.g. through soil erosion. (See **Soil Erosion**)

Grazing block: Veld is divided into management areas called grazing blocks. Each grazing block can be subdivided into camps. Grazing blocks can be grazed, burnt or rested in any given year.

Greywater: the relatively clean waste water from baths, sinks, washing machines, and other kitchen appliances. Different to blackwater. (See **Blackwater**)

Household(s*):* this refers to the all the occupants of a house as a single unit.

Infiltration: Process of water seeping, soaking or entering the ground from the ground surface resulting in recharging of the water table. Can occur naturally or by man-made intervention.

Integrated Catchment Management (ICM): the cooperative management of all the components that operate within a catchment, i.e. natural resources and human activities, that impact on and/or are impacted by the different components and activities.

Intercropping (or Companion Cropping or Mixed Cropping): a combination of different crops in the same field to provide benefits greater than planting separately but also to reduce risk, e.g. for pest control, nutritional diversity, soil nitrification, soil stability, etc. (See **Agroforestry** and **Permaculture**)

Invasive and Alien Species: species that have been introduced from outside the country (or outside a particular zone) are called Alien species; species that reproduce rapidly and reduce production of desired (ideally indigenous/endemic) species are called Invasive Species. Not limited to plants, can apply to all types of species.

Land Tenure: the rights to use of land – may be temporary or permanent. Rights may be formal e.g. title deeds to land, or through traditional processes through the Chief.

Livestock tracks: see **Cattle paths**

Micro-Catchment: a smaller catchment area within the main catchment, e.g. catchment of a tributary. There are several micro-catchments within a Catchment. (See **Catchment**)

Micro-grid: a small network of resource (e.g. water, electricity) users with a local source of supply that can still be connected to a centralized national grid but is able to function independently from the national grid.

Minimum tillage – a reduced tillage technique through loosening only top of the soil (5 cm), ripping of planting rows with a ripper tine (chisel plough), or making permanent planting basins by hand, without disturbing the soil in between. (See **Conservation Agriculture**, **Conservation Tillage**, **Tillage** and **Zero-till**)

Mitigation: the implementation of practical measures to reduce adverse impacts. (See **Climate Change Mitigation**)

Overgrazing: repeated, heavy grazing of an area, resulting in the disappearance of grass cover, increase in undesirable grasses, bush encroachment, bare soil, and soil erosion. (See **Soil Erosion**, **Threshold** and **Veld Type Unit**)

Participatory Rural Appraisal (PRA): a participatory methodology aimed at discussing or voicing problems and potentials, involving members of the local community and facilitated by a trained 'outsider'. Combines various tools, such as transect walks, historical profiles, participatory mapping, wealth ranking, and ranking/ scoring of different options. (See **Rapid Appraisal of Agriculture Knowledge Systems (RAAKS)** and **Transect Walk**)

Permaculture: a system of 'natural' farming that makes use of a combination of plants, mulching and conservation agriculture, ensuring maximum integration of resources and seeking symbiotic relationships and continuous production, intended to be sustainable and self-sufficient. (See **Conservation Agriculture**)

Perpendicular: Two items which are at right angles (90 degrees) from each other, e.g. ⊥

Pollution: the occurrence, presence or introduction into the environment of a substance which has harmful or poisonous effects. May occur naturally or through human activities. In relation to water, pollution' means the direct or indirect alteration of the physical, chemical or biological properties of a water resource so as to make it –

(a) less fit for any beneficial purpose for which it may reasonably be expected to be used; or

(b) harmful or potentially harmful –

(aa) to the welfare, health or safety of human beings;

(bb) to any aquatic or non-aquatic organisms;

(cc) to the resource quality; or

(dd) to property; (NWA 36 of 1998)

Protection: protection', in relation to a water resource, means –

(a) maintenance of the quality of the water resource to the extent that the water resource may be used in an ecologically sustainable way;

(b) prevention of the degradation of the water resource; and

(c) the rehabilitation of the water resource; (NWA 36 of 1998)

Rapid Appraisal of Agriculture Knowledge Systems (RAAKS): combines elements of Participatory Rural Appraisal and institutional analysis to create a framework for participatory action research to understand and improve agricultural knowledge systems. (See **Participatory Rural Appraisal**)

Reclaimed land: Land that was eroded, degraded or lost that has been rehabilitated or restored and can be used productively again.

Rehabilitation: the process of bringing natural resources – soil, land, water, wetlands, forest, croplands, rangelands, etc. – back to a functioning (not necessarily pristine) state after degradation has taken place. (See **Degradation, Restoration** and **Threshold**)

Reservoir: volume of water stored behind a dam. Used to augment water availability. (See **Augmentation** and **Dam**)

Resilience: the ability of a living system to adapt itself to keep functioning after being exposed to an outside disturbance. (See **Adaptation** and **Climate Change Resilience**)

Restoration: the process of bring natural resources – soil, land, water, wetlands, forest, croplands, rangelands, etc.- back to a pristine state after degradation has taken place. (See **Degradation, Rehabilitation** and **Threshold**)

Retention: the continued or temporary holding or storing of something e.g. runoff water. Often linked with infiltration. (See **Attenuation** and **Infiltration**)

Riparian Buffer Zone: a strip of several metres in width (depending on the size of the river, and its flow regime) alongside a river which is planted with perennial vegetation, including trees, principally to protect the riverbanks from erosion.

River Basin: the catchment of a whole river, source to sea. The river may be shared across countries.

Runoff: flow of rainfall (and other precipitation) across the ground or a surface e.g. roof.

Sand dam: dam built across a seasonal sandy river. The reservoir of the dam holds sand that the runoff water infiltrates into. (See **Dam**, **Infiltration**, **Reservoir** and **Runoff**)

Semi-Structured Interview: a participatory methodology tool that is used to gather information in an informal way by discussion with participants, guided a small number of key questions.

Siltation: process by which water becomes dirty as a result of fine mineral particles in the water, mostly silt or clay particles. (See **Soil Erosion**)

Slope: the slant or rise of land. Calculated as a ratio of horizontal distance for every metre of vertical distance. For example, a slope of 4:1 means that for every 4 metres measured along the ground, there will be a 1 m increase in height.

Soil Erosion: the process of detaching and breaking away of soil particles form the original site, resulting in a loss of soil and contributing to siltation. (See **Erosion**, **Erodible Soil** and **Siltation**)

Sourveld: veld that has very poor nutritional value in winter. Animals will lose weight in winter unless they are supplemented with protein. This veld is usually found in wetter, cooler areas where there is more grass. (See **Sweetveld** and **Veld**)

Strengths, Weakness, Opportunities, Threats (SWOT): a participatory exercise used to evaluate a system, activity, project, organisation etc. Usually a SWOT is developed and depicted on a wallchart divided into the four sections of Strength, Weaknesses, Opportunities and Threats.

Sub-Catchment: A smaller catchment area within a Catchment but larger than a micro-catchment. It is comprised of several micro-catchments. For example, a stem of a river comprised of one or several tributaries. (See **Catchment** and **Micro-catchment**)

Sustainability: the ability of a system to survive for unspecified (infinite) time without degrading or requiring constant rehabilitation or interventions. (See **Carrying Capacity**, **Rehabilitation** and **Threshold**)

Sweetveld: veld that has better nutritional value for animals in winter. This veld is usually found in drier, warmer areas, where there is less grass. (See **Sourveld** and **Veld**)

Threshold: the limit, carrying capacity or intensity that must be exceeded for a certain reaction, result, or condition to occur or be manifested, i.e. degradation, system collapse or unsustainability. Depending on the system this can be either irreversible/permanent or require rehabilitation/restoration. (See **Carrying Capacity**, **Degradation**, **Rehabilitation**, **Restoration** and **Sustainability**)

Tillage: working the soil by plough or hoe or mechanical turning. **Minimum Tillage** implies reducing the amount of tillage as much as possible. **Zero-Tillage or No-till** means no tillage at all. (See **Conservation Agriculture**, **Conservation Tillage, Minimum Tillage** and **Zero-till**)

Tractor-Loader-Backhoe (TLB): a machine for digging ditches and moving rock and rubble.

Transect Walk: is a systematic walk along a defined path (transect) across the community/project area together with the local people to explore the environmental, land use, water and sanitation conditions by observing, asking, listening, looking and producing a transect diagram of observations.

Tributary: or affluent is a stream or river that flows into a larger stream or main stem (or parent) river or a lake. A tributary does not flow directly into a sea or ocean.

Veld: open, uncultivated grassland, can be used for livestock grazing. (See **Sourveld**, **Sweetveld** and **Veld Type Unit**)

Veld type unit: these are areas of veld with similar productivity (the amount of grass produced per year) and management requirements. Veld type units are used to determine grazing blocks. (See **Sourveld**, **Sweetveld**, **Grazing Block** and **Overgrazing**)

Water Conservation: the sustainable and efficient non-wasteful management of surface and underground water, drinking water, and water in rivers, streams, reservoirs, wells, dams, canals, channels, lakes or wetlands.

Water Demand Management: various means of managing demand on water supplies to only what is necessary, these may be done through physical infrastructure e.g. flow regulators, reduced pressure, water shedding, or through policy and tariff instruments such as water restrictions and stepped tariffs.

Water Harvesting: refers to the collection and concentration of rainfall runoff for productive purposes, e.g. from the roof of structures, runoff over land, roads or other infrastructure.

Water resource: water resource" includes a watercourse, surface water, estuary, or aquifer; (NWA 36 of 1998) watercourse" means –

(a) a river or spring;

(b) a natural channel in which water flows regularly or intermittently;

(c) a wetland, lake or dam into which, or from which, water flows; and

(d) any collection of water which the Minister may, by notice in the *Gazette,* declare to be a watercourse,

and a reference to a watercourse includes, where relevant, its bed and banks.

Water Management Area: is an area established as a management unit in the national water resource strategy within which a catchment management agency will conduct the protection, use, development, conservation, management and control of water resources; this area usually forms the primary catchment area.

Water Table: the level below ground at which the ground is saturated with water.

Water Use Efficiency: maximising productivity in relation to water use, thereby avoiding wasting materials, especially water in doing something or in producing a desired result or product.

Weather variability: variations in the mean the state of the atmosphere at a particular place and time as regards heat, cloudiness, dryness, sunshine, wind, rain. Climate variability is at a much larger scale, refer **climate change.**

Wetlands: means land which is transitional between terrestrial (*dry land*) and aquatic (*water-based*) systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land is in normal circumstances supports or would support vegetation typically adapted to life in saturated soil. (NWA 36 of 1998)

Zero-till (or No-till) – direct planting through a mulch layer using a special planter (oxen-drawn) or hand tool (jab planter), i.e. there is no tillage of the ground before planting. (See **Conservation Agriculture**, **Conservation Tillage**, **Minimum Tillage**, and **Tillage**)

FOREWORD

The aim of the WRC Green Village: Community-Based Catchment Management Guidelines, and Learning Project (i.e. Guidelines) is to contextualise the household within the catchment, and build the relationship between household, the village, the community and the broader catchment. The primary objective of this project is to compile a single source reference document aimed at resource-poor farmers and rural villages, covering Green Village activities and village-scale catchment management including natural resources management and household resource utilisation. Ultimately this will be a "How to" handbook in understanding, managing and rehabilitating the local environment; a comprehensive document that villagers can pick up and use without expensive consultants to support it or outside intervention. The guidelines provide information on the basics of conservation agriculture, wise use, green energy, land restoration, and rehabilitation. This was developed for use in a community context, where the ‘catchment area' is both the village and its surrounds of concern.

Natural Resource Management (NRM) and Catchment Management (CM) strategies may be grouped into three broad themes, i.e. Policy, Management and Practice. Policy acts as the overarching framework, which informs management strategies, and includes legislation and regulations. Good practice and guidelines act from the opposite end being informed by management and implementation strategies. In terms of Management this can be further separated into Community, Land, Biodiversity based, Climate change adaption and preparedness and integrated management. Although at the higher level the particular management strategy is noticeable, at the grassroots level the distinction is harder to make due to the inherent overlap in many projects.

HOW TO USE THE GUIDELINES

The Guidelines comprise two Parts that complement one another. **Part I: Theory** is intended to provide background thinking to catchment management. **Part II: Technical Toolbox** is a field manual providing basic “How to” instructions for various catchment management activities. Part I and Part II are summarised, by Chapter, with a short explanation of the purpose of each section, and its main content. Annexures provide more detailed information on a specific activity.

PART I: Theory

	Section	Content and objective
1	Introduction	This section introduces some of the key issues that have led to degradation of catchments in South Africa. Degradation of catchments is not limited to the state of the water resources but also the impact on the land by land use activities that then results in impacts to water resources.
2	Catchment management: concept and principles	This section introduces the concepts and context of integrated catchment management.
3	Participation	This section identifies who are the people (stakeholders and role players) responsible for catchment management activities from the village members to various levels and spheres of government.
4	Getting the process started	Catchment management planning can be driven by external forces such as a non-governmental organisation or a Catchment Management Agency, or it can be driven internally by members of the community. This section outlines how to get the process going to develop a village catchment management plan.

PART II: Technical Toolbox

	Section	Content and objective
	Toolbox introduction	A simple decision support system is described to help villagers choose appropriate measures and guidelines. The icons of the tool box guidelines are explained.
A	Sustainable Land Management	The sub-themes that are covered in this section include: Soil erosion and degradation; Rangeland management; Communal land management; Erosion and runoff control measures; Gully management and sediment trapping; and Stream/river bank management.
B	Soil Fertility Management	The sub-themes that are covered in this section include: Climate-smart agriculture practices; and Nutrient management.
C	Water Efficiency and Resource Management	The sub-themes that are covered in this section include: Water use efficiency and recycling; Water harvesting and storage; Groundwater protection and infiltration; Small dams; and Small-scale-irrigation.
D	Natural Resources Management	The sub-themes that are covered in this section include: Forests; Grasslands; Medicinal plants; Wetlands; and Alien and invasive plant management.
E	Sustainable Households	The sub-themes that are covered in this section include: Money management; Nutrition; Plot management; Sanitation and latrine management; Energy, efficiency and alternatives; Waste management.
F	Disaster Preparedness	The sub-themes that are covered in this section include: Risk management; Fire management; landslide and land collapse; Health; and Emergency response procedures.

ANNEXURES

	Section	Content and objective
I	Participatory Processes	This section describes different participatory techniques to engage members of the catchment in the planning process in terms of making contributions and identifying problems and issues that need to be addressed.
II	Streamlined Environmental Authorisation Process	The South African environmental legislation is a very cumbersome hurdle to rehabilitation of natural resources. This section proposes a streamlined version that is more user friendly to the rural communities engage in proactive rehabilitation activities.
III	Establishing a Green Village Committee	The planning process is driven by a committee of volunteers from the village or community. If there is an already existing committee that can serve this purpose then it is best to use that committee, otherwise a specific committee will need to be establish. However, for the purpose of these guidelines this committee is referred to as the Green Village Committee. This section outlines some of the requirements for this committee and lessons learnt.
IV	Compiling a Budget	Some of the activities identified in the village catchment plan will require resources in order to implement, either physical or monetary resources. It is important to compile a budget for the plan in order to identify where financial support can be applied from, and to make sure the financial support is used appropriately for the implementation of the activities. This section outlines how to compile a budget, how to monitor against the budget as well as how to apply for funding.
V	Monitoring and Evaluation	Monitoring and evaluation ensuring the village's plans are implemented correctly and that they achieve their set objectives. This section outlines the key principles that villagers need to be aware of.

Part I: Theory

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PART I: THEORY

1 INTRODUCTION

Economic growth and development depend largely on water quality and availability, which are affected by competing demands between people, industry, food security, the environment, and development. South Africa is classified as water scarce, in part due to the unequal spatial and climatic distribution of water resources, high rainfall variability, and frequent occurrence of drought. This is further compounded by increasing demand due to population pressure, and declining supply due to climate change, watershed degradation and pollution, both in urban and rural areas. South Africa has a long history of engagement in soil and water conservation through natural resources management (NRM) activities (Department of Agriculture and Water Supply, 1985; National Veld Trust, 1994; Von Maltitz et al., 1998), but uptake in rural village communities has been limited and slow. This slow uptake may be related to the overlapping and conflicting strategies being implemented in these communities. These well-meaning strategies are usually implemented from a top-down overarching National framework, with little consideration for the "everyday" NRM practices that in most cases ensure rural communities' livelihoods and survival on the ground.

In order to implement effective natural resources management, it is therefore necessary to look at the bigger picture and understand the role of the natural resources within the greater system and understand the impacts of their degradation. The system unit that is used for this management context is the catchment. The catchment can be a major river basin right down to a particular tributary in a specific village. It is important to contextualise the household within the catchment; and build the relationship between household, the village, the community and the broader catchment. Through this process it is possible to develop a model for Integrated Catchment Management (ICM), whereby land use, biodiversity, livelihoods and community-based management can be dealt with in a holistic manner and where a relevant "awareness" of Natural Resources Management (NRM) and catchment management can be brought home to the individual and community while still promoting development.

This set of guidelines sets out the context that has/is caused/causing land degradation in rural South Africa; introduces the principles of catchment management, who is involved in catchment management, how to get the process started; as well as a detailed Toolbox of specific activities for implementation towards sustainable catchment management and rehabilitation. While the focus of these guidelines is in rural South Africa, specifically Eastern Cape and KwaZulu-Natal, the threats to resources, and the concepts and principles of catchment management and the guidelines are applicable throughout the country.

1.1 Rationale for Integrated Catchment Management

Integrated resources management approaches include integrated catchment management and are characterised by a proactive, all-inclusive and systems-based approach to natural resource management challenges. In many developing countries, governments and development agencies are turning to integrated natural resource management as a means of safeguarding the natural resource base, improving agricultural productivity and sustaining livelihoods. The integrated approach moves away from managing resources and specific ecosystems in isolation of each other, but rather brings the management of their utilisation and rehabilitation together in a coordinated and collaborative approach. For example, addressing siltation of rivers requires improved management of land-based activities and can't be addressed solely in terms of water resources or aquatic ecosystems management alone. There are numerous examples of integrated resources management e.g. Integrated Water Resources Management (IWRM), Integrated National Resources Management (INRM), Bioregional planning, integrated landscape management, etc. For the purpose of working with catchments we advocate

Integrated Catchment Management (ICM) as defined by Cairns and Crawford[1] (1991) who define integrated natural resource management as a:

> "Coordinated control, direction or influence of all human activities in a defined environmental system *(i.e. the catchment)* to achieve and balance the broadest possible range of short- and long-term objectives."

The concept aims to set a balance between how we use our resources in our catchment for today's needs (like harvesting wood, planting crops, herding livestock and building houses, cutting tree copse to lay infrastructure) and protecting those resources for tomorrow's needs. The principle of ICM is that the process of developing the strategic approach to integrate resource use should be inclusive and holistic. As water is the common link among resource users in a catchment, it is appropriate that the catchment is used as a planning unit for resource management.

The short- and long-term objectives include:

- Sustaining natural capital and ecosystem services
- Developing resilient livelihoods
- Reducing, preventing and rehabilitating environmental degradation

1.1.1 Sustaining Natural Capital and Ecosystem Services

Natural Capital is the available stock of renewable and non-renewable natural resources (e.g., plants, animals, air, water, soils, minerals) that combine to produce a flow of benefits to people (adapted from Atkinson and Pearce, 1995[2]; Jansson et al., 1994[3]), Figure 1-1. These benefits are often called ecosystem goods and services, which make human life possible, Goods, for example include the food we eat, water we drink, plant materials used for medicines, building and shelter, and fuel or energy. Services include the processes that we can't necessarily see but we need them to happen, for example transpiration to put moisture into the air to generate rain, carbon storage for climate regulation, pollination by bees and insects to produce fruit, photosynthesis in plants to grow, the hydrological cycle to produce water, etc. Furthermore, natural capital and ecosystem services are also used for cultural, tourism, and religious activities such as Umhlanga or Reed Dance ceremony (an annual Swazi and Zulu event), or using rivers for baptism.

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[1] Cairns, J. Jr. & Crawford, T.V. (Ed.) (1991) Integrated Environmental Management (Chelsea, MI, Lewis).
[2] Atkinson, G. and D. Pearce, 1995. "Measuring sustainable development." In: Bromley, D.W., (ed) Handbook of Environmental Economics. Blackwell, Oxford, UK, pp:166-182.
[3] Jansson, A., M. Hammer, C. Folke, and R. Costanza (eds.) 1994. Investing in Natural Capital: The Ecological Economics Approach to Sustainability. Island Press, Washington, DC.

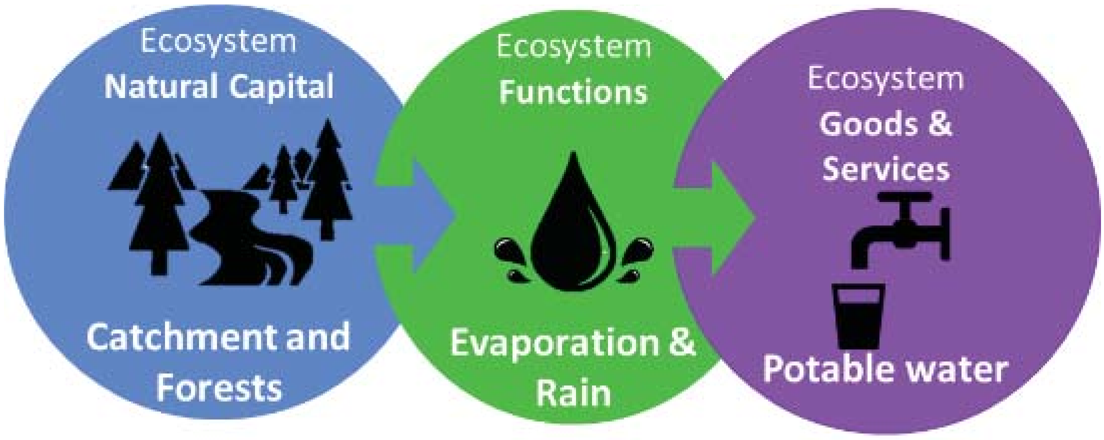

Figure 1-1: Illustrating how natural capital produces goods and services (Source: adapted from Greenanalytics[4])

The natural capital is the stock asset in the environment. We use the stock through ecosystem functions to provide goods and services. However, we need to manage that we don't over utilise the stock, such that it can continue providing the goods and services. We need to replenish the stock e.g. through re-planting forests, replenishing aquifers, re-nourishing the soil, rehabilitating erosion and overgrazing. Overutilization of the natural capital does not just mean a loss of environment or biodiversity, but can cause ecosystem collapse, and reduction in provision of goods and services, which impacts on human livelihoods.

1.1.2 Resilient Livelihoods

Livelihoods is the means (i.e. capability, activities, and assets) of securing basic necessities or resources to live, i.e. food, water, shelter, clothing. It is not necessarily monetary, although the means of accessing these resources may be through monetary processes. These basic necessities or resources are derived from the goods and services provided by the environment, ecosystem functions and natural resources/capital. The accessibility, affordability and availability of these resources contribute to the quality of life of a person. A livelihood strategy may involve wage-based activities, i.e. earning an income that is then used to purchase the required resources; or for poorer or subsistence households, deriving these resources through self-sufficiency, e.g. subsistence farming; or a combination of both wage-earning and subsistence living.

The availability of the resources is at risk of disaster and/or degradation. This may be through sudden events e.g. floods, landslide, wildfire, or pest infestation, or by slower events such as drought, or overutilization. These may be a single event e.g. a flood; or multiple events such as wildfire burning the vegetation which in turn triggers landslides and flooding during heavy rains which impact on water quality and thus availability, loss of crops, etc. These events threaten the availability of – and access to – resources, but also impact on the economic value of the resources, i.e. the scarcer or less available a resource the more valuable it is, and therefore the monetary value increases.
According to the FAO[5], in particular, the poor in rural and urban areas are disproportionately affected, and the inability of families, communities and institutions to anticipate, absorb, accommodate or recover and adapt from crises and disasters in a timely, efficient and sustainable manner is a critical weakness in livelihood strategies.
Therefore, the resilience not only of the natural resources but also of households to provide or access resources for livelihoods is an important component of adaptability, sustainability and community-based

[4] www.greenanalytics.ca
[5] Food and Agricultural Organisation of the United Nations (FAO), website: http://www.fao.org/about/what-we-do/so5/en/ last accessed on 13 December 2018

catchment management. These guidelines not only aim to protect and restore the natural resources, but by doing so also provide sustainable and resilient livelihoods so that the integrity of the communities that depend on the resources through farming, livestock, fishing, forestry and other activities are not detrimentally threatened by disasters, degradation or other risks.

It is important to note that livelihood resilience is not resolved only by natural resource resilience; livelihood resilience also requires land tenure, supportive policy and legislation, risk-reduction strategies and implementation, political will, investment, coordination, involvement and engagement with communities, local authorities, civil society amongst others. These latter aspects are not comprehensively addressed in the scope of these guidelines.

1.1.3 Reducing and rehabilitating environmental degradation

Degradation is the process of breaking down, destroying, or collapse of a system; in the context of this project and guidelines, the degradation of environmental systems. Water resources degradation and land degradation are interlinked. In order to improve the state of water resources, one needs to improve the state of land resources and land use activities. According to International Fund for Agricultural Development (IFAD, 2011)[6] "About 1.2 billion hectares (ha) has been degraded by human activity over the past 45 years. An estimated 5 million to 12 million ha are lost annually to severe degradation in developing countries. The causes include deforestation, biomass burning and agricultural practices such as repetitive tillage and inadequate application of nutrients" as well as not addressing (rehabilitating or mitigating) erosion issues when they start. Land degradation results in loss of soil fertility and increased soil erosion, resulting in loss of arable land. Eroded soils result in siltation and contamination of water resources, thereby impacting the usability of the water resource. Eroded land is unproductive and possess threats to human life and livestock and loss of ecosystem functions which in turn impacts negatively on livelihoods.

In order to reduce the degradation of land and water resources, a sustainable management approach must be implemented. According to South African legislation this is through a Catchment Management approach. It is important that resource management activities not only apply to new activities, but that rehabilitation of already degraded resources is also critical in order to ensure sustainable management and continuation of ecosystem functions and availability of resources. Degradation of resources will continue if no action is implemented and resources will be further depleted.

A critical component of reducing degradation is to also rehabilitate areas that have already been or are currently being degraded. Where rehabilitation is the active process of bringing natural resources – soil, land, water, wetlands, forest, croplands, rangelands, etc. – back to a functioning (not necessarily pristine) state after degradation has taken place. Therefore, sustainable management must incorporate rehabilitation activities.

1.2 Institutional aspects of natural resource management

In many cases, community responses to natural resource management challenges are being hampered by the growing compartmentalisation of government departments, i.e. separate laws, institutions and policy objectives to govern sectors such as agriculture, forestry, water, energy and health. The compartmentalisation frequently means that decisions to govern a sector are made without sufficient regard for issues outside the sector's narrow mandate despite the objectives having impacts (positive and negative) on other resources or sectors. For example, an agricultural policy objective to increase areas of irrigation is made by the Department of Agriculture, however in order to achieve this objective

[6] INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT (IFAD)(2011). Climate-smart smallholder agriculture: What's different? *IFAD Occasional Paper 3.*

requires that there is sufficient water availability and of a suitable quality for the increased irrigation; water availability for irrigation is the mandate of the Department of Water Affairs and Sanitation who have their own national priorities and policy objectives. The increased tillage of soil as a result of increased irrigation will impact on the loss of topsoil causing sedimentation downstream of water resources, which in turn will impact on the ability of the water resource to be used for irrigation and hydropower electricity generation. Unfortunately, it is the communities on the ground who are negatively impacted by this compartmentalisation.

The fragmented approach of government departments to natural resource management issues has high administrative costs, e.g. interdepartmental committees or new multi-sector units, and other challenges such as who, which department, is accountable for the budget or funding of these activities and taking the lead to drive the process. By contrast, communities find it relatively easy to think and act holistically. The administrative costs of integrated natural resource management can be reduced by devolving significant management responsibility to community-based organisations where possible, and to a centralised-community based management plan. The challenge is to effectively connect government departments with each other and with local-level organisations. This connection is made by working towards one integrated management plan, i.e. a catchment management plan. The plan identifies all the issues relevant to a geographic location, i.e. a village. The plan sets out all the activities that are required to be implemented in that area, including land management, water resources management, biodiversity management, energy, education, disaster and risk management, health, infrastructure, etc. The plan is compiled in an integrated approach with the applicable community. Specific activities that fall under the mandates of the different departments are then implemented by the relevant departments however all the role-players are working towards the same goal and vision for that catchment.

Government funding allocated to integrated resource management programmes and especially to village level catchment management plans instead of individual departments will facilitate cross-sector collaboration. The challenges of departmental collaboration should also be easier to overcome through properly established decentralisation. However, this requires adequate capacity and genuine social empowerment through devolution of authority and responsibility. The authority and responsibility for management must be vested together at the lowest appropriate level and only delegated upward where necessary.

A catchment management plan is a strategic document used to guide the management, allocation and sustainable utilisation of water resources within the catchment area in order to support the national objectives and sector development objectives within the catchment. Water, surface and ground-, is not an infinite resource to be used and impacted at free will. The impacts to the resource quality affect downstream users e.g. heavy metals from mining and industrial utilisation has a negative impact on utilisation of the water for irrigation and domestic utilisation. Over abstraction at one point reduces the availability for other users, e.g. silting up of the proposed Nthabelanga-Laleni Dam will reduce hydropower generation and reduce water available for irrigation schemes and drinking water for the development of communities in the catchment. Therefore, all demands of users and impacts to water resources must be addressed in an integrated manner, the Catchment Management Plan.

1.3 Key issues in rural South Africa

The key issue in rural areas is usually the influence of population pressures on the existing landscape-biodiversity dynamics. Whereas many years ago, prior to industrial revolution, when humans lived in unison with nature this was not an issue, but with an increasing demand for natural resources and under the influence of historic-political and socio-economic influences the human footprint has pushed many natural systems beyond a stable threshold. One may consider the human population balancing on the foundation of natural resources as illustrated in Figure 1-2, with the main foundation being land, water and air; and the second tier being plants and animals. Any disruption to the foundation layers would naturally impact the secondary layer and the human population, more so in rural areas where communities still depend directly on subsistence farming, and natural resources. In South Africa the Apartheid era forced the concentration of people into rural areas that were sensitive to the pressure of sustaining high population growth. Since Democracy and the rural-urban migration, although the population pressure in these homeland areas may have reduced slightly, the damage has already been done and continues to have detrimental impacts because the problems are not being addressed, and sustainable land management has stopped taking place or only to a limited extent. One of the challenges in rural South Africa relates to land tenure, i.e. who owns the land and who is responsible for the land? The complexity of chieftain and communal land leads to "tragedy of the commons" effect; and the question "who is responsible for the rehabilitation and management of the land?" Ultimately anyone who uses the land, whether they own it or not, has the responsibility to use it sustainably and not cause harm or degradation.

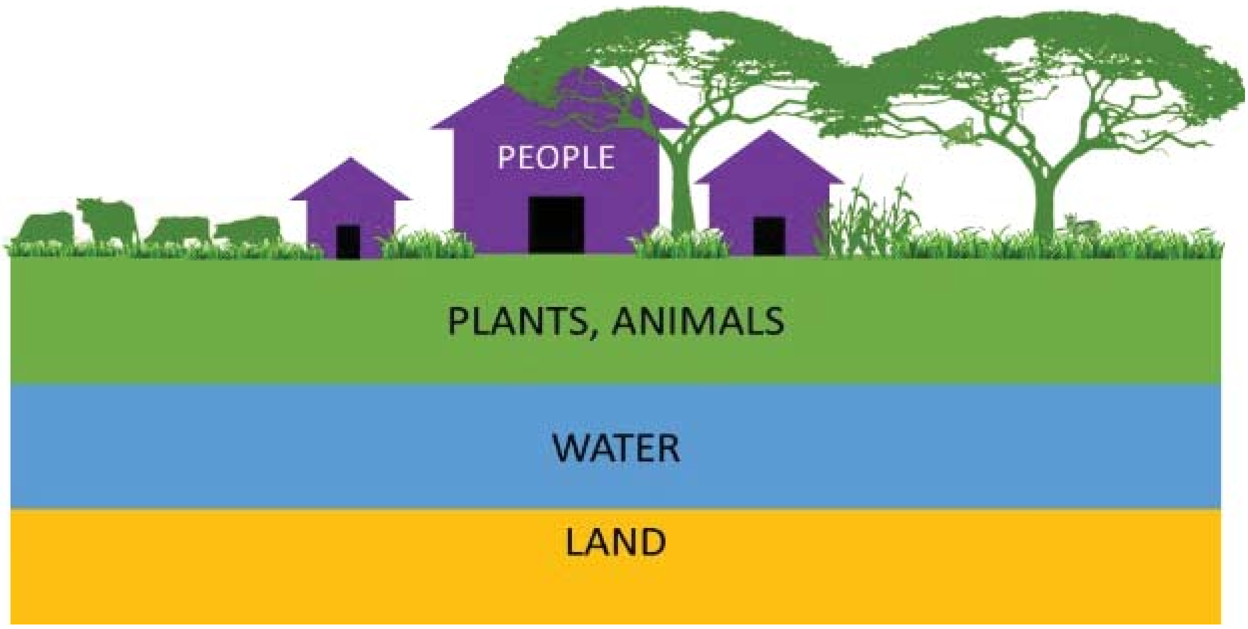

Figure 1-2: Foundation structure of natural resources

Non-urban populations face challenges that are both cause and consequences of environmental degradation. A dependency on natural resources leads to degradation and depletion under the pressures of high population growth/concentration, historic-political, socio-economic issues and biophysical aspects. In some cases, these aspects are interconnected and share a cause/response relationship.

The evolution of the National Water Act, Act 36 of 1998 ("water law") has meant that water resource managers have been given the policy and legal framework to manage land use activities that increase a catchments sediment yield, but implementation has been constrained by a lack of both financial and human resources (Slaughter, 2011) and a disconnect between all the role-players managing land use activities. It may also be said that the methodology of addressing one component of the system is not effective when considering the complex relationship between land, water, plants, animals and humans in terms of land degradation. Addressing an erosion gully (land) without looking at the related layers of plants, animals and humans will not be sufficient or sustainable. This is particularly true when considering the importance of rehabilitation, maintenance and monitoring.

Under the influence of climate change there has been an increase in extreme climatic events. Rainfall events have become more erratic and intense, droughts are more likely and temperatures are swinging to extremes on either end of the spectrum. Changing rainfall seasonality will have a particular impact on farm crop selection and planting regimes. With more rain falling as heavy storm events it will be less effective, and there will be increased erosion, an increased risk of flooding, and greater environmental degradation. Higher evaporative demand will offset any benefits should rainfall possibly increase, also resulting in less effective rainfall. Altered rainfall and evapotranspiration rates will impact on the vegetation, with an increased pressure on marginal species. Ultimately biological diversity is reduced.

These changes also have societal impacts through crop yields, as well as on the forestry industry. Climate changes may alter human health and settlement distribution with disease vectors changing in response to temperature and moisture availability. The impact of changes in rainfall patterns to the flow dynamics of the catchment make proper sustained catchment management implementation ever more essential.

Air quality in rural areas remains a neglected issue. The common belief is that rural areas are free from air pollution, whereas on the contrary air quality in the rural area may be more polluted than some of the urban areas. Rural areas suffer from outdoor air pollution, as well as indoor air pollution. A major source of air pollution is the burning of coal or wood for fuel. This happens both outside and inside dwellings, which leads to various health problems mainly affecting the respiratory and cardio-vascular system.

Although above highlights just a few of the key biophysical issues in rural areas, many of these issues are interrelated with each other and are under the influence of socio-economic and historic-political aspects. Figure 1-3 illustrates the linkages between different factors causing and resulting from land degradation.

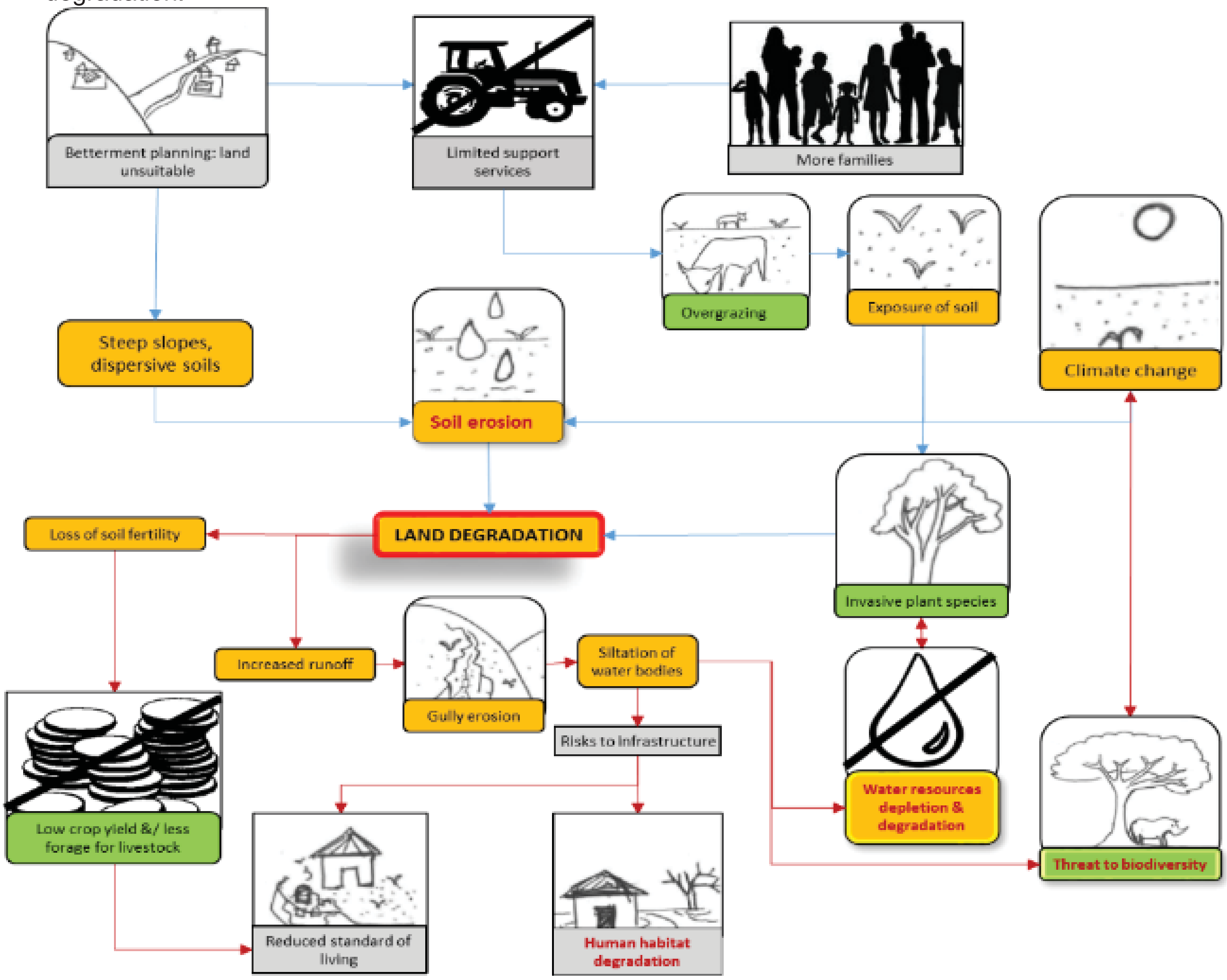

Figure 1-3: An example of the interconnected links of land degradation

Integrated Catchment Management seeks to understand the problems holistically and address them in a sustainable and systemic manner. There is a need to intervene and reverse the degradation of the environment in order to improve the lives of the rural population in South Africa. These guidelines are aimed at working with those that are most vulnerable to the effects of environmental degradation in order to reverse the trend and improve the livelihoods of those who depend on the land to sustain them. Much can be achieved with the right attitude and approaches.

It is essential to improve the overall environment of rural areas. Although initially this means working on the foundational aspects of improving the land, air and water, at a later stage this will also mean improving the infrastructure, utilities, services and governance. At the same time, it is also fundamental to invest in education to empower women, men, young people and children to develop the knowledge and skills they need to take advantage of new economic opportunities. This will enable poor rural people to manage and reduce the level of risk they face.

1.4 Objectives of these Guidelines

The objective of these Guidelines is to provide knowledge and enable communities, Districts and Government Departments to implement Integrated Catchment Management at the community or village scale. Implementing catchment management activities will result in healthier catchments (representative of all-natural resources) and improve livelihoods, as illustrated in Figure 1-4.

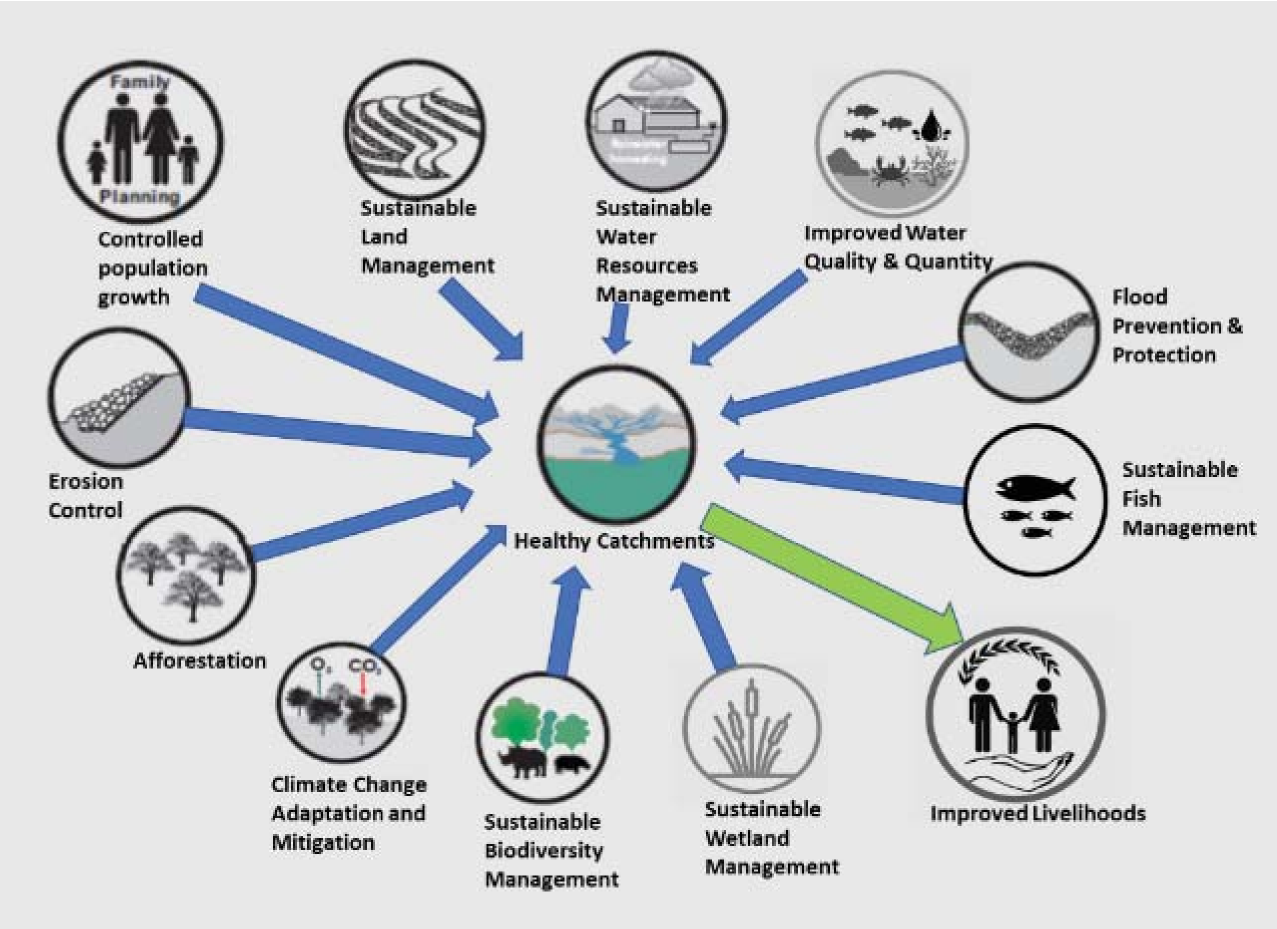

Figure 1-4: The implementation of catchment management activities results in healthy catchments and improved livelihoods

The principle of Integrated Catchment Management (ICM) is that the process of developing the strategic approach to integrated resource use should be inclusive and holistic. As water is the common link among resource users in a catchment, it is appropriate that the catchment is used as a planning unit for resource management. Thus, ICM is aimed at deriving the greatest possible mix of sustainable benefits for current and future generations of the communities in the area of concern whilst protecting the natural resources upon which these communities rely.

In effect, the ICM approach seeks to maintain a balance between the competing pressures exerted by the need to maintain resource integrity in the long-term, against the compelling call for social upliftment and advancement, and the need for continuous economic growth and use of environmental resources. This means an integrated approach to resource management, as illustrated in Figure 1-5. Therefore the toolbox includes guidelines of management, conservation, rehabilitation and maintenance in order to achieve resource protection.

- **Resource protection:** formal measures and actions to prevent harm and/or loss.

- **Sustainable resource management:** the process of dealing with or controlling things or people to ensure sustainable utilisation.
- **Conservation:** maintaining the constant total value of a physical parameter, i.e. ensuring it (parameter) remains constant while the system is subject to external influence
- **Rehabilitation:** restore to an original state / function.
- **Maintenance:** actively preserving a condition or situation

Figure 1-5: Integrated nature of resource protection

1.4.1 Structure of the Guidelines

The Guidelines comprise two Parts that complement one another. Part I is intended to provide background thinking to catchment management activities. Part II is a field manual providing detailed "How to" instructions for various catchment management activities.

1.4.2 Proposed target audience

Given the demographics of the case study area (rural Eastern Cape and KwaZulu-Natal) and the need to implement activities immediately, the proposed target audience is limited education women over 40 years of age. It is important to identify who the target audience is upfront to compiling the guidelines, in order to ensure that the necessary information is included into each guideline specifications, and assumptions are not made. Furthermore, in terms of communicating the guidelines, by understanding the target audience upfront helps to ensure the appropriate communication mediums are utilised. We have identified the target audience as women of limited education over 40 years of age; this means the guidelines should rely more on graphic communication rather than complex theoretical text-based communication.

This does not mean that only 40+ year old illiterate women can use the guidelines, it just means that they are the basic category or grassroots category that will be able to utilise the guidelines, as opposed to technical specialists. If the target audience can use the guidelines and learn from them, they are then capacitated to teach people around them including youths.

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2. SOUTH AFRICAN INSTITUTIONAL AND LEGISLATIVE FRAMEWORK

ACRONYMS

BA	Basic Assessment
DEDEAT	Department of Economic Development, Environment Affairs and Tourism (Eastern Cape)
EA	Environmental Authorisation
EAP	Environmental Assessment Practitioner
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMPr	Environmental Management Programme
GA	General Authorisation
GN	Government Notice
HWC	Heritage Western Cape
MMP	Maintenance Management Plan
MCAA	Mountain Catchment Areas Act, Act 63 of 1970
NEMA	National Environmental Management Act, Act 107 of 1998
NEM:AQA	National Environmental Management: Air Quality Act, Act 39 of 2004
NEM:BA	National Environmental Management: Biodiversity Act, Act 10 of 2004
NEM:PAA	National Environmental Management: Protected Areas Act, Act 57 of 2003
NEM:WA	National Environmental Management: Waste Act, Act 59 of 2008
NHRA	National Heritage Resources Act, Act 25 of 1999
NWA	National Water Act, Act 36 of 1998
SAHRA	South Africa Heritage Resource Agency
R	Regulation (*as per* Government Notice)

2.1 Introduction

One of the core purposes of this guideline is the protection of important land resources through rehabilitation and sustainable management practices. These rehabilitation and management practices are underpinned by environmental legislation that sets out to regulate activities involved as well as promote the sustainability of these practices. This is particularly important due to the scale of the proposed rehabilitation which pushes the project activities over several thresholds in terms of the environmental legislation, subsequently requiring authorisations and permits from several authorities to undertake these activities. This chapter sets out to briefly explain the mechanisms involved with the most pertinent environmental legislation, what processes are required and *how to*- best approach scenarios that would typically form part of these guidelines.

The following environmental related legislation, *inter alia*, is of relevance to these guidelines:

- Constitution of South Africa (Act No. 108 of 1996);
- National Environmental Management Act (Act 107 No. of 1998) as amended (including the National Environmental Management Amendment Act, (Act No. 62 of 2008) (NEMA); and the amended NEMA EIA Regulations (R982-985) (promulgated 4 December 2014) *and further amended 2017 (GN R324-327);*
- National Water Act (Act No. 36 of 1998);
- Conservation of Agricultural Resources Act (Act No. 43 of 1983);
- National Heritage Resources Act (Act No. 25 of 1999);
- National Environmental Management: Biodiversity Act (Act No. 10 of 2004);
- National Environmental Management: Protected Areas Act (Act No. 57 of 2003);
- Mountain Catchment Areas Act (No 63 of 1970);
- National Environmental Management Waste Act (No. 59 of 2008);
- Mineral and Petroleum Resources Development Act (Act No. 28 of 2002).

The Constitution of the Republic of South Africa (Act No. 108 of 1996) includes far-reaching clauses relevant to the environment. In particular, the Bill of Rights stipulates that:

"Everyone has the right –

(a) to an environment that is not harmful to their health or well-being; and
(b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that –
 (i) prevent pollution and ecological degradation;
 (ii) promote conservation; and
 (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development".

South Africa has rigorous and comprehensive environmental legislation aimed at preventing degradation of the environment, including severe erosion. Section 28(1) of the National Environmental Management Act (Act 107 No. of 1998) (NEMA) places a "duty of care and remediation of environmental damage" on every person who causes, has caused, or may cause, significant environmental degradation. This is a far-reaching obligation, and accordingly, those parties responsible for the degradation of the environment have a legal duty to avoid, minimise or mitigate such impacts, whether they own the land that was degraded or not, similarly landowners have a duty of care to ensure their land, whether under their control or not, is not degraded; this is particularly pertinent to land under tribal systems, in particular to communal land. Due to the cumulative scale at which the rehabilitative measures are proposed, it is given that the proposed protection measures will trigger various components of South Africa's environmental legislation. Similarly, the location of activities causing environmental degradation may also be subject to specific management requirements, especially within a protected area or within the buffer area of a declared protected area.

In order to address these issues of erosion, both hard and soft interventions (both rehabilitation and prevention measures) should be implemented in the system, and it is the activities associated with the construction of these interventions that triggers requirements for various authorisations, licenses or permits. However, it is important to note that the very objective of this guideline is to improve both environmental and social circumstances.

2.2 The National Environmental Management Act (Act 107 of 1998), as amended (NEMA)

The National Environmental Management Act (Act 107 of 1998) states in its preamble:

"Whereas many inhabitants of South Africa live in an environment that is harmful to their health and wellbeing; everyone has the right to an environment that is not harmful to his or her health or wellbeing; the State must respect, protect, promote and fulfil the social, economic and environmental rights of everyone and strive to meet the basic needs of previously disadvantaged communities; inequality in the distribution of wealth and resources, and the resultant poverty, are among the important causes as well as the results of environmental harmful practices; sustainable development requires the integration of social, economic and environmental factors in the planning, implementation and evaluation of decisions to ensure that development serves present and future generations; everyone has the right to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that – prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development; the environment is a functional area of concurrent national and provincial legislative competence, and all spheres of government and all organs of state must cooperate with, consult and support one another…"

In terms of the 2014 Environmental Impact Assessment (EIA) regulations (*as amended*) pursuant to NEMA (GN R326), certain activities that may have a detrimental impact on the environment (termed Listed Activities) require an Environmental Authorisation (EA) from the competent authority[7]. The implementation of interventions could trigger NEMA Listing Notices 1 (GN R327), 2 (GN R325) and 3 (GN R324).

Specifically, the following activities (detailed further in Table 2-1):

- Listing Notice 1, GN R327: 12, 19, 27, and 48
- Listing Notice 2, GN R325: 24
- Listing Notice 3, GN R324: 12, 14, and 23

Should the proposed interventions trigger activities listed in Listing Notice 1 or 3, a Basic Assessment (BA) process[8] will be required to meet the necessary requirements of the Regulations, through the application for an Environmental Authorisation (EA). The BA process have two main deliverables a BA Report and an Environmental Management Programme (EMPr). The process and timeframes for undertaking a BA is shown in Figure 2-1. It is highly unlikely that a Listing 2 activity will be triggered, but in the event that it does a full Scoping and Environmental Impact Assessment (EIA) will be required. Furthermore, it is important to note that certain exclusion principles apply to those activities listed above in bold. Should the activities be triggered for maintenance purposes, then a maintenance management plan (MMP) can be compiled and submitted for approval to the DEDEAT. In this case, a full BA process is not required, and neither are its associated costs. This would require consultation with DEDEAT to ensure they are familiar with the process and legislation which have been undertaken in other Provinces.

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[7] Section 6 of Regulation R326 of NEMA indicates that if the Minister is the competent authority in respect of a specific application, the application must be submitted to the national Department of Environmental Affairs (DEA). If a MEC is the competent authority in respect of a particular application, the application must be submitted to the provincial department responsible for environmental affairs in that province, in this case the Eastern Cape Department of Economic Development, Environmental Affairs and Tourism (DEDEAT).

[8] A Basic Assessment is an assessment designed for smaller scale activities where the impacts are generally known and can easily be managed, whilst a Scoping and EIA is a more comprehensive assessment designed for larger or more complex projects. Both processes require public participation.

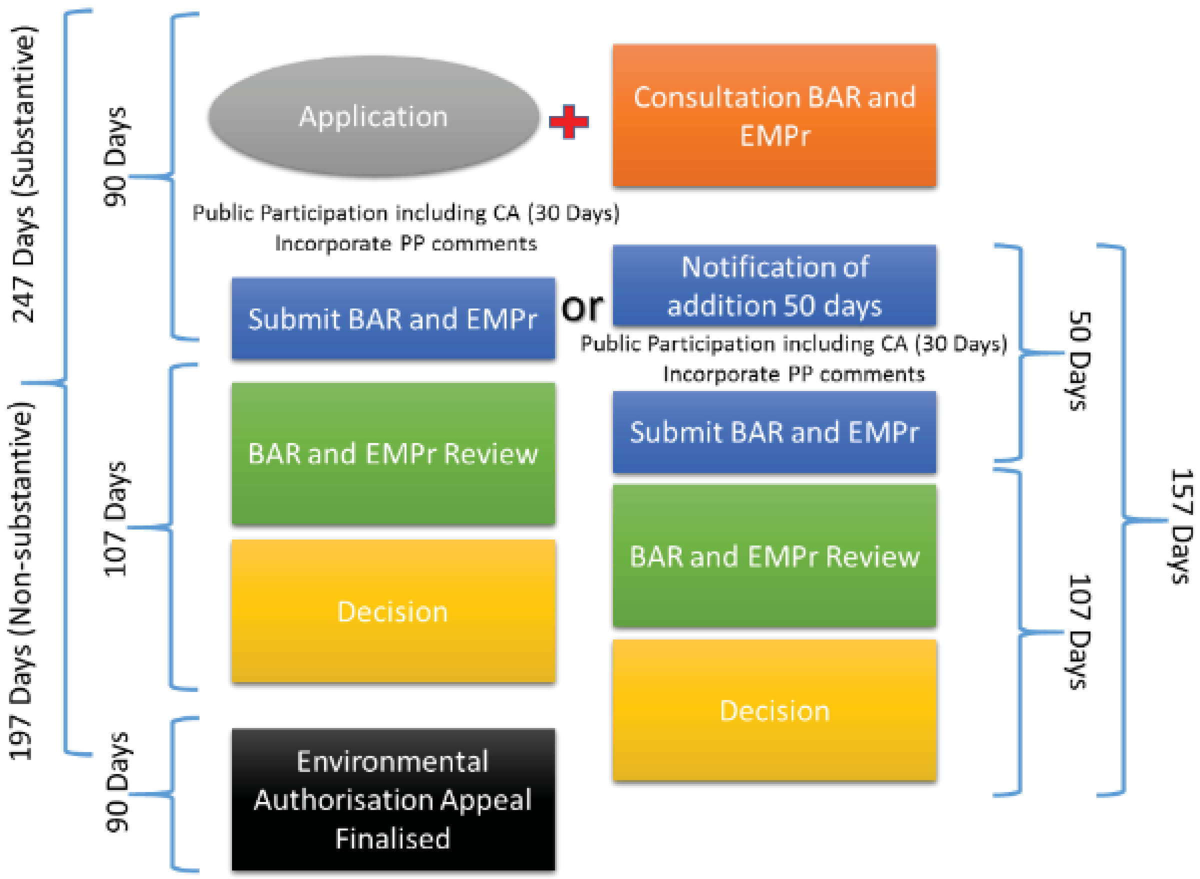

Figure 2-1: Basic Assessment Process indicating timeframes in terms of NEMA 2014, *as amended*

Further to the main Act and associated Regulations, a range of subsidiary Acts have been promulgated under the NEMA, which may have a bearing on the civil engineering projects (especially relating to large scale rehabilitation works). These Acts, hereunder, include:

- The National Environmental Management: Waste Act (No. 59 of 2008), (NEM:WA);
- The National Environmental Management: Protected Areas Act (No. 57 of 2003) (NEM:PAA);
- The National Environmental Management: Air Quality Act (No. 39 of 2004), (NEM:AQA); and
- The National Environmental Management: Biodiversity Act (No 10 of 2004), (NEM:BA);
- The National Environmental Management: Protected Areas Act (Act 57 of 2003).

It is not foreseen that permits / license will necessarily be required in terms of these Acts, but cognisance should be taken of requirements set out in them to ensure compliance with the requirements set out. In this regard, NEM:WA provides for national norms and standards for regulating waste management in all spheres of government and provides for the licensing and control of waste management activities. Waste is always generated during civil works and waste products should be dealt with in terms of this Act. Furthermore, waste material, i.e. building rubble is often resorted to as fill material without cognisance been taken of the legislative requirements regarding the deposition of waste to land. However, works in a watercourse may require a water use licence.

National Environmental Management Air Quality Act (No. 39 of 2004), (NEM:AQA)

NEM:AQA provides for, amongst others, the control of dust, noise and air pollution. The Act therefore aims to prevent pollution and ecological degradation via regulating air quality, to reform current air quality legislation and to provide national standards regulating the monitoring, management and control of air quality, while at the same time promoting justifiable economic and social development. NEM:AQA in terms of this project will mostly relate to the generation of dust during civil works. With regards to the control of dust, Section 32 (Control of Dust) of NEM:AQA refers to measures that may be prescribed to control dust in specified places or areas, as well as steps that must be taken to prevent nuisance by dust, and measures aimed at controlling dust.

The Department of Environmental Affairs draft model air quality management bylaw (GN 964 of 2009) states in Section 10 that any person conducting activities which customarily produce emission of dust that may be harmful to public health, well-being and/or cause a nuisance shall take control measures to prevent emissions into the atmosphere. Section 10(3) states that “any person who undertakes any activity that causes dust emissions must implement one or more of the following control measures:

i) pave;
ii) use dust palliatives or dust suppressants,
iii) uniformly apply and maintain any surface gravel;
iv) erect physical barriers and signs to prohibit access to the disturbed areas;
v) use ground covers;
vi) re-vegetation which is similar to adjacent undisturbed native conditions; or
vii) any alternative control measure approved in writing by the air quality officer.”

National Environmental Management Biodiversity Act (Act 10 of 2004), (NEM:BA)

NEM:BA provides for the management and conservation of South Africa’s biodiversity via the protection of species and ecosystems (particularly those threatened) as well as promoting the sustainable use of indigenous natural resources via equitable sharing of such resources in a sustainable manner. Chapter 3 of the Act stipulates that a national biodiversity framework, a bioregional plan and a biodiversity management plan are required and that monitoring mechanisms and set indicators need to be designated in order to determine the conservation status of various components of South Africa’s biodiversity; and any negative and positive trends affecting the conservation status of the various components. The national biodiversity framework, bioregional plan and any biodiversity environmental implementation or environmental management plans prepared in terms of this Chapter 3 of this Act may not be in conflict with any environmental implementation or environmental management plans prepared in terms of Chapter 3 of the NEMA.

In terms of Chapter 5 of NEM:BA all organs of state in all spheres of government must prepare an invasive species monitoring, control and eradication plan for land under their control, as part of their environmental plans in accordance with section 11 of the NEMA. The invasive species monitoring, control and eradication plan of municipalities must be part of their Integrated Development Plans. This is of key importance because part of the project works would be to undertake clearing of invasive alien plant species. In terms of Section 10 of NEM:BA, the South African National Biodiversity Institute (SANBI) is the competent authority who oversees the implementation of this legislation. However, in terms of Section 36, in the event of absence of a functional Board, the powers and duties of the Board revert to the Minister who, in such a case, must exercise those powers and perform those duties until the board is functional again. In order to trigger any requirements under the NEM:BA, Activity 27 of Regulation R982 under NEMA will be triggered, thus requiring a Basic Assessment process to be undertaken. If a Basic Assessment process is required, the competent authority overseeing the NEM:BA will be the DEDEAT.

Furthermore, recently (GN R598 of 1 August 2014), an amendment to the National Environmental Management: Biodiversity Act (Act 10 of 2004) (NEMBA) promulgated the decision to require Invasive Species Monitoring, Control and Eradication Plans for listed invasive species as contemplated in Section 76 of the Act. These Plans will be required for each municipality and each Organ of State. If a landowner holds invasive species on their land, they are either required by law, to clear the invasive, or to compile a Control Plan and submit it to the municipality. Should a private landowner require funding to assist in the clearing of invasive species, by submitting a Control Plan, they are able to apply for state funding assistance.

In order to undertake these legal requirements, the environment needs to be assessed by an independent Environmental Assessment Practitioner (EAP) with suitable skills and experience, as well as relevant specialists which most likely include freshwater ecologist, botanist and heritage (archaeology or palaeontology). Both the Basic Assessment and full Scoping and EIA processes require a considerable financial input (hundreds of thousands of Rands) and are subject to timeframes which are often in excess of a year to undertake. Local communities invariably do not have access to sufficient funds to undertake these studies. Incidentally the legal requirements are therefore hindering the ability for the land to be appropriately rehabilitated. Furthermore, contravention of the stipulations in the NEMA and its subsidiaries could lead to severe fines. In terms of Section 102 of NEM:BA, failure to comply with the requirements of the NEM:BA would constitute an offence, and the person will be liable to a fine not exceeding R5 million or to imprisonment for a period not exceeding 5 years. In the case of a second of subsequent conviction, the guilt person will be liable to a fine not exceeding R10 million or to imprisonment for a period not exceeding 10 years.

National Environmental Management: Protected Areas Act (Act 57 of 2003), (NEM:PAA)

The NEM:PAA sets out, *inter alia*, to provide for the protection and conservation of ecologically viable areas representative of South Africa's biological diversity and its natural landscapes and seascapes; for establishment of a register or protected areas; and the management of those areas in accordance with national norms and standards. Of relevance to catchment management, is the Mountain Catchment Areas Act, Act 63 of 1970 (MCAA), which set out to provide for the conservation, use, management and control of land situated in mountain catchment areas, and to provide for matters related incidental thereto. The MCAA was absorbed into the NEM:PAA, i.e. that areas declared under the MCAA are still recognised as Protected Areas in terms of the NEM:PAA, and therefore governed by the provisions and regulations where applicable of the NEM:PAA.

In particular, and of relevance to land tenure, the MCAA definers an "occupier", in relation to land, as any person who as owner, lessee or otherwise has the management, charge, control or use of any land, whether he resides on that land or not, and includes any person who has the right of cutting trees or wood on any land or of removing trees or wood from any land, and in relation to land under the control of a local authority, that local authority, but does include any person who as "bywoner" or "deeisaaier" is in occupation or has the use of any land.[9]

In terms of section 3[10], the Minister may issue a directive on land within a declared Mountain Catchment Area, or within a 5 km buffer around a mountain catchment area, in respect of:

3(1)(b)(i) Within a catchment area:

(aa)The conservation, use, management and control of such land;

(bb) the prevention of soil erosion, the protection and treatment of the natural vegetation and the destruction of vegetation which is, in the opinion of the Minister, intruding vegetation;

(cc) any other matter which he considers necessary or expedient for the achievement of the objects of the Act in respect of such land; and

3(1)(b)(ii) With the 5 km buffer area:

The destruction of vegetation which is, in the opinion of the Minister, intruding vegetation.

Therefore, anyone using land within a Mountain Catchment Area may be instructed to rehabilitate the land, especially where soil erosion has/is occurring.

2.3 National Water Act (Act 36 of 1998) (NWA)

The National Water Act (Act No. 36 of 1998) (NWA) recognises that water is a scarce and unevenly distributed national resource and deals with water resource management and the sustainable use of water for the benefit of all users. The Act provides for the integrated management of all aspects of water

[9] Definition of "occupier" substituted by section 28(a) of Act 108 of 1991.

[10] Section 3(1) substituted by section 2 of Act 76 of 1981

resources and the delegation of management functions to a regional or catchment level so as to enable everyone to participate. The guiding principles of the NWA recognise the need to protect water resources. Sustainability and equity are identified as central guiding principles in the protection, use, development, conservation, management and control of water resources. These guiding principles recognise the basic human needs of present and future generations, the need to protect water resources, the need to share some water resources with other countries, the need to promote social and economic development through the use of water and the need to establish suitable institutions in order to achieve the purpose of the Act. In terms of this Act, the responsibility for water quality and control of water pollution falls under the national government, but water services authorities have a role in the control of industrial water pollution.

In general, a water use must be licensed unless it is listed in Schedule I of the National Water Act, is an existing lawful use, is permissible under a General Authorisation (GA), or if a responsible authority waives the need for a licence. Chapter 4 of the Act lays the basis for regulating water use. The various types of licensed and unlicensed entitlements to use water are dealt with in detail in this Chapter 4 of the Act.

In terms of the Act "Water use" includes:

- taking water from a water resource;
- storing water;
- impeding or diverting the flow of water in a watercourse;
- engaging in a stream flow reduction activity;
- discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;
- disposing of waste in a manner which may detrimentally impact on a water resource;
- disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process;
- altering the bed, banks, course or characteristics of a watercourse;
- removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; and
- using water for recreational purposes.

Many of these water uses can occur during infrastructure work and must be licensed unless they comply with the requirements in terms of a General Authorisation.

Based on the information requirements and administrative process involved with the issuing of a license, the process typically takes approximately 18 to 24 months. Subsequently, cognisance must be taken of the time frames associated with such a process, and ensuing implications for projects and associated funding. There are several implications in the event of licence conditions being contravened. These range from the responsible authority requiring the licensee to take remedial action, failing which it may take the necessary action and recover reasonable costs from that person, to the suspension or withdrawal of a licence. The licence application must be compiled by a competent person and may require specialist studies.

2.4 The National Heritage Resources Act (Act 25 of 1999) (NHRA)

The Act distinguishes between Grade 1 (of national significance), Grade 2 (of provincial/ regional significance) and Grade 3 (other) heritage resources[11]. Grade 1 heritage resources are administered

[11] Heritage resources are defined as places, buildings, structures and equipment, oral traditions, historical settlements, geological sites and landscapes of cultural significance, archaeological and paleontological sites;

by the National South African Heritage Resources Agency (SAHRA), whereas Grade 2 and 3 heritage resources will be dealt with by the provincial Heritage Agency.

According to Section 27 of the NHRA, "no person may destroy, damage, deface, excavate, alter, remove from its original position, subdivide or change the planning status of any heritage site without a permit issued by the heritage resources authority responsible for the protection of such site." Furthermore, according to Section 34 of the NHRA, "No person may alter or demolish any structure or part of a structure which is older than 60 years without a permit issued by the relevant provincial heritage resources authority". This is particularly important if there are historical structures in the watercourses affected that requires removal or removal e.g. bridge, weir, canal.

Section 38 of the NHRA states that any person who intends to undertake a development categorised as:

"(1) (a) the construction of a road … or other similar form of linear development or barrier exceeding 300 m in length;

(b) any development or other activity which will change the character of a site:

(i) exceeding 5 000 m² in extent; or

(ii) involving three or more existing even or subdivisions thereof; or

(iii) involving three or more even or divisions thereof which have been consolidated within the past five years; or

(c) the re-zoning of a site exceeding 10 000 m² in extent,

…must at the very earliest stages of initiating such a development, notify the responsible heritage resources authority and furnish it with details regarding the location, nature and extent of the proposed development." To assist in this regard, the South African Heritage Resources Agency (SAHRA) have developed a form, "Notification of Intent to Develop," to be completed for any activity that meets one or more of the above criteria. The responsible heritage resources authority must, within 14 days of receipt of a notification, notify the person who intends to undertake the development whether an impact assessment report is required. If considered necessary, an impact assessment report must be compiled at the cost of the person proposing the development, by a person approved by the responsible heritage resources authority[12]. Should a permit be required for the damaging or removal of specific heritage resources, an application will be submitted to provincial Agency e.g. ECPHRA, for the approval of such an activity. According to the 2014 EIA Regulations, *as amended*, pursuant to NEMA, this can take place alongside the BA process under the "One Environmental Process."

2.5 Key Issues

It is important to consider that the proposed project is not a development proposal and the project activities that requires an EA, licenses and permits in terms of Regulations pursuant to NEMA are only being undertaken to benefit the environment. Nevertheless, these processes are not only aimed at preventing negative environmental impact through development, but also to enhance the positive impacts and ensure the long-term sustainability of activities such as rehabilitation projects. The issue however comes in with the financial cost of compliance with legislative requirements as well as the time and often bureaucratic impediments that face projects of this nature.

graves and burial grounds, meteorites and rare geological specimens; ethnographic art and objects; military objects; books, records, etc.

[12] The competent authority to issue a Record of Decision to undertake an activity that triggers the requirements under the NHRA would depend on the nature of the activity. Should the activity involve a Grade 1 Heritage site, then the SAHRA would be the competent authority. All remaining requirements under the NHRA would be overseen by the provincial authorities, e.g. ECPHRA.

This problem is not unique, and other large-scale projects have faced similar challenges. The Working for Wetlands Programme is a national programme managed by the Natural Resource Management Directorate of the Department of Environmental Affairs. Each year, several projects are chosen within a province and a planning process is undertaken, meeting the necessary legal requirements. However, the planning of this project is all undertaken by the South African Government, and the funding is sourced through tax payers' money. As some of the abovementioned activities are also triggered by the Working for Wetlands Programme, Maintenance Management Plans (MMPs) are created for each site in the form of project specific Rehabilitation Plans.

On the other side of the scale, a Water Research Commission (WRC) study have produced a set of guidelines for River Rehabilitation. The focus on these rehabilitative efforts are supposed to be used at a site-specific scale, to assist landowners in rehabilitating their wetlands. It is not intended for greater scale or to compete with the Working for Wetlands Programme. The guidelines provide general information about water resources in South Africa and include specific rehabilitation intervention suggestions, and how they can be implemented by the landowner. However, the legislation currently hinders these small interventions as they all require a BA process.

However, households in the rural areas do not have the finances to compile and submit these expensive and administratively burdensome processes.

The above-mentioned examples are important considerations for acts of land rehabilitation and restoration projects that are currently underway in South Africa. They each provide the argument that rehabilitation efforts are hindered by the environmental legislation, however are finding alternative ways that the environment is assessed and the interventions are planned appropriately. It is recommended that through consultation with the relevant authorities and key stakeholders, that a plan such as one of the above be proposed for strategic land management in rural areas of the Eastern Cape.

Remediation and rehabilitation measures might require substantive amounts of material to be used for infilling and deposition in, i.e., erosion gullies or removal as a result of regrading gullies for re-vegetation. Due to the rural nature of the project area it's possible that material will not be obtained from a commercial source or that the cost implication thereof would be excessive and therefore material would have to be borrowed locally. This would mean an application to extract material will have to be lodged at the Department of Mineral Resources (DMR) and a Basic Assessment will have to be undertaken to obtain an EA for this specific activity. Yet another financial burdening activity that may have to be funded by the local community.

2.6 Way Forward

In order for the project to comply with the relevant environmental legislation (listed in Table 2-1 to lessen the financial burden associated with compliance and to ensure that the project proponent does not fall liable to non-compliance fines and / or prosecution certain strategic measures can be put in place to streamline activities. For example, a Municipality or Provincial Government could compile a Catchment Management Plan, which identifies all the types of rehabilitation and land management activities that are required within the catchment area, the plan is approved by the various stakeholders e.g. DEDEAT, DWS, AND DRDLR – similar to a Spatial Development Framework. The various departments can then include these activities within their business plans, and local communities can implement small scale rehabilitation projects themselves without going through the necessary burdensome and expensively authorising processes.

Maintenance and Management Plans (MMP) in terms of NEMA

The aim of the MMP is to acquire authorization for the following Listed Activities, considered permissible provided that they are undertaken in accordance with the MMP once approved by DEDEAT:

1. LN 1 (19): The infilling or depositing of any material of more than 10 m^3 into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock of more than 10 cubic metres from a watercourse.
2. LN 1 (27): The clearance of an area of 1 ha or more, but less than 20 ha of indigenous vegetation.
3. LN 3 (12): The clearance of an area of 300 square metres or more of indigenous vegetation in the Eastern Cape.

An MMP can be undertaken for a specific geographical area (e.g. watercourse, drainage area and / or municipality) and thus all the activities listed above can be applied for in terms of one MMP.

Basic Assessment Reports (BAR) in terms of NEMA

For those activities where, other Listed Activities would be triggered, and where an exemption option of an MMP is not provided, a Basic Assessment Process would be required. Typically, such processes are required per structure. It is however possible that the submission of one Basic Assessment Report per geographical area (village, municipality), which would allow for the assessment of all listed activities that could potentially be triggered whilst undertaking rehabilitation work (i.e. a blanket approval would be obtained for all listed activities related to developments and expansion). This would require the consultation and buy-in from DEADEAT and other authorities such as DWS and DAFF to ensure that certain aspects of the project does not delay the whole application.

General Authorisations (GA) in terms of NWA

In terms of Section 39 (GN 1199 of 18 December 2009) of the NWA, a GA has been granted for certain activities that are listed under the NWA that usually require a Water Use Licence. Such a GA exists for activities that entail (c) ‘impeding or diverting the flow of water in a watercourse’ and/or (i) ‘altering the bed, banks, course or characteristics of a watercourse’ or undertaking the above-mentioned water uses for the rehabilitation of a wetland’. In order to register these interventions, consultation with the Eastern Cape regional Department of Water and Sanitation (DWS) will be required.

Emergency situations

It’s important to note that there is specific legislation in both NEMA and the NWA that address emergency situations. Certain rehabilitation measure might fall within the parameters of what constitutes an emergency situation and therefor rehabilitation measures can be put in places to remediate measures without going through timeous legislative processes. It’s very important to note that legislation is time sensitive and if remedial efforts are not undertaken within reasonable time of the event which caused the situation e.g. flooding, it is exceedingly difficult to motivate to the competent authority why this constitutes and emergency situation.

Section 30 of NEMA has recently been amended in terms of the National Environmental Management Laws Second Amendment Act 30 of 2013 by the insertion of section 30A. Section 30A makes specific provision for dealing with emergency situations. An “emergency situation” is defined as:

> “a situation that has arisen suddenly that poses an imminent and serious threat to the environment, human life or property, including ‘disaster’ as defined in section 1 of the Disaster Management Act, 2002 (Act No. 57 of 2002)”

Section 30A came into effect on 18 December 2014. Section 30A (1) allows for verbal and written directives to be issued by a competent authority to the person responsible to undertake listed or specified activities without obtaining the prerequisite environmental authorisation in order to prevent or contain an emergency situation or to prevent, contain or mitigate the effects of an emergency situation. General Notice 1081 of 2014 introduced “Regulations relating to the procedures to be followed when oral requests are made in terms of Section 30 A. Specifically, General Notice 1081 of 2014 states that an Application in terms of section 30A of NEMA is permissible when:

3. (1) Any person who reasonably foresees that:

(a) he or she may commence with a listed or specified activity identified in terms of Regulations promulgated under Section 24(2) of National Environment Management Act, 1998 (Act No. 107 of 1998) without an environmental authorisation; and

(b) commencement with such listed or specified activity would be directly in response to a situation that has arisen suddenly and which poses an imminent and serious threat to the environment, human life or property; or

(c) commencement with such listed or specified activity would be directly in response to a 'disaster' as defined in section 1 of the Disaster Management Act, 2002 (Act No. 57 of 2002),

The definition of what constitutes a disaster in terms of the Disaster Management Act is therefore important. A disaster is defined as “a progressive or sudden, widespread or localised, natural or human-caused occurrence which –

(a) Causes or threatens to cause

(i) Death, injury or disease;

(ii) Damage to property, infrastructure or the environment; or

(iii) Disruption of the life of a community; and

(b) Is of a magnitude that exceeds the ability of those affected by the disaster to cope with its effects using only their own resources”[13]

Thus, where an environmental emergency situation arises, the competent authority may dispense with the requirements for obtaining environmental authorisation where a listed activity is triggered for purposes of undertaking reasonable measures to prevent or contain an emergency situation or to prevent, contain or mitigate the effects of an emergency situation.[14]

In cases of extreme urgency involving the safety of humans or property or the protection of a water resource or the environment, section 67(1) of the National Water Act No 36 of 1998, allows for dispensing with certain requirements of Act:

(1) In an emergency situation, or in cases of extreme urgency involving the safety of humans or property or the protection of a water resource or the environment, the Minister may

(a) dispense with the requirements of this Act relating to prior publication or to obtaining and considering public comment before any instrument contemplated in section 158 (1) is made or issued;

(b) dispense with notice periods or time limits required by or under this Act;

(c) authorise a water management institution to dispense with –

(i) the requirements of this Act relating to prior publication or to obtaining and considering public comment before any instrument is made or issued; and

(ii) notice periods or time limits required by or under this Act.

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[13] http://www.greenafricadirectory.org/wp-content/uploads/2014/07/IMBEWU_Section-30-of-NEMA-and-amendment-thereto_Sept-2014.pdf

[14] http://iaiasa.co.za/wp-content/uploads/2012/06/26.11.14-38253_gen1081-S30A-Regs-Draft.pdf

(2) Anything done under subsection (1) –

(a) must be withdrawn or repealed within a maximum period of two years after the emergency situation or the urgency ceases to exist; and

(b) must be mentioned in the Minister's annual report to Parliament.

Table 2-1: Summary of listed activities related to rehabilitation of erosion, that may require prior authorisation (NEMA 2014 Regs, *as amended*) *inter alia*

Activity	Listed Trigger	Project Relevance
Listing Notice 1, GN R327		
GN R327: Activity 12	The development of – (i) Dams or weirs, where the dam or weir, including infrastructure and water surface area, exceeds 100 m^2; or (ii) Infrastructure or structures with a physical footprint o 100 m^2 or more; Where such development occurs – (a) within a watercourse; (c) if no development setback exists, within 32 m of a watercourse, measured from the edge of a watercourse;	The proposed rehabilitation interventions include interventions such as stone check dams, gabions, etc. which may exceed 100 m^2 either individually or cumulatively within the system. Furthermore, these will be constructed within the gully channel, which is considered a watercourse.
GN R327: Activity 19	The infilling or depositing of any material of more than 10 m^3 into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock of more than 10 m^3 from a watercourse; But excluding where such infilling, depositing, dredging, excavation, removal or moving – (b) is for maintenance purposes undertaken in accordance with a maintenance management plan;	Beyond the building of the infrastructure mentioned above, interventions may be required to remove material from the gulley walls to reduce the gradient to a stable 1:2 slope. This activity will not need a BA if a maintenance management plan is compiled; this still requires approval by the competent authority.
GN R983: Activity 27	The clearance of an area of 1 ha or more, but less than 20 ha of indigenous vegetation, except where such clearance of indigenous vegetation is required for – (i) the undertaking of a linear activity; or (ii) maintenance purposes undertaken in accordance with a maintenance management plan. (If more than 20 ha then activity 15 of GN R325 applies)	In order to shape the gully appropriately, and construct the hard interventions like gabions, some indigenous vegetation may need to be cleared. This activity will not need a BA if a maintenance management plan is compiled; this still requires approval by the competent authority.
GN R327: Activity 48	The expansion of – (i) infrastructure or structures where the physical footprint is expanded by 100 m^2 or more; or	The proposed rehabilitation interventions include interventions such as stone check dams, gabions, or gully reshaping, etc. which may lead to the expansion of structures by 100 m^2 either individually or cumulatively within the

	(ii) dams or weirs, where the dam or weir, including infrastructure and water surface area, is expanded by 100 m^2 or more; Where such expansion occurs – (a) within a watercourse; (c) if no development setback exists, within 32 m of a watercourse, measured from the edge of a watercourse	system. Furthermore, these will be constructed within the gully channel, which is considered a watercourse.
Listing Notice 2, GN R325		
GN R325: Activity 24	The extraction or removal of peat or peat soils, including the disturbance of vegetation or soils in anticipation of the extraction or removal of peat or peat soils, but excluding where such extraction is for the rehabilitation of wetlands in accordance with a maintenance management plan.	This activity will not need a BA if a maintenance management plan is compiled; this still requires approval by the competent authority.
Listing Notice 3, GN R324		
GN R324: Activity 12	The clearance of an area of 300 m^2 or more of indigenous vegetation except where such clearance of indigenous vegetation is required for maintenance purposes undertaken in accordance with a maintenance management plan. (a) In Eastern Cape… (i) within any critically endangered or endangered ecosystem listed in terms of section 52 of the NEMBA or prior to the publication of such a list, within an area that has been identified as critically endangered in the National Spatial Biodiversity Assessment 2004; (ii) within critical biodiversity areas identified in bioregional plans; (iv) on land, where, at the time of the coming into effect of this Notice or thereafter such land was zoned open space, conservation or had an equivalent zoning.	In order to shape the gully appropriately, and construct the hard interventions like gabions, some indigenous vegetation may need to be cleared. This activity will not need a BA if a maintenance management plan is compiled; this still requires approval by the competent authority.
GN R324: Activity 14	The development of – (i) dams or weirs, where the dam or weir, including infrastructure and water surface area exceeds 10 m^2; or (ii) infrastructure or structures with a physical footprint of 10 m^2 or more; where such development occurs – (a) within a watercourse; (c) if no development setback has been adopted, within 32 m of a watercourse, measured from the edge of a watercourse; (c) In Eastern Cape: (ii) Outside urban areas:	The proposed rehabilitation interventions include interventions such as stone check dams, gabions, etc. which may exceed 10 m^2 either individually or cumulatively within the system. Furthermore, these will be constructed within the gully channel, which is considered a watercourse. Declared Mountain Catchment Areas are listed protected areas in terms of the NEMPAA

	(aa) A protected area identified in terms of NEMPAA, excluding conservancies; (bb) National Protected Area Expansion Strategy Focus areas; (cc) World Heritage Sites; (dd) Sensitive areas as identified in an environmental management framework as contemplated in chapter 5 of the Act and as adopted by the competent authority; (ee) Sites or areas identified in terms of an International Convention; (ff) Critical biodiversity areas or ecosystem service areas as identified in systematic biodiversity plans adopted by the competent authority or in bioregional plans; (gg) Core areas in biosphere reserves; (hh) Areas within 10 km from national parks or world heritage sites or 5 km from any other protected area identified in terms of NEMPAA or from the core area of a biosphere reserve; or (ii) Areas seawards of the development setback line or within 1 km from the high-water mark of the sea if no such development setback line is determined	
GN R324: Activity 23	The expansion of – (i) dams or weirs where the dam or weir is expanded by 10 m^2 or more; or (ii) infrastructure or structures where the physical footprint I expanded by 10 m^2 or more; where such expansion occurs – (a) within a watercourse; (c) if no development setback has been adopted, within 32 m of a watercourse, measured from the edge of a watercourse; (b) In Eastern Cape: (ii) Outside urban areas: (aa) A protected area identified in terms of NEMPAA, excluding conservancies; (bb) National Protected Area Expansion Strategy Focus areas; (cc) Sensitive areas as identified in an environmental management framework as contemplated in chapter 5 of the Act and as adopted by the competent authority; (dd) Sites or areas identified in terms of an International Convention; (ee) Critical biodiversity areas or ecosystem service areas as identified in systematic biodiversity plans adopted by the competent authority or in bioregional plans; (ff) Core areas in biosphere reserves;	The proposed rehabilitation interventions include interventions such as stone check dams, gabions, gully reshaping, etc. which may exceed 10 m^2 either individually or cumulatively within the system. Furthermore, these will be constructed within the gully channel, which is considered a watercourse. Previously declared Mountain Catchment Areas are listed as protected areas in terms of the NEMPAA.

	(gg) Areas within 10 km from national parks or world heritage sites or 5 km from any other protected area identified in terms of NEMPAA or from the core area of a biosphere reserve; (hh) Areas seawards of the development setback line or within 1 km from the high-water mark of the sea if no such development setback line is determined.	

3. CATCHMENT MANAGEMENT: CONCEPTS AND PRINCIPLES

3.1 Introduction

Water is the basis of life and is needed for people, animals and plants to survive. It shapes the earth's surface and is part of our climate and how it works. Similarly, soil provides the nutrients for plants to grow and feed people and animals, as well as provide resources for human livelihoods such as clothing, shelter, medicine, etc.

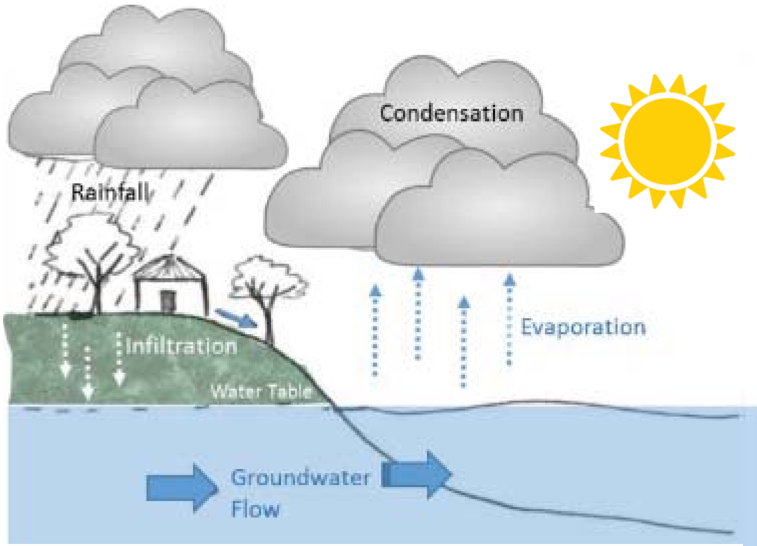


Figure 3-1: The water cycle

Earth receives water as rain, which runs into rivers or filters into the soil. Water may be stored underground, or in dams or lakes before it flows into the sea. Evaporation occurs when water in soils or rivers, lakes and the sea changes to a gas and moves back into the atmosphere as the surface warms-up.
This process allows water to collect in clouds and be returned to the earth again as rain, in what is known as the water cycle, as illustrated in Figure 3-1.

A water resource is any water supply on earth including springs, seeps, groundwater, lakes, dams, rivers, channels, and wetlands.

In order to understand where the water in our rives comes from, what sustains low flows, why we get floods, and how we can manage our water resources better, we need to understand what happens when rain falls on to the ground. This will also help us to understand how we can protect the soil so that it is better able to grow crops and to protect it against erosion. Rivers and springs that continue to flow strongly in the dry season tend to be linked to soils on the catchment slopes that support healthy crops and provide good grazing for livestock. Rivers and springs that stop flowing in the dry season and flood easily are linked to poor, eroded soils that do not support healthy crops or livestock. So, we will see how healthy crops, good grazing land and river water that is available through the dry season are linked through the hydrological cycle taking place at the catchment scale.

3.2 What is a catchment?

Land and water are linked spatially in a natural system called a catchment. It is the physical area of land that catches water and directs it to a stream, river or lake, i.e. the drainage area of a river, Figure 3-2. A catchment is drained by different types of streams and rivers, some that flow only when it rains (*ephemeral*), some flow for only part of the year e.g. in the rainy season (*non-perennial*), some that flow all of the time (*perennial*).

Figure 3-2: Illustration of a catchment area.

A catchment boundary is called a watershed, which is usually on top of a ridge, hill or mountain. A watershed divides the pathways that water will follow into the catchments on either side of it, as illustrated in Figure 3-2, the red line indicates the watershed. Water makes its way down the catchment slopes, either as runoff or as groundwater, into the streams and rivers, where it joins that of other catchments in bigger rivers until it reaches the sea.

In South Africa, the Braamfontein Ridge in Johannesburg is an International watershed, as the runoff flows not only into two different river basins, but also into two different oceans. Rain that falls on the northern side of the ridge eventually flows into the Limpopo River Basin and into the Indian Ocean on the east coast of the country, while rain that falls on the southern side of the ridge eventually flows into the Orange-Senqu River Basin and into the Atlantic Ocean on the west coast of the country, as illustrated in Figure 3-3.

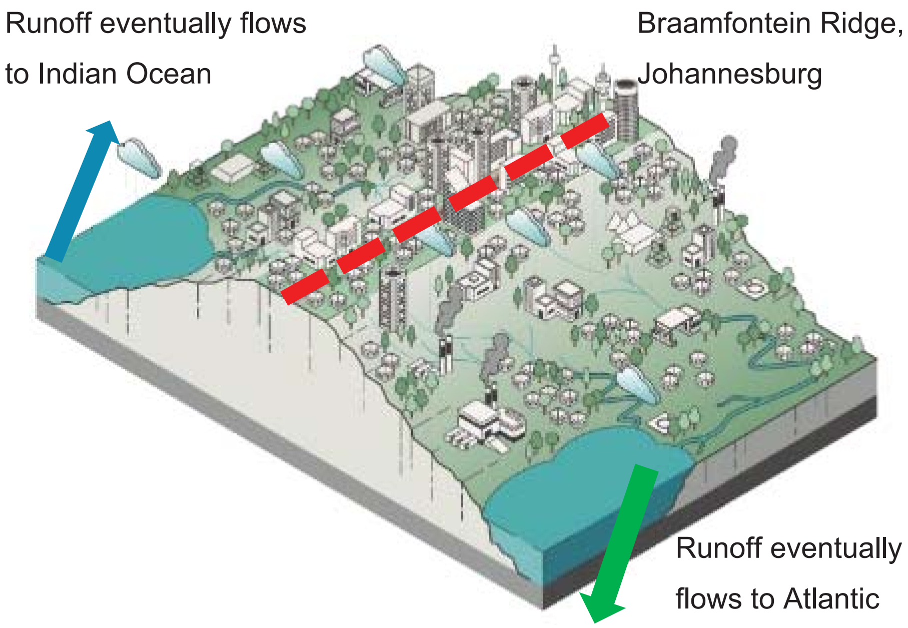


Figure 3-3: Illustration of a watershed

3.3 Vegetation-soil-streamflow interactions in a catchment

Rain falling onto a porous (permeable) soil surface will infiltrate (sink) into the soil where it becomes available to the roots of plants. The plants use the water in the process of photosynthesis (using sunlight to make food from carbon dioxide and water) but they also loose water to the atmosphere through the process of transpiration. Transpiration loss increases on hot, windy days, in the same way as evaporation from wet surfaces. This means that South Africa suffers from high evaporation and transpiration rates. A lake or pond can lose over 5 mm of water on a hot day due to evaporation (nearly 2 m over a year). This rapid loss of water means that we must do whatever we can to keep water in the soil where it is available to plants or groundwater recharge.

Infiltration will only take place if the surface of the soil is porous, with lots of holes for the water to enter (like a sponge). During heavy rain the large drops have a lot of energy and can cause a skin or crust of fine soil to form on the surface of bare soil. This crust lacks large pores and seals the soil so that rain can no longer sink in. A good ground cover of vegetation is the best way to keep the soil porous. The leaves protect the surface from the impact of the rain drops and the roots make pathways through the soil for water to flow. Leaf litter provides further protection.

If rain continues to infiltrate into the soil some of the soil pores will become saturated (full) and the extra water moves downwards into the deeper layers of the soil and, eventually, into the underlying bedrock. Here the water is stored as groundwater. Water in the deep soil layers and the groundwater moves slowly downslope to feed seeps, springs and the river from underground. The movement is slow and it may be a long way to the river so that summer rainfall may only get to the river the following winter or even later.

Groundwater tends to be found deep in the rocks so is away from the roots of vegetation and is not lost through transpiration, or evaporation. It is also unaffected by soil erosion so the water is usually free of sediment. Groundwater does spend a lot of time next to rocks so that it will contain dissolved minerals such as calcium carbonate or sodium chloride from these rocks. Calcium is important for human health especially bone growth, but sodium may be a problem. Fortunately, high levels of sodium in groundwater is not common in the wetter areas of South Africa.

As we have seen, groundwater is essential for keeping rivers flowing through the dry season. It can also be accessed directly from the rocks through a borehole. We need to be careful not to drill too many boreholes as the river may stop flowing if we use up the groundwater by pumping too much of it out before it reaches the river.

3.3.1 What happens if the soil is bare?

We have seen that a good ground cover of vegetation is important to keep an open soil structure and allow water to infiltrate. Crusting and sealing takes place on bare soils, especially if they are dispersive and turn into liquid mud when wet. Many soils in the Mzimvubu and Thukela catchments suffer in this way. Rain that cannot infiltrate into the soil collects in puddles on a flat surface or flows down a slope as overland flow, called runoff. This water can move quickly, especially where flow converges (or is channelled) to form small streams. This flow can reach the river in a matter of minutes or hours, depending on how far it is to the river, how steep the slope is and how much the water is channelled. This overland flow results in a flood in the river. Flood water can be dangerous and cause damage, for example to bridges and infrastructure and cropping on the banks of the river. A large volume of water is lost as it moves quickly down the river. This water will no longer be available during the dry season, or even between rain events. The water collects sand particles as it moves over the land to the river, this causes soil erosion, and high sediment in the river, reducing the water quality of the river for use.

Floods are also common in urban areas where the ground has been made impervious (not porous) due to extensive roads, paving and roofs. Storm drains are designed to lead water away as quickly as possible, resulting in floods in an urban river. Floods in urban areas wash rubbish and other pollutants such as fuel leaking from cars into the river, making the water dirty and unfit for drinking by people who live downstream.

Flood water that comes from overland flow in rural areas also tends to be full of sediment. This is because the overland flow has sufficient energy to cause erosion. If the water flows over a bare soil it picks up soil particles and carries them downslope. Channelling the water gives it more energy and greater potential to erode and the channels carry the sediment to the river.
Erosion puts sediment into the river; it also causes productive soil to be lost so that fewer plants can be grown. Erosion along channels leads to gullies (dongas). Erosion is the main cause of land degradation in South Africa, and globally. Erosion control and rehabilitation of eroded areas is therefore an important consideration on the management of South African catchments, and is covered extensively in the Guidelines that follow in Part II.

3.3.2 How can we stop erosion, maintain dry season flow and reduce flooding?

The first step in controlling erosion, increasing dry season flow and reducing flooding is to reduce overland flow and get the water into the soil where it is needed by plants and can recharge groundwater. The best way to do this is to keep a good cover of vegetation, especially during the rainy season. Special care should be taken when planting on steep slopes. Planting two crops together, for example beans and maize (intercropping), is a good way to reduce the exposure of bare soil. Allowing livestock to graze the same areas for long periods also reduces the ability of the vegetation to protect the soil from overland flow and erosion. Livestock should be moved around and areas allowed to rest (allow the grasses to regrow) in order to prevent ‘overgrazing’ and, if necessary, numbers should be reduced. Roads, tracks and footpaths are all areas vulnerable to overland flow. Where possible these should not be aligned straight up and down a slope as this encourages rapid runoff and erosion, often leading to gullies, but should rather follow a zig-zag pattern with swales to disperse runoff off the pathway.

Often it is not possible to stop all overland flow during heavy rains. Many erosion control methods are designed to catch and store overland flow or direct it to where it can be used. These methods include grass strips along the contour, swales, pits and ponding, part of an assemblage of water harvesting techniques. Once water gets into channels it is much harder to control because of the increased energy. Gabion structures (stone walls) can be built in gullies to slow down the flow and trap sediment but they need to be carefully designed by a person with engineering skills. These various options are outline in more detail in Part II: Toolbox Guidelines.

3.4 Catchment Characteristics

While the process of vegetation-soil-streamflow interactions are the same in each catchment, the characteristics of each catchment are different. These differing characteristics further impact on the vegetation-soil-streamflow interactions. No two catchments are identical. Catchment characteristics are influenced by both bio-physical as well as human influences. Bio-physical influences include climate, slope, and vegetation cover; while human influences include extent of development, population pressures, and land use activities.

We all live in a catchment area. A catchment is not just about the water, it includes the land on which the rain falls and runs off, and all the activities on the land that use the runoff water, or that impact on the flow and quality of the runoff, as illustrated in Figure 3-4

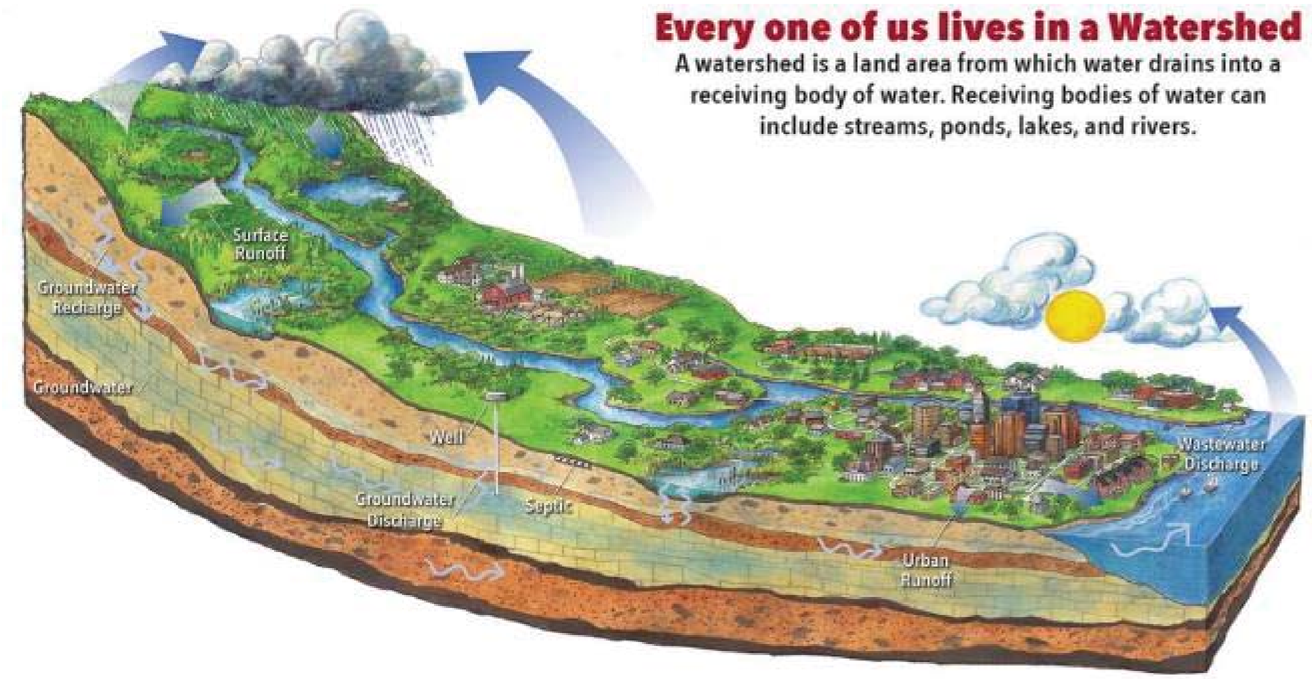


Figure 3-4: A catchment includes all the land and activities

Figuratively a catchment may be considered to be made up of the foundation resources of land and water, with plants and animals relying on these important resources. People are balancing on top of these resources by relying on the underlying resources (land, water, air, plants and animals) for their sustenance, survival and land use activities. This holistic system of resources and dependencies requires an integrated approach to ensure the sustainability of the resources in order to support human livelihoods. A catchment is therefore referred to as the integration of these resources and uses within a demarcated area, as illustrated in Figure 3-5.

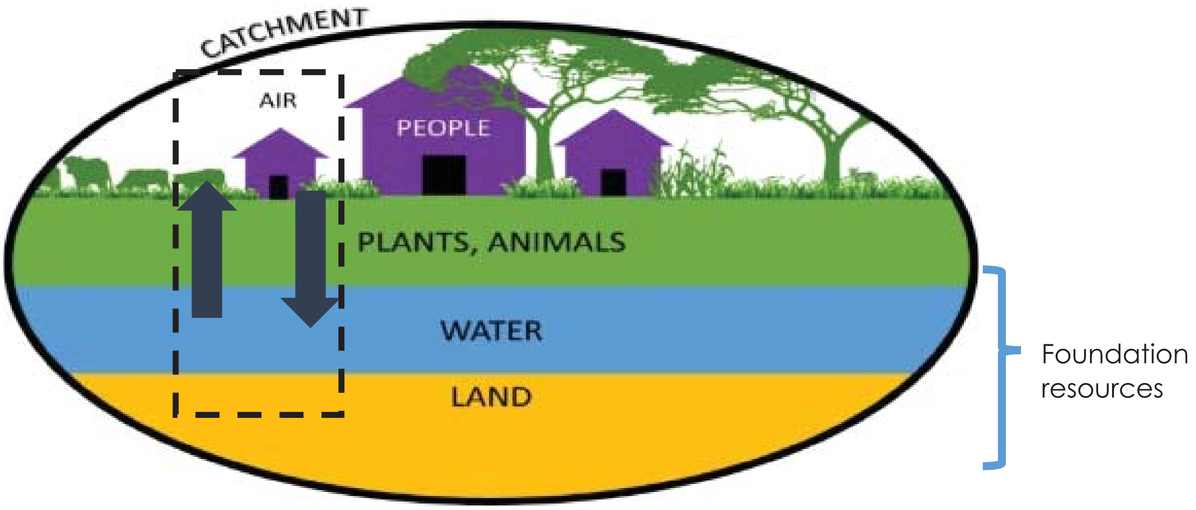


Figure 3-5: Figurative representation of a catchment and its resources

3.4.1 How does climate affect our catchment?

Land and water are closely linked through the water cycle, which is driven by energy from the sun, cycle, as illustrated in Figure 3-6. The amount of water in the water cycle cannot be increased, but the amount of water naturally available to a region is somewhat dependent on climate. The amount of precipitation, such as rain, and the seasonal changes in temperature determine how much water is received by a catchment. Climate is the big picture of temperature, rainfall and wind over a large region and a long period of time. Weather is what happens at a particular place at a specific time and refers to wind or rain events. Climate, not weather, determines how much water is received by a catchment. This is based on how much rain, snow and mist (known as precipitation) occurs. Seasonal changes in temperature also affect how much water evaporates in the catchment. Where the climate is hot, dry and windy, there will be high levels of evaporation from bare soil and water surfaces. Therefore, the climate of a catchment affects how much water is in the catchment. The climate of each catchment is different.

3.4.2 How do slopes affect our catchment?

The amount of sun our catchment receives affects local temperature and evaporation rates, which in turn affect how we use the land and what we are able to grow. The type of vegetation and density of the vegetation that will grow in a catchment depends on the direction the slopes are facing. A slope that gets lots of sunshine for most of the day, will lose more water from the soil due to evaporation and result in a thinner vegetation density. Slopes that have less sun tend to have more moisture available and denser vegetation cover. In South Africa, and other countries below the equator, north facing slopes receive more sun, and south facing slopes receive less sun. Countries above the equator, the south facing slopes receive more sun and the north facing slopes receive less sun.

Depending on the prevailing wind direction, one side of a slope may receive more rain, as the moist air rises over the slope, the moisture condenses forming rain. The other side of the slope may receive less water as the rain fell on the other side of the slope, this is called rain shadow. Rain shadow can have a significant impact on the characteristics of a catchment as it affects the availability of water and vegetation in the catchment, Figure 3-6.

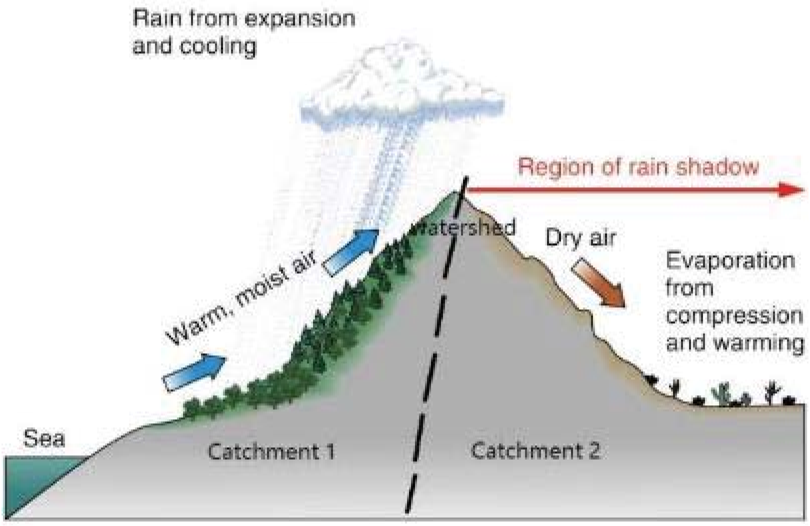


Figure 3-6: Illustration of rain shadow effect on catchment characteristics

The way in which water drains from our catchment is also influenced by the slopes. Water running quickly down the catchment slopes often washes the soil away with it, which is called erosion. The loss of soil from a catchment reduces the ability for plants to grow. The soil is washed into the rivers and pollutes the water making it difficult for fishes, aquatic animals and plant life to exist or be used for productive uses such as energy generation (hydropower) or irrigation. The soil is eventually deposited in the floodplains or washed out to sea. The steepness or gradient of the slopes, and the geology or soil type of the slopes effects how much erosion takes place and how fast.

3.4.3 How does vegetation cover and soil affect our catchment?

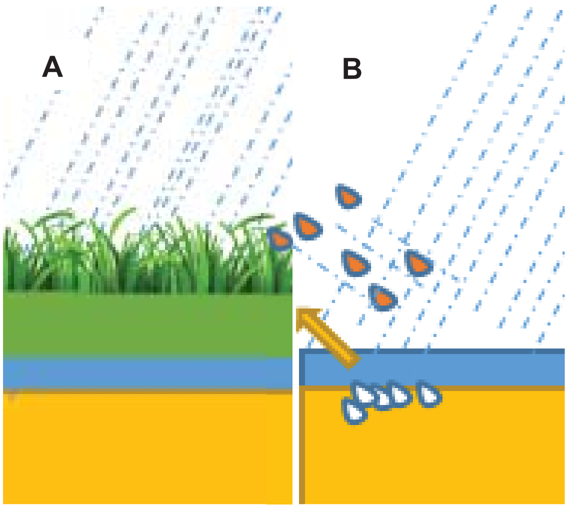


Figure 3-7: Vegetation cover of soil protects it from rain, figure A. Whereas as no vegetation allows soil to be displaced causing erosion, figure B.

The type of vegetation and the density of vegetation in our catchment affect the amount of water that reaches the soil. Dense vegetation cover slows down the force of rain and wind, and stops soil from washing away (soil erosion) (**Figure 3-7**, Figure A versus Figure B). The leaves and twigs of plants also fall to the ground and as they decompose, they add nutrients back to the soil, but before decomposing, the leaves and twigs protect the soil from wind and rain.

In addition, plants and decomposing material protect the soil against evaporation, preventing the soil from excessive drying out. Deep rooted plants like trees draw water from the soil and make it available for transpiration. Roots open up spaces for water to seep into the soil. Plants that are natural to an area are very good at helping prevent pollution of streams and rivers. If there are a lot of natural plants on the banks of a river, they help stop soil and nutrients from washing into the river (soil erosion and sedimentation).

Animals need plants and water to survive, but often have a negative impact on the land through these needs. Overgrazing by animals and cattle tracks removes vegetation, which allows for the forces of water to remove more soil, leading to soil erosion, Figure 3-8. Over farming of land removes the nutrients from the soil leading to soil degradation, and abandoned farm land if erosion is left unattended will continue, Figure 3-8.

Figure 3-8: Erosion along cattle tracks, and continuing erosion of abandoned farm land. (Source: S. Braid)

3.4.4 How do people affect our catchment?

Everything we do affects our catchment, from the way in which we farm and grow food, to the way we collect water for washing our clothes or drinking, or even the way we build our homes, roads, bridges and dams, and where we layout infrastructure. Our catchment also affects everything we do from the type of food we grow, the number and types of animals we can sustainably support on our land, to the way in which we store water, or develop land use activities. We usually live upstream from someone, and downstream from someone else, so the way in which others impact the catchment affects us, and the way in which we impact the catchment affects others. The water quality of a catchment can therefore be impacted by activities that happen many kilometres away, for example water can become undrinkable from pollution occurring in a village upstream. It is therefore important to consider an entire catchment and all the activities being undertaken in it when trying to improve the quality and availability of water. Figure 3-9 illustrates different types of land use activities that may take place within a single catchment; each activity will have impacts on the catchment and the other catchment users. The resources we use on a daily basis are not limited to being found in our catchment only, we use resources from other catchments as well, especially food stuffs that are grown in different climate conditions. Likewise, the waste produced from using or producing goods contaminate our catchment, or we may dispose of it in another catchment and thereby contaminating that catchment.

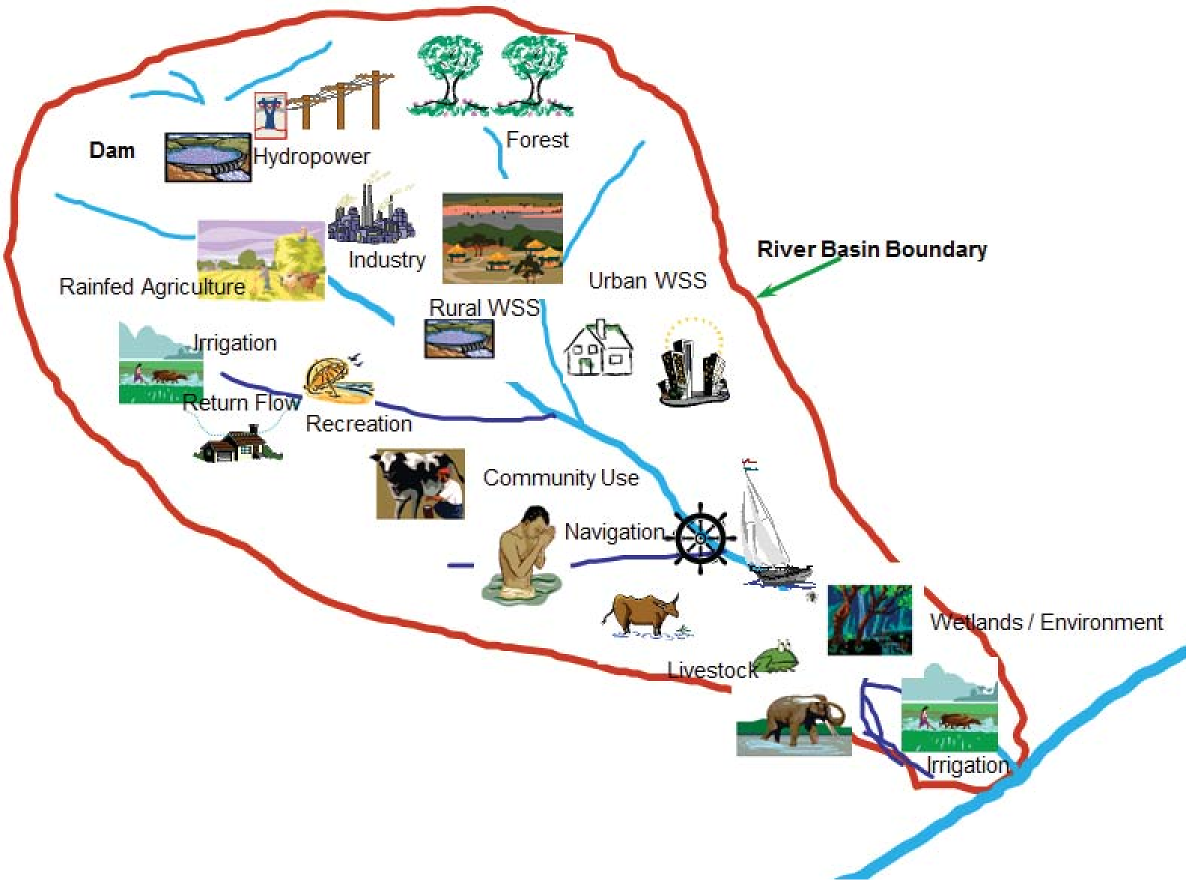


Figure 3-9: Typical water and land use activities within a catchment

Over time people's activities negatively affect catchment areas, which in turn affects how people farm and live in the same areas today. While different catchments may have different problems, there are some issues that are common to many catchments in South Africa, as illustrated in Figure 3-10.

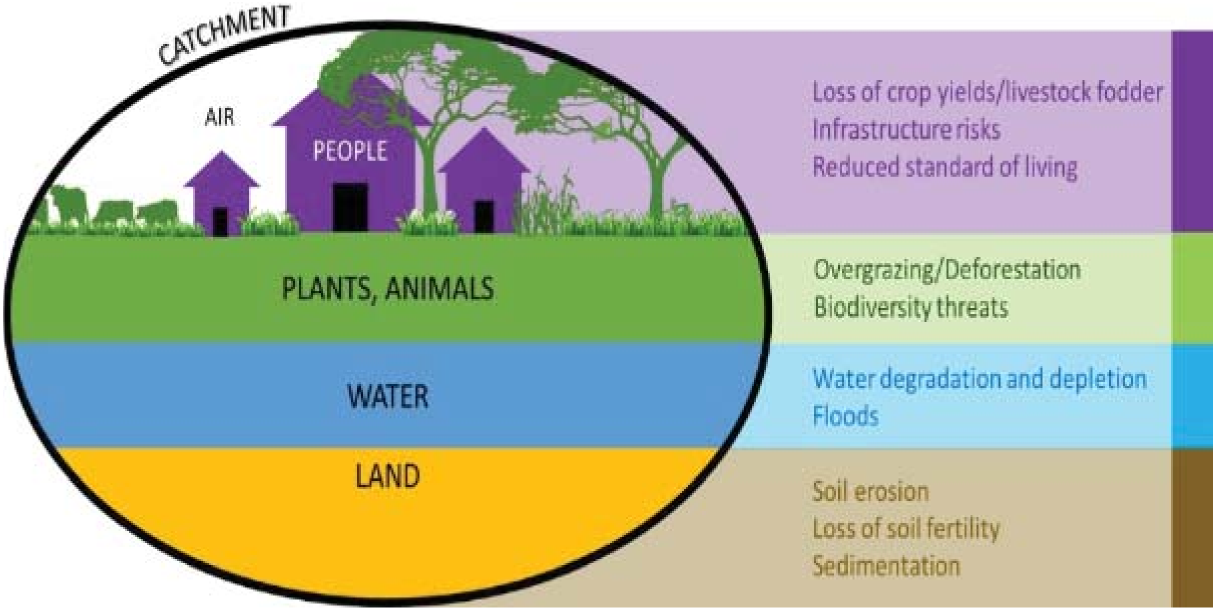


Figure 3-10: Common issues affecting natural resources in a catchment

3.5 Why is it important to manage our catchments?

All the plants, animals and people in an area make up an ecosystem in which all the parts depend on each other to survive. When one part of the ecosystem is damaged it impacts on the other parts of the ecosystem. A healthy ecosystem means that all parts are in balance and can function. People living in an area benefit from a healthy ecosystem through “ecosystem function” and the goods and services it provides. These are the benefits that nature produces. These include all our food, our water, safe places for living, materials such as wood, energy and many of our medicines.

It is important to manage catchments properly to protect the natural capital and ecosystem services that a healthy catchment can provide. There is a point, known as the “tipping point” (threshold), where a degraded ecosystem will stop functioning and no longer provide the benefits we rely on. It can be very expensive, and sometimes impossible to fix ecosystems that have been damaged to this point by man’s activities.

It is better that the local farmers, other land users and the community who depend on the land are involved from the very beginning in planning how to manage catchments as they will need to implement the activities in order to ensure continuous provision of ecosystem benefits.

3.6 Catchment Management

As people’s activities affect the range of resources, it is important to manage the resources in a coordinated and integrated manner.

Integrated Catchment Management (ICM) is a strategic approach to manage the natural resources, as well as people's actions and livelihoods within a catchment.

Catchment management recognises all of the resources in our catchment, and the way we use them, are interdependent and linked. ICM should not just focus on development but also rehabilitate what is damaged or degraded and also promote good practices. For example, to use a river for electricity generation (hydropower) or for irrigation requires reliable water availability and little sediment. However poor land use practices upstream may result in high soil erosion which will then negatively impact the hydropower or irrigation potential downstream.

What is Integrated Catchment Management (ICM)?

Integrated Catchment management looks at sustainable resource management at the catchment scale. Land and water resources are managed together, and ecosystems are recognised as providing important services to society.

Catchment management can be difficult to coordinate, because catchments do not respect political, administrative or tribal boundaries, and in many instances fall over several economic, cultural or even provincial or national boundaries. Catchment management planning is therefore carried out at various scales from a district level strategy down to village level planning, but this all has to be integrated so that everyone is aiming and working towards achieving the same goals. For example, the upgrading of a national road through a catchment must include appropriate stormwater management to allow for water harvesting and prevent erosion to a local village, it should avoid good fertile soils and natural woodlands.

For ICM to work, it needs the input of all stakeholders and the whole community. It is best to get everyone involved early on in the process to achieve the best results.

The purpose of ICM is to integrate the management and development of land, water and related resources across sectors and across spheres of government and departments, in order to achieve sustainable and balanced use of these resources for sustainable current and future development. ICM is aimed at deriving the greatest possible mix of sustainable benefits for future generations and the communities in the area of concern whilst protecting the natural resources upon which these communities rely.

3.7 Catchment Management in South Africa

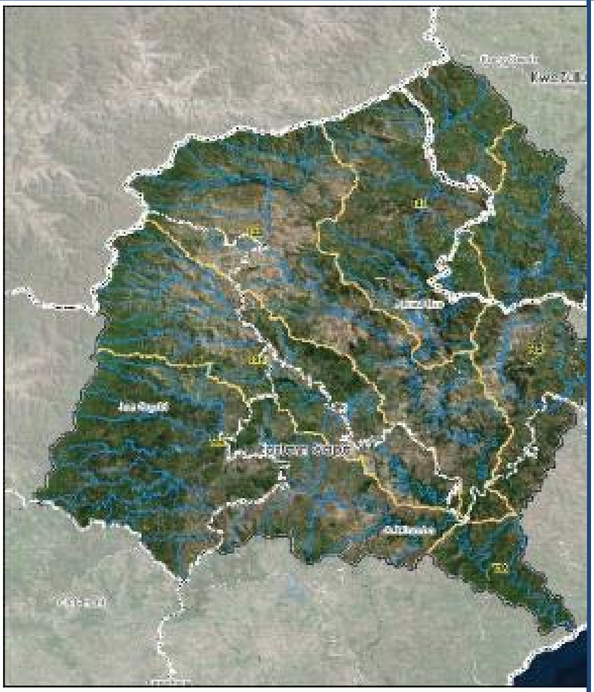
South Africa has 19 major catchments called Water Management Areas. These are grouped and managed respectively by 9 Catchment Management Agencies, as per the National Water Act, Act 36 of 1998. Figure 3-11 identifies the 19 water management areas, and Table 3-1 indicates their respective Catchment Management Agency.

Figure 3-11: Map of Water Management Areas (Catchments) in South Africa

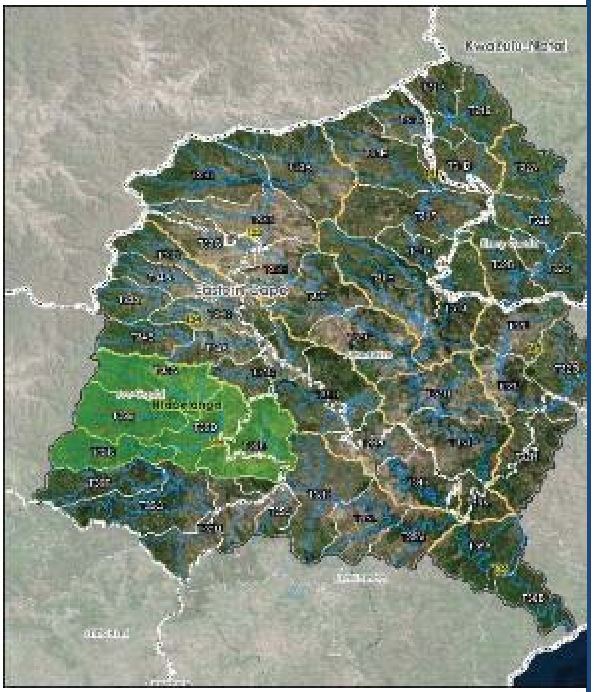
Table 3-1: List of WMAs and respective Catchment Management Agencies

Water Management Area (WMA)	Catchment Management Agency (CMA)
1 Limpopo	1 Limpopo CMA
3 Crocodile (West) and Marico WMA	
2 Letaba WMA	2 Olifants CMA
4 Olifants (East) WMA	
5 Inkomati WMA	3 Inkomti-Usuthu CMA
6 Usuthu to Mhlathuze WMA	
7 Thukela WMA	4 Pongola-Umzimkulu CMA
11 Mloti to Mzimkulu WMA	
8 Upper Vaal WMA	5 Vaal CMA
9 Middle Vaal WMA	
10 Lower Vaal WMA	
13 Upper Orange WMA	6 Orange CMA
14 Lower Orange WMA	
15 Fish to Tsitsikama	7 Mzimvubu-Tsitsikama
12 Mzimvubu to Keiskama	
16 Gouritz WMA	8 Breede-Gouritz CMA
18 Breede WMA	
17 Olifants (West) WMA	9 Berg-Olifants CMA
19 Berg WMA	

Catchments are managed at various scales e.g. regional broad water resource management area (primary catchment) catchments down to through smaller catchment areas to micro and village level catchments, as illustrated in Figure 3-12. As catchments do not adhere to administrative and political borders, implementation is carried out at the smaller scale. Catchment management is implemented through different strategies and plans.



Primary Catchment Scale, Usuthu Water Management Area



Sub-catchment indicated in green area

Quaternary-catchment, indicated by the yellow area within the green area.

There are several quaternary catchments within subcatchments, and several subcatchments within a primary catchment. For the purpose of these Guidelines we are looking at quaternary catchments and smaller, down to village based catchments.

Figure 3-12: Example of the different scales of catchments

3.7.1 Catchment Management Strategies (CMS)

Catchment Management Strategies focus on the broadest catchment scale, i.e. primary catchment area or Water Management Area. They reflect strategic thinking, such as national strategic objectives, to provide for the management of natural resources of a particular catchment. The Catchment Management Strategy should be for a period of not less than 5 years and address issues of strategic importance for the catchment. It should be driven by principles (for example equity and sustainability) and should recognise the major drivers in the catchment (e.g. degradation, soil erosion, economic development opportunities and demographic issues). It should acknowledge that the catchment is a system with many inter-connections. A Catchment Management Strategy usually does not have any details on budgets and implementation plans, nor does it identify any individuals and institutions. It provides the opportunity to apply national policies, objectives and activities from other sectors to the catchment scale.

3.7.2 Catchment Management Plans (CMP)

Catchment Management Plans are based on the principles in the Catchment Management Strategy and form specific management plans relating to these. Catchment Management Plans are compiled based on various comprehensive and detailed specialist studies. They set out a vision which recognises specific areas of strategic importance. The plan provides details related to: how, what, who, when, and where needs to be implemented to achieve the vision. The Catchment Management Plans should contain information on timeframes as well costs and a description of how the plan will be implemented. Catchment Management Plans might focus on specific issues such as climate adaptation, disaster management, gender equity, infrastructure development and so on. There should be some prioritisation of the most important and urgent issues for the catchment, for example flood management. Catchment Management Plans should provide the basis for addressing significant issues in the specific catchments and provide important guidance on the use and management of natural resources.

In particular, the issues that this process should address include inter alia:

- Sustainably developing natural resources;
- Rural infrastructure;
- Managing, reducing and rehabilitating undesirable off-site effects such as water pollution, induced soil salinity and degradation of groundwater; and
- Mitigating the loss of essential ecological processes, ecosystems and biodiversity, while developing national priorities for sector development.

3.7.3 Proposed: Village Catchment Plans (VCP)

Village Catchment Plans (VCP) are plans focused at the village level for managing the resources and infrastructure at a village level and in-field activities that typically cover a period of two-five years. The focus of the village plans should be on how to conduct preventative maintenance, sustainable use, and rehabilitation of parts of the ecosystem that provide resources and support village livelihoods. The VCP provides a single vision and action plan that various stakeholders, Government Departments, NGOs, etc. can support and implement according to their applicable activities, allowing a coordinated approach.

Despite the scale of planning, the basic planning process follows a similar circular flow, as illustrated in Figure 3-13. The process is initiated and investigations and stakeholder engagement commence, followed by various assessments and analysis which leads to drafting a plan. The plan is an iterative process with feedback from role-players and stakeholders, and leads to implementation and monitoring and review of the implementation, which leads back to updating or adapting the plan.

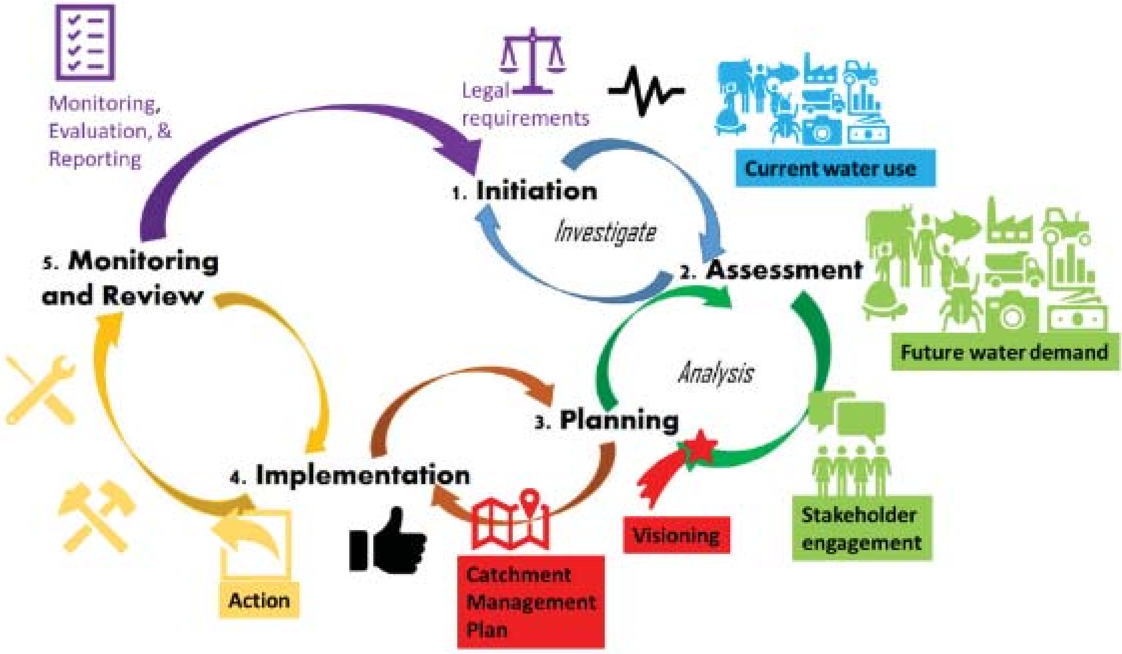


Figure 3-13: Basic planning process for catchment management planning

4. HOW TO START THE CATCHMENT MANAGEMENT PROCESS

4.1 Introduction

The aim of catchment planning at village level is to plan the activities of the village in an efficient and sustainable manner to achieve optimum benefits for all in the village, through making use of available resources in a sustainable and efficient manner. This ensures that the projects and programmes within the catchment area work to achieve the same goals and vision; preventing conflicts, overlaps or contradiction between project activities. The Catchment Plan aims to ensure sustainable utilisation of the Natural Capital of the catchment, protecting ecosystem goods and services in order to ensure sustainable livelihoods, while still promoting economic growth and development. The process and purpose of the Village Catchment Plan (VCP) is to empower the people of the village to make decisions and take responsibility for and promote the collective action for the rehabilitation, sustainable management and utilisation of their natural resources. The VCP is developed by the community of the village, **for** the community of the village. The plan accommodates the resources available to the village community and their needs.

Ultimately the village level plans contribute to the higher-level overall Catchment Management Strategy (CMS), and similarly where national strategic objectives are filtered down through the CMS to this plan, these activities can be integrated into the *VCPs.* The catchment plans at all scales need to be integrated, regularly monitored, revised and updated.

What is a *Catchment Management Strategy*?

The Catchment Management Agency of a Water Management Area needs to develop a Catchment Management Strategy (CMS) according to the National Water Act (No. 36 of 1998). A CMS defines the strategic objectives for management.

The VCP sets out a **vision** towards which the community works; specifically a vision statement describes where the village wants to be in the next five (or ten) years (see Section 4.3.3, entitled “Step 3: Developing a vision” for an example). The vision is broken down into several **goals**; these address different sectors or aspects of catchment management and village life. Under each of these goals various **activities** are identified that need to be implemented in order to achieve the goals (e.g. water for drinking, erosion rehabilitation and prevention, improved soil fertility – all catchment management activities spanning different but related issues). Achieving the goals then realises the vision. Some of the activities will be carried out in the short term with rapid pay-back, other activities will be longer term with slower turn-around of benefits. It is good to have a good mix of activities to build trust in the plan. Seeing and reaping quick rewards strengthens confidence in the process and breeds positive attitudes. The longer-term benefits are an investment in the catchment. Some activities will require the entire community to be involved in implementing; others may be limited to particular farms or plots. The success of the plans lies in the whole community being involved and taking ownership of the plan and its implementation. Village level catchment planning incorporates the following principles:

Figure 4-1: Village Level Catchment Planning principles

4.2 What is a Village Catchment Plan?

A VCP is a written document, which includes drawings depicting the village, its infrastructure and natural resources. It identifies issues of concern to the village: particularly in terms of land and water resources. The plan identifies opportunities, strengths, threats and weaknesses within the village catchment. It also provides practical actions that will result in improved catchment management at the village level. It identifies opportunities for resource mobilisation, outside investment, and development.

A VCP does three essential things. It provides a **vision** of what the local stakeholders would like their village to look like; sets out clear **goals** to achieve that vision; and provides an integrated **action plan** comprising of **activities** to reach those goals. It is important that the plan is integrated to ensure all sectors are working towards the same vision and goals of the village or community. This vision is useful for outside stakeholders intending to conduct projects within the catchment, to ensure the projects contribute to the overall vision and goals.

4.2.1 What are the benefits of a Village Catchment Plan process?

- It brings residents, business communities, traditional authorities and civil society organizations together to **share ideas and work together** on issues that are important to everyone
- It **improves information** collection, sharing, communication, focuses ideas and builds consensus
- It helps a village or community **identify its strengths** and evaluate its own resources for example taking time to identifying the Village's natural capital.
- It **increases the level of concern** in the village about the problems that affect the community, e.g. impacts to livelihoods.
- It helps to **translate community concerns into action**
- It **encourages creativity and builds partnerships** both within and outside the village
- It **enables others to become more informed** and responsive about what is needed
- It can **influence the policy and financial decisions** of local government, development partners and the business community
- It helps the communities to **build their capacities** in implementation of, and monitoring their activities in a sustainable manner
- It helps communities in **identifying and mobilizing local and external resources**
- It creates a **sense of commitment, ownership and belonging** in the community and at village level
- It incorporates all members of the village: young, old, disabled, men and women.

4.2.2 Who do you involve?

Since collaboration and inclusion are key principles, everybody in the village and community is a stakeholder who could be involved. Representation from a broad range of local stakeholders will help strengthen support for the VCP and make implementation easier.

4.3 Steps of the Village Catchment Planning process

These are the typical steps that a village should follow in developing a VCP. First a Green Village Committee is established. Once this committee is established it takes stock of what is in the community and the strengths and weaknesses of the area. Through open communication with local residents and business owners, the team develops a vision of what the community would like the village to be within a given time frame (usually five or ten years). To achieve that vision, the plan will include actions to reach those goals. To monitor progress, these actions and accomplishments need to be reviewed from time to time (e.g. every year), to measure and celebrate the successes of the plan; or where necessary, changes can be made to better suit the current situation. The steps of compiling the VCP are listed in Figure 4-2:

Figure 4-2: Steps of compiling the Village Catchment Plan (VCP)

4.3.1 Step 1: Initiating the process

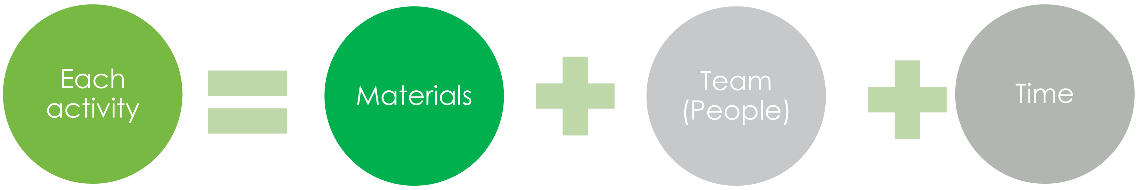
The village level planning process can be initiated by Government planning cycles or requirements such as a Water Management Area scale Catchment Management Plan, or by the community themselves. The facilitator (person/s driving the process, can be an extension officer, member of the community, or project manager) must remember that the plan has to come from the people of the village. It depends on local leadership and engagement to be successful. The key activities to initiating the process include:

1. *Organise the Green Village Committee for action*

Establish a Green Village Committee (refer **Annexure 3** for detailed process). This process is carried out by the community. The committee is a voluntary activity. The Committee should have the support of the Chief or Village Headmen, in order to secure support of the Committee's activities. When establishing the committee think about the following:

- Who is going to take ownership of the plan and follow up with implementation activities by the community and monitoring of the plan?
- Decide where and how often the Green Village Committee will meet to discuss progress of the plan.
- Decide who will be selected to keep order, call meetings, or assign work.

- Decide who will record the minutes of the meetings, so there is a record of decisions from the meetings.
- Compile a rough schedule of activities that may be required in order to develop the plan, and who is responsible for these activities. Important things to think about with respect to each activity include:



2. *Raise awareness in the village or community*

The Green Village Committee should find the core group of opinion leaders, local leaders, and village/ community committees who are prepared to help develop a VCP. It is important to ensure that involvement is not influenced by vested interests (e.g. political campaigning or bias). The following groups could be approached:

- The Chief or Group Village Headman or Village Headman for permission and support.
- The Village Natural Resources Management Committee and/or other community or village-based resource management committees. They will ultimately need to take ownership of the implementation of the VCP.
- Other village elders or key village community or village members to be involved in the planning process.
- Neighbouring villages so there is coordination and knowledge transfer.

A village community meeting or workshop can be held to assist in the identification of this core group or champions.

For example, it doesn't help to plan activities along a river bank, if the opposite bank falls under a different village and they don't know what is being done, or why it is being done, they may respond negatively to the activities that are being implemented.

Tip: Support is very important!! People need to buy-into the idea, so emphasise the benefits of the plan to them and demonstrate other successful examples.

3. *Characterising the planning area*

One of the first decisions to be made before starting to plan is how to define the village catchment. A map of the area and discussion with the planning team or Green Village Committee is a good place to start, Figure 4-3. This is known as participatory mapping.

The following questions should be asked:

- What are the physical boundaries that describe the village?
- What are traditional and/or cultural boundaries of the village?
- What social, economic and other characteristics best describe the make-up of the village?
- What are the main activities of the village?
- Where is communal land, where are individual/private plots, and lease hold plots?

Figure 4-3: Village members contributing to drawing the village map on the ground. The copied onto paper for record keeping. (Source: S. Braid)

Tip: A map of the village is a good place to start, either printed or hand drawn. You will need a pen and paper to write down the other information.

4. *Communicate with the village*

It is important that the Green Village Committee communicates with the village or community for their input. This community dialogue for “Getting the word out” to people in the village/community as the plan develops is important for a number of reasons:

- It keeps everyone informed as the process unfolds;
- It invites members of the community to participate through meetings, focus groups, round table discussions and information events; and
- It helps the Green Village Committee determine the village’s response to its ideas and proposals.

It is important to develop a communication strategy at the outset and stick with it. People are more likely to participate if they are kept informed about the process as well as the benefits of the process. The plan is only limited by the Green Village Committee’s imagination and creativity! The communication strategy identifies what communication activities need to be conducted by whom, how and when. There are several ways that the Green Village Committee can get messages out to the village. Figure 4-4 suggests some ideas how to get the message out.

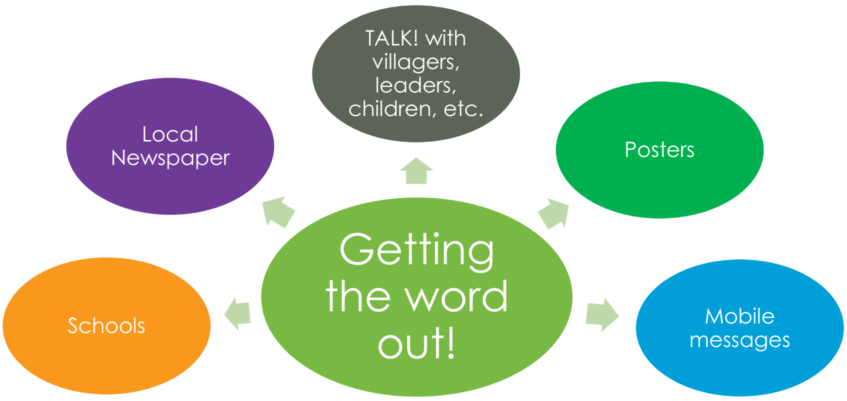


Figure 4-4: Communication means to get messages out to the village

4.3.2 Step 2: Understanding the village catchment

The VCP vision will define what the village wants to achieve for the village today, and in the future. It should be realistic, clear and inclusive.

To determine the vision, the team should undertake participatory planning which will involve asking the following questions illustrated in Figure 4-5.

Figure 4-5: Participatory planning key questions

To answer these questions a clear picture of the village's key characteristics, past and present, is needed. This is called a community profile, and is compiled using Participatory Rural Appraisal (PRA) techniques which are described further in **Annexure I**.

The community profile can include:

- Land use mapping – defines location and types of residential, commercial, institutional uses, etc.;
- Population characteristics – statistics/ numbers about the people who live in the village, e.g. number of children, adults, men, women, etc.;
- Community assets and resources – an inventory of village natural resources, natural forests, water sources, boreholes, wetlands, services and facilities and local agencies, organisations and groups;
- Community perceptions – what people are saying about the natural resources and catchment management in the village; and
- Other information, such as how the village is currently laid out, its physical assets (e.g. borehole, church, mill, woodlot, etc.) provide a snapshot of the village.

The community profile is created by various participatory tools that are used during PRA techniques, for example Figure 4-6.

Researching village organisations, community associations, cultural, religious, social and other community groups (with roots in the village) will provide information on the resident involvement in the village, and cultural and traditional roles that influence resource management within the village.

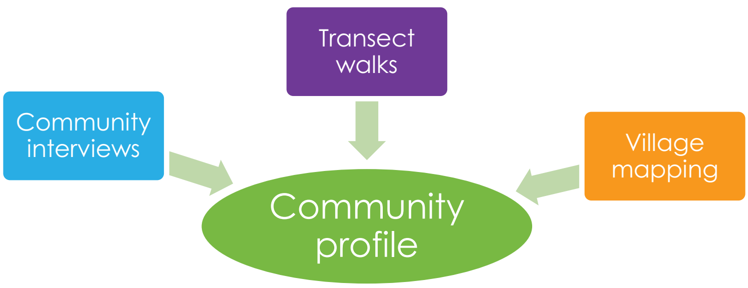


Figure 4-6: Participatory technique used to create the community profile

In addition, basic statistical data on the village, including population, household size, family composition, income, proportion of migratory residents, length of residency, etc., provide a profile of the people who make up the village.

Ask the focus group (selected representative group from the community) to sketch major watershed units (dividers of land use, e.g. a ridge, a road, line of trees). This is an exercise in village resource mapping, this process is detailed further in **Annexure I**. These major watershed units should report the main features related to land use and their value in terms of productivity and basic community assets. This is based on their perception. For example: the best land for corn or other crops, best land for vegetables, grazing, poor cultivated land, poor grazing land, good forest, bush land, water logged areas, woodlots, homesteads, schools, churches, stores, health post, road, foot path, market, steep slopes, drainage, and others.

The process of mapping should lead to the identification of problems and opportunities within the geographic area of the community, and what the community composition is, as illustrated in Figure 4-7.

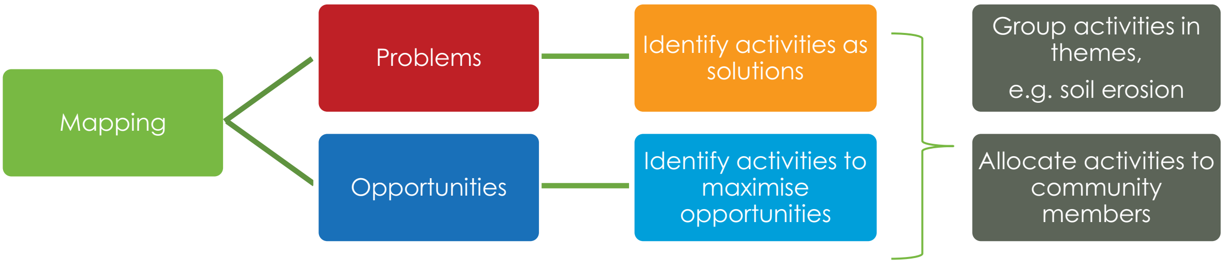


Figure 4-7: Mapping process

In catchment management, as there are so many different activities that impact on the water resources both to the village and by the village, it is important to identify what the **strengths, weaknesses, opportunities and threats** are, especially in light of the recent droughts and soil erosion. This exercise is focused on establishing the baseline and the context for the VCP.

What is SWOT Analysis?

SWOT Analysis is a tool to help identify the **strengths** and **weaknesses**, and to examine the **opportunities** and **threats** that face the village resources.

To carry out a SWOT analysis, the facilitator asks the focus group to provide answers to the following questions, and writes these down. Additional questions and variations of the question can be asked. The questions can be applied to different themes or sectors, for example, current and improved water management, access to improved sanitation, soil erosion, current and improved crop management, soil health and fertility, and other natural resources. Questions to ask when undertaking a SWOT analysis are set out in Table 4-1 and an example of a SWOT matrix is illustrated in Table 4-2.

Table 4-1: Examples of questions to ask when undertaking a SWOT analysis

Strengths:	Weaknesses:
What does the village do well? What advantages do you have? What resources (people, places, programs and services) does the village have?	What in the village / household / farm / forest level can be improved or changed? What do you struggle with? What should you avoid? *Where are problem lands?*
Opportunities:	**Threats:**
Where do good opportunities exist? What are the favourable trends in the village? What do you need to make the village a better place to live?	What barriers are preventing change? Where gets flooded / very muddy during/after heavy rains? What threats face the village / the land? Could any of your weaknesses seriously threaten the homestead / farm / village / forest?

Tip: To help focus the discussion, consider asking the following questions… How can our village:

- Improve water management?
- Reduce erosion?
- Improve livelihoods?
- Reduce pressures on land resources?
- Improve access to services?
- Improved development and/or employment opportunities?

Use the activities of the strengths, weaknesses, threats and opportunities to identify the types of actions that the VCP plan needs to include. For example:

- **Strengths:** what actions need to be implemented to maintain or preserve these strengths; what types of actions are required to extend or replicate these strengths; what types of actions can be carried out to grow or develop these strengths?
- **Weaknesses:** what activities can be implemented to reduce or minimise the weaknesses; what activities can be implemented to improve the weaknesses?
- **Opportunities:** what activities can be implemented to develop these opportunities?
- **Threats:** What activities can be implemented to mitigate or reduce these threats?

The particular issue identified in the SWOT analysis can be the management action (worded in a positive way, e.g. to improve poor farming practices). The various actions identified and the activities needed to implement those actions then help form the details of the VCP.

Table 4-2: Example of a SWOT Analysis

Strengths:	Weaknesses:
Village tree nursery	Lots of exposed soil
Reliable borehole	Encroachment into forest reserve
No conflicts over boundaries or water use	Disconnected contour rows on hills
Opportunities:	**Threats:**
Water storage to facilitate irrigation and second crop	Increasingly unreliable rainfall
Ties in contour furrows for water conservation	Deforestation
	Pit latrines close to boreholes

A Logical Framework Approach also known as a Problem Tree Analysis follows on from a SWOT analysis and helps to identify the cause and effect of activities. In order to sustainably manage resources, the cause of degrading activities needs to be identified and remediated to prevent further negative effect. Similarly, the cause of positive impacts also needs to be identified in order to be able to replicate them.

To conduct a problem tree analysis, the following steps should apply and the facilitator should assist the focus groups in these tasks:

- Identify a key issue, e.g. deforestation, and write this in the centre of the page.
- Then identify and write a list of all the activities, issues and effects of the key issue.
- From the list write the activities that cause the key issue below the key issue on the page. Write all the activities that are a result or impact of the key issue above the key issue on the page. Draw lines between activities that can be linked or impact on each other. It is important to address the cause of impacts and not just remediate the effects or impacts of a key issue.
- Identify what types of activities are needed to be implemented in order to prevent, remediate or resolve the causes and the effect impacts.

Note: Using cards is useful for a focus group exercise to move activities and issues around until all the links are made

Key themes to start with (or issues identified in the SWOT):

- Water management – runoff, storage, supply
- Soil erosion – occurring, prevention
- Crop management – yield
- Soil health – fertility
- Waste management – solid waste, sanitation
- Forest status
- Other natural resource management

The cause and effects of a problem, using erosion gullies as an example, are depicted in Figure 4-8.

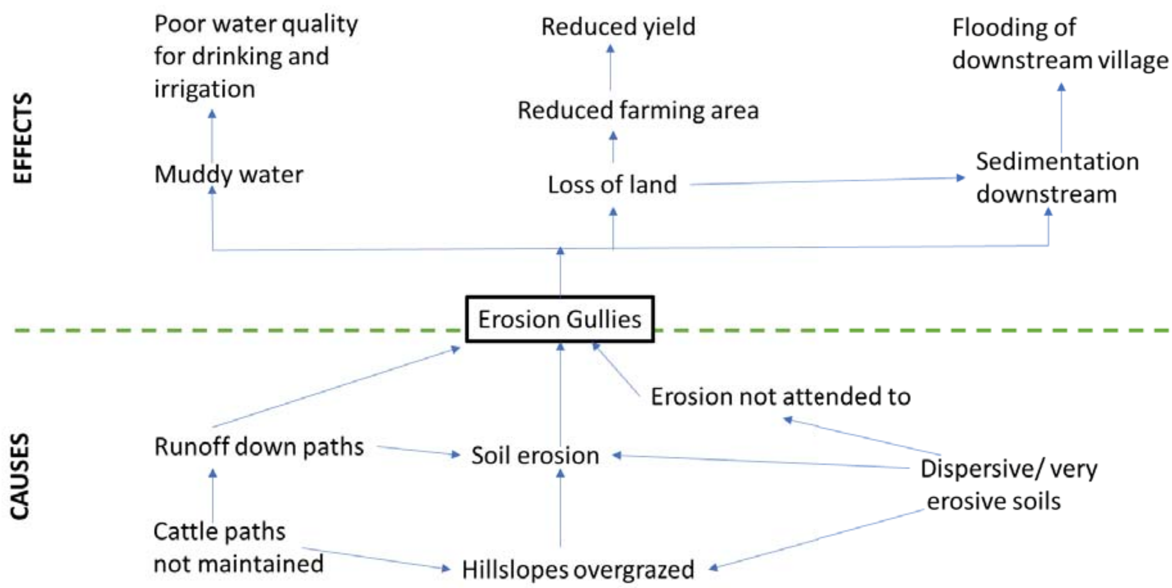
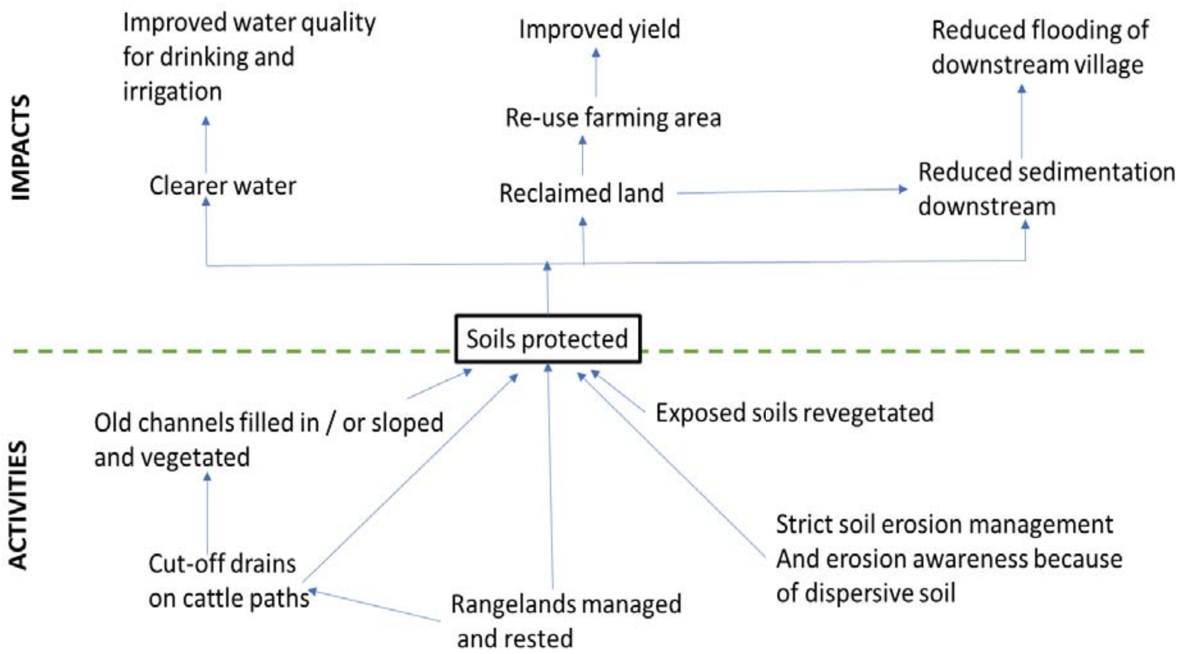


Figure 4-8: Example of a Problem Tree Analysis, identifying the cause and effects.

The next step is to identify what types of management activities are needed to prevent, remediate or resolve the cause and effects. This is illustrated in Figure 4-9.



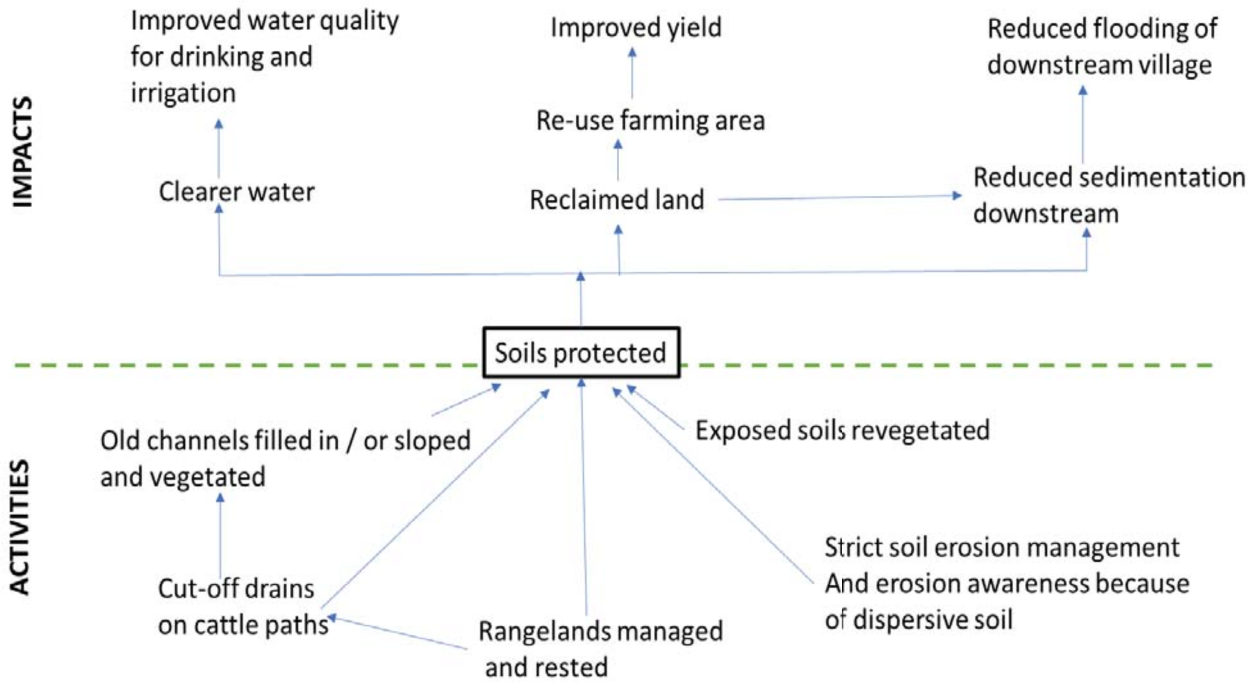


Figure 4-9: Problem Tree Analysis used to identify required management activities

4.3.3 **Step 3**: Developing a vision

The information obtained from the village assessments and the community consultations will allow for a vision statement to be developed. There may be a number of statements, or a single statement describing the desired future for the village.

A vision is a simple statement of the desired outcome over a specific period of time, usually five or ten years. There is no right or wrong way of doing this, whatever process is followed in preparing the vision statement, the Green Village Committee should:

- Encourage full participation in discussion by all Green Village Committee members.
- Focus on a realistic and achievable future based upon the village assessment.
- Be conscious of the village's people and their values.
- Be conscious of the need for sustainable development that respects the environment (physical assets) as well as strengthening the village economy.
- Some of the topics that may be included in preparing the vision statement include:
- The desired physical condition of the village;
- The nature and quality of future services (e.g. water, sanitation, food security, etc.) and/or, the desired social and economic outlook for the village.

The SMART tool can be used to help ensure that the vision is realistic, refer Figure 4-10.

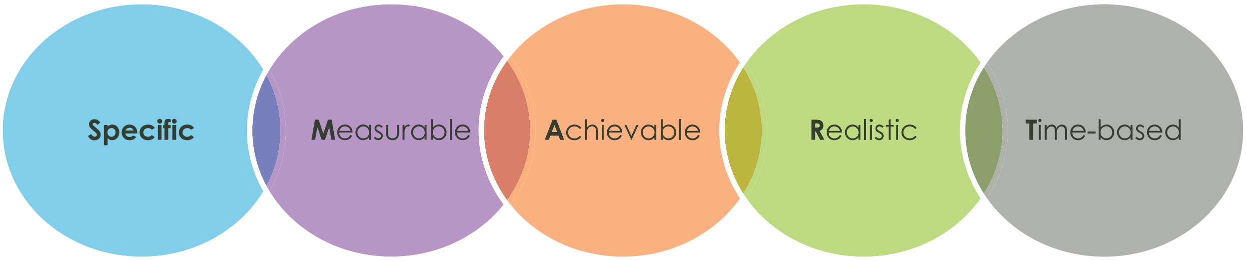


Figure 4-10: SMART tool

For example, the following vision statement of the Department of Water Affairs and Sanitation:

A vision can also be a visual representation of before and after, for example Figure 4-11

Figure 4-11: Vision of the village based on photographs

Village support of the vision statement is essential to the success of the VCP. This step builds on initial community dialogue held at the beginning of the VCP process.

There are many effective ways to seek village input and support as has been noted previously.

4.3.4 <u>Step 4:</u> Developing a Village Catchment Plan

A VCP sets out the vision for the village, as well as the associated goals and objectives; and identifies actions to achieve them, as illustrated in Figure 4-12. Many of the actions are identified through the previous steps, however more actions can be added.

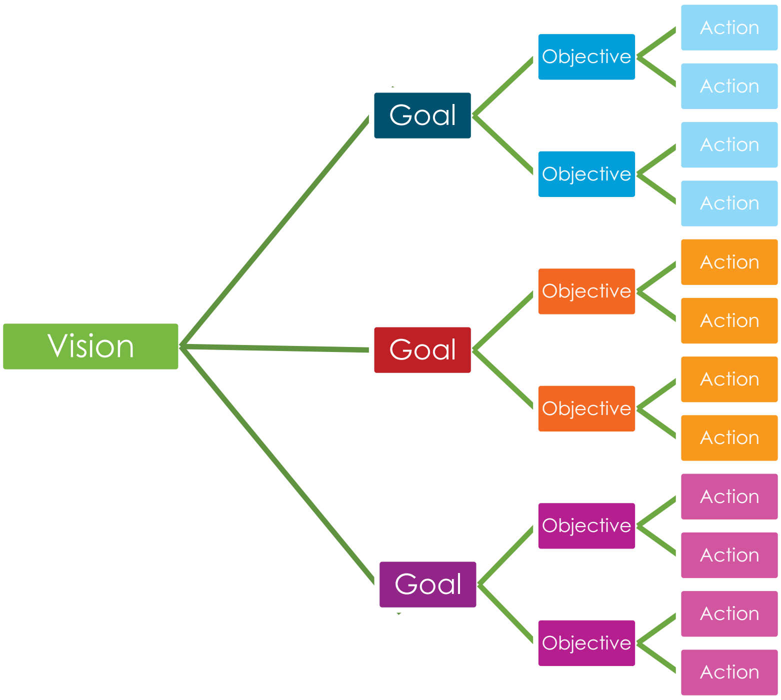


Figure 4-12: Schematic representation of contents of a Village Catchment Plan

A **goal** describes an achievement that helps realise the vision, for example, improved access to clean water. The village may have a long list of goals they want to accomplish. Grouping the village goals by themes or categories may help to focus the discussion and plan development. Some questions that may help to set priorities:

- What goals are most important to the village?
- What goals are the most practical and achievable?

An **objective** is also something the village wants to achieve but it is more tangible and specific: in turn it helps reach one of the village goals. There may be more than one objective to achieve a specific goal. For example, in order to achieve improved access to water, requires improving water access, as well as reducing pollution to water resources (e.g. human, waste, sediment contamination). Objectives should be clear and have a measurable outcome in a given time frame. The benefits of each objective should be stated, as a reminder of why the activities are being carried out.

An **action plan** formalises the activities that need to be implemented to achieve the objectives, goals and vision. The action plan includes details of:

- **What** needs to be done;
- **When** it needs to be done;
- **Who** will do the activity;
- **Where** will the specific activities be carried out; and
- **How much** it will cost/ what resources are required, e.g. labour, materials, etc.

When detailing the plan, try and be specific as possible about the activity, for example refer Table 4-3.

Table 4-3: Example of one of the goals in a VCP

Goal	To improve catchment's ecosystem health				
Objective	To prevent and control soil erosion				
Benefit	Keep water in the soil for longer to support crop growth Keep top soil in the field for farming, and not allowing it to be transported to the river				
Management Action	Improved farming activities				
Action	Activity / What	Who	Where	When	Resources & Cost
1. Implement contour bunding	1.1. Measure and peg ridges.	Farmers	All farm land	Before wet season. Before planting	Line level or A-frame Labour

	1.2. Align bunds across fields.	Farmers	All farm land	Before wet season. Before planting	Labour
	1.3. Dig trenches and make ridges	Farmers	All farm land	Before wet season. Before planting	Hoe or spade Labour
	1.4. Plant vetiver or other grass	Farmers	All farm land	Before wet season. Before planting	Vetiver grass Labour
2. Mulching	2.1. Collect vegetative material	Farmers	All farm land	Before wet season. After planting	Vegetation materials Labour
	2.2. Place mulching materials on garden and fields	Farmers	Vegetable gardens first	Before wet season. After planting	Labour

Developing village indicators to measure progress helps to assess the success of the plan and guide adjustments to the plan, based upon what has been learnt. Such measurements are called **indicators**. Once it has been decided what activity will be measured and how, the *Green Village Committee* monitors progress, stimulates discussion and feedback from the village and adjusts the action plan to reflect what has been learnt. Refer to **Step 8** for more information on Monitoring and Evaluation (M&E).

Using the example above, the alignment of contour bunds across adjacent plots can be measured visually by observing if the contour bunds link up across farm plots or not. Refer to Figure 4-13 and Figure 4-14. This can be reported by noting if (a) all of the contour bunds align, (b) the majority of the contour bunds align, (c) some align, or (d) none of the contour bunds align across adjacent farm plots.

Figure 4-13: Example of aligned contour bunds across adjacent plots = good practice

Figure 4-14: Example of little contour bunding and no alignment across adjacent plots =bad practice

Source: S. Braid

4.3.5 Step 5: Approval of the Village Catchment Plan

The vision, goals, and proposed actions must be widely known and generally agreed upon by the village. The more closely the Green Village Committee keeps the villager's involved in, and informed about the proposed plan, the greater the acceptance of the plan is likely to be. It is also important that the Traditional Authority and Local Government both approve and are in support of the plan.

Some examples of consulting the village on the plan include:

- A series of "meetings at homes" at different times and at accessible location to encourage all members of the community to attend;
- Parish or religious group meetings to engage debate and discussion on the plan.

Tip: Whatever method is chosen, keep the communication open and the ***Green Village Committee*** must be prepared to modify the village plan in response to concerns raised by the community.

4.3.6 <u>**Step 6**</u>: Establishing a Project Implementation Committee team

The Project Implementation Committee is a group of people selected by the village who are responsible for the implementation of the VCP. The role of the Project Implementation Committee can be carried out by the Green Village Committee or a subcommittee of the Green Village Committee.

4.3.7 <u>**Step 7**</u>: Implementing the Village Catchment Plan

Once there is community consensus on the village plan and it is supported by the main stakeholders, then the first steps towards implementation are to prioritise the activities and develop budgets for the proposed activities.

Compiling the implementation plan is the responsibility of the Project Implementation Committee. Using the details from the action plan, the different activities need to be prioritised and ordered based on their timing. Prioritisation can be done using various criteria, for example:

- ***Rapid benefits:*** activities can be implemented with the least resources and costs and provide the quickest benefits. Longer term activities may require more time to source resources or funding.
- ***Sequence:*** activities that need to occur progressively, or that rely on other activities to occur first: for example, a diversion weir should only be built after the furrows in the fields are constructed.
- ***Timing:*** some activities can only be implemented in the dry months and some activities need to be implemented in the wet period; similarly, some activities need to occur prior to planting and some afterwards. Some actions may have long periods between activities; for example, compost making, so this should be initiated early so the different stages can progress over time.
- ***Location:*** some activities are site-specific and may influence other activities because of their location. For example, if carrying out several activities on a slope to reduce runoff, start with the interventions at the top of the slope and work your way down.

Once the different actions and activities are prioritised and ordered, these can be summarised into an Implementation plan. The Implementation plan lists the action and activities, when it should occur and what resources are needed and who is responsible for each activity. An example is provided in Table 4-4. Compiling the implementation plan is done by the Project Implementation Committee and GVC.

Table 4-4: Example of an implementation plan template

Action	Activity	Months of the year												Resources	Who
		J	F	M	A	M	J	J	A	S	O	N	D		
Nursery	Plant vetiver Grass		X	X	X									Parent grass; Nursery area	Green Village Committee
Build contour ridges	Measure and peg ridges					X								A-frame measure; Pegs or markers; Labour	Farmers
	Align contour ridges					X								Pegs or markers; Labour	Farmers
	Dig ridges						X	X						Labour; Hoes; Shovel	Farmers
	Plant vetiver grass on ridges						X	X						Labour; Watering can; Vetiver plants	Farmers

Also consider groups of people to include in the implementation plan, not just the Green Village Committee, Implementation Committee or individuals, e.g. school groups, religious groups, etc.

Tip: It is a good idea to start implementing the actions that can be accomplished in a short time frame. The success of these initial efforts will demonstrate to the village and community that changes are happening, and will help sustain and build interest and involvement as implementation of the plan progresses.

The **action plan** provides all the details of the various activities, including the vision, goals, objectives, benefits. The **implementation plan** on the other hand indicates the order in which the activities should be carried out, what resources are needed and who is responsible for each activity.

Both these plans should be available to the village; for example, paint them on the side of the school wall, so everyone is reminded of what they are working towards.

Once the activities have been prioritised and ordered, a budget needs to be compiled. The Implementation plan will indicate what resources and costs are needed and by when. As we have seen in **Step 4:** Developing a VCP, it is important to consider the cost and resources that go into each activity planned to reach an overlying goal. While much village work will need to be voluntary, resources such as skilled artisans, materials, services and transport usually mean that money needs to be spent. Budgets should be calculated for each year of the plan. The basic steps to compiling a budget are listed in Figure 4-15. How to compile a budget is detailed in **Annexure III.**

Figure 4-15: Basic steps to compiling a budget

Keeping track of the amount of money needed for a project is an important part of the planning process. To start with a budget, there needs to be a calculation of what inputs/resources are required for each activity. Be realistic in compiling the budget, i.e. don't say a Mercedes 4x4 when a wheel barrow is sufficient. It is also important to consider the running costs over the future years. Sometimes implementation costs are high: thus, prioritisation of activities will dictate which activities can be implemented first without a heavy budget reliance.

It is essential to keep close track of the income and expenses during the implementation of the project for good management. Some items in the budget items may cost more or less than budgeted. Record keeping helps to indicate if there are additional funds available or needed, as well as to properly guide the next year's budget. Budgeting is also useful in comparing estimates with actual costs: this is a valuable planning tool for the future.

4.3.8 **<u>Step 8</u>**: Monitoring and evaluation

It is the responsibility of the PIC to monitor and evaluate the process during and after implementation; that is known as monitoring and evaluation (M&E). Village stakeholders, government, donors and other communities can all benefit from the information that is obtained from monitoring and evaluation. Refer to **Annexure IV** for more detailed information on how to conduct Monitoring and Evaluation.

The village community should be encouraged to take time out to celebrate. Village members need to feel that they are valued for their contributions. A function to celebrate successes will go a long way in helping the community members see that their efforts are needed and that there are visible results of their work in their catchment. Use successes as demonstration for other villagers and community areas. Use failures or short comings to learn from mistakes, or adapt to village conditions.

4.3.9 Next steps

The *Green Village Committee* and the Project Implementation Committee should review the plan on a regular basis to revise goals or set new ones. This may be based upon lessons learned from the monitoring and evaluation process or caused by changes that are occurring in the village. Some questions they could ask:

Do some activities need more attention than others?

What new issues have arisen?

What new opportunities do we have?

What new resources have we created or found?

Were our targets realistic?

What new strategies could be employed?

What assistance or resources do we need?

The *Green Village Committee* and Project Implementation Committee have worked long and hard to get to this point. It is important they stay involved in future action plans in the quest to meet the village goals.

These groups have played a valuable role in guiding and assisting local initiatives, and should continue to do so in the future – though there may need to be changes in personnel: not all members will want to continue indefinitely; or the process may become too subjective to personal interest – therefore it is important to also revise the *Green Village Committee* members. But it is important to keep the momentum going and capacitate as many of the community members as possible.

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PART II: TOOLBOX

5. USING THE GUIDELINES

There are six main themes in the Toolbox Guidelines, those of:

A. Sustainable Land Management

B. Soil Fertility Management

C. Water Efficiency and Management

D. Natural Resources Management

E. Sustainable Households

F. Disaster Preparedness.

The Toolbox guidelines are arranged according to the environmental foundations of the catchment. Each main theme has a series of sections which further group similar guidelines. When considering which guideline to use, first consider what issue needs to be addressed and then your capacity to implement the activity.

5.1 Identifying the issue

Poor catchment management occurs when the collective impact of land, water, biodiversity and people issues create “holes” in a functioning catchment (Figure 5-1A). These “holes” can be filled up by “building blocks” from the Catchment Management Guidelines (Figure 5-1B). Look at the problem tree to help you decide what the catchment management issue is, and how it relates to other issues/guidelines (Table 5-1). When identifying the issue to be addressed, try to identify what is causing the problem, not just the effect of the problem. Note that an issue in a different theme may be resolved through action in another theme, for example, the effect may be muddy water, but it’s the erosion at the cattle crossing that is causing the water to be muddy. Therefore, the issue is the cattle crossing. Look up the guideline for cattle crossings under the Sustainable Land Management Theme and the stream/River Bank management section.

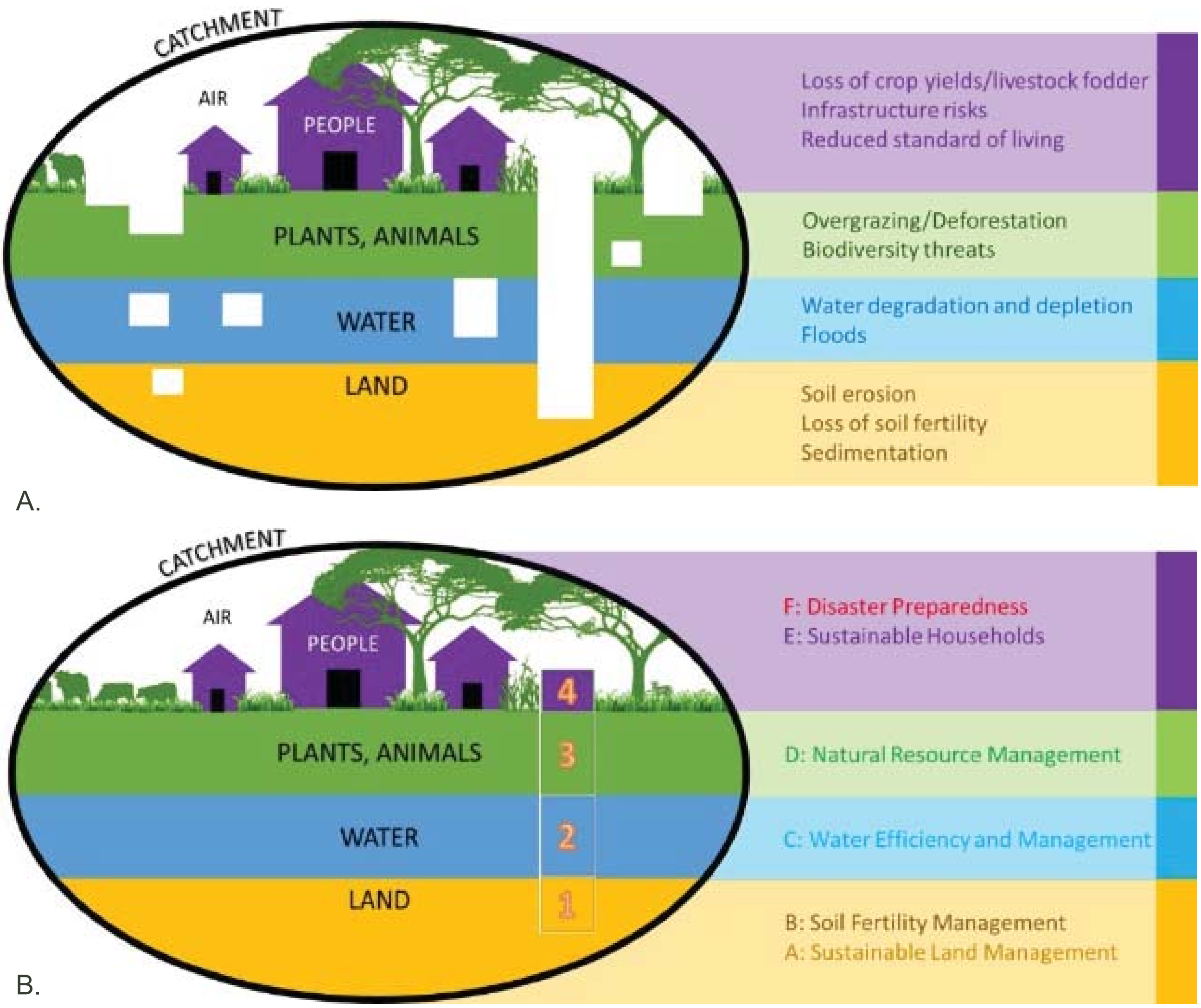


Figure 5-1: The main issues in a catchment (A) and the Catchment Management Guidelines related to each foundation of a catchment (B).

5.1.1 Identifying which guideline to use (problem tree)

A series of Problem Tree analyses has been carried out on the key issues identified across rural areas in South Africa. Each problem tree comprises two sections:

- Cause-effect identification (red block)
    - The central issue is broken up into a problem tree whereby the individual causes (bottom) and effects (top) are determined.
- Solutions pathway (green block)
    - A solution pathway proposes a possible solution to the issue, indicating which guidelines/activities need to be implemented (bottom) in order to improve or resolve the issue and the resultant benefits (top) of the issue being resolved.

The user turns to the problem tree of the particular issue, reviews the causes and effects, then reviews the guidelines suggested for implementation. See Figure 5-2 as an example. The biophysical issues that have been identified through problem trees are listed in Table 5-1.

Table 5-1: The biophysical and socio-economic problem trees identified.

	Biophysical Issue	Solution	Reference

Problem Trees	Land degradation	Sustainable land management	Figure 5-3
	Soil erosion	Erosion control	Figure 5-4
	Water degradation and depletion	Water resources management	Figure 5-5
	Floods	Flood prevention and control	Figure 5-6
	Climate change	Climate change adaptation	Figure 5-7
	Overgrazing	Rangeland management	Figure 5-8
	Threat to Biodiversity	Sustainable biodiversity management	Figure 5-9

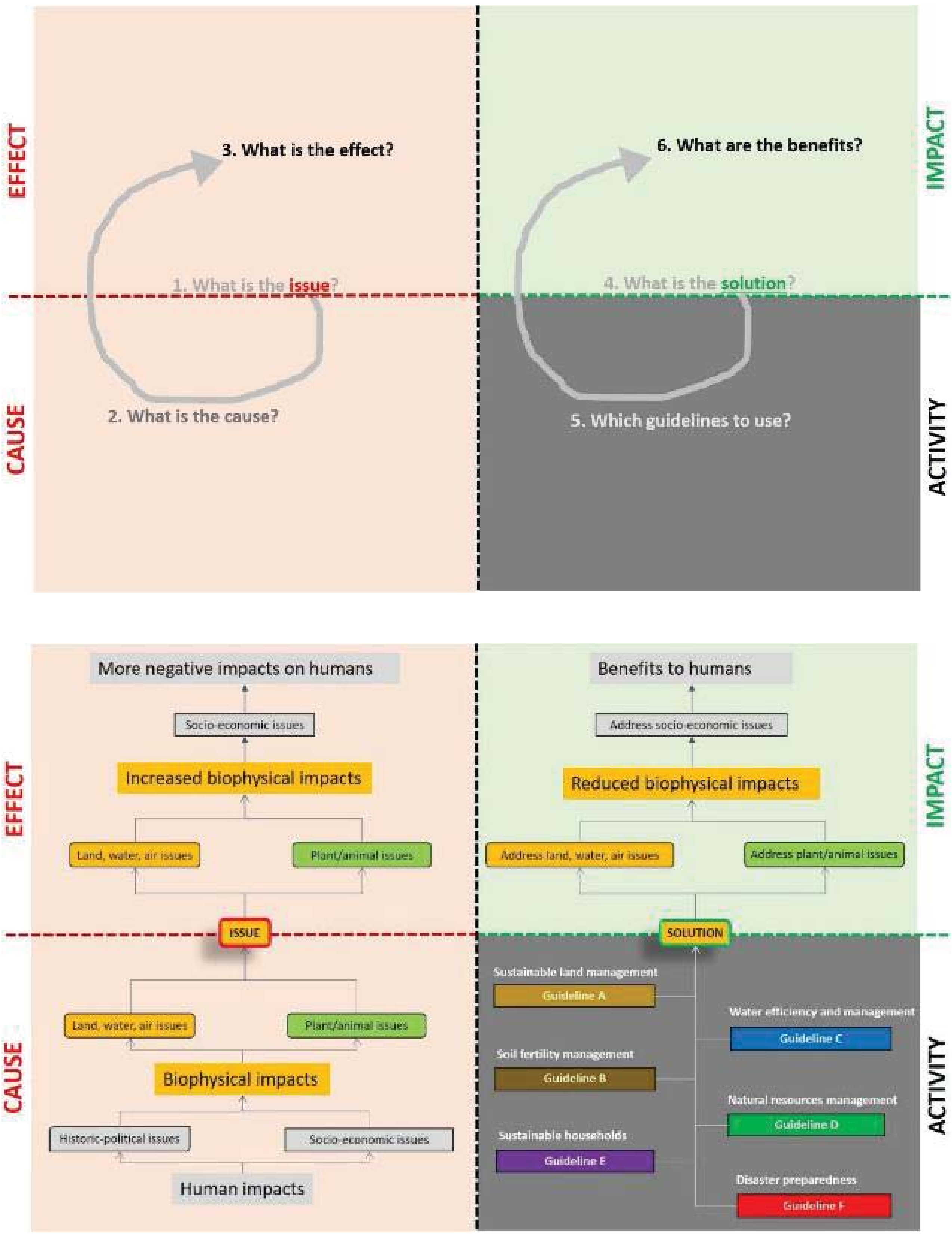


Figure 5-2: The steps to identify causes and effects of an issue, as well as the activities and beneficial impacts when the Guidelines are used to develop a holistic solution to the issue.

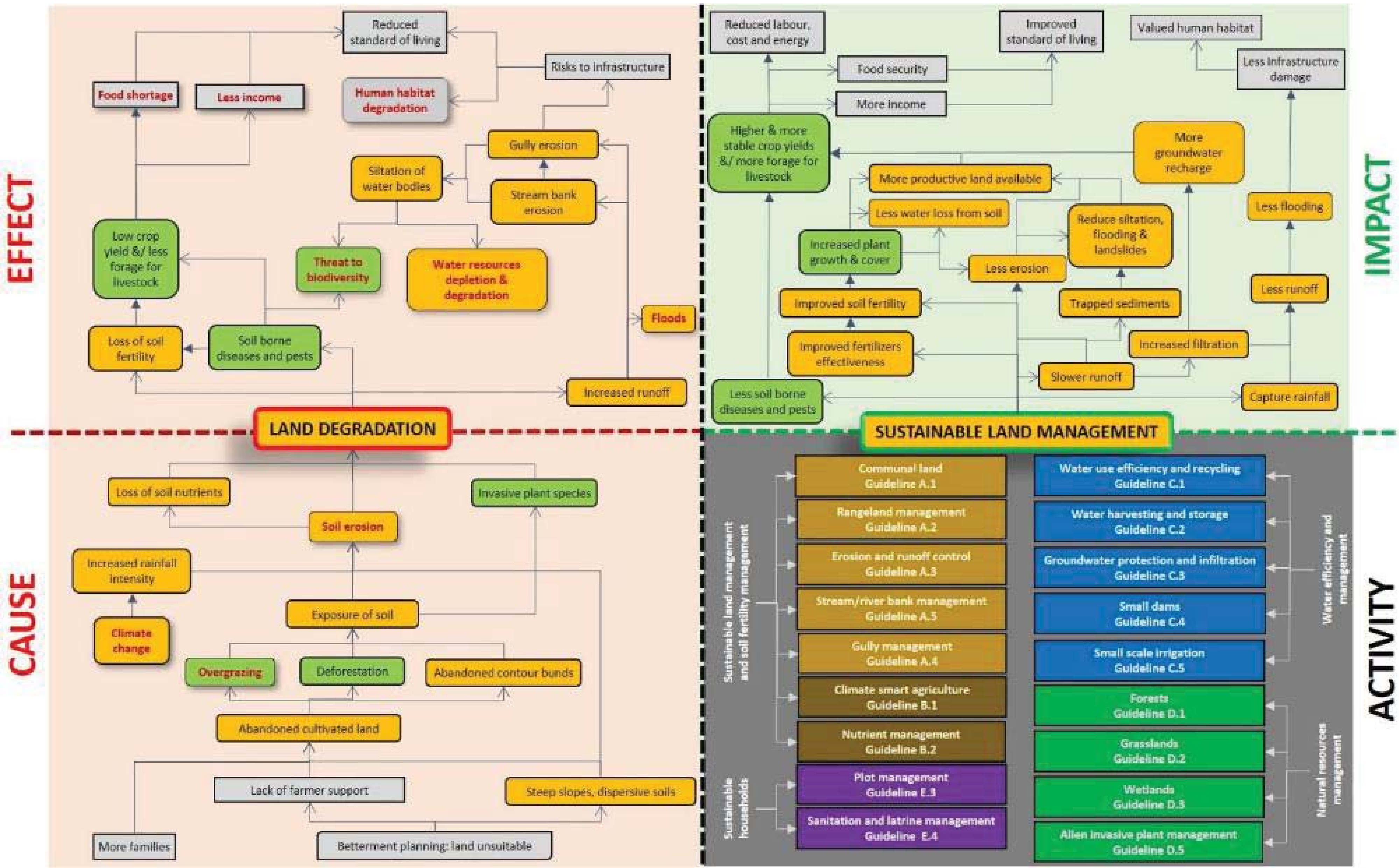


Figure 5-3: The problem tree for the issue of land degradation and solution of sustainable land management.

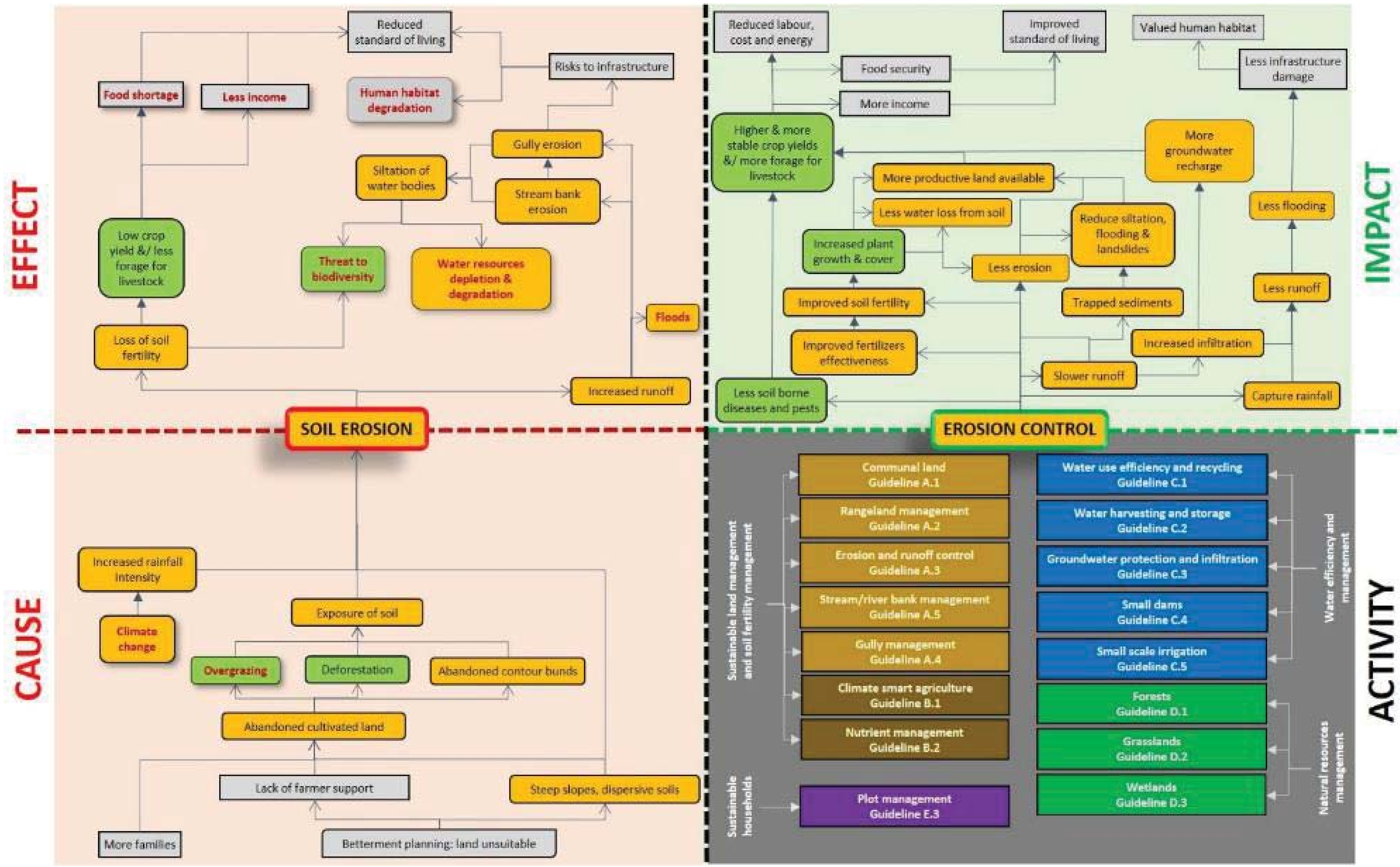


Figure 5-4: The problem tree for the issue of soil erosion and solution of erosion control.

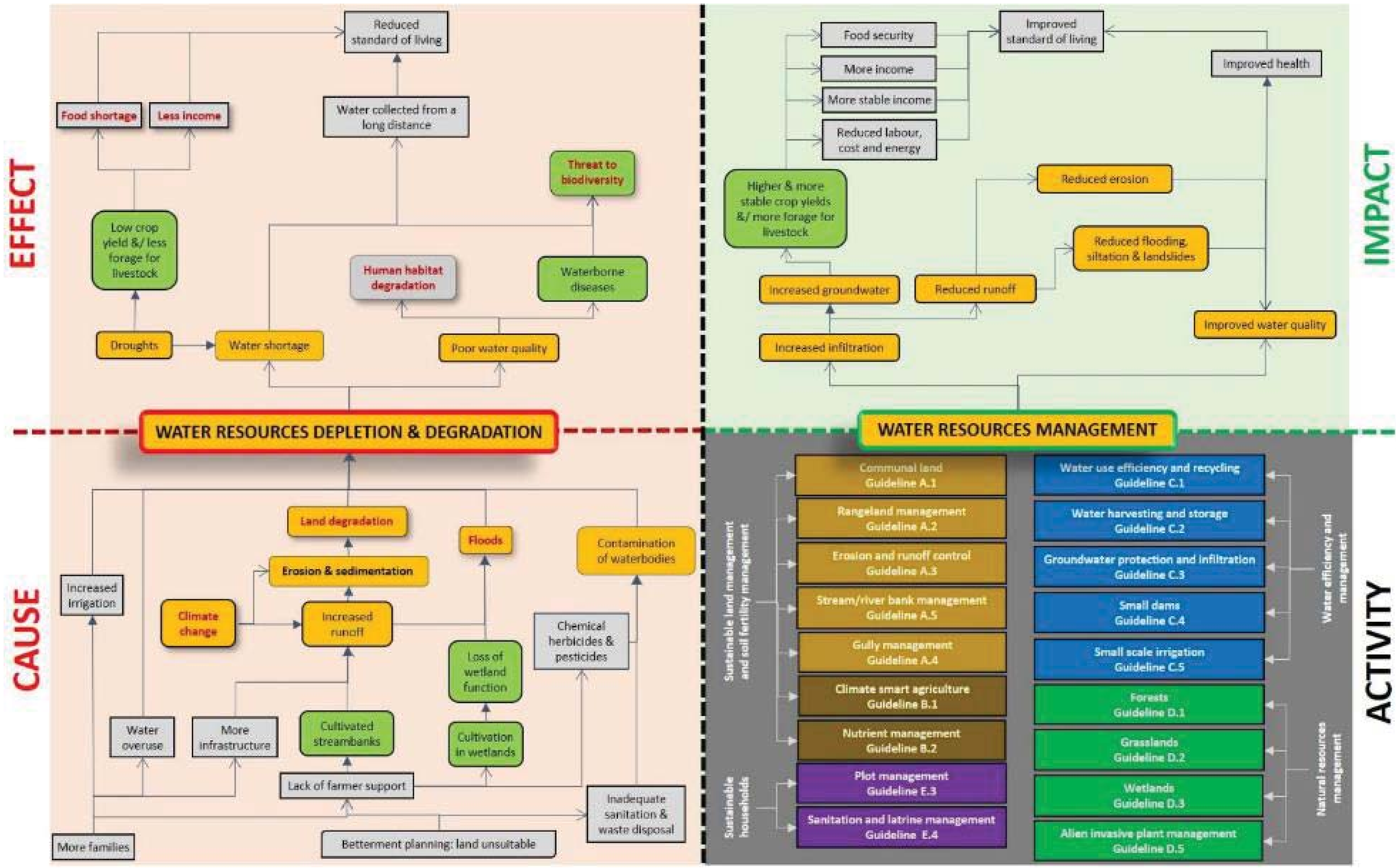


Figure 5-5: The problem tree for the issue of water resources depletion and degradation, and solution of water resources management.

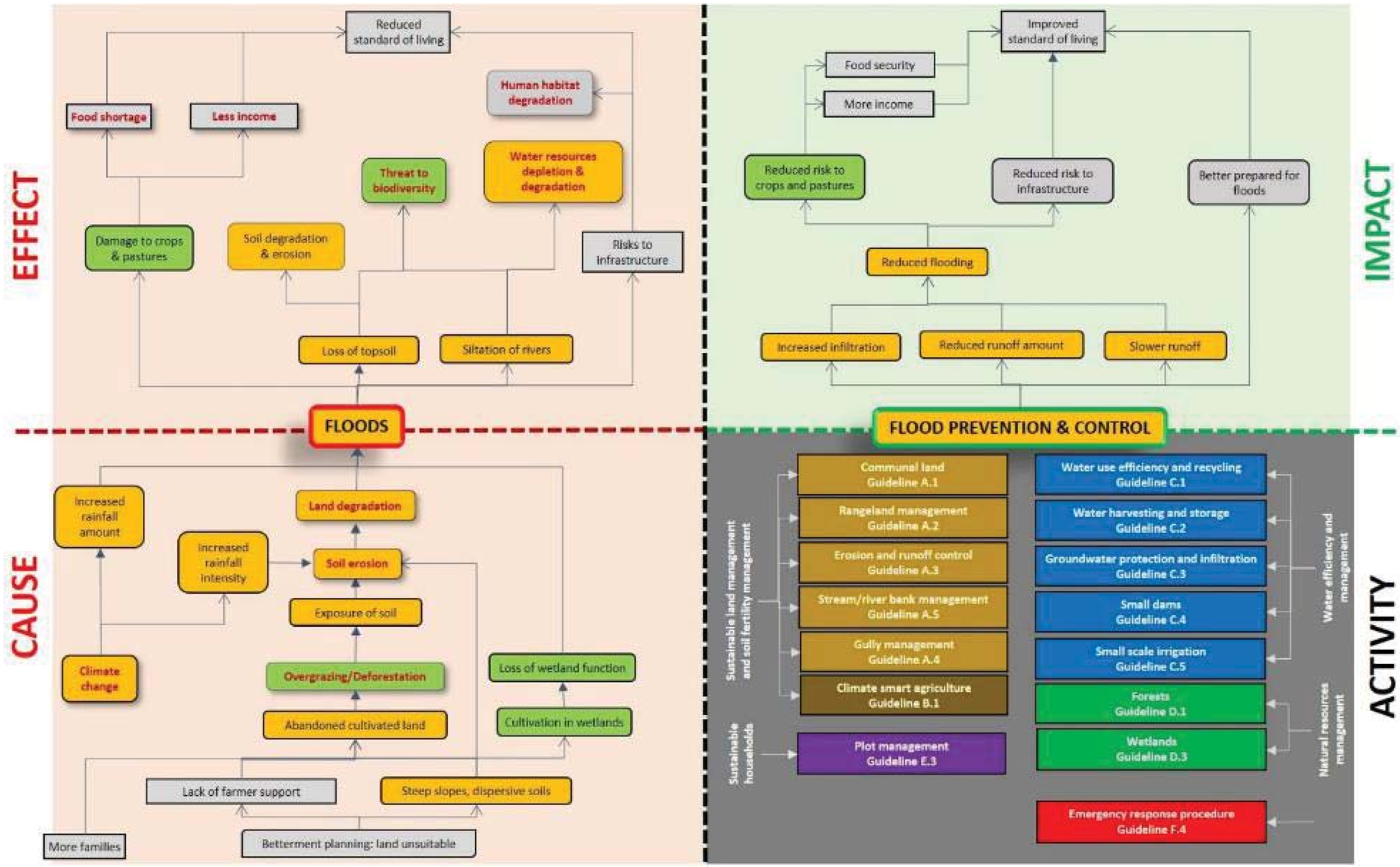


Figure 5-6: The problem tree for the issue of flooding and solution of flood prevention and control.

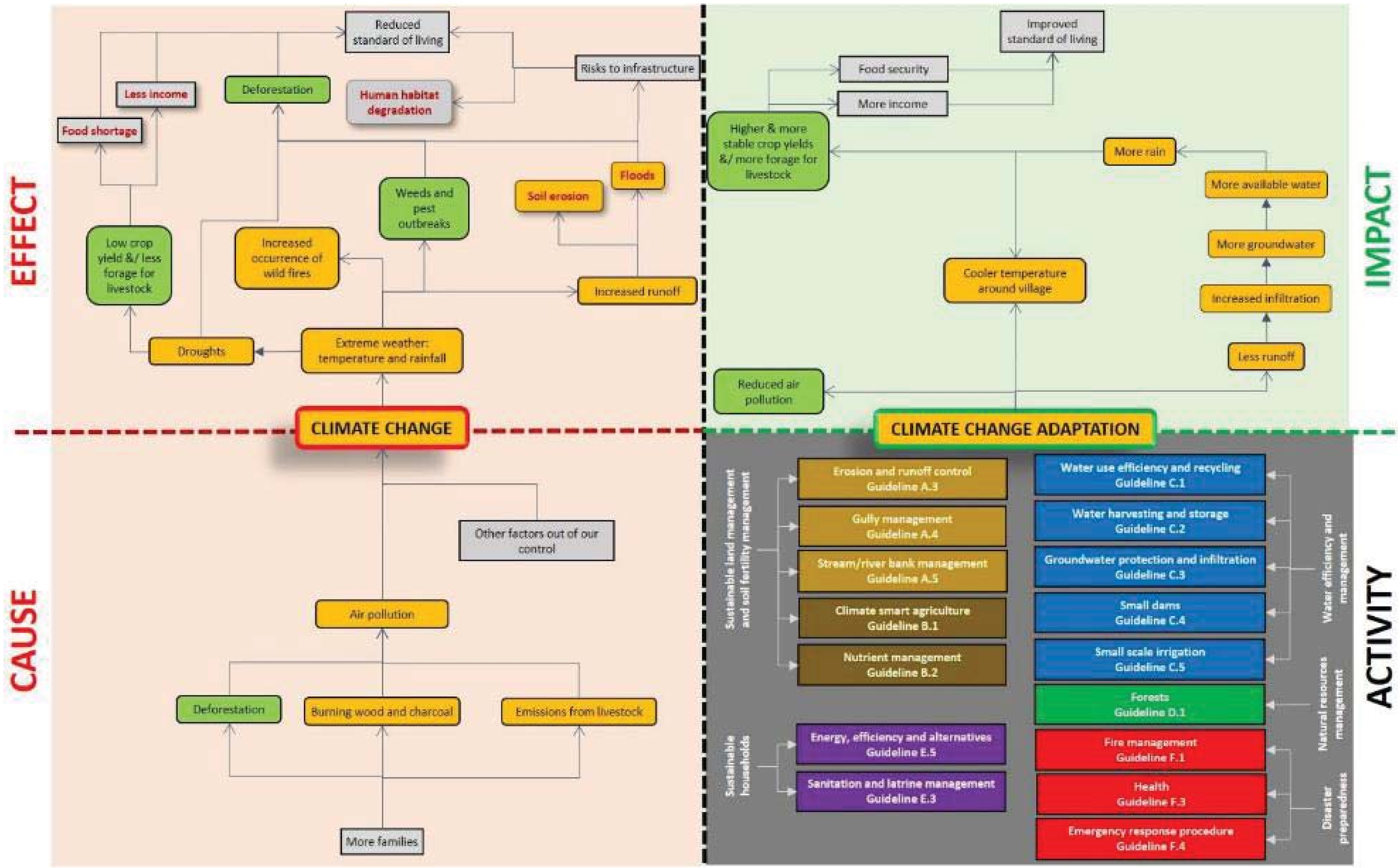


Figure 5-7: The problem tree for the issue of climate change and solution of climate change adaptation.

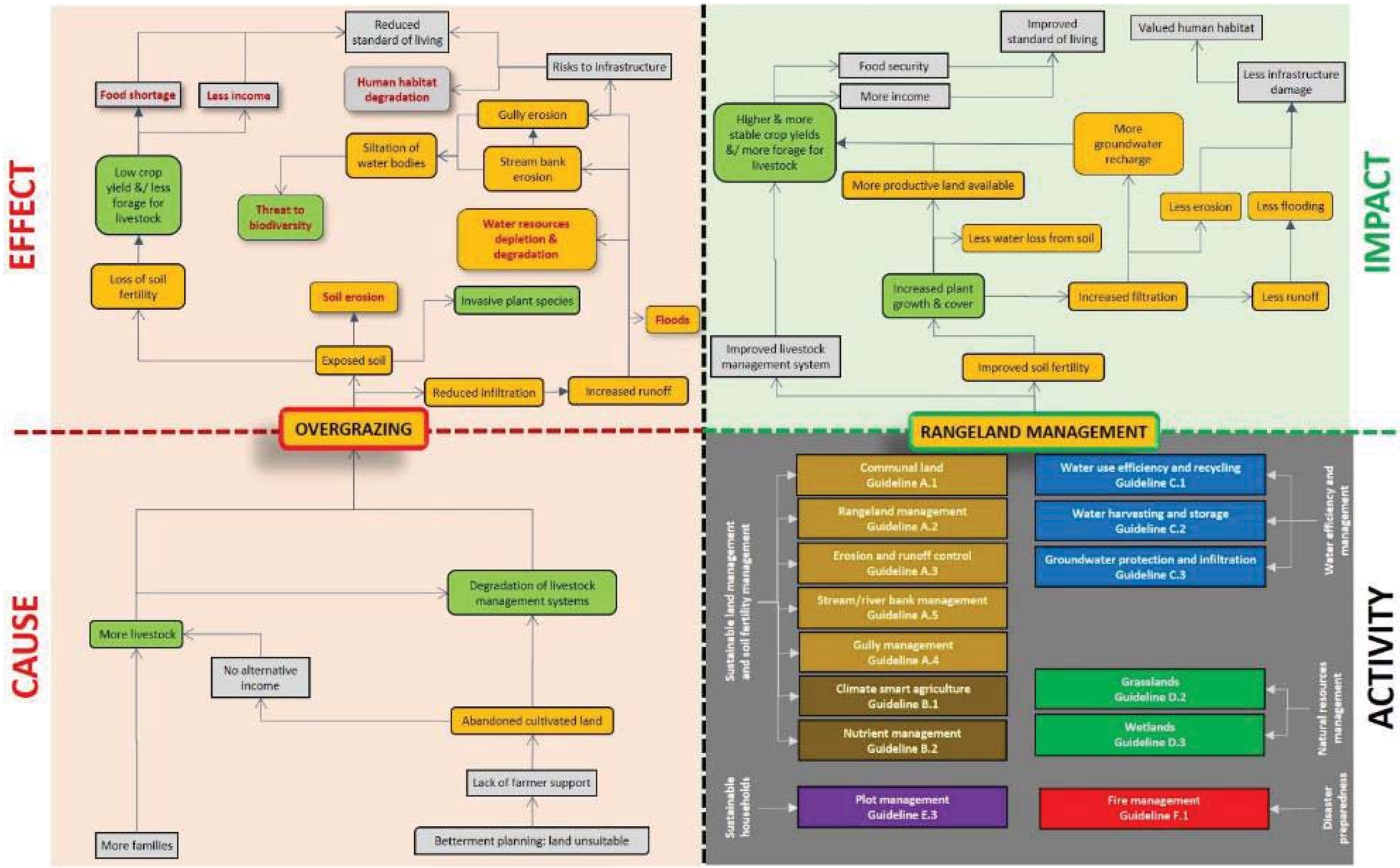


Figure 5-8: The problem tree for the issue of overgrazing and solution of rangeland management.

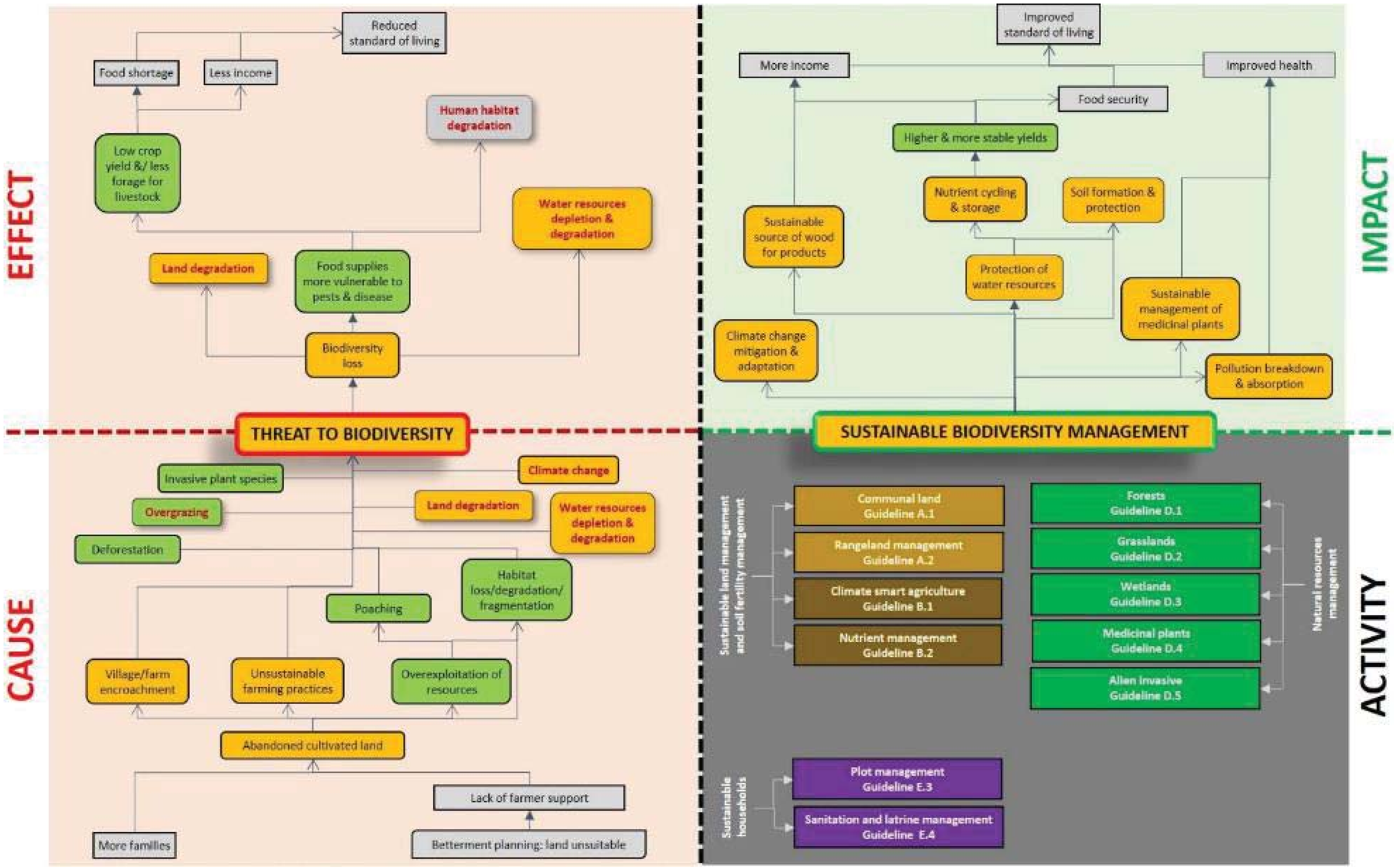
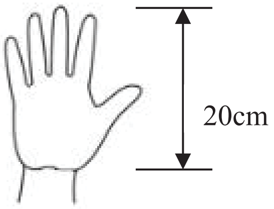


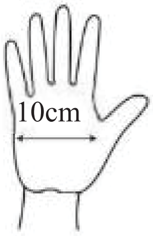
Figure 5-9: The problem tree for the issue of threat to biodiversity and solution of sustainable biodiversity management.

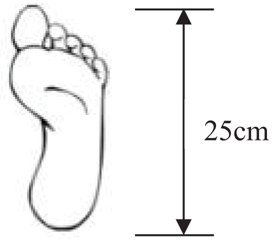
5.1.2 Measurement guide

Some of the guidelines require measurements in their application. Table 5-2 provides an indication of some of the measurements if measuring tools are unavailable.

Table 5-2: Indication of some of the measurements if measuring tools are unavailable.

<table>
<tr>
<td>

Hand length (fingertip to palm)</td>
<td>

Hand width</td>
<td>

Foot</td>
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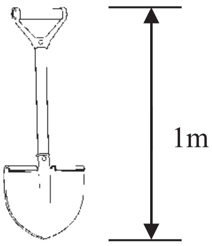
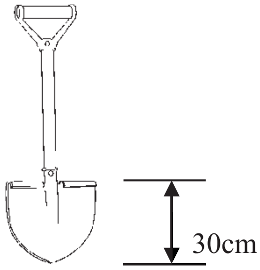
<td>

Shovel length</td>
<td colspan="2">

Shovel head</td>
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</table>

5.2 Identifying your capacity

Each guideline has a series of icons in the heading section. Once you have determined the appropriate guideline to use it is then necessary to determine how appropriate the guideline is according to the individual circumstance. This will involve determining whether any environmental legislation is triggered by the activity, what the scale of the activity is, what the labour requirements are, what the contribution to livelihood is, what is the level of complexity needed to implement the activity and what the cost implications are.

The icons are described further in Table 5-3.

Table 5-3: Capacity icons

KEY: Capacity Icons					
Action	**Legislation**	**Scale**	**Labour**	**Complexity**	**Cost**
Prevention	Other	Household	Single person	Simple	Free to little
Rehabilitation	NWA/NEMA	Village	Few people	Advanced	Medium cost
		Catchment	Many people	Complex	Expensive

PREVENTION / REHABILITATION	
	This activity, if implemented, will act to manage natural resources and prevent potential environmental damage.
	This activity, if implemented, will act to improve and rehabilitate the state of the environment from a degraded state.

LEGISLATION	
	This activity **does not** require authorisations in terms of the National Water Act (No.107 of 1998) (NWA) and the National Environmental Management Act (No. 36 of 1998) (NEMA); **BUT** other legislation may still apply.
	This activity **does** require authorisations in terms of the National Water Act (No.107 of 1998) (NWA) and the National Environmental Management Act (No. 36 of 1998) (NEMA).

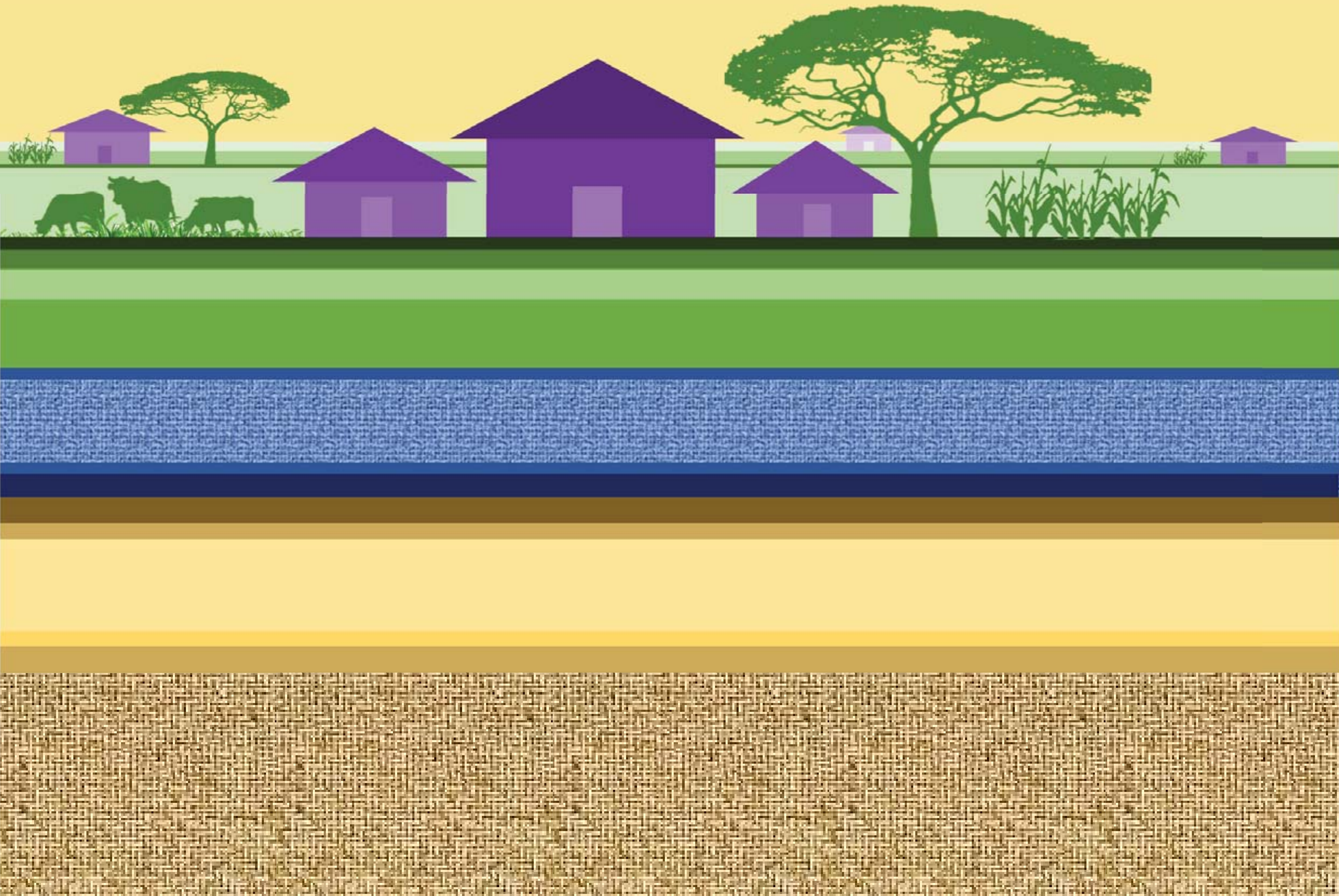
SCALE	
	Small, easily managed interventions that can be carried out by members of a household. These interventions should be carefully thought-out and family members should be aware of possible impacts beyond the household. They will be of benefit to few people only unless carried out by
	Medium-scale interventions that require buy-in, set-up and ongoing management from the majority of a village. These interventions require planning and agreement by the community, but have benefits for all of the village.
	Large-scale interventions that require agreement and joint set-up and management from several villages in a shared catchment. These interventions require the highest level of planning and collaboration, but will benefit all villages in the catchment and serve as an example to other areas.

LABOUR	
	This activity is small enough for a single person to complete over the course of a few days and would take up to 10 person-days.
	This activity will need between 3 and 10 people to complete over a period between one week and a month. It would take up to 50 person-days.
	This activity is large and will take more than 10 people working over a period between one week and several months depending on the size of the task. The longer duration tasks need over 100 person-days, while the more focused tasks would need between 10 and 50 person-days.

COMPLEXITY	
	This activity is simple to set-up and manage, and relies mainly on labour and basic tools.
	This activity is more advanced and requires technical planning and assistance from relevant programs under either the DAFF or DEA.
	This activity is advanced and technical, which requires input from a specialist or engineer.

COST	
	This actitiy often relies on labour only, or readily available materials. Costs range from R0 to R1 000.
	This activity relies on labour but will require some more advanced tools or the purchasing of materials/resources. Costs range from R1 000 to R10 000.
	This task is expensive due to the resources required (labour, specialist input, and/or materials). Funding requirements for these activities would likely need to be sourced from District funding, loans or NGO/Donor funding. The costs arve above R10 000.

A: Sustainable Land Management



A. SUSTAINABLE LAND MANAGEMENT

CATCHMENT MANAGEMENT GUIDELINES	ISSUES										CAPACITY					
A. Sustainable land management	Soil Erosion	Loss of soil fertility	Sedimentation	Water degradation and depletion	Floods	Overgrazing / Deforestation	Threat to biodiversity	Loss of crop yields / Livestock fodder	Risk to infrastructure	Reduced standard of living	Prevention/Rehabilitation	Legislation	Scale	Labour requirement	Complexity	Cost
A.1. Communal land management																
A.1.1. Land administration in communal areas	■	■	■			■		■		■	Prevention	Other	Village	Few people	Complex	Medium cost
A.2. Rangeland management																
A.2.1. Rotational resting of rangeland	■	■	■			■	■	■		■	Rehabilitation	Other	Village	Few people	Simple	Free to little
A.2.2. Prevention and rehabilitating overgrazing	■	■	■			■	■	■		■	Rehabilitation	Other	Village	Few people	Simple	Free to little
A.2.3. Grazing movement	■	■	■			■		■		■	Prevention	Other	Village	Single person	Simple	Free to little
A.2.4. Cattle paths up slopes	■	■	■			■		■		■	Prevention	Other	Village	Single person	Simple	Free to little
A.3. Erosion and runoff control measures																
A.3.1. Contour ridging / Contour Bunds	■	■	■			■		■		■	Rehabilitation	NWA/NEMA	Household	Single person	Advanced	Free to little
A.3.2. Contour vegetation rows	■	■	■			■		■		■	Rehabilitation	Other	Household	Single person	Simple	Free to little
A.4. Gully management and sediment trapping																
A.4.1. Gully prevention	■	■	■	■		■		■	■	■	Prevention	Other	Village	Few people	Simple	Medium cost
A.4.2. Gully reclamation (small gullies)	■	■	■	■				■	■	■	Rehabilitation	NWA/NEMA	Village	Few people	Advanced	Medium cost
A.4.3. Stone check dams	■	■	■	■				■	■	■	Rehabilitation	NWA/NEMA	Village	Few people	Advanced	Free to little
A.4.4. Brushwood check dams	■	■	■	■				■	■	■	Rehabilitation	NWA/NEMA	Village	Single person	Advanced	Free to little
A.4.5. Vegetation barriers	■	■	■	■				■	■	■	Rehabilitation	NWA/NEMA	Household	Single person	Advanced	Free to little
A.4.6. Gully re-shaping	■	■	■	■				■	■	■	Rehabilitation	NWA/NEMA	Village	Few people	Complex	Medium cost
A.4.7. Erosion management along roadsides	■	■	■	■				■	■	■	Prevention	NWA/NEMA	Village	Few people	Advanced	Medium cost
A.5. Stream/River bank management																
A.5.1. Riparian buffer zones	■	■	■	■	■				■	■	Prevention	NWA/NEMA	Catchment	Few people	Advanced	Medium cost
A.5.2. River crossing for cattle	■	■	■	■			■			■	Rehabilitation	NWA/NEMA	Village	Few people	Advanced	Medium cost
A.5.3. Earth berms / dykes / flood levees	■	■	■	■	■			■	■	■	Prevention	NWA/NEMA	Village	Few people	Complex	Medium cost
A.5.4. Gabion baskets	■	■	■	■	■			■	■	■	Rehabilitation	NWA/NEMA	Village	Few people	Complex	Expensive

KEY: Capacity Icons

Action	Legislation	Scale	Labour	Complexity	Cost
Prevention	Other	Household	Single person	Simple	Free to little
Rehabilitation	NWA/NEMA	Village	Few people	Advanced	Medium cost
		Catchment	Many people	Complex	Expensive

Overgrazing, deforestation, poor agricultural practices, loss of soil fertility, lack of runoff management and gully formation each contribute to the degradation of land resources through soil erosion, with resultant impacts on the catchment both up and downstream. In order to reduce land degradation, one needs to mitigate or rehabilitate the degradation and soil erosion, by implementing sustainable land use practices, this section of guidelines provides technical guidance covering various aspects of Sustainable Land Management. Implementing these techniques and practices will minimise the loss of topsoil (through erosion) and reduce the erodibility of a catchment.

A.1. Communal land management

Not all land is privately owned, and therefore it is not simply the landowner's responsibility to manage, repair or maintain the land. Communal land includes grazing land, cultivation land as well as pathways, roads, and community properties, e.g. schools, clinic, etc. Although the physical land management activities are the same for other land, the process to address hierarchy in tenure, and who is responsible for initiating and authorising activities on communal land need to be appropriately followed. These guidelines provide some guidance towards this communal/tenure hierarchy process.

A.2. Rangeland management

This set of guidelines provides techniques to ensure continuous yield of rangeland products while protecting and improving the basic rangeland resources of soils and water – which support plant and animal life. These include conservation and sustainable management practices which take into account natural features, and regulate the periods of grazing, the number of animals allowed to graze on a given range area, and intensity of use. Rangelands must be provided ample resting time to enable the master grass species (the most palatable to livestock) to re-generate, else other species will invade. These guidelines also include techniques to rehabilitate overgrazed lands.

A.3. Erosion and runoff control measures

Soil, termed sediment once eroded, causes issues when carried downstream with runoff as it reduces water quality and storage capacity of reservoirs. These guidelines provide a number of measures to be applied in cultivated lands, roads and pathways in order manage runoff. Management of runoff will minimise soil erosion, increase infiltration and water use efficiency, as well as reduce sedimentation downstream.

A.4. Gully management and sediment trapping

Unmanaged erosion rapidly turns steep slopes into gullies with the loss of farming land and topsoil and threatens infrastructure including houses and roads. Preventive practices are the best way to control gullies. Where gullies have been formed, these should be rehabilitated to prevent further damage and degradation. These guidelines provide techniques for both gully prevention, and gully rehabilitation, for both hillsides/farms and roadsides.

A.5. Stream/River bank management

These guidelines present methods for the improvement of stream/riverbank stability where these are already suffering from erosion for example from cattle crossings. Also demonstrated are ways and means of rehabilitating stream/river banks with buffers. These will contribute to the creation of a more manageable riverbank habitat that is beneficial to wildlife and at the same time manages the riverine zone, ensuring adequate river function through sediment control and water quality improvement.

A.1 Communal land management

Tenure systems define and regulate how people, communities and others gain access to natural resources, whether through formal law or informal arrangements. The rules of tenure determine who can use which resources, for how long, and under what conditions. They may be based on written policies and laws, as well as on unwritten customs and practices.

A.1.1 Land administration in communal areas

OVERVIEW

Land administration covers a range of cross-cutting functions, which collectively support land tenure systems. An adequate land administration system is therefore the first step in effective communal land management. Tenure systems increasingly face stress as a growing population requires food security, and as environmental degradation and climate change reduce the availability natural resources. Inadequate and insecure tenure rights increase vulnerability, hunger and poverty, and can lead to conflict and environmental degradation when competing users fight for control of the resources.

Objectives:

Setting out established best practices, norms and standards for development of bottom up land record systems as an anchor of a land administration system.

Catchment perspective:

It is important to understand land administration from a catchment scale before working in an area as land administration collectively supports land tenure systems.

Criteria for application:

Primary target for these guidelines are:

- National government departments, Proto-Catchment Management Agency, land administration policy makers, Non-Governmental organisations and practitioners in the land sector.
- Traditional leadership institutions that currently play some role in land administration.
- Communities living in the particular area.

Benefits:

- Contribute to achieving sustainable livelihoods, social stability, housing, security, rural development, environmental protection, and sustainable social and economic development.
- Allow governments, civil society, the private sector and citizens to judge whether their proposed actions and the actions of others constitute acceptable practices.

Funding opportunities:

Not applicable

Legislation:

- Communal Property Associations Act 28 of 1996
- Restitution of Land Rights Act 22 of 1994
- Communal Land Rights Act 11 of 2004

METHODOLOGY

Methodology:

Decisions in one area of land administration usually affect the other areas, which is why it is important to have a coherent system. Land administration entails the following elements:

Land rights record: the acquisition, maintenance and dissemination of information on the land rights to support land policy implementation. This entails norms about which state/ civil institutions are the custodians of land records, and how do they define the rights they safeguard?

Land rights transmission: How are land rights transferred? How does land devolve from one generation to the next, and/or how is land transferred from one land occupation and use rights holder to another?

Land rights adjudication: How are existing claims to land rights verified and checked? Who decides which rights to accept? Adjudication in this context refers to the processes by which existing rights to a particular parcel/piece of land are authoritatively ascertained, i.e. it does not mean creating new rights. In a conventional cadastral system, it refers to the painstaking checks performed by registered land surveyors and legal conveyancers to ascertain the precise spatial and textual characteristics of ownership to prevent overlaying boundaries and overlapping rights. A new set of adjudication principles are required for social tenures in communal land areas where rights may overlap and boundaries may be fluid.

Land planning: What activities are envisaged to take place on the land in future? Who decides?

Land use management: How is land use changed from one use to another? What activities can be undertaken on the land? Who decides?

Land taxes and fees: How are land taxes and fees determined and collected in relation to land and services from occupants and users? What are land taxes and fees used for?

Enforcement: How are above functions enforced and by whom?

Different forms of Land Administration:

1. **General tenure systems**: The following characterisations are examples of some of the general tenure systems:
    a) Peri-urban informal settlements
    b) Traditional communal, not impacted or little affected by betterment planning
    c) Trust tenure situations characterised by planned settled with grid layouts.
    d) Demographically fast-growing settlements

A.1.1 Land administration in communal areas

e) Demographically stable settlements
f) Demographically declining settlements
g) Surveyed or un-surveyed areas

Source of rights: Land rights originate from different sources, some rights arise from custom others from common law, whilst others may arise from illegal new practice. The different land rights need to be understood as if local customs are not understood and are ignored when making decisions, people will ignore them and will revert back to what they know. The alignment of common law with customary law should be a key focus.

Managing contestations: Contentions in terms of vesting of rights, succession and boundaries may be at the household level, the bigger lineage group level, the neighbourhood level, the municipal area level or even the traditional council level. Individual/s, group/s, household (umzi), or 'guardian'/ keeper name (umninimzi) have flexible local socially mediated procedures for managing boundaries and succession based on the concept of the extended family, and with local socially mediated procedures and guidelines for transferring rights. It is likely that there will be less accurate forms of data and maps pertaining to these land rights.

Traditional leadership: An overview of the paid personnel in a local municipality in the former Transkei highlights that there are many traditional leaders, traditional council secretaries, headmen and sub-head-men which are in the payroll of the government. These numbers far outweigh the ward councils for the local municipality, most of which do not receive large remuneration. Whilst the institutional capacity may be lacking in the municipality, the role of traditional leadership must not be overlooked as a key component of decision making.

Principles of implementation: A key lesson when dealing with land tenure is the recognition of off-register tenure rights. It is important to recognise the complex nature of communal land rights operating across a multiple gradient of "nested" scales. These may range from rights of:

a) Individuals within a household context
b) Household units
c) Lineage or clan
d) Neighbourhood clusters
e) Village inhabitants
f) Inhabitants of an administrative area
g) Tribal or wider community grouping
h) Members of a kingdom.

While it is important to understand and appreciate the nature and content of the rights in each level, it is also important to understand that these rights operate relative to each other in constantly dynamic ebbs and flows (i.e. while the individual household may have very strong and secure rights to arable land, these may be extinguished as a result of the right not being exercised, subject to local customary rules). At micro-scale the household/individual makes most decisions about what happens on the household land as well as succession and land transfer decisions related to this land. The higher echelons in the nested system can override lower levels, depending on circumstances. Key to note is that land rights and rights holders do not fit one-to-one as is usually the case in Western land systems, but are a dynamic complex web that is subject to local customary rules.

Illustrations/ Diagrams:

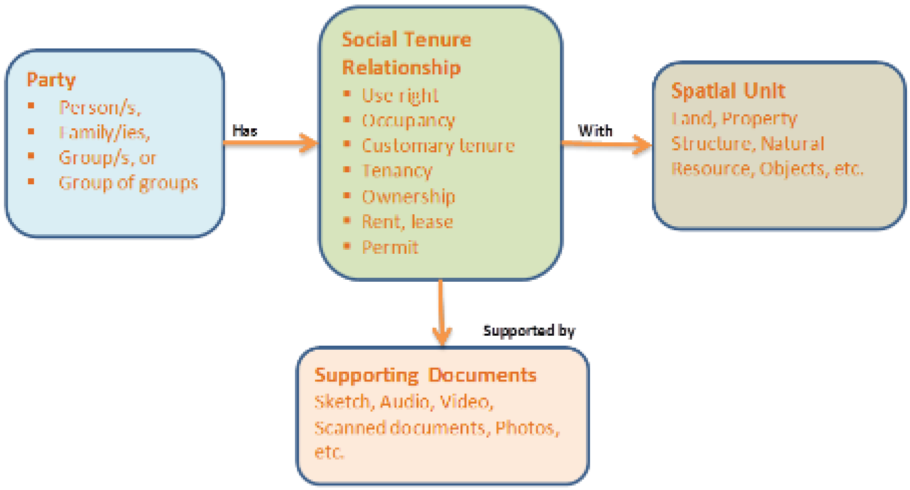


Figure A.1.1-1: The social tenure relationships in a rural context

A.1.1 Land administration in communal areas

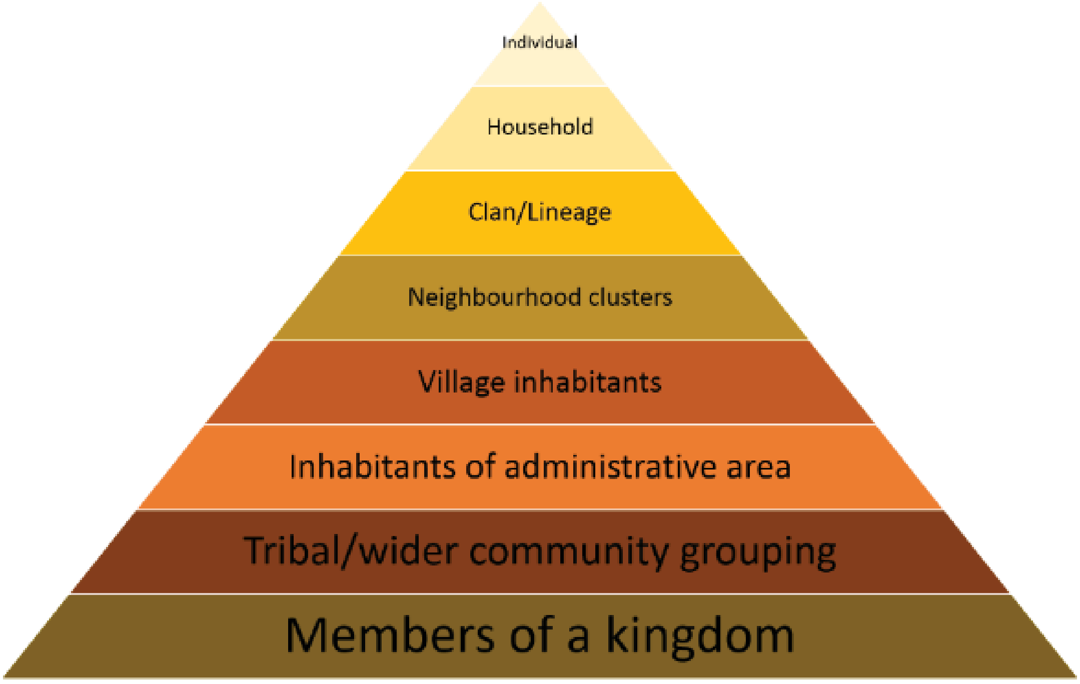


Figure A.1.1-2: The nested hierarchy of authority in areas of communal land tenure. This is not the same for all areas, but is a broad-based overview

Photos: Not applicable	**Equipment requirements:** Not applicable
Variations/Adaptations: Not applicable	**Seasonal variations:** In each of these different nested levels the rights of outsiders are also relative and vary with time place and circumstances. For example, the community of Amajingqi may ordinarily be allowed to graze their cattle across under normal circumstances, but may be not be allowed during winter or during planting season.

MAINTENANCE	REFERENCES
Maintenance requirements: Not applicable	**See also:** Guideline A.1.2. Land tenure and land management Guideline A.2.1. Rotational resting of rangeland Guideline A.2.2. Prevention and rehabilitating overgrazing Guideline A.2.3. Grazing movement

A.2 Rangeland management

Rangeland is known as “veld” in South Africa. Veld is the area, outside of towns and cultivated fields, where animals graze. Rangeland management is the practice of deciding where to graze animals, how many animals to graze at one time, when to burn, how to harvest firewood and thatch-grass, and other issues relevant to managing natural resources in veld. In this section, we will focus on how to manage rangelands to ensure that both the animals and the grass are cared for.

A.2.1. Rotational resting of rangeland

OVERVIEW

Overgrazed land leads to increased soil erosion and loss of soil nutrients. This guideline outlines mechanisms to rest grazing land to allow critical vegetation to recover and protect the soils while other areas are being grazed in rotation.

Objectives:	**Criteria for application:**
• To allocate grazing according to resources • To allow resting of portions of the rangeland for plant recovery • To better manage livestock	• Separate wetlands (vlei areas) from dry areas • Separate steep slopes with shallow soils from gentle slopes with deeper soils • Separate north-facing slopes from south-facing slopes

A.2.1. Rotational resting of rangeland

Benefits:

- Increase forage production
- Increase grass cover
- Increase water infiltration
- Decrease soil erosion
- Prevent encroachment of poor-quality grasses and bushes into grazing areas.
- Separate bushveld from grasslands
- Separate badly degraded areas from healthy areas

Livelihood opportunity:
The sustainable management of rangelands provides food for cattle, which in turn contribute to food security.

Funding opportunities:

- LandCare
- Heifer International
- Eastern Cape Department of Rural Development and Agrarian Reform

Legislation:

- Conservation of Agricultural Resources Act 43 of 1983.
- National Environmental Management Act 107 of 1998.
- The Conservation of Agricultural Resources Act lays out recommended stocking rates and veld management practices.

Catchment perspective:
Rotational resting of rangeland requires a grazing management committee. Setting up this committee requires input from the village as the whole village will need to be aware of grazing management in order to have long term benefits. Benefits will include strengthened grazing management institutions.

METHODOLOGY

Methodology:

1. Set-up a **village grazing management committee** to implement this guideline

- Use local knowledge of the area to divide the rangeland into different grazing blocks according to the environment. (refer to Figure A.2.1-1) Divide the grazing area according to natural features (rivers, steep slopes, gentle slopes, wetlands, agricultural lands, grasslands), community boundaries and roads.

Allocate different blocks to different times of the year, allocate portions to be grazed and portions to be rested in different seasons and different years, e.g. blocks A, B, C, etc. in Figure A.2.1-1.

Allocate a resting schedule every year – try to set aside at least one or two blocks to be rested for the whole summer

Use roads or natural boundaries, or lay-out large marker stones to show the boundaries of the blocks

Meet twice a year (dry and wet season) to discuss which areas will be burned, grazed, and rested

Use existing community structures to decide how to keep animals out of the rested blocks

Rotational burning can be used to attract animals towards burned areas

Make sure the whole community (all owners of livestock) are aware of the plan. Keep the plan accessible.

For example, a grazing plan could look like this:

Block Ref.	Description	Wet Season			Dry season		
		Graze	Burn	Rest	Graze	Burn	Rest
Block A	Road to tree, ridge to river						
Block B	Tree to river, river to big rock						
Block c	River to cliff, river to school						
Block D	Cliff to road, river to church						

A.2.1. Rotational resting of rangeland

Illustrations/ Diagrams:

Figure A.2.1-1: Example of a landscape divided into veld type units (coloured lines) and grazing blocks (white lines). The divisions are made using rivers, ridges, roads and other obvious features (Image: Google Earth)

Photos:

Figure A.2.1-2: Two patches of grazing adjacent to each other, taken on the same day. The area on the left has been heavily grazed until there is no grass left, the area on the right has been rested (Source: A. Short)

Equipment requirements:

- Large map or model of the grazing lands for discussion and allocating blocks
- Marker stones for boundaries between blocks

Variations/Adaptations:

- Rotational burning: burn different blocks in different years to attract animals to one area and encourage resting of another area
- Use herders to keep animals away from rested blocks

Seasonal variations:

- Importantly: Vlei areas should be grazed in the dry season and rested in the wet season
- Decide which areas are for summer grazing and which are for winter grazing
- Prepare for droughts early by selling animals or preparing feed

MAINTENANCE

- Protect rested blocks from fire
- Only burn grazed blocks if necessary (when the grass is tall and old, and when bush encroachment is a problem)

REFERENCES

Definitions:

Veld type unit: these are areas of veld with similar productivity (the amount of grass produced per year) and management requirements. Veld type units are used to determine grazing blocks

Grazing block: Veld is divided into management areas called grazing blocks. Each grazing block can be subdivided into camps. Grazing blocks can be grazed, burnt or rested in any given year.

Vlei: wetland, marsh, damp area.

See also:

Guideline A.2.2. Prevention and rehabilitating overgrazing
Guideline A.4.1. Gully prevention
Guideline A.4.2. Gully reclamation
Guideline A.4.6. Gully re-shaping
Guidelines D.3.1 Sustainable utilisation of wetlands
Guideline D.3.2 Wetlands conservation
Guideline F.1.1. Firefighting wildfires (practical)
Guideline F.1.2. Firefighting tools (construction and usage)
Guideline F.1.3. Firebreaks

Further references:

1. Morris CD, and Kotze DC. 2006. Introduction to VeldCare. Agricultural Research Council: Pietermaritzburg

Van Oudtshoorn, F. 2015. Veld Management Principles and Practice. Briza, Pretoria

A.2.2. Prevention and rehabilitating overgrazing

OVERVIEW

Where land has been overgrazed, it needs to be rehabilitated in order to improve ecosystem function and goods and services provision. This guideline outlines how to rehabilitate and protect overgrazed lands.

Objectives:
To prevent overgrazing and restore overgrazed areas

Benefits:
- Increase forage production
- Increase grass cover and soil cover
- Increase water infiltration Decrease soil erosion
- Reduce encroachment of poor-quality grasses into grazing areas

Criteria for application:
- Lots of poor-quality grasses with low grazing value (e.g. *ngongoni, umtshiki*)
- Very few good grasses; e.g. umsinde (*Themeda triandra*); Guinea grass, (*Panicum maximum*), trident grass (*Tristachya leaucothrix*)
- Lots of small bushes and trees taking over the grazing (bush encroachment)
- Lots of weeds
- Bare soil and dongas

Catchment perspective:
Prevention and rehabilitation of overgrazing requires allowing grasses to recover and using measures to stop soil erosion. All village members with livestock must implement the guideline. This can be implemented by members of a household which relies on livestock for livelihoods.

Livelihood opportunity:
The sustainable management of rangelands provides food for cattle, which in turn contribute to food security.

Funding opportunities:
- LandCare
- Heifer International
- Eastern Cape Department of Rural Development and Agrarian Reform
- Working for Wetlands

Legislation:
Conservation of Agricultural Resources Act 43 of 1983.

METHODOLOGY

Methodology:
1. Divide the area into different management blocks (see **Guideline A.2.1 Rotational resting of rangeland**)
2. Do not burn the overgrazed area

Use rotational resting to allow the grasses time to recover (see **Guideline A.2.1. Rotational resting**)

Use soil erosion control measures to stop soil erosion and allow grasses to grow (see **Guidelines A.5 Gully management)**

Use brush packing (lay out the cut branches of trees with all their twigs and leaves in contours on degraded rangeland to protect grasses beneath from grazing for 2-3 years)

For some degraded areas, take a large herd of animals through the area for a very short time (a few days) then rest the area for a long time (a few months). This will enable the animals to bring seeds and dung into the degraded area.

Indicator grasses for:

Overgrazing
- Aristida junciformis – ngongoni, umgogoni
- *Eragrostis rigidior*, Eragrostis curvula (lovegrasses)*Eragrostis plana,* Sporobolus africanus, Sporobolus pyramidalis – umtshiki
- *Microchloa caffra* – pincushion grass
- Cynodon dactylon – uqaqaqa
- Heteropogon contortus – steekgras

Land in good condition
- Themeda triandra – Umsinde
- Tristachya leucothrix – trident grass
- *Panicum maximum* – guinea grass
- Chloris gayana – Rhodes grass
- Setaria sphacelata – Golden setaria
- Digitaria eriantha – injica

Seasonal variations:
- Examine the overgrazed area once a year to decide whether it can be grazed. In good rainfall years there may be good grass cover, and the area can be grazed. In bad years the area should be rested. Occasionally walk the cattle through the land other grazing areas, to allow dung to spread over resting land.
- Areas that are rested in the wet season can be grazed in the dry season if the need is urgent

Illustrations/ Diagrams:

Photos:

A.2.2. Prevention and rehabilitating overgrazing

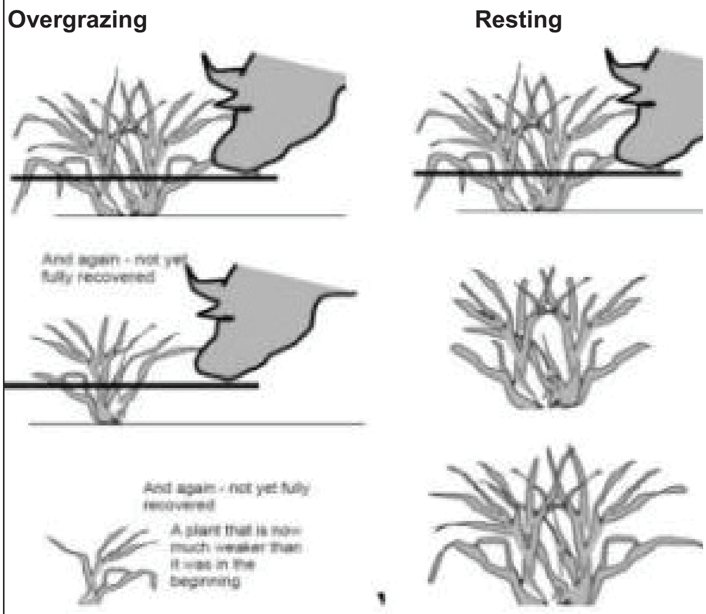


Figure A.2.2-1: The effect of grazing a plant repeatedly without giving it a chance to rest.

The plant on the left is grazed again and again by cattle, and becomes smaller and weaker over the growing season. The plant on the right is grazed and then allowed to rest. It recovers to its full strength

Figure A.2.2-2: A heavily grazed vlei. The grass is very short and there is a lot of bare soil. This vlei needs to be rested by dividing it in half and grazing a different section of the vlei every year. (Source: S. Braid)

Figure A.2.2-3: Brush packing. Branches of trees are laid on the bare ground. The branches protect the grasses from being grazed and allow them time to recover and produce leaves and seeds. After a few years, the covering branches will rot away. (Source: A. van Zyl)

Variations/Adaptations:

Provide alternative feed or pastures for animals

Equipment requirements:

Cut brush/bushes to keep cattle out of resting land

MAINTENANCE

Maintenance requirements:

- Keep animals out of overgrazed areas for 6-18 months. Occasionally walk animals through these area on way to grazing area, to spread dung over the recovering land.
- Keep fires out of overgrazed areas for 1-2 years
- Meet every year to discuss whether to graze or burn the area, or whether to rest it for a while, or whether to use it only in the winter or the summer Grazing Schedule.

REFERENCES

Definitions:

Overgrazing: repeated, heavy grazing of an area, resulting in the disappearance of grass cover, increase in undesirable grasses, bush encroachment, bare soil, and soil erosion.

Further references:

a. Morris CD, and Kotze DC. 2006. Introduction to VeldCare. Agricultural Research Council: Pietermaritzburg
b. Dold, AP and Cocks, M. 1999. Preliminary list of Xhosa plant names from the Eastern Cape, South Africa. Bothalia, 29(2):267-292
c. Van Oudtshoorn, F. 2015. Veld Management Principles and Practice. Briza, Pretoria.

See also:

Guideline A.2.1. Rotational resting of rangeland
Guideline A.4.1. Gully prevention
Guideline A.4.2. Gully reclamation
Guideline A.4.3. Stone check dams
Guideline A.4.4. Brushwood check dams
Guideline A.4.5. Vegetation barriers
Guideline A.4.6. Gully re-shaping
Guideline A.4.7. Erosion management along road sides
Guideline B.1.1.2. Crop rotation and intercropping
Guideline D.3.2. Wetland conservation
Guideline F.1.1. Firefighting wild fires (practical)
Guideline F.1.3. Firebreaks

A.2.3. Grazing movement

OVERVIEW

Moving animals around allows livestock owners to control where and when animals graze the veld. This allows much greater control over the feeding of the animals and the resting of different areas of veld. Keeping cattle corralled at night helps concentrate manure and urine in a specific area to help improve soil nutrition and critical vegetation recover during resting. This guideline sets out how to manage grazing blocks.

Objectives:

- Allow some areas to be grazed and some areas to rest, to improve veld condition
- Improved animal performance
- Better breeding

Catchment perspective:

By coordinating the movement of grazing between different livestock owners, the veld condition in the catchment can improve, which will improve the water, animal forage and health of the catchment

Livelihood opportunity:

Managing grazing movement requires a grazing management committee. Setting up this committee requires input from the village as the whole village will need to be aware of grazing management in order to have long term benefits. Benefits will include strengthened grazing management institutions, healthier livestock and reduced soil erosion. This contributes to food security.

Criteria for application:

- A livestock management forum or other village forum for discussing livestock management
- Fencing for some areas and corals at night
- Herders to move animals from day to day
- Allocated grazing blocks (see **Guideline A.2.1 Rotational Resting of Rangelands**)

Benefits:

- Better forage for animals
- Better control over livestock
- Reduced soil erosion
- Improved water quality
- Reduced bush encroachment
- Less unplanned fires

Funding opportunities:

- Landcare
- Heifer International
- Eastern Cape Department of Rural Development and Agrarian Reform

Legislation:

- Conservation of Agricultural Resources Act 43 of 83
- Fencing Act

METHODOLOGY

Methodology:

1. Allocate different grazing blocks by consensus (See **Guideline A.2.1. Rotational resting of rangeland**)
2. Decide which areas are to be rested and which areas are to be grazed
3. Use fences or herders to keep the animals in the areas to be grazed and keep them out of the areas to be rested
4. Move the herds to the next grazing block when the veld is ready to be grazed, i.e. when all the grasses have been eaten not just the most palatable ones.
5. Keep herds together rather than let them scatter, to keep impacts localised, and dung dropping for natural fertilizin fog the grazed area.
6. If the area is fenced into many camps, then animals can be moved around the camps according to a schedule, allowing sufficient resting times of the camps, e.g. at least 2-3 growing seasons.

Variations/Adaptations:

- Where fencing and herding is impractical, different blocks can be burned alternately to attract animals to the burnt areas.
- Animals are often kraaled overnight. They can be kraaled in temporary kraals in different areas with a herder to watch over them, this allows concentration of manure and urine to help improve soil nutrition, which is necessary for vegetation recovery. The kraals should be moved every couple of nights to ensure the manure and urine is spread over the grazed area. Kraals can be located on already grazed areas allocated for resting, so the manure helps with the resting process.

Seasonal variations:

- Different areas should be grazed in the wet and dry months. Keep animals out of croplands in the summer and graze the croplands in winter after the crops have been harvested
- Keep animals out of vlei areas in summer when the ground is wet
- Graze sweeter veld in winter/ dry and Sourveld in summer/ wet

Equipment requirements:

- Fencing: fencing standards, fencing wire, binding wire and other fencing tools, even woven grass screens where formal fencing is not available.
- Herder

Illustrations/ Diagrams:

A.2.3. Grazing movement

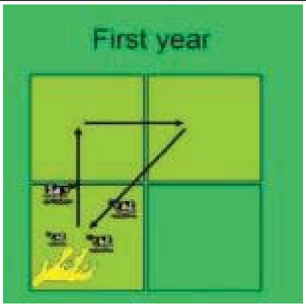


Figure A.2.3-1: An example of moving animals around 4 grazing blocks. Two blocks are rested (right). One block is burned and grazed (bottom left), and the other block is grazed depending on the amount of grass available. Each year, at least different block is rested and a different block is burnt

Figure A.2.3-2: A two-block system. Each year, one half of the veld is burnt and grazed, and the other half is rested. Animals can be moved around different areas of the grazed half using herding or fences. The following year, the other half of the veld will be burnt and grazed

Figure A.2.3-3: A rotational burning system, for cases when fences are too expensive. Each year, a different portion of the veld is burnt in spring. Animals will spend most of their time in early spring on the burnt veld. Herders can help to move the animals around and keep them away from areas that should be rested

Photos:

Figure A.2.3-4: Herding or fencing can be used to control the movement of animals which will help with veld and livestock management. (A. Short)

Definitions:

- Sweetveld: veld that has better nutritional value for animals in winter. This veld is usually found in drier, warmer areas, where there is less grass
- Sourveld: veld that has very poor nutritional value in dry/winter. Animals will lose weight in winter unless they are supplemented with protein. This veld is usually found in wetter, cooler areas where there is more grass
- Grazing block: Veld is divided into management areas called grazing blocks. Each grazing block can be subdivided into camps. Grazing blocks can be grazed, burnt or rested in any given year.

MAINTENANCE

Maintenance requirements:

Inspect and maintain fences and gates to prevent animals breaking through.

REFERENCES

Further references:

a. Van Oudtshoorn, F. 2015. Veld Management Principles and Practice. Briza, Pretoria

b. Smith JMB. 2006. The Farming Handbook. University of KwaZulu-Natal Press, Pietermaritzburg.

See also:

Guideline A.1.1. Land administration in communal areas
Guideline A.2.1. Rotational Resting of rangelands
Guideline A.2.2. Prevention and rehabilitating overgrazing
Guideline A.1. Gully prevention
Guideline A.4.6. Gully re-shaping
Guideline D.3.2. Wetland conservation
Guideline F.1.1. Firefighting wildfires (practical)
Guideline F.1.2. Firefighting tools (construction and usage)
Guideline F.1.3. Firebreaks

A.2.4. Cattle paths up slopes	
OVERVIEW	
Cattle paths on slopes can be a major source of erosion. Cattle paths can quickly become large gullies. Reducing cattle paths up slopes requires a combination of rehabilitating existing paths and using strategies to prevent future paths from forming.	
Objectives: Reduce soil erosion	**Criteria for application:** Steep slopes with deeply cut cattle paths (livestock tracks) leading to water or to homesteads.
Benefits: • Reduced soil erosion • Improved runoff and water quality • Improved livestock condition • Reduced distance to water for livestock	**Livelihood opportunity:** Maintaining the land protects the ecosystem services that provide plants and crops, which contributes towards food security.
Catchment perspective: Gully erosion causes sedimentation of rivers and substantially alters the infiltration and increases runoff in the catchment. Reducing and rehabilitating paths will improve the water cycling of the catchment.	
Funding opportunities: • Eastern Cape Department of Rural Development and Agrarian Reform. • LandCare	**Legislation:** • Conservation of Agricultural Resources Act 43 of 1983. • National Environmental Management Act 107 of 1998.
METHODOLOGY	

Methodology:

1. Identify the reasons why cattle walk along the same paths
2. Identify methods to encourage the cattle to use different routes
3. Distribute watering and feeding points away from rivers and sensitive soils to prevent cattle from following the same route to water every day
4. Use gully rehabilitation methods to repair cattle paths (see Guideline A.5.1 and Guideline A.5.2)
5. Allocate grazing blocks so that herders take animals to different areas of the grazing lands regularly and do not follow the same route every day.
6. Encourage zig-zag routes on steep slopes rather than straight up and down.
7. Implement runoff prevent measures along the pathways to prevent erosion.

Illustrations/ Diagrams:

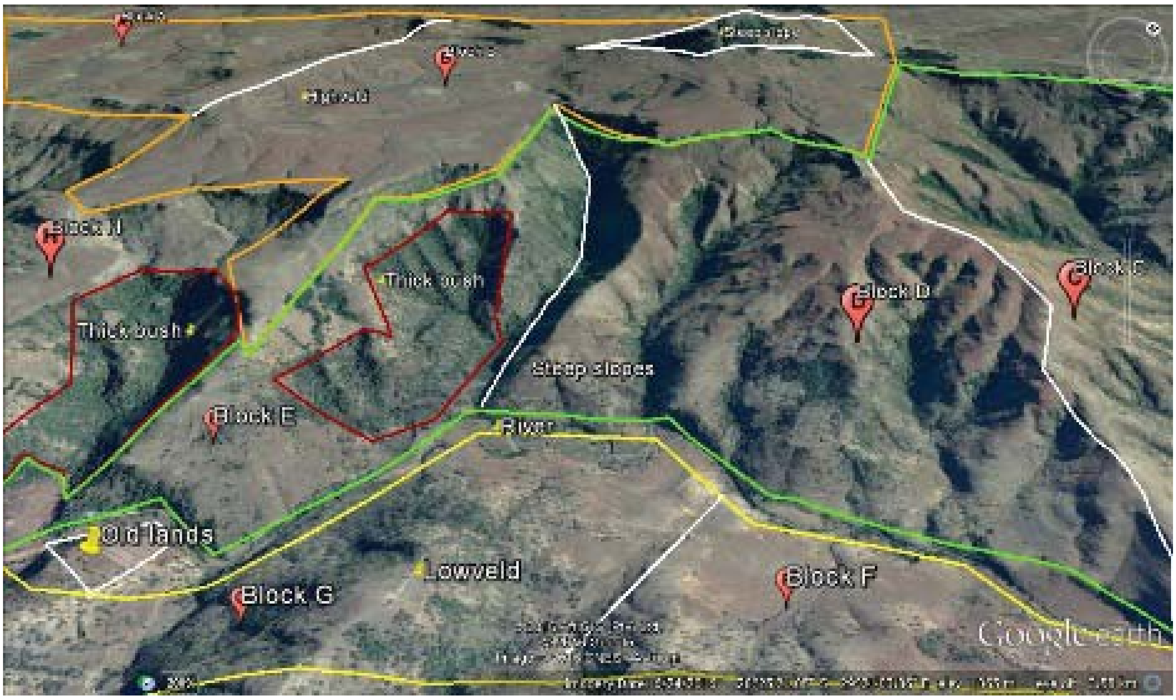


Figure A.2.4-1: Identify and include watering points in each grazing block, away from rivers, to prevent cattle following the same path to water

Photos:

A.2.4. Cattle paths up slopes

Figure A.2.4-2: Cattle paths can become gullies very quickly if not rehabilitated. (source: S. Braid)

Figure A.2.4-3: Water points can become degraded. Make sure they are placed away from wetlands, rivers or sensitive soils, so that the degradation is localised and not severe. This waterpoint for sheep is on a steep slope, causing increased erosion. (Source: A. Short)

Figure A.2.4-4: Small wooden poles to direct runoff off the path, and path covered with cut grass when muddy to prevent erosion.

Equipment requirements:

- Water points: Boreholes, water reservoirs, pipes and valves
- Gully rehabilitation equipment (See **Guideline A.4.2. Gully reclamation (small gullies)**)

Seasonal variations:

During the rainy season, soils are more easily compacted and more easily damaged, especially soils in wetter areas. Put cut dry grass on very muddy patches to prevent hooves slipping and causing more erosion.

Variations/Adaptations:

Not applicable

Maintenance requirements:

- Waterpoints: regular inspection for leaks and equipment failure
- Gullies: inspection of gully rehabilitation structures

Definitions:

Cattle paths/livestock tracks: Livestock continually using the same path damages and exposes soil to erosion. The tracks also become drainage paths during high flow runoff events.

Compacted soils: soils that have been trampled repeatedly by cattle, vehicles or farming equipment can become compressed or compacted. This reduced the ability of water to infiltrate into the soil and encourages runoff and erosion

REFERENCES

Further references:

a. Scotcher, JSB. 2009. The GreenChoice reference for well-managed farms. Goldblatt, A. (ed.). Unpublished report to GreenChoice (A World Wide Fund for Nature and Conservation International Partnership)

b. Van Oudtshoorn, F. 2015. Veld Management Principles and Practice. Chapter 4: Veld Management Practices. Briza, Pretoria. Pp 131-215.

See also:

Guideline A.1.1. Land administration in communal areas
Guideline A.4.1. Gully prevention
Guideline A.4.2. Gully reclamation (small gullies)
Guideline A.4.6. Gully re-shaping
Guideline A.5.1. Riparian buffer zones
Guideline D.3.2 Wetland conservation

A.3 Erosion and runoff control measures

Erosion and runoff control tools are structures or measures, located in drainage lines or near culvert outlets, which are put in place to prevent or reduce sedimentation and erosion of the landscape caused by intensive rainfall and direct runoff. These tools may be structural, vegetative, or a combination of both. They may involve structures or measures to control runoff velocity, reduce flow, or dissipate runoff energy.

A.3.1. Contour ridging

OVERVIEW

One of the biggest contributors to erosion is poor runoff management. This guideline provides an outline of how to implement contour ridging as a mechanism to more effectively manage runoff on land.

Objectives:

- Prevent water from running down-slope.
- Increase retention and infiltration of rainwater.
- Reduce erosion with runoff control.
- Reduce stream siltation and flooding.
- Water conservation.

Catchment perspective:
Involve the entire community and implement on catchment basis to avoid compromising runoff and erosion control results from individual farm fields.

Criteria for application:

- Tied ridging suitable for slopes up to 7%.
- Construct during dry season to allow time for re-aligning ridges.
- Height of ridges is usually 30-40 cm.
- Interval between contour ridges varies according to slope gradient:

Slope of the field	Ridge interval
Gentle (<5%)	**20 m**
Relative steep slopes (5-12%)	**15 m**
Steep slopes (≥12%)	**10 m**

Livelihood opportunity:
Reduced erosion in the field increases productivity of the field and reduces loss of land to erosion.

Funding opportunities:

- Landcare

Benefits:

- Conserve soil moisture for crop production.
- Improved crop and pasture yields.
- Increased ground water recharge.
- Labour requirements are relatively low; but increases for constructing tied ridges.
- Other practices can be incorporated.

Legislation:

- National Environmental Management Act 107 of 1998.
- Mountain Catchment Areas Act 63 of 1970.
- Runoff management is considered a Schedule 1: permissible use of water in terms of the NWA.

METHODOLOGY

Methodology:

Contour ridging

1. Mark and build contour lines between June and September after harvesting and clearing.
2. Start about 20 m below upper corner of the field. Mark 1st contour line across the slope with a line level, A-frame or Phiri-lino frame by inserting pegs.
3. Move down to next contour line and mark 2nd contour across the slope. The contour interval depends on the slope of the field indicated in the table.
4. Repeat marking contour lines until the whole field is pegged.
5. Smooth pegged contour lines to reduce sharp angles between pegs on uniform terrain. Shorten the string of the line level to half its length for smoothing on irregular terrain.
6. Build the pegged contour line into a ridge.
7. Re-align crop ridges between 2 marker ridges by aligning the top half of the area to the top marker ridge, and the bottom half to the lower marker ridge.
8. Crops are planted on both sides of the furrow.
9. Ridge can be planted, e.g. Vetiver to trap silt, Napier grass to provide fodder to livestock, or creeper crops that will stabilise the soil of the ridge.

Tied/box ridging

10. Construct tied ridges across entire furrow perpendicular to contour ridges, but two thirds the height of the contour ridges to allow spill-over. Space tied ridges 1-3 m apart depending on terrain and rate of water flow within the field.
11. Move to the next furrow and repeat step 10 but locate the tied ridges half-way between those in the previous furrow.
12. Repeat steps 10 and 11 until the whole field is covered.

Illustrations/ Diagrams:

Figure A.3.1-1: Mark out contour lines[a].

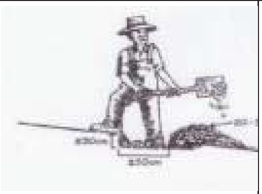


Figure A.3.1-2: Build contour ridge[a].

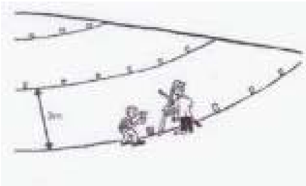


Figure A A.3.1-3: Create cross ties[a].

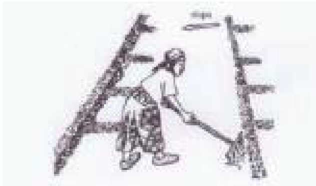


Figure A.3.1-4: Level out basin[a].

Photos:

Figure A.3.1-5: Ridging

Figure A.3.1-6: Contour ridging stabilized with *Phalaris sp.* and combined with zero tillage. (Source: FAO)

Equipment requirements:

- Pegs
- Line level / A-frame
- Hammer / stone
- Spade

Variations/Adaptations:

Tied/box ridging (Limit runoff outflow from ridge furrows at field boundaries).

Seasonal variations:

Height of ridges/depth of ditches may need to be altered to suit high rainfall areas.

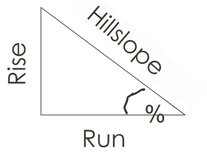
MAINTENANCE

Potential drawbacks/disadvantages:

- Smoothing of contour lines on irregular terrain can cause runoff problems and erosion
- Increased erosion with overtopping of ridges when rainfall exceeds furrow storage capacity
- Waterlogging can occur during heavy rainfall
- Rill and gully formation from footpaths and field boundaries if not constructed for runoff control.

Definitions:

- Retention: The absorbing and holding of something.
- Infiltration: Process of water entering soil from ground surface.
- Siltation: Increase in suspended sediment, mostly silt or clay particles, in water.
- Slope percentage**:** Slope(%) = rise/run x 100 :



- Perpendicular: Two items which are 90 degrees from each other.

Maintenance requirements:

- Repeat construction once every 4-5 years between June and September
- Repair breaches in ridges immediately

See also:

Guideline A.3.2. Contour Vegetation rows
Guideline A.4.5. Vegetation barriers
Guideline C.3.1. Contour bunds
Guideline C.3.2. Zaï planting pits
Guideline C.3.3. Half-moon pits

REFERENCES

Further references:

a. Bunderson WT, Jere ZD, Hayes IM and Phombeya HSK. 2002. Landcare practices in Malawi. Malawi Agroforestry Extension Project. Publication no. 42

b. Bunderson, WT, Jere ZD and Hayes IM. 2002. Best-bet Agroforestry and Soil Conservation Practices. Malawi Agroforestry Extension Project. Publication no. 43

c. Ministry of Agriculture and Irrigation. Guide to agricultural production and natural resources Management in Malawi. Agricultural Communication Branch, Ministry of Agriculture, Irrigation and Food Security

d. Desta L, Carucci V, Wendem-Agenehu A and Abebe Y (eds.). 2005. Community Based Participatory Watershed Development: A Guidelines. Ministry of Agriculture and Rural Development: Addis Ababa, Ethiopia

e. Denison J, Smulders H, Kruger E, Ndingi H ad Botha M. 2011. Water Harvesting and Conservation – Volume 2 Part 1: Technical Manual and Farmer Handouts. Water Research Commission

f. FAO Soils Bulletin 79. Optimising soil moisture for plant production: The significance of soil porosity ISSN 0253-2050. http://www.fao.org/docrep/006/y4690e/y4690e09.htm accessed on 27 Aug 2015

A.3.2. Contour vegetation rows

OVERVIEW

Poor runoff management contributes significantly to soil erosion. Reducing the velocity and volume of runoff will help reduce soil erosion, increase infiltration and reduce sedimentation downstream. This guideline provides an outline of how to create effective vegetation barriers to sustainably management runoff across land and slopes. **Also referred to as:** Vegetation hedges/ hedgerows/ lines OR Contour strip cropping

Objectives:

- Vegetation barrier to slow down and retain runoff and reduce erosion
- Deposition of eroded soil at vegetation barrier
- Roots increase resistance to rills and gullies
- Reduce stream siltation and floods

Benefits:

- Traps sediment and organic matter, which enhances vegetation re-growth
- Not competitive with crops, not a host to pests
- Multi-purpose trees/shrubs can be incorporated
- Species selection can have multiple benefits, e.g. Napier grass can be harvested as fodder for livestock. Vetiver can supply thatching, mulch.
- Can replace more costly physical structures effectively – up to about 8% slope
- Low cost and labour requirement

Criteria for application:

	Rainfall	Soil	Slope	Topography
Vetiver grass	Semi-arid to high rainfall	Wide range	<12%	Even topography not required
Napier grass	preferably >1000 mm/yr			

Slope of field	<5% (gentle)	5-12% (moderate)	>12% (steep)
Hedgerow spacing guideline	15 m	10 m	<5 m
Amount of slips/ha	7 000	10 000	20 000

Livelihood opportunities:
By protecting soil nutrition, fertility and preventing soil erosion increases field productivity.

Catchment perspective:
Try to align contour vegetation hedges across a series of fields, even if fields are individually owned by different families.

Funding opportunities:
Not applicable

Legislation:
LandCare

METHODOLOGY

Methodology:

Establish nurseries and prepare planting material

1. Prepare nursery sites. Sites should be close to water.
2. Collect vegetation clumps for nursery (i.e. 7 ton truckload will plant 0.5 ha) and plant within 48 hours.
3. Plant slips 45 x 45 cm apart and press soil firmly around each.
4. Trim leaves to 30 cm to promote tillering and fast growth.
5. After 1 season, trim to 15 cm and dig out clumps with roots. Leave 30% of clump for regeneration.
6. For Vetiver, divide clumps into slips with 3-4 tillers each and 5-10 cm roots.
7. For Napier, divide clumps into cuttings that are 20-30 cm long with 4-5 nodes.

Planting contour hedges

1. Mark contour hedgerows by following steps 1-6 for **contour ridging**. The intervals between the hedgerows lines should be marked according to the spacing indicated in the table.
2. Re-align planting ridges by following step 7 for contour ridging.
3. For Vetiver, plant slips within 48 hours in furrow 10 cm apart.
4. For Napier, push stem cutting 8-10 cm into soil at 45° and 20 cm apart with at least 2 nodes buried.
5. Press firmly around each slip/cutting. The flat side of vetiver must be perpendicular to the slope (facing downwards) to encourage dense lateral growth which minimises gaps in the hedge.
6. After good establishment, trim hedges to 30 cm to encourage tillering and dense growth.
7. Use trimmings for thatching, mulch or bedding for livestock. Napier can also be used as fodder.
8. Fill/plug gaps in hedge with the onset of rainy season. Dig a 20 cm trench across gap and plant Vetiver slips 10 cm apart. Plant Napier stem cuttings 20 cm apart.

Seasonal variations:

- June-October: Mark & build contour hedgerow
- August-October: Re-align planting ridges
- November-January: Plant grass slips/cutting
- February-March & April-June: Trim hedges

Equipment requirements:

- Line level / A-frame or Phiri-Lino-frame
- Pegs, hammer/stone and hand hoe
- Vetiver plant slips / Napier stem cuttings

A.3.2. Contour vegetation rows

Illustrations/ Diagrams:

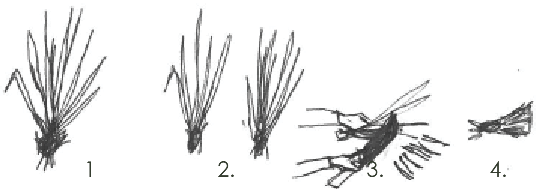


Figure A.3.2-1: Making Vetiver / Napier grass slips. *A clump of grass (1) can be divided into a slip (2) and trimmed (3 and 4) for optimal growth.*

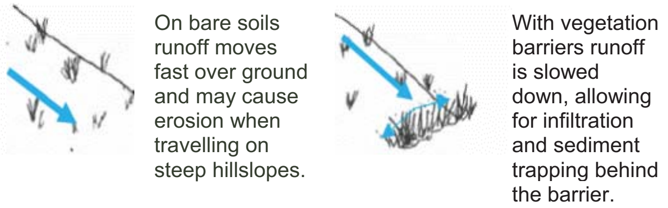


Figure A.3.2-2: How a vegetation row breaks and disperses the flow of runoff water.

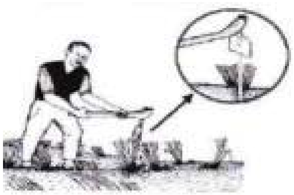


Figure A.3.2-3: Trim vetiver to 15 cm, dig out clumps & divide clumps into slips

Figure A.3.2-4: Plant slips in furrow in wet soil 10 cm apart

Figure A.3.2-5: Trim hedges to 30 cm to encourage tilling

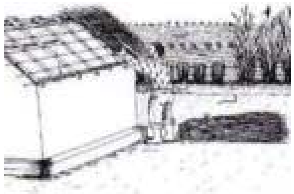


Figure A.3.2-6: Vetiver trimmings for thatching / mulching. Napier for livestock fodder.

Photos:

Figure A.3.2-7: Contour hedge with vetiver grass

Figure A.3.2-8: Filling a gap in contour vetiver hedge

Variations/Adaptations:

- Vetiver grass hedges (*Vetiveria* spp.)
- Napier grass hedges (*Pennisetum purpureum*)

The same concept can be applied to bare soil areas to prevent erosion, as well as in small gullies to reduce rate of erosion and promote sediment trapping

MAINTENANCE

Maintenance requirements:

- Fill/plug gaps in hedges to prevent erosion from runoff through the gaps.

Potential drawbacks/ disadvantages:

- Required dense spacing of grass along hedge to be effective for runoff and erosion control.
- Gaps should be filled within first two growing seasons of establishment to be effective.
- Napier grass requires regular trimming to prevent spreading and competing with crops.
- Vetiver is relatively unpalatable to animals.

REFERENCES

Further references:

a. Bunderson WT, Jere ZD, Hayes IM and Phombeya HSK. 2002. Landcare practices in Malawi. Malawi Agroforestry Extension Project. Publication no. 42

b. Environmental Affairs Department. 2005. Community environmental management manual – Soil conservation and fertility improvement

c. Kuypers H, Mollema A and Topper E. 2005. Erosion control in the tropics. Agromisa Foundation: Wageningen, The Netherlands

See also:

Guidelines A.4.1. Gully prevention
Guideline A.4.5. Vegetation barriers
Guidelines A.5.1. Riparian buffer zones
Guideline D.1.4. Selecting beneficial trees

A.4. Gully management and sediment trapping

A.4.1. Gully prevention

OVERVIEW

A.4.1. Gully prevention

Severe erosion is characterised by gullies. Gullies may not be actively eroding in some cases, but provide a channel for increased runoff and sediment delivery. Prevention is better than rehabilitation. This guideline provides an outline how to prevent erosion gullies from forming.

Objectives:

- Prevent gully development through sound land use, runoff control and reduction in flow concentration.
- Reduce flooding and siltation.
- Reduce risk of loss of agricultural land.

Criteria for application:

The principles of gully prevention and rehabilitation can be applied to managing roadside drainage too.

Livelihood opportunities:

By preventing gullies maintains and area and farm area, and prevents soil erosion.

Catchment perspective:

- Conduct land use planning and promote sound land use on catchment basis.
- Involve the whole community on a catchment basis to implement land management practices that increase water infiltration and reduce runoff.
- Gullies may form on private or communal land, however both individuals and the village need to prevent and rehabilitate gullies.

Benefits:

- Gully prevention is much more cost-effective than gully reclamation.
- Soil moisture is conserved for crop production with preventive practices that retain and increase rainwater infiltration.
- Raised footpaths and field boundaries prevent water from flowing out of agricultural fields and development of gullies at field boundaries.
- Prevention of gullies is not only cost effective, but it also limits the likelihood of needing to obtain authorisations in terms of the NWA and NEMA.

Funding opportunities:

- LandCare
- Working for Wetlands

Legislation:

- National Environmental Management Act 107 of 1998.
- National Water Act 36 of 1998.
- Conservation of Agricultural Resources Act 43 of 1983.

METHODOLOGY

Methodology:

Sound land use and land management practices that limit runoff

1. Adapt land use to land use potential, i.e. cultivated land should match land that is classified as arable land, and prevent/abandonment of cultivation on steep slopes/highly erodible soils.
2. Promote and implement land management practices that limit runoff and concentrate flows from fields. This includes practices such as conservation agriculture, contour and tied/box ridging and contour vegetation (See **Guidelines B.1.1 Conservation agriculture** and **Guidelines A.3 Erosion and runoff control measures**)
3. Plan the placing of livestock water points so that they are not on erodible soil or on steep stream banks.
4. Grazing and fire management to maintain good vegetation cover and prevent livestock tracks developing.

Raised footpaths and field boundaries

1. Mark designated footpaths and field boundaries with pegs from top to bottom, perpendicular to or at an angle to the crop ridges.
2. Construct a path 50 cm wide along the pegged line slightly above the crop ridges. Do this by collecting soil from the furrows between ridges.
3. Ensure that all ridges are tied adjacent to the edges of footpaths and field boundaries.

Seasonal variations:

- June-October: Mark contour lines, build and re-align contour and tied ridges as discussed in the Guideline A.4.1 Contour ridging
- August-October: Build raised footpaths and field boundaries

Equipment requirements:

- Standard farming equipment
- Markers

Illustrations/ Diagrams:

A.4.1. Gully prevention

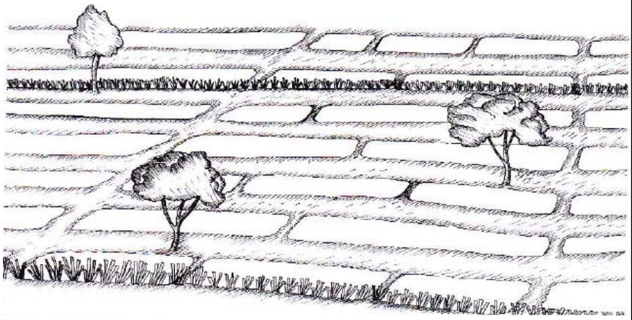


Figure A.4.1-1: Tied/box ridges, raised footpaths and contour hedges to reduce runoff and erosion. [a]

Variations/Adaptations:

- Land use planning, i.e. identify and prevent cultivation of non-arable/erodible/steep land
- Land management practices that limit runoff
- Raised footpaths and field boundaries
- Planning of livestock watering points

Photos:

Figure A.4.1-2: Unmanaged erosion, e.g. along footpaths and livestock tracks can rapidly progress into gully erosion (S. Braid).

Figure A.4.1-3: Gullies, once formed, provide a channel for runoff and sediment movement. The gully wall is unstable and may collapse during heavy rainfall (S. Braid).

MAINTENANCE

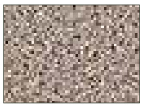
Maintenance requirements:

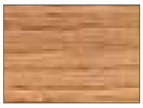
- Maintain ridges that are tied adjacent to the edges of the footpaths and field boundaries
- Maintain raised footpaths and boundaries to prevent any channelling

REFERENCES

Definitions:

Erodible soil: Soils high in clay restrict infiltration (a), whilst sandy soils allow for more infiltration (b). Soils with high silt content are the most erodible (c). Erodibility is a measure of the susceptibility of a soil particle to detachment and transport by runoff.


a.

b.

c.

Livestock tracks: Livestock continually using the same path damages and exposes soil to erosion. The tracks also become drainage paths during high flow runoff events.

See also:

Guideline A.2.2. Prevention and rehabilitating overgrazing
Guideline A.4.2. Gully reclamation (small gullies)
Guideline A.4.3. Stone check dams
Guideline A.4.4. Brushwood check dams
Guideline A.4.5. Vegetation barriers
Guideline A.4.6. Gully re-shaping
Guideline A.4.7. Erosion management along roadsides
Guideline A.5.1. Riparian buffer zones
Guideline A.5.2. River crossing for cattle
Guideline A.5.4. Gabion baskets

Further references:

a. Bunderson WT, Jere ZD, Hayes IM and Phombeya HSK. 2002. Landcare practices in Malawi. Malawi Agroforestry Extension Project. Publication no. 42.
b. Environmental Affairs Department. 2005. Community environmental management manual – Soil conservation and fertility improvement.
c. Kuypers H, Mollema A and Topper E. 2005. Erosion control in the tropics. Agromisa Foundation: Wageningen, The Netherlands.

A.4.2. Gully reclamation (small gullies)

OVERVIEW

Gully erosion contributes to the loss of soil as well as the loss of farmable land. Gullies can be reclaimed either to cultivate, or simply to prevent further loss of soil and land. This guideline provides an outline of how to reclaim smaller gullies.

Objectives:

- Reduce runoff into a gully.
- Convey water through a gully.
- Use of structural and vegetative measures to trap sediment and organic material in the gully.
- Reclaim gullied land for agricultural use.
- Reduce stream flooding and siltation.

Criteria for application:

- Re-vegetation should be done by using stoloniferous or rhizomatous grasses (i.e. spreading) preferably those found locally
- Vetiver can be used as vegetation barrier, but it is not a spreading grass.

Large gullies will require more technical intervention.

Benefits:

- Small gullies are easier and more-cost effective to rehabilitate than medium and large gullies.
- Physical structures give temporary relief while vegetation becomes established as a long-term measure.
- Effectiveness of vegetation improves with time as it establishes and spreads.
- Area closure can increase the productivity of degraded land.
- Silt build-up in gullies provides rich material for use (in the reclaimed gully) as a garden and/or fodder production.

Catchment perspective:

- Align runoff and erosion control measures between individual fields to reduce runoff from hill slopes into gullies on a catchment basis.
- The whole community is involved in matters such as area closure, reclamation and use of gullies, placement of livestock watering points, etc. (Driven by GVC or PIC).

Livelihood opportunities:

Gullies result in loss of land area which reduces area for productivity.

Funding opportunities:

Landcare

Legislation:

- National Environmental Management Act 107 of 1998.
- National Water Act 36 of 1998.
- Conservation of Agricultural Resources Act 43 of 1983.

Prevention of gullies is not only cost effective, but it also limits the likelihood of needing to obtain authorisations in terms of the NWA and NEMA.

See also:

Guideline A.3.2. Contour vegetation rows
Guideline A.4.5. Vegetation barriers
Guideline A.4.1. Gully prevention
Guideline A.4.3. Stone check dams
Guideline A.4.4 Brushwood check dams.
Guideline A.4.6. Gully re-shaping
Guideline A.4.7. Erosion management along road sides
Guideline A.2.2. Prevention and rehabilitating overgrazing
Guideline A.5.2. River crossing for cattle
Guideline A.5.4. Gabion baskets
Guideline C.5.1. Diversion weirs
Guideline C.2.5. Hillside runoff (swales)

METHODOLOGY

Methodology: (to reclaim small gullies of <1-1.5 m (1 to 11/2 spade lengths) deep on farmland):

Land use and management

1. Identify causes of gully development, such as improper land use, overgrazing, placement of livestock water points on erodible soil / steep stream banks, runoff and water concentration from agricultural fields into footpaths at field boundaries. Plan and take the proper remedial action.
2. Implement land management practices in the gully catchment that limit runoff into the gully. This includes practices such as contour and tied/box ridging, contour vegetation, and raised footpaths and field boundaries.

Area closure and runoff diversion

3. Construct a storm water diversion 3-5 m (3 to 5 spade lengths) above gully head to divert runoff from above the gully and spreading it over surrounding area, i.e. swale; diversion ditch.
4. Establish vegetation fences with shrubs and trees to close area around gully head and sides for livestock as discussed in guideline on vegetation barriers, and prevent and rehabilitating overgrazed lands.

Reshaping of gully head

5. Reshape gully head to about 2 m horizontal distance per 1 m vertical height (2 spades wide per 1 spade deep) to reduce slope to a stable angle and to create conditions for rainfall infiltration and vegetation establishment.
6. Compact loose soil that was moved from the reshaping in layers to form a stable surface.
7. Reshape gully bank/sides if undercutting occurs and side slopes are unstable.

Stone or brushwood carpet on reshaped gully head slopes

8. Small stones, pebbles and/or gravel (if available) can be laid along the entire length of the reshaped gully head for protection against raindrop impact and overland flow.
9. Small tree branches with leaves still attached can be used to create a 10 cm (hand length) thick carpet of brushwood. The brushwood carpet can be laid on the entire length of the reshaped gully head to prevent erosion.

A.4.2. Gully reclamation (small gullies)

It is important that the carpet reaches into the sides of the gully and is anchored into the ground with wooden pegs or stakes to prevent them from being washed away.

Vegetation of reshaped slopes

10. Gully sides should be vegetated with a mixture of creeping and drought resistant grasses, trees and shrubs
11. Planting of splits or seedlings should preferably be done by using grasses and trees that occur naturally in the agro-ecological region. There are various non-invasive exotics that can be used also.

Vegetation of areas around gully edges

12. Leave a strip of uncultivated land around gully.
13. Plant a vetiver hedge on the area around the gully with slips 10 cm (hand length) apart to stabilize gully sides/walls. The establishment of vetiver hedges is discussed in the **Guideline A.3.2 Contour vegetation rows**.
14. Vigorously rooting trees can also be planted in combination with vetiver hedges to stabilize gully sides/walls. Succulents such as sisal and finger euphorbia can be used if areas tend to be dry.

Check dams and vegetation barriers

15. Construct stone or brushwood check dams inside gully as discussed in the **Guideline A.4.3 Stone check dams** and **Guideline A.4.4 Brushwood check dams**.
16. Establish vegetation barriers inside the gully as discussed in the **Guideline A.4.5 Vegetation barriers**.

Illustrations/ Diagrams:

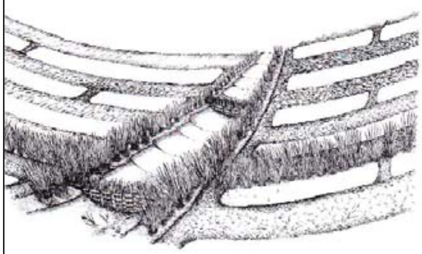


Figure A.4.2-1: Reduce water flow into gullies with tied ridges, check dams and vetiver on the sides.[a]

Photos:

Figure A.4.2-2: Unmanaged small gully erosion become large gullies. (S. Braid).

Variations/Adaptations:

- Physical structures such as cut-off drains, graded terraces, check dams.
- Vegetative measures such as vegetation fences, brushwood layering, vegetation barriers.

Equipment requirements:

- Pegs / stones
- Straw or mulch
- Shovel / hoe
- Vegetation
- Branches

Seasonal variations:

- Dry months: Identify gullies that need reclamation, build check dams and organise production of nursery seedlings and Vetiver.
- First rains: Collect vegetation material for planting and plant selected tree seedlings and grass at identified areas.
- Dams need to be constructed before onset of rain for silt build-up in dam with first runoff.

MAINTENANCE

Maintenance requirements:

- Regular review of an area closure and runoff diversion ditch is needed.
- Maintenance of structures is needed.
- Maintain the vetiver hedge on both sides of the gully to prevent further collapse of the sides.

Potential drawbacks/disadvantages:

- Control measures for medium and large gullies >1-1.5 m (1-11/2 spade lengths) deep are expensive and require an engineering design. Refer to Check dam guidelines.
- The long-term effectiveness of structures are limited by inherent weaknesses.
- Medium and large gullies with significant undercutting must be stabilised with engineered structures such as masonry or gabion dams.

REFERENCES

Further references:

a. Environmental Affairs Department. 2005. Community environmental management manual – Soil conservation and fertility improvement.

b. Bunderson WT, Jere ZD, Hayes IM and Phombeya HSK. 2002. Landcare practices in Malawi. Malawi Agroforestry Extension Project. Publication no. 42.

A.4.3. Stone check dams

OVERVIEW

Large gully rehabilitation requires more complex interventions to prevent continued erosion. Check dams can be implemented in a stepped-approach for larger gullies to gradually trap sediment and be reclaimed. This guideline provides an outline on how to implement stone check dams for this purpose.

Objectives:

- Stone structure placed across a gully to:

Criteria for application:

A.4.3. Stone check dams

- Reduce the velocity of runoff.
- Prevent deepening and widening of the gully.
- Collect sediment.
- Recharge water table.

- Only to be used in gullies up to 1.5 m, 11/2 spade lengths deep as not easy to build in larger gullies.
- Placed at exits of bunds or terraces.
- Used as silt trap above large dams/ water storage
- Where large stones are locally available.
- Water should percolate / seep through the dam.

Livelihood opportunities:
Reduced runoff promotes groundwater recharge and prevents soil erosion, thereby increasing crop watering and area of productivity.

Legislation:
- National Environmental Management Act 107 of 1998.
- National Water Act 36 of 1998.
- Conservation of Agricultural Resources Act 43 of 1983.

Funding opportunities:
- Landcare
- Working for Wetlands

Catchment perspective:
- Placed in series to rehabilitate long gullies.
- Smaller brushwood check dams should be located upstream of larger stone check dams.
- The smaller brushwood dams collect infertile sand and the larger stone dams collect fertile silt.
- Collected sediment can then be used to plant crops.

Benefits:
- Increase absorption/infiltration of water into the soil.
- Reduce speed of runoff, and therefore erosive power.
- Allow for planting of crops once dam is mature.

METHODOLOGY

Methodology:
1. Dig trench across gully – 0.2 to 0.5 m (spade head to half spade length) deep also cut into the sides of the gully. The trench must be longer than the gully is wide. The higher the “wall” the deeper the trench. 1 m high = ½ m deep
2. The width of the trench depends on the height of the dam
   (i) Width = 4 to 6 x Height
3. Fill base of trench with hand placed stones 200 to 300 mm (up to spade head size) in diameter and gravel
4. Pack downstream side with large stones and the upstream side with smaller stones and gravel
5. Place sand on upstream side once complete
6. Very important to remember to:
   (i) cut and embed the check dam into the sidewall of the gully so that the stone check dam is not cut around by runoff (see above);
   (ii) place stones in a 2 m (2 spade lengths) wide layer (or apron) on the downstream side if the flow is strong and erosion is occurring – this way the runoff lands on the stone apron, not the erodible gully bed.

Illustrations/ Diagrams:

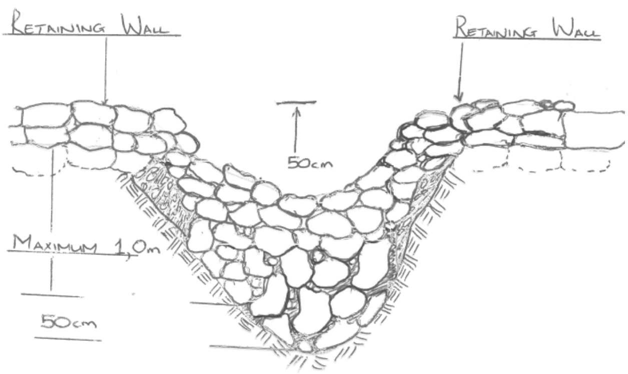


Figure A.4.3-1: Cross section. [a]

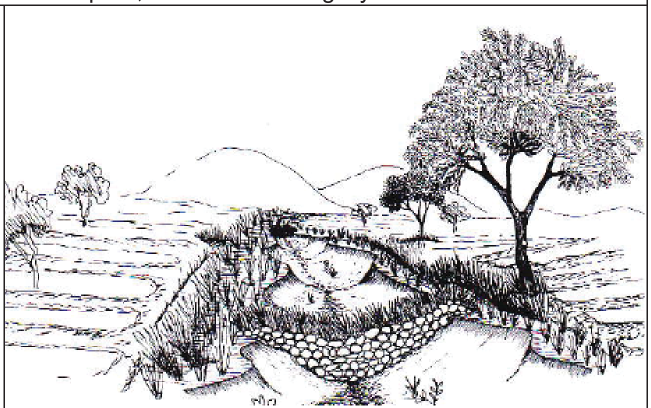


Figure A.4.3-2: Stone check dam with Vetiver planted above it. [a]

A.4.3. Stone check dams

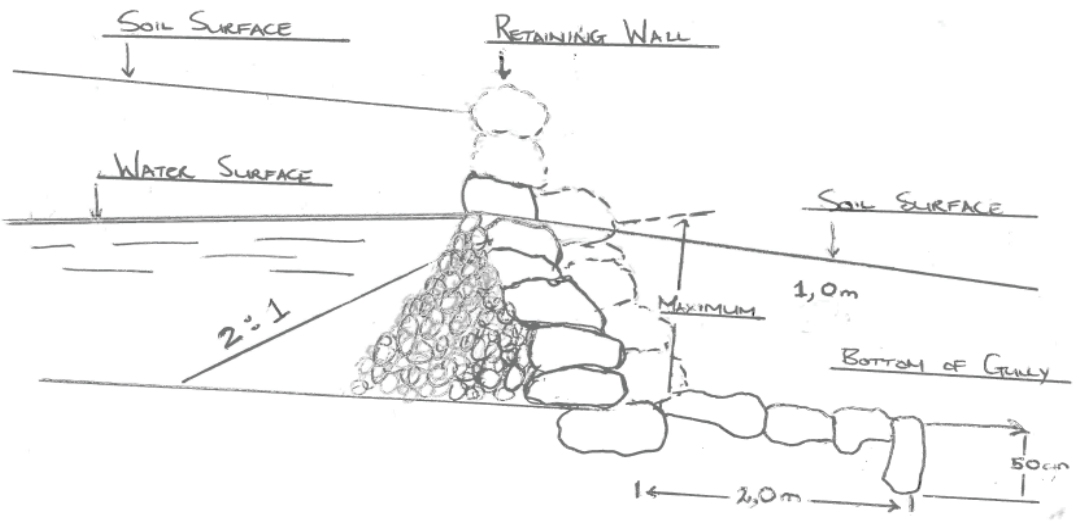


Figure A.4.3-3: Section along gully.

Photos:

Figure A.4.3-4: Stone check dams in Tukela catchment. (Source: S. Braid).

Equipment requirements:
- Need large stones, gravel and sand – locally available.
- Shovel/spade
- Line level

Variations/Adaptations:
- Brushwood check dams (plant debris and sticks)
- Live check dams (live plants, e.g. vetiver grass, controlled bamboo (**Guideline D.5.4 Utilising and controlling Bamboo**))
- Also placed at bund or terrace exits

Seasonal variations:
- To be constructed during the dry season.
- Regularly maintained during wet season.

MAINTENANCE

Maintenance requirements:
- Water should be able to easily pass over the top of the structure once it has sealed with sand and silt. Check for erosion, replace stones if they wash away.
- It is very important that the area downstream of wall (the apron) remains erosion-free, so it must be protected with a layer of stone.

See also:

Guideline A.4.2. Gully reclamation (small gullies)
Guideline A.4.5. Vegetation barriers
Guideline A.4.6. Gully re-shaping
Guideline C.4.2. Sand dams
Guideline C.4.3. Farm dam
Guideline D.5.4. Utilising and controlling Bamboo

REFERENCES

Definitions:
- Reclaimed land: A gully usually forms in areas of increased activity/flow. Limiting activity and reducing flow will result in the gully being able to rehabilitate naturally. Over time this land may become productive again.
- Recharge water table: Reducing runoff velocity will allow for increased infiltration, which would allow for groundwater recharge.
- Infertile sand/fertile silt: Natural erosion in the surrounds of the stone check dam will mainly produce infertile sand, whilst during high flow events the gully acts as a channel for the movement of fertile silt from the hillslopes.
- Silt trap: Runoff will flow along drainage lines towards water storage zones such as dams or reservoirs. During high flow events sediment transport will increase in these drainage lies. Creating a silt trap will reduce the amount of sediment reaching the dam/reservoir.

Further references:

a. Nissen-Petersen E. 2006. Water from Roads. A handbook for technicians and farmers on harvesting rainwater from roads. Danish International Development Assistance.
b. Denison J, Smulders H, Kruger E, Ndingi H ad Botha M. 2011. Water Harvesting and Conservation – Volume 2 Part 1: Technical Manual and Farmer Handouts. Water Research Commission.
c. Desta L, Carucci V, Wendem-Agenehu A, Abebe Y. 2005. Community based participatory watershed development: A Guideline. Ministry of Agriculture and Rural Development, Ethiopia.

A.4.4. Brushwood check dams

OVERVIEW

Larger gully rehabilitation requires more complex interventions to prevent continued erosion. Check dams can be implemented in a stepped-approach for larger gullies to slowly trap sediment and reclaim gullies. Where stones are not readily available, this guideline provides an outline of how to implement brushwood check dams.

Objectives:

Branches and sticks structure placed at the bottom of a gully to:

- Reduce the velocity of runoff
- Prevent deepening and widening of the gully
- Collect sediment
- Recharge water table

Benefits:

- Increase absorption/infiltration of water into the soil
- Reduce speed of runoff, and therefore erosive power
- Allow for planting of crops once dam is mature
- Easy to build

Criteria for application:

- Only to be used in smaller part of gullies (less than 2 m deep and 3 m wide (2 spades deep, 3 spades wide)) as not effective to build in larger section of gullies.
- Placed at exits of bunds or terraces.
- Used as silt trap above large dams.
- Need branches and plant material / brushwood, ideally use cuttings of trees that will strike (i.e. grow from cuttings) for the struts.
- **Caution:** do not use invasive vegetation, e.g. spreading bamboo (some bamboo are suitable – others not).
- Should be placed in series at regular intervals, 5 metres (5 spade lengths).
- Needs regular repair.
- Water should percolate / seep through the dam.

Catchment perspective:

- Placed in series to rehabilitate long gullies.
- Placed upstream of larger and more permanent stone check dams to collect sand.

Legislation:

- National Environmental Management Act 107 of 1998.
- National Water Act 36 of 1998.
- Conservation of Agricultural Resources Act 43 of 1983.

Livelihood opportunities:

Reduced runoff promotes groundwater recharge and prevents soil erosion, thereby increasing crop watering and area of productivity.

Funding opportunities:

Not applicable

METHODOLOGY

Methodology:

1. Place vertical posts (6 to 10 cm thick (palm to hand length)) in a line up to 0.5 m (1/2 spade length) deep into the ground. They should be roughly 0.4 m apart. They should also lean slightly in an upstream direction.
2. Thinner branches are then interwoven through the posts to form a fence. Each of these branches should be pushed into the side wall of the gully by at least 30 cm (spade head). Can also incorporate wire netting
3. Wall can be placed in a single or double layer.
4. Place a thick layer of a mixture of soil and rubble upstream of the stick wall.

Variations/Adaptations:

- Stone check dams.
- Live check dams (live plants, e.g. bamboo).
- Also placed at bund or terrace exits.

Equipment requirements:

- Need strong branches, sticks and brushwood.
- Sledgehammer.
- Line level.

Seasonal variations:

- To be constructed during the dry season.
- Regularly maintained during wet season.

Maintenance requirements:

Check for erosion, replace branches and brushwood when they wash away.

Illustrations/ Diagrams:

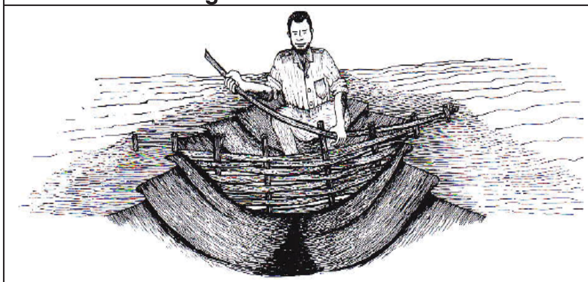


Figure A.4.4-1: Construction of a brushwood check dam.[a]

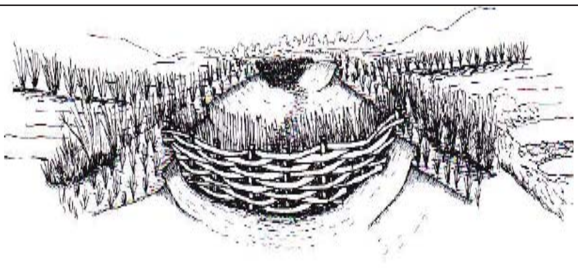


Figure A.4.4-2: Brushwood check dam with vetiver hedges.[a]

A.4.4. Brushwood check dams

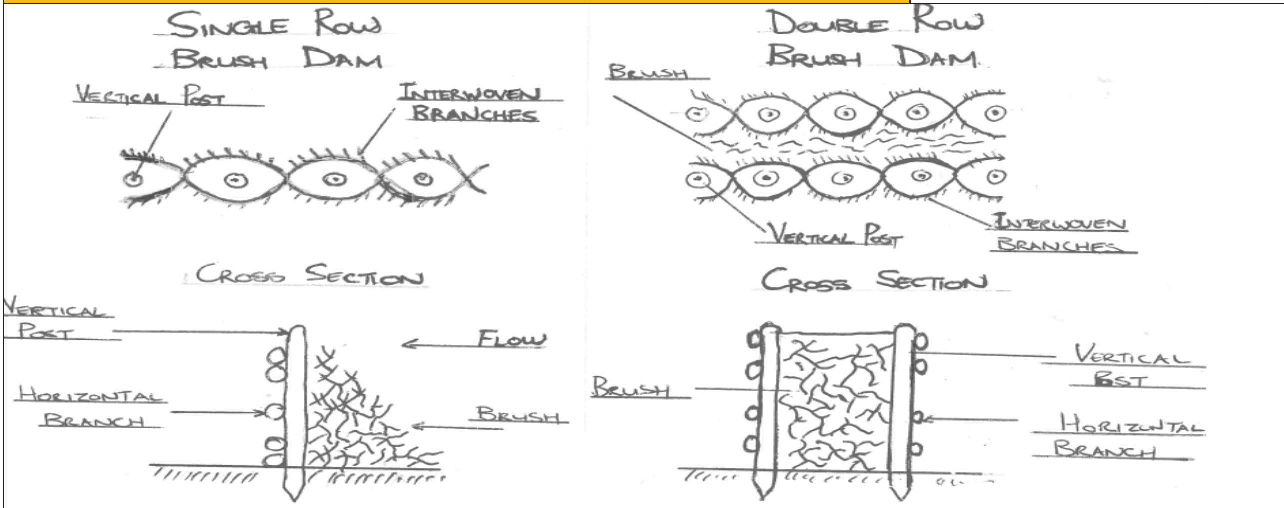


Figure A.4.4-3: Plan view and cross section of brushwood check dam.

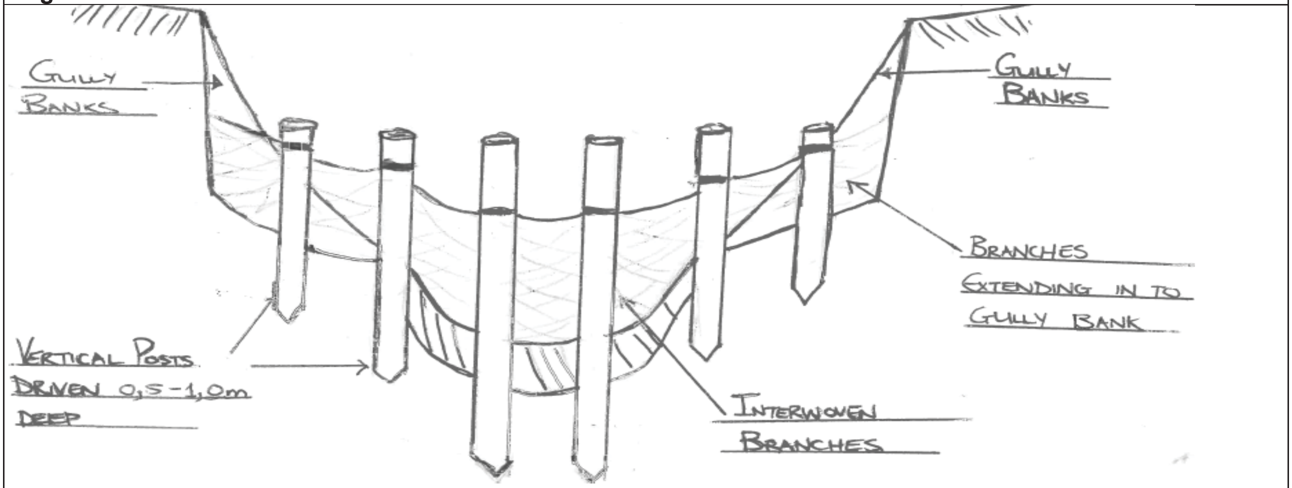


Figure A.4.4-4: Cross section of a brushwood check dam.

Photos:

Figure A.4.4-5: Small gully erosion with several vegetation barriers (Source: S. Braid)

Figure A.4.4-5: A vegetation barrier, with woven material, and a strip of vetiver grass upstream. (Source: S. Braid)

Figure A.4.4-7: Sediment accumulating behind (upstream) of a vegetation barrier. (Source: unknown)

See also:

Guideline A.4.2. Gully reclamation (small gullies)
Guideline A.4.3. Stone check dams
Guideline A.4.5. Vegetation barriers
Guideline C.4.3. Farm dams
Guideline C.4.2. Sand dams
Guideline D.5.4. Utilising and controlling bamboo

REFERENCES

Further references:

a. Environmental Affairs Department. 2005. Community environmental management manual – Soil conservation and fertility improvement

b. Desta L, Carucci V, Wendem-Agenehu A, Abebe Y. 2005. Community based participatory watershed development: A Guideline. Ministry of Agriculture and Rural Development, Ethiopia

c. Denison J, Smulders H, Kruger E, Ndingi H ad Botha M. 2011. Water Harvesting and Conservation – Volume 2 Part 1: Technical Manual and Farmer Handouts. Water Research Commission

d. Bunderson WT, Jere ZD, Hayes IM and Phombeya HSK. 2002. Landcare practices in Malawi. Malawi Agroforestry Extension Project. Publication no. 42

A.4.5. Vegetation barriers

OVERVIEW

One of the main components of catchment degradation in rural areas is the loss of soil and the resultant sedimentation of rivers which affects their flooding pattern. In order to reduce the loss of soil, silt trapping needs to take place at the site of erosion. Vegetation barriers can be used to fence-off areas of erosion and slow the runoff into those erosion zones. Vegetation barriers can also be used to trap silt in the same areas. This guideline outlines how to implement vegetation barriers. (Note section A.3.2 describes "Contour Vegetation Rows" for use in fields: they are similar in principle but differ in size and where they are located).

Objectives:

- Vegetation barriers functions as semi-permeable living structures to slow runoff while trapping sediment and organic matter behind the barrier.
- Vegetation barriers encourage terrace formation within gullies for re-growth of vegetation.
- Vegetation fences can be used to close areas around gullies and degraded stream banks against livestock.

Criteria for application:

- Vetiver and napier are preferred grasses for establishing a vegetation barrier. Stoloniferous or rhizomatous (spreading) grasses can be planted between the erect vegetative barriers. The barriers need to trap the silt
- Space the vegetation barriers along the gully bed, about 10 m apart, on gentle to moderate slopes
- Reduce distance between vegetation barriers for gullies with steeper gradients, i.e. about 5 m apart.

Catchment perspective:
The whole community benefits from preventing erosion and providing livestock fodder from the vegetation barriers.

Livelihood opportunities:
Protection from soil erosion increases productivity of land and prevents loss of land area.

Legislation:

- National Water Act 36 of 1998.
- Conservation of Agricultural Resources Act 43 of 1983.

Funding opportunities:
Not applicable

Benefits:

- Vegetation barriers are inexpensive measures.
- Effectiveness of vegetation improves with time as it establishes and spreads.
- Deposited sediment and organic matter enhance vegetation re-growth and terrace formation within gully or at stream bank.
- Vegetation fences are permanent or semi-permanent structures for area closure.
- Vegetation fences eliminate cost of constructing, maintaining and replacing other type of fences (stone for example).
- Vegetation fences can also provide other products and uses such as fodder, fruit, and wood.
- Area closure with vegetation fences helps to rehabilitate degraded land/ large gully networks.

METHODOLOGY

Methodology:

Vegetation barrier

1. Construct a check dam of brushwood or stones in gully as discussed in guideline on check dams.
2. Plant large slips of vetiver with 5-10 tillers 10 cm (1 hand length) apart in gully bed above the check dam to make use of sediment deposits. See Guideline **A.3.2. Contour vegetation rows** for nurseries and planting of vetiver.
3. Large clumps can be anchored with stakes driven in the middle to reduce chances of being washed away by runoff.
4. Plant with the first rains to allow fast growth and early establishment.
5. Stoloniferous or rhizomatous (spreading) grasses can be planted between the vegetative barriers. The barriers need to trap the silt.

Vegetation fences

1. Drought resistant species are planted as the framework of the fence during the first two months of the rainy season. The main fence is made preferably of 2 rows of species planted staggered, about 50 cm (1/2 spade) between rows and 20 cm (2 hand lengths) within rows.
2. Plant preferable at least three different tree species to allow for undergrowth and the root systems to explore different soil depths. See Environmental Affairs Department (2005) for information on nursery production and outplanting.
3. Grasses/legumes are planted behind the main fence for further support.

A.4.5. Vegetation barriers

Illustrations/ Diagrams:

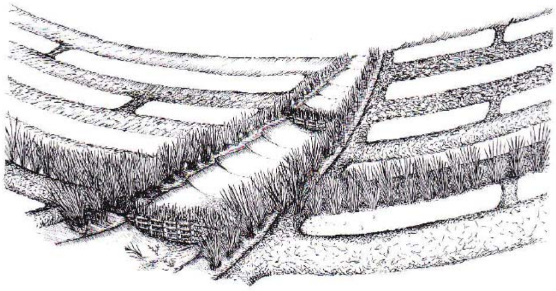


Figure A.4.5-1: Reduce water flow into gullies with vegetation barriers along the gully edge and behind the check dam in the gully[b]

Photos:

Figure A.4.5-2: Planted grid of vegetation barriers to protect soil loss.

Source: http://www.gettyimages.com/detail/photo/vegetation-barriers-to-stabilize-migration-high-res-stock-photography/128560098

Equipment requirements:

- Grasses for barriers – can be grown in a nursery
- Trees for fences – can be grown in a nursery
- Hoe, watering can

Variations/Adaptations:

- Vegetation barriers inside gullies.
- Vegetation barrier around gully head and sides.
- Vegetation fences to close area around gully head and sides against livestock.

Seasonal variations:

- November-January: Plant grass slips/cuttings with the first rains.
- February-March & April-June: Trim.

MAINTENANCE

Maintenance requirements:

- Trim vegetation fences at onset of second and third year to 50-75 cm height and 1-1.5 m width to encourage low and dense lateral branching.
- Trimmed material can be used for mulching or compost.
- No grazing is allowed for the first 3-5 years.

REFERENCES

Further references:

a. Environmental Affairs Department. 2005. Community environmental management manual – Soil conservation and fertility improvement.

b. Bunderson WT, Jere ZD, Hayes IM and Phombeya HSK. 2002. Landcare practices in Malawi. Malawi Agroforestry Extension Project. Publication no. 42.

c. Shaxson TF, Hunter ND, Jackson TR, Alder JR, 1996. A Land Husbandry Manual. 2nd Edition. Malawi.

See also:

Guideline A.2.2. Prevention and rehabilitating overgrazing
Guideline A.2.3. Grazing movement
Guideline A.3.2. Contour vegetation rows
Guideline A.4.6. Gully re-shaping
Guideline B.1.1.3. Soil cover (mulching)
Guideline B.2.1. Compost making
Guideline C.3.2. Zaï planting pits
Guideline C.3.3. Half-moon pits
Guideline D.1.4. Selecting beneficial trees
Guideline E.3.1. Living fences and wind breaks
Guideline E.3.5. Tree nursery

A.4.6. Gully re-shaping

OVERVIEW

Gully re-shaping is an option where gullies are too large for simple measures or engineering works would be unfeasible. The sides of a gully can be shaped where it is too deep for filling to be practical, or if the gully still needs to carry water. By flattening the gully sides, slumping is prevented and vegetation will begin to re-establish on the reshaped areas, resulting in a stable watercourse. Gully erosion is a severe form of land degradation resulting in loss of land, loss of soil, drying out of adjacent land, depleting groundwater resources, contaminating downstream water resources and posing a safety risk, as well as potentially threatening the integrity of infrastructure such as roads, buildings, pipelines, etc. Preventing erosion is the first priority. This information is for when prevention fails.

Objectives:

To stop and rehabilitate gully erosion, in order to:

- Prevent loss of land;
- Prevent soil erosion;
- Prevent sediment washing into water resources;
- Protect infrastructure, and safety.

Criteria for application:

- Deep and long gullies, where smaller interventions will not work.
- Areas of dispersive, or highly erosive soils.
- Re-shaping can be carried out using machinery, but to save costs can also be done manually using shovels.

Catchment perspective:

Erosion gullies may start as a small soil erosion but unmanaged can rapidly turn into long deep dongas. Where these occur, there is extensive loss of land which could be productive, as well as threats to infrastructure and safety of livestock and people. The rehabilitation of gullies prevents further loss of land and fertile soil, as well as reducing sedimentation of downstream water resources.

Livelihood opportunities:

Protection from soil erosion increases productivity of land and prevents loss of land area. Reduction in sedimentation improves the water quality of water resources, thereby making them more usable.

Funding opportunities:

- Landcare
- Working
- for Wetlands

Legislation:

- National Environmental Management Act 107 of 1998.
- National Water Act 36 of 1998.
- Conservation of Agricultural Resources Act 43 of 1983.

Benefits:

- Prevent further loss of land, and reclaim land that has already been lost.
- Prevent drying out of gully banks and impacting on groundwater.
- Reduce sediment into downstream water resources.
- Protect infrastructure and reduce safety hazards.
- Manage runoff water more effectively.

METHODOLOGY

Methodology:

1. Where water is flowing from the surrounding land into the gully, divert the runoff around the gully using sand banks. Where the flow is inside the gully, divert the flow away from the area you are working in, using sand banks – this will need to be repeated as you work in different areas.
2. Steep gully heads and gully banks should be shaped to a gentler slope. About a 1:1 slope, i.e. 1 m height per 1 m width. Rills and shallow branch gullies may be filled in by spade, shovel or plough.
3. Using the 1 m marker sticks or pegs, measure the height of the gully bank. Use a marking stick or peg secured firmly in the ground at the bottom of the bank where you are measuring from; leave the marker here. Using the 1:1 ratio, for each 1 m of height, measure 1 m of width away from the top of gully bank. At the correct distance, place a peg or marker stick securely in the ground; leave the marker here. The area of soil to be removed for re-shaping is between the marker at the bottom of the gully and the marker measured away from the gully. Once the soil is removed you should be able to run a string from one marker to the other in a straight line. This is cut only, and is suitable where there is constant flow of water in the gully. Where there is not constant flow, the bed of the gully can be filled, to raise the bed higher, this will make the total slope to the top marker shorter; see Figure A.4.6-1 for example of Cut and Fill technique.
4. In order to create the 1:1 slope, some soil will need to be removed, and in some areas, soil will need to be added. Use the soil that is removed for the areas where soil needs to be added.
5. Stockpile the topsoil and vegetation removed from the top of the gully bank. This will be used later to revegetate the reshaped gully bed. If dispersive (sodic) clay is exposed in the gully floor, then apply gypsum before spreading the topsoil.
6. Begin removing the soil.

a. Where gullies have steep banks, undercut erosion or piping erosion, it is better to start removing this soil using manual labour as it is unsafe for machinery.

b. For long gullies, graders can strip and stockpile topsoil in windrows parallel to the gully. The gully is then filled from a 'borrow zone' and progressively compacted by the grader. When filled, the grader spreads topsoil over the stripped borrow areas and the filled gully walls and base.

A.4.6. Gully re-shaping

c. If long stretches of gully are to be filled, it is best to split the gully repair into sections, spreading the topsoil from new sections onto areas previously filled. This minimises the distance topsoil needs to be transported. Topsoil should also be pushed to the head of the gully for later spreading over the gully centre.

7. Where gullies are long, or receive a lot of runoff water, also install check dams across the gully bottom (**Guideline A.4.3. Stone check dams)**.
8. Establish vegetation cover as soon as possible after earthworks are finished. Ideally, this means filling gullies in before heavy rains. Plant at least 1 year of heavily sown grassy annual pasture on newly repaired erosion scars. The denser cover and matting roots of annuals provide better protection than taller tillering grasses and crops, such as canola and lupins.
9. In high traffic areas (people and livestock), it is worth fencing large repaired gullies and any grassed waterways below them to protect the groundcover. The area can be grazed as necessary after groundcover has re-established.)

Precautions:

1. In areas of cultivation, do not crop across filled gullies until the whole gully is well stabilised, and only use zero tillage (**Guideline B.1.1.1. Conservation tillage**)
2. Remove obstacles in the gully.
3. Do not plant or allow trees and shrubs to grow in the repaired gully because these act as obstacles that can increase erosion by scouring in heavy flows. Dumped machinery, loose rocks and general rubbish in the gully may also cause more scouring.
4. Gully walls may have steep gradients that are a hazard to machinery operation. Take all normal precautions on such sites.

Illustrations/ Diagrams:

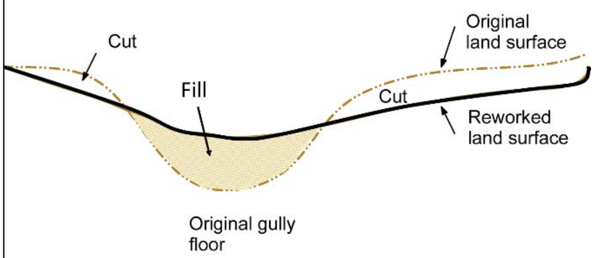


Figure A.4.6-1: Diagram illustrating cutting soil from banks and using it to fill the gully ditch, resulting in a reshaped gully with a gentler slope. Cut and Fill is suitable where there is not constant flow of water. This can eventually be re-cultivated with zero tillage. (Source: Adapted from www.agric.wa.gov.au).

Photos:

Figure A.4.6-3: LandCare workers, manually reshaping a small gully head.

Figure A.4.6-4: Manual reshaping o gully bed and banks to a gentler slop.

A.4.6. Gully re-shaping

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Figure A.4.6-2: Severe gully erosion before (top) and after reshaping (bottom) including check dams across the gully to manage runoff. Gully banks are stepped for revegetation. (Source: Researchgate)

Figure A.4.6-5: A grader, mechanically reshaping a gully bank. (source: www.scs.nsw.gov.au)

Equipment requirements:

- Shovels and pick / earth moving equipment
- Wooden markers (1 m length sticks)
- String
- Grasses for barriers, and soil cover – can be grown in a nursery using seeds from surrounding grass area.

Seasonal variations:
No seasonal variations

Variations/Adaptations:

- Vegetation barriers inside gullies.
- Vegetation barrier around gully head and sides.
- Vegetation fences to close area around gully head and sides against livestock.
- Note that gullies in dispersive soils need special management:
  - Do not leave rip lines or loose soil if the soil is dispersive.
  - Use gypsum treatment on suitable clays.
  - Add deeper topsoil to the exposed dispersive subsoil if possible.
  - Seed with a suitable annual to get rapid groundcover as early in the season as possible.
- With very deep gullies, can implement bench terraces in the reshape, instead of a continuous slope.

MAINTENANCE

Maintenance requirements:

- Monitor runoff into the gully, implement stone check dams if necessary, to prevent erosion starting again. (**Guideline A.4.3. Stone check dams**).
- Monitor vegetation regrowth, use compost or livestock manure to help improve soil fertility to help regrowth. (**Guideline B.2.1. Compost making**)
- No grazing is allowed for the first 3 years.

REFERENCES

Further references:

a. https://www.agric.wa.gov.au/water-erosion/repairing-gully-erosion

b. https://www.scs.nsw.gov.au/conservation-earthworks/erosion-gully-shaping

c. https://www.researchgate.net/figure/Effect-of-SWC-on-natural-resource-improvements-a1-gully-formation-before-2005-a2_fig9_325386835

See also:

Guideline A.2.2. Prevention and rehabilitating overgrazing
Guideline A.2.3. Grazing movement
Guideline A.3.2. Contour vegetation rows
Guideline A.4.3. Stone Check Dams
Guideline A.4.4. Brushwood Check Dams
Guideline A.4.5. Vegetation barriers
Guideline B.1.1.1. Conservation tillage
Guideline B.1.1.3. Soil cover (mulching)

A.4.7. Erosion management along roadsides

OVERVIEW

One of the areas most prone to erosion and gully formation is along the side of roads, especially dirt roads. This affects the usability of these roads during the wet season. Improved runoff management, such as mitre drains, along the roads will help mitigate this problem. This guideline outlines how to manage runoff along roadsides to prevent gully formation.

Objectives:

- To prevent the build-up of a high concentration of water.
- To prevent the water from reaching high flow velocities.
- To prevent erosion caused by runoff from roads.

Criteria for application:

- To be applied at locations where runoff from roads cause erosion.
- To be applied in areas where the in-situ material and the topography are susceptible to erosion.

Catchment perspective:
Very important for whole catchment as roads and tracks are major contributors to erosion and sedimentation.

Livelihood opportunities:
Preventing erosion along roads protects infrastructure and water resources, which contribute to improved transport and water supply.

Benefits:

- Reduce erosion.
- Prevent damage to the road.
- Improve road usage in wet conditions.
- Reduce maintenance cost.
- Reduce sedimentation deposited by runoff.

Funding opportunities:
Not applicable

Legislation:

- National Environmental Management Act 107 of 1998.
- National Water Act 36 of 1998.

METHODOLOGY

Methodology:

1. Assess the in-situ soil conditions and identify the material type, i.e. non-cohesive soil, cohesive soil or rock
2. Calculate the longitudinal slope of the road, i.e. slope = height difference / distance
3. Assess the terrain and cross-section of the road
4. If the terrain is suitable for the construction of mitre drains (e.g. shallow cut in flat terrain):
   (i) Select the required spacing of the mitre drains as per the following table

SLOPE ($^m/_m$)	SPACING (m)
0.100 (10%) very steep slope	10
0.050	20
0.033	30
0.025	40
0.020	50
0.010 (1%) very gentle slope	100

5. Construct mitre drain according to the specifications (see illustration below).
6. Otherwise, if the terrain is not suitable for the construction of mitre drains (e.g. deep cuttings or steep terrain) select the checkwall, type of lining and checkwall spacing as per the following table. Checkwall is similar to a check dam.

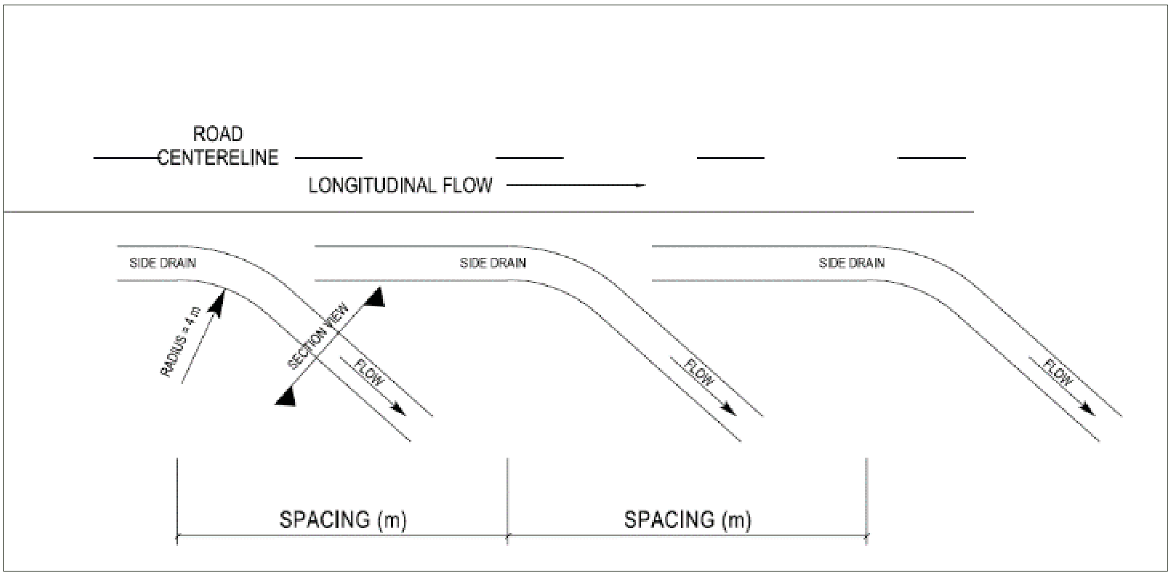
SLOPE	CHECKWALL TYPE			CHECKWALL SPACING (m)
	LINING TYPE			
	NON-COHESIVE SOIL	COHESIVE SOIL	ROCK	
0.100	Checkwall: 3 Lining: 2	Checkwall: 3 Lining: 2	Checkwall: 3 Lining: NONE	2.5
0.090	Checkwall: 3 Lining: 2	Checkwall: 3 Lining: 2	Checkwall: 3 Lining: NONE	5.0
0.050	Checkwall: 3 Lining: 2	Checkwall: 3 Lining: 2	Checkwall: 3 Lining: NONE	10
0.045	Checkwall: 2 Lining: 2	Checkwall: 2 Lining: 2	Checkwall: 2 Lining: NONE	10
0.030	Checkwall: 2 Lining: 2	Checkwall: 2 Lining: 2	Checkwall: 2 Lining: NONE	15
0.020	Checkwall: 2 Lining: 2	Checkwall: 2 Lining: 2	Checkwall: 2 Lining: NONE	20

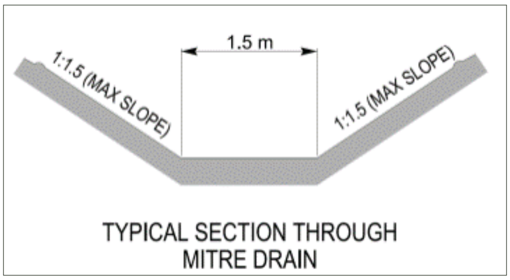
A.4.7. Erosion management along roadsides

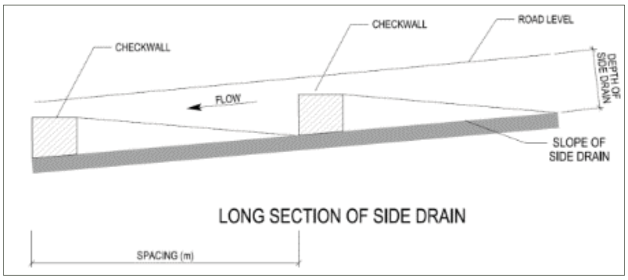
0.010	Checkwall: 2 Lining: 2	Checkwall: 2 Lining: 1	Checkwall: 2 Lining: NONE	50
0.005	Checkwall: 1 Lining: 1	Checkwall: 1 Lining: 1	Checkwall: 2 Lining: NONE	100
Notes: Checkwall Type: Refer below for details Lining Type: (1) Grass; (2) Stone pitching				

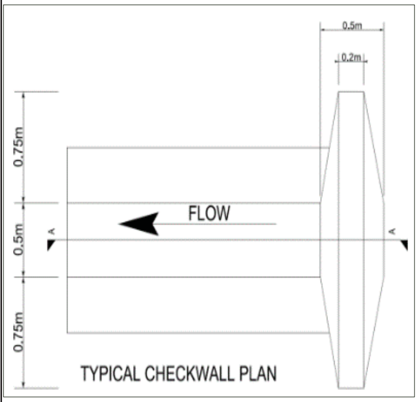
7. Construct the checkwall according to the typical details (see Illustrations / Diagrams below). Note: Stone pitching can be replaced with gabion baskets if it is more cost-effective.

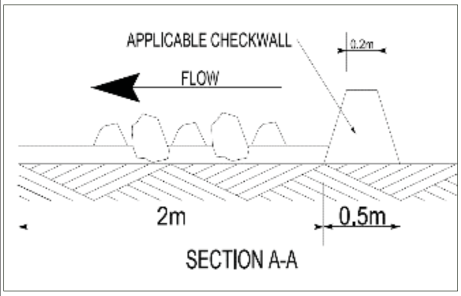
Illustrations/ Diagrams:

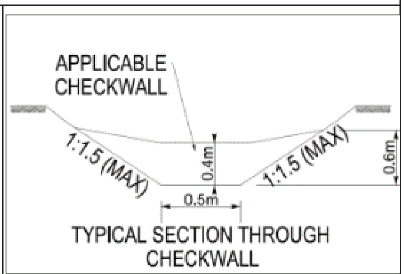




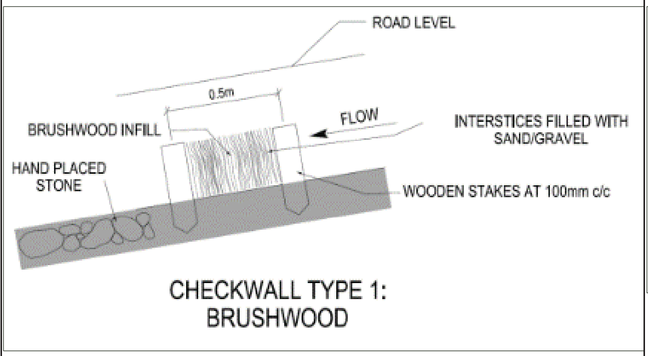


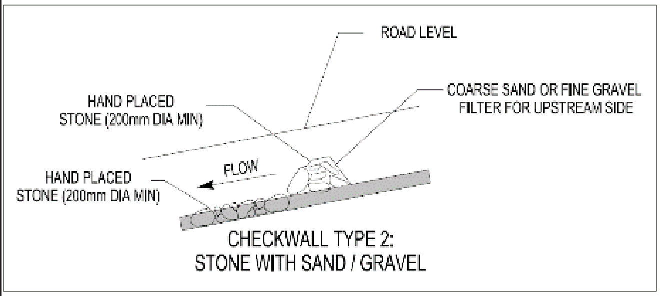


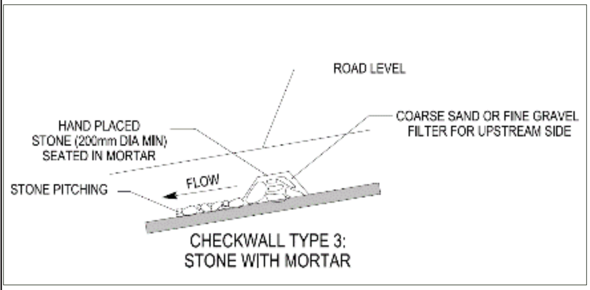




A.4.7. Erosion management along roadsides







Variations/Adaptations:
Can use vegetation barriers instead of concrete, or brickwork

Seasonal variations:
Construct during the dry months.

Equipment requirements:
General equipment required:
- Line level and measuring tape

Additional equipment required for construction of stone pitching:
- Cement, water, rock, shovel and wheel barrow

Additional equipment required for construction of mitre drains:
- Grader or plough and tractor.

Photos:

Figure A.4.7-1: Vegetation barrier at each mitre drain, with spreading grass in-between (S. Braid).

MAINTENANCE

Maintenance requirements:
- Mitre drains have to be maintained by clearing vegetation, repairing eroded sections and removing siltation.
- Eroded side drains have to be repaired by filling the eroded sections with rocks with a minimum diameter of 0.2 m.
- Checkwalls have to be inspected routinely and erosion around the edges of the checkwalls must be repaired. Stone pitching has to be constructed (refer to detail below) if the material downstream of the checkwalls are washed away.
- Can plant stoloniferous or rhizomatous (spreading) grass between mitre drains or barriers.

REFERENCES

Further references:

a. SANRAL. 2013. Drainage Manual – 6th Edition. Pretoria: SANRAL

See also:
Guideline A.4.5. Vegetation barriers
Guideline A.4.3. Stone check dams
Guideline A.4.4. Brushwood check dams
Guideline A.5.4. Gabion baskets
Guideline C.2.5. Hillside runoff (swales)

A.5. Stream/River bank management

A.5.1. Riparian buffer zones

OVERVIEW

Some of the most productive farming areas are on stream/river banks because of the fertile silt and ease of access to water. However, this practice results in the loss of important riparian vegetation which amongst other things helps to clean the water, reduce flood flows, trap sediments, provide food and is also an important habitat for biodiversity. This guideline provides an outline how to implement buffer zones along stream/river banks, in order to protect these important areas.

A.5.1. Riparian buffer zones

Objectives:

- Control runoff and concentration of flows from hillslopes.
- Trap sediment from hillslopes before entering a stream/river.
- Reduce risk of flooding, siltation, landslides.
- Stabilise and protect riparian areas from erosion.
- Protect riverine function and habitat.

Catchment perspective:

- Riparian buffer zones should be demarcated and protected according to legislation.
- Riparian buffer zones must not be cultivated, even under high pressure for agriculture land.
- Protection and sustainable use of riparian buffer zone critical to reduce/buffer impacts of land use on stream flow and sedimentation.

Criteria for application:

- Farming activities along river banks and floodplains
- Landuse activities, infrastructure, development along river banks
- Protecting landuse activities from effects of flooding
- Reducing impacts to water resources from landuse activities, e.g. sediment and waste.

Livelihood opportunities:

Maintaining the ecological functions of river banks provides for livelihoods through flood attenuation, sediment trapping, improving water quality, and provision functions, e.g. reeds for weaving. The buffers protect the river bank integrity.

Funding opportunities:

Not applicable

Benefits:

- Uncultivated stream banks with natural vegetation provides better and more permanent protection to erosion than physical structures
- Riparian buffer zones can significantly reduce stream flow concentration and sedimentation

Legislation:

- National Environmental Management Act 107 of 1998.
- National Water Act 36 of 1998.
- Conservation of Agricultural Resources Act 43 of 1983.

METHODOLOGY

Methodology:

1. Demarcate a strip to cover both banks of the stream channel. The width depends on the size of the steam. Approximately:

Stream/river width:	**0-1 m**	**1-3 m**	**>3 m**
Barrier width per bank:	**5 m**	**15 m**	**30-40 m**

2. Plant Vetiver or Napier grass inside the strips. Space Vetiver and Napier at 0.45 x 0.2 m (See **Guideline A.4.5 Vegetation barriers** and **Guideline A.3.2 Contour vegetation rows**)
3. The Vetiver, Napier and Bamboo vegetation can be combined with shrubs such as *Sesbania sesban* at a spacing of 0.45 x 0.45 m
4. Trees can be planted in strips at 2 x 2 m (2 spades by 2 spades). Tree species that are recommended include Acacia galpinii, A. polyacantha, A. seiberiana, Faidherbia albida, Ficus natalensis, F. capensis, F. sycomorus, Khaya nyasica, Rauvolfia caffra, Syzygium cordatum, Trichilia emetic, Ziziphus abyssinica, Z. mauritiana and Z. mucronata. See Bunderson et al., (2002) for information on nursery production and outplanting
5. Where trees and shrubs are used, leave a 1 m (1 spade length) strip on each side of the channel for grass regeneration to increase surface roughness for reducing water runoff.

Equipment requirements:

- Vetiver or napier grass for the barriers, or coloured rocks to demarcate barrier edge
- Usual farming tools

Seasonal variations:

- June-August: Organise production of nursery seedlings for planned buffer zones and stream bank protection.
- November-January: Plant selected tree seedlings and grasses in identified areas.

Illustrations/ Diagrams:

A.5.1. Riparian buffer zones

Photos:

Figure A.5.1-1: The stream bank is lined with grass and vegetation and farm fields are set back from the stream (S. Braid).

Figure A.5.1-2: watercourse with clear riverine vegetation buffer clearly protected, and then a buffer of grasses before cultivated fields. (Source: kanabecswcd.org)

Variations/Adaptations:

Floodplain / valley bottom		Riparian buffer zone
Topography	**Flood peak depth**	
Large/wide and flat	Low	In cases where pressure on agricultural land is high on areas with *large flat floodplains* – Plant permanent grasses or fodder around stream buffer zone and permanent crops, such as bananas, sugar cane, napier grass, in outer floodplain area
Small/narrow and steep sided valley	High	Plant permanent grasses and fodder in floodplain/valley bottom and permanent crops (bananas, sugar cane) with soil conservation measures outside floodplain/valley bottom

MAINTENANCE

Maintenance requirements:

- Vetiver needs to be cut back regularly.
- Nurseries required for seedlings.

Potential drawbacks/disadvantages:

- Require provision of planting material.
- Some of the planting materials are needed to be grown in nurseries.

REFERENCES

Definitions:

See also:

Guideline A.5.2. River crossing for cattle
Guideline A.4.1. Gully prevention
Guideline A.4.5. Vegetation barriers

Further references:

a. http://www.kanabecswcd.org/tag/buffers/
b. ICLEI. (2017) Development of sustainable urban river-based planning guidelines. Stockholm Resilience Centre.

A.5.2. River crossing for cattle

OVERVIEW

Cattle can cause a lot of damage to river banks where they cross rivers. They cause soil erosion, and also can drop dung and urine in rivers, which pollutes the water for people living downstream of the cattle crossing. Well-designed cattle crossings can substantially improve the water quality, as well as making it safer for animals and people to cross rivers

Objectives:

- Reduce pollution of the water by livestock
- Reduce soil erosion on river banks
- Improve water quality and safety

Criteria for application:

- Existing river crossing requiring improvement
- Banks not too steep
- Straight section of river

Catchment perspective:

River crossings can be sources of erosion and pollution which can severely impact downstream water quality, and cause erosion of river banks.

Legislation:

- National Water Act 36 of 1998.
- Conservation of Agricultural Resources Act 43 of 1983.
- National Environmental Management Act 107 of 1998.

Benefits:

- Reduced siltation of the water
- Better water quality for drinking and washing
- Stable river banks which help with flood control
- Improved livestock health (cleaner water)
- Reduced livestock deaths

Funding opportunities:

- Working on Wetlands
- Expanded Public Works Programme
- LandCare

Livelihood opportunity:

Improved quality of river water contributes to food and water security.

METHODOLOGY

Methodology:

1. Identify a suitable crossing place – the banks must not be too steep, and the river should be straight (i.e. not on a curve). The crossing point must be convenient for cattle.
2. Use layers of stone and gravel to construct a hard surface across the river.
3. The upstream side of the crossing should be constructed with a maximum slope of 4:1 (horizontal to vertical).
4. The main crossing should have a maximum slope from upstream to downstream of 10:1.
5. The height of the crossing should be as low as practical.
6. Dig the bed of the channel out (if it is soft) and lay a sheet of filter cloth or geotextile material to stabilise the bed.
7. Add layers of rock of different sizes. Add a final layer of gravel and compact.
8. Bury the upstream end about 1 m into the bed.
9. Lay the rock bank all the way up the embankment, to prevent the soft embankment from being broken up during floods (Figure A.5.2-5).
10. The bed of the crossing should not be too high; the river must flow freely over the crossing.
11. Fence both sides of the crossing to guide the livestock to the crossing, and a suspended fence across the river where possible to keep the cattle within the crossing to the exit (Figure A.5.2.-3 and Figure A.5.2-5).

Illustrations/ Diagrams: Not applicable

Photos:

Figure A.5.2-1: Livestock disturbing a watercourse, causing siltation and erosion.

Figure A.5.2-2: A designed cattle crossing with guiding fence.

Figure A.5.2-3: Use a suspended fence to guide the cattle across the river to the exit point.

A.5.2. River crossing for cattle

Figure A.5.2-4: Cattle crossings can cause erosion of streambanks and pollute water for downstream users. They can also be dangerous to livestock. An improved cattle crossing will improve water quality and safety for people and animals.

Figure A.5.2-5: Cattle crossing should have a hard surface to enter and exit the water, to prevent mud and siltation of the watercourse, prevent bank erosion, and make it easier for the cattle to eneter and exit.

Variations/Adaptations:

Not Applicable

Seasonal variations:

- Conduct work during dry months and water level is low.
- Fences should be constructed with failure points so that only portions of the fence are damaged during floods. These portions can be easily repaired or replaced. Suspended fences are ideal so the float up during floods.

Equipment requirements:

- Shovels, picks or digging equipment.
- Rock and gravel for the bed. A range of rock sizes is required
- Geotextiles or other stabilising materials (optional)
- Fencing and fencing posts for the land fence
- Rope and pieces of piping tied on it for the river suspended fence. (**Figure A.5.2-3**)

MAINTENANCE

Maintenance requirements:

- Regular inspection and maintenance of crossing surface after each rainy season
- Replacement and repair of fencing

REFERENCES

Definitions:

- **Geotextile:** Strong fabrics that are used to stabilise soil
- **Slope:** horizontal distance for every metre of vertical distance. For example, a slope of 4:1 means that for every 4 metres measured along the ground, there will be a 1 m increase in height.
- **Failure point:** A weak point that is deliberately built into a structure or a fence. This will allow the fence to break at a specific place if, for example, severe flooding occurs. The rest of the fence will remain intact and the failure point can be easily repaired

See also:

Guideline A.2.3. Grazing Movement
Guideline A.4.1. Gully prevention
Guideline A.4.2. Gully reclamation (small gullies)
Guideline A.4.3. Stone check dams
Guideline A.4.5. Vegetation barriers
Guideline A.4.6. Gully re-shaping
Guideline A.5.1. Riparian buffer zones

Further references:

a. Water and Rivers Commission. 2000. Livestock management: construction of livestock crossings. Water Notes WN6 (January).

A.5.3. Earth berms / dykes / flood levees

OVERVIEW

Flooding is a natural phenomenon of rivers. For ease of access to water and highly fertile soils, many villages are established near rivers. However, these are affected by floods. A berm/dyke is a wall that runs parallel with the watercourse. Berms or dykes help reduce flood waters affecting villages –they do not stop floods or prevent damage. They require prioritised maintenance. This guideline provides an outline of how to construct and maintain berms/dykes.

Objectives:

To prevent watercourses from flooding adjacent areas.

Catchment perspective:

Applicable from village up to municipality scale.

Benefits:

- Reduced risk of flooding and causing damage to property and crops.

Limitations:

- The construction of earth berms to constrain the watercourse will result in increased velocity through the affected section. This can have negative effects downstream such as increased erosion/deposition and higher flood peaks.
- The environmental impacts of constraining the watercourse to a set path need to be considered, e.g. seasonal wetlands may be deprived of water obtained from annual floods.
- They must be carefully maintained to prevent breaches.

Funding

Not applicable

Legislation:

- National Environmental Management Act 107 of 1998.
- National Water Act 36 of 1998.
- Conservation of Agricultural Resources Act 43 of 1983.

Criteria for application:

- Earth berms to be built to a height so that they will not be overtopped by flood events (unless these are exceptional).
- The less steep the side slopes the better. The ratio of vertical elevation to horizontal distance of the side walls to be at a minimum slope of 1:3 (i.e. it should not be steeper than this).
- The wider the central section berm section the better. The minimum width is 1 m. Where animal traffic is expected (e.g. cows) the width should be extended to 2 m.
- Erosion protection of all exposed faces is important, particularly on the water side. This could be undertaken by planting vegetation, e.g. vetiver grass, to hold together the wall faces or lining with rock. The bigger the rock sizes and the greater the number of layers of rock, the greater the protection offered.
- Should be set back from the edge of the watercourse, e.g. along the riparian barrier edge, to allow the river to flood within its natural floodplain
- Do not build houses, schools, etc. on the watercourse side of the berm.
- A berm is as strong as its weakest points. The start of the berm should be regularly maintained to ensure the flood water does not bypass the berm. The berm itself should be regularly maintained to ensure it does not fail for, e.g. at crossing points over the berm.
- In high floods, the berm may be overtopped.

METHODOLOGY

Methodology:

1. The position of earth berms needs to be identified. Berms should not be placed too close to watercourses as there needs to be sufficient additional space alongside the normal watercourse for floods to pass through without overtopping berms. The berms must extend far enough or to an elevation where floodwaters cannot impact areas to be protected. For large areas consideration should be given to constructing various internal earth berms so that if there is a breach the entire area is not compromised.
2. The height and footprint of the earth berms is to be established. The height should exceed that expected during normal floods. Where hydrological and hydraulic analysis cannot be done, consideration of historic floods should be undertaken: older local inhabitants should be consulted. It is important to allow additional elevation to the historic flood levels due to constricting the flow area as well as an additional freeboard as a safety factor.
3. Make sure the start of the berm is directed inland away from the watercourse so that acts like a funnel
4. The ground must be cleared and made level where berms are to be placed. The first 100 mm of topsoil is to be stockpiled and placed on top of the berm after construction.
5. Suitable material must be used to form the earth berm. This should be a cohesive material that will not be eroded and not allow water to flow through it easily. Dispersive, highly erodible soils and soils with high organic content should not be used.
6. A key should be excavated for the earth berm. This is essentially a trapezoidal shaped trench along the centreline of the berm. (See Figure A.5.3-1).
7. The earth berm is to be placed in 100 mm layers and compacted as best as possible until the final height is reached. All loose rocks and vegetation to be removed as the layers are placed.
8. Once the berm is complete it should be vegetated or lined with rock to protect against erosion.

Illustrations/ Diagrams:

A.5.3. Earth berms / dykes / flood levees

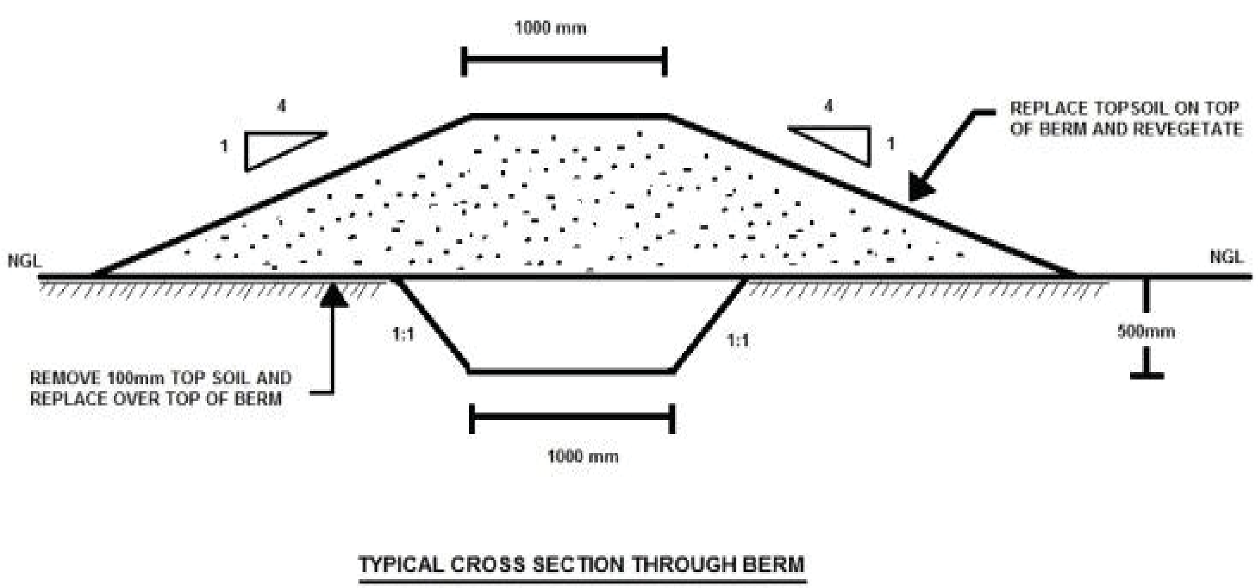


Figure A.5.3-1: Typical cross section through berm

Photos:

Figure A.5.3-2: Unlined earth berm (F. Nagdi)

Figure A.5.3-3: Berm – well vegetated on left poor condition on the right, e.g. cattle walking over it breaking it up (S. Braid).

Equipment requirements:

- Line level
- Tape measure
- Implements for moving and compacting soil (Spades, wheelbarrow, plough, etc.)

Seasonal variations:

Conduct routine inspections, especially during the wet season.

Variations/Adaptations:

Rows of gabion baskets can be used in areas where there is abundant supply of stones.

MAINTENANCE

Maintenance requirements:

- Check for erosion and protect with vegetation, rocks as necessary after floods and before the wet season.
- Keep crossing points located at strongest points.

REFERENCES

Further references:

a. US Army Corps of Engineers. 2000. Design and Construction of Levees Engineer Manual.

See also:

Guideline A.5.4. Gabion baskets
Guideline A.5.1. Riparian buffer zones
Guideline A.4.5. Vegetation barriers
Guideline A.4.2. Gully reclamation (small gullies)

A.5.4. Gabion baskets

OVERVIEW

A.5.4. Gabion baskets

Bank collapse along rivers and gullies, and floods, contribute to catchment degradation. Gabion baskets are rock filled structures to protect banks, reduce erosion and prevent bank collapse. This guideline outlines how to site and install gabion baskets.

Objectives:
To protect and stabilise river bank slopes from erosion by protecting exposed faces.

Catchment perspective:
Applicable from village up to district level and river basin wide.

Benefits:

- Reduced risk of erosion and causing damage to property and crops
- Can be vegetated, e.g. Napier grass

Limitations

- Construction that constrains the watercourse will result in increased velocity through the affected section. This can have negative effects downstream such as increased erosion/deposition and higher flood peaks
- The environmental impacts of constraining the watercourse to a set path need to be considered, e.g. seasonal wetlands may be deprived of water obtained from annual floods
- The sourcing of rock for gabion structures is crucial: if abundant rock/stone is not local available, then do not implement this structure

Criteria for application:

- The scale of the problem should be such that it warrants the use of rock filled gabion structures. This is typically the case where high flow velocities are experienced and a resistant, robust structure is needed.
- Rock filled gabion structures lend themselves to applications where rock is available. Rock should not fragment/disperse easily and should range from 100 mm to 200 mm in size. Otherwise concrete structures may be preferable.
- Cost is a key factor. The cost of obtaining/making the gabion baskets and filling them with stone needs to be calculated and evaluated.
- Gabion baskets are subject to corrosion overtime: they will eventually need to be replaced or the original structures re-covered with a new outer shell of gabion wire.
- Consideration needs to be given to the abrasive power of the watercourse especially in high impact zones, as this could cause the wire mesh to wear away quickly. Lining exposed faces with a layer of concrete could be considered in these instances.

Funding opportunities:

- Working for Wetlands
- LandCare

Legislation:

- National Environmental Management Act 107 of 1998.
- National Water Act 36 of 1998.
- Conservation of Agricultural Resources Act 43 of 1983.

METHODOLOGY

Methodology:

1. The location of the gabion structure is to be identified and the shape and size to be determined. Thus, a design exercise is required to be carried out. Individual gabion baskets are typically rectangular in shape, with varying dimensions and thicknesses. Basket must be stepped towards the slope to be protected so consideration needs to be given to the starting and end positions of the gabion structure. It is generally safe to shape gabion walls at a 1:1 slope so that the upper rows of rock filled gabion baskets are underlain by others that form a foundation. Steeper slopes and rock filled gabion baskets placed on soil backfilled behind the structure are acceptable but it is essential that a suitably qualified/ experienced person be consulted in this regard.
2. The two materials required are rocks and wire baskets. For small-scale erosion projects, gabion baskets can be woven from rolls of heavy-duty wire. However, for larger applications, purchased baskets (in collapsed form for transportation – but easily assembled) are more likely to meet the lifetime requirements of the solution. In the latter case, suppliers provide good advice on application.
3. The area where baskets are to be placed should be cleared so that it is smooth and level. In watercourses, it is essential to install gabions in the dry season.
4. Geotextiles need to be installed at all soil/mesh interfaces so this needs to be put down before the first layer of gabion baskets is put into place. Geotextiles are fabrics which allow water to pass through but not the small fine sandy material, which could cause erosion behind the gabion structure.
5. The base layer of the structure should be installed first. Baskets should be tied together using steel wire. Wire cutters and pliers will be required. Fill the gabions with rock and use wire to tie the lids down. Manufacturers' guidelines must be followed.
6. Install subsequent layers in a step-wise process.

Seasonal variations:
Should be constructed in the dry months.

Variations/Adaptations:

- Can be vegetated to help trap silt, e.g. Napier or Vetiver grass.
- Could use stacked and staked tyres where rocks aren't readily available.

A.5.4. Gabion baskets

Photos:

Figure A.5.4-1: Stacked tyres providing bank protection (Source: S. Braid).

Figure A.5.4-2: Example of gabion structure used to guide watercourse (Source: F. Nagdi).

Figure A.5.4-3: Example of gabion structure used to guide watercourse (Source: F. Nagdi).

Figure A.5.4-4: Example of gabion structure used to guide watercourse (Source: F. Nagdi).

Illustrations/ Diagrams:

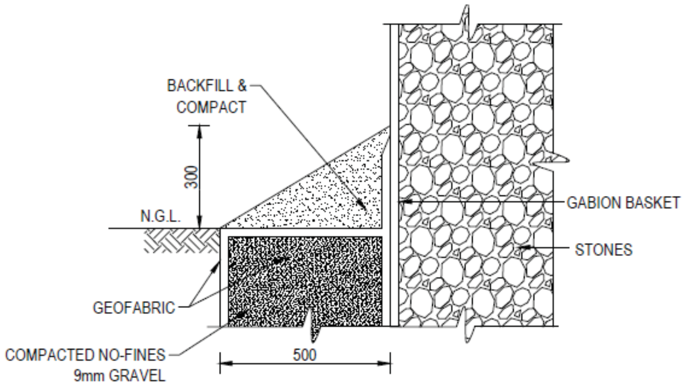


Figure A.5.4-5: Cross section of gabion basket and spillway for a simple gabion weir. (Source: Aurecon)

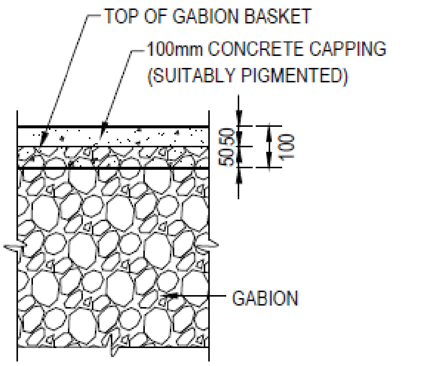


Figure A.5.4-6: Cross section of concrete capped gabion basket. (Aurecon)

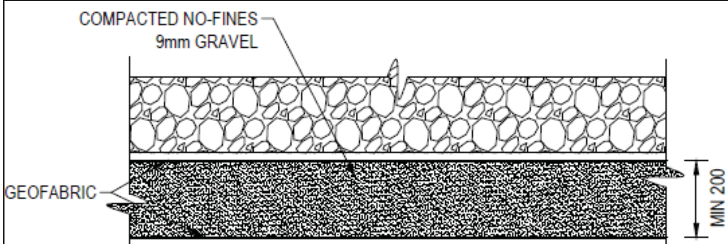


Figure A.5.4-7: Longitudinal section of boulder foundation for gabion basket and spillway. (Source: Aurecon)

Equipment requirements:

- Line level.
- Tape measure.
- Implements for moving and compacting soil (Spades, wheelbarrow, plough, etc.).
- Wheelbarrow to move rock (in some cases bakkie will be needed to carry stone).
- Wire cutters and pliers.

A.5.4. Gabion baskets

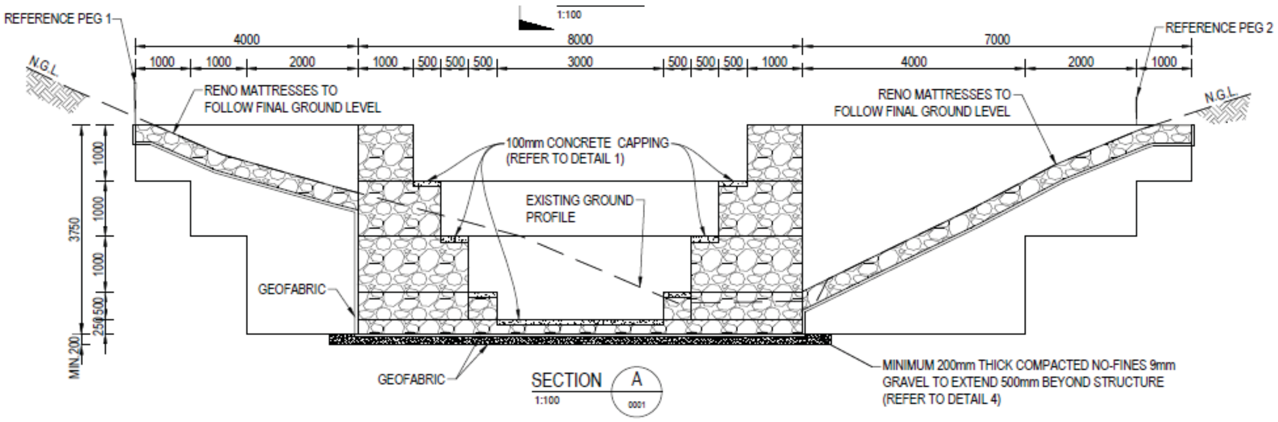


Figure A.5.4-8: Longitudinal section of a multi-spill gabion weir structure (Source: Aurecon).

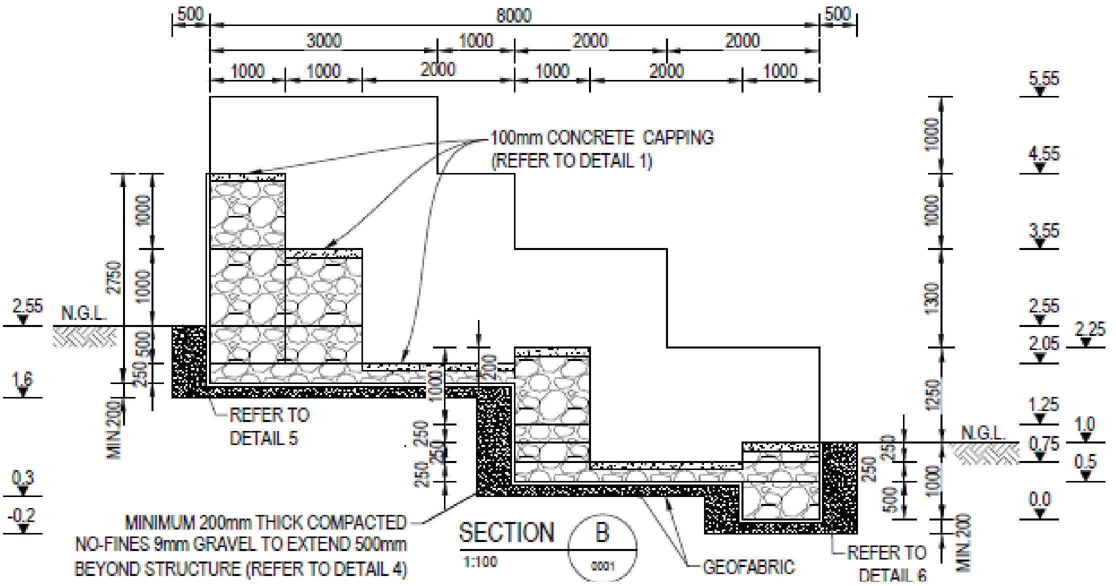


Figure A.5.4-9: Cross section of a multi-spill gabion weir (Source: Aurecon).

MAINTENANCE

Maintenance requirements:

It is important to check on the structure after large floods. Especially check the lower gabions for failure.

REFERENCES

Further references:

a. www.maccaferri.co.za

b. African Gabions. Channelling works manual.

c. African Gabions. Flexible weirs for river and water supply manual.

See also:

Guideline A.4.2. Gully reclamation (small gullies)
Guideline A.4.3. Stone check dams
Guideline A.4.4. Brushwood check dams
Guideline A.4.5. Vegetation barriers
Guideline A.5.1. Riparian buffer zones

B SOIL FERTILITY MANAGEMENT

CATCHMENT MANAGEMENT GUIDELINES	ISSUES										CAPACITY					
B. Soil fertility management	Soil Erosion	Loss of soil fertility	Sedimentation	Water degradation and depletion	Floods	Overgrazing / Deforestation	Threat to biodiversity	Loss of crop yields / Livestock fodder	Risk to infrastructure	Reduced standard of living	Prevention/Rehabilitation	Legislation	Scale	Labour requirement	Complexity	Cost
B.1. Climate-smart agriculture practices																
B.1.1. Conservation agriculture																
B.1.1.1. Conservation tillage	■	■						■		■						
B.1.1.2. Crop rotation and intercropping	■	■						■		■						
B.1.1.3. Soil cover (mulching)	■	■	■					■		■						
B.1.2. Natural farming																
B.1.2.1. Designing a natural farming garden		■						■		■						
B.1.2.2. Where to plant what		■						■		■						
B.1.2.3. When to plant what		■						■		■						
B.2. Nutrient management																
B.2.1. Compost making		■		■				■		■						
B.2.2. Natural fertilizers		■						■		■						
B.2.3. Microdosing		■						■		■						
B.2.4. Weeding		■						■		■						
B.2.5. Agroforestry	■	■						■		■						

KEY: Capacity Icons

Action	Legislation	Scale	Labour	Complexity	Cost
Prevention	Other	Household	Single person	Simple	Free to little
Rehabilitation	NWA/NEMA	Village	Few people	Advanced	Medium cost
		Catchment	Many people	Complex	Expensive

One of the most important natural resources is the soil. Healthy and fertile soils produce good yields of crops; whereas poor or degraded soils produce low and unreliable yields. Soil health is a function of rooting depth, nutrient fertility, structure, organic matter content, below-ground biodiversity and water holding capacity – all of which are related. Ensuring soils remain healthy and fertile requires a variety of management techniques including climate-smart farming practices and nutrient management.

B.1 Climate-smart agriculture practices

This set of guidelines provides techniques for sustainable agriculture – which will contribute to improving the health of the soil by enhancing its physical, chemical and biological properties. Good soil health will produce higher and more stable yields. These techniques contribute to avoiding erosion and controlling rainfall runoff, by increasing infiltration of rainwater and water holding properties and thereby improving soil moisture. Climate-smart agriculture covers the principles and practices of conservation agriculture (CA) and

Permaculture (natural farming). Maintaining soil fertility is critical in changing climate conditions to ensure food security.

B.2 Nutrient management

Soil fertility is of fundamental importance for agricultural production. These guidelines provide basic information on techniques which maximize the efficiency of nutrients and water use for better agricultural productivity. This improves and sustains soil quality for the future. These include compost techniques and natural fertilizers.

B.1 Climate-smart agriculture practices

B.1.1. Conservation agriculture

Conservation agriculture (CA) combines profitable agricultural production with environmental concerns and sustainability by conserving, improving, and using natural resources more efficiently through integrated management of soil, water and biological resources. CA contributes to food security and increases tolerance to changes in temperature and rainfall including incidences of drought and flooding. CA combines three basic principles or ‘pillars’: (i) conservation (minimum) tillage (see B.1.1.1), (ii) crop rotation and intercropping (see B.1.1.2) and (iii) maintaining soil cover by mulching or crop residues (see B.1.1.3).

B.1.1.1. Conservation tillage

OVERVIEW

A common method of land preparation involves clearing and burning weeds and crop residues, followed by manual construction of ridges (90 cm apart) using hand hoes. These practices result in valuable biomass loss and an enormous amount of hard physical labour to build the ridges of dry loose soil from compacted ground.

Objectives:
CA involves minimal soil disturbance during planting and growing of crops in place of practices such as tillage, ridging, weeding and banking with hand hoes. This is critical for improving general soil health by enhancing its physical, chemical and biological properties.

Criteria for application:
Not applicable

Legislation:
National Veld and Forest Fire Act 101 of 1998.

Funding opportunities:
Not applicable

Catchment perspective:
The labour and time needed to ridge a field often leads to late planting. Missing the first planting rains and the nitrogen flush that comes with these rains typically reduces the yield of the crop by 25-30%. These tillage practices contribute to increased water runoff, erosion and general soil degradation.

Benefits:

- Produces higher and more stable yields under low or variable rainfall conditions
- Saves labour, energy and production input costs through reduced soil tillage
- It is a simple practice that any household can adopt
- Builds resilience to the increasing threats of variable weather and climate change

METHODOLOGY

Methodology:

1. Residues on the soil surface:
   a. Normal Tillage <15% or <560 kg/ha
   b. Conservation Tillage >30% or >1120 kg/ha
2. Management of crop residues
   a. Immediately after harvest, distribute crop residues and any weed biomass on the ground surface parallel to the direction of intended planting rows.
   b. Do not burn or remove crop residues and weeds. If feed for livestock or fuel for cooking is a priority, 25-50% of the biomass may be removed – but leave no more than 30% of the ground surface exposed by planting time.
   c. The stems of weeds should be broken or cut, leaving the roots in the soil to help bind it and leaving the broken or cut biomass on the soil as protective cover. As it decomposes it will return nutrients to the soil. The green matter will protect the soil from evaporation and erosion.
3. Planting with conservation tillage
   a. Use pegs and string to mark planting rows.
   b. Open the mulch in lines along the marked row to allow for easy planting.
   c. Sow seeds on the flat or on old ridges with a dibble stick (or jab planter) at the conventional depth and spacing. Maize: 90 cm between rows, 25 cm between planting stations, 1 seed per hole.
   d. Do not construct any new ridges

Illustrations/ Diagrams: Not applicable

B.1.1.1. Conservation tillage

Photos:

Figure B.1.1.1-1: Demonstrating soil cover between crop rows (Source: J. Rutherfoord)

Seasonal variations:

- Slashing of weeds and cutting of stalks should take place in winter when growth is slower and prior to the planting season
- Planting soon after slashing will create competition for nitrogen with the seedlings

Equipment requirements:

- Slashers
- Hoe

Variations/Adaptations:

Other agricultural practices that complement conservation agriculture include:

- The integration of agroforestry especially with *Faidherbia albida* (the “fertilizer tree”) to improve soil fertility and reduce fertilizer costs
- The application of CA with low cost irrigation in the dry/winter season to provide a buffer against failure of the rainfed crop, while offering opportunities to improve production, nutrition and incomes
- The use of vegetation barriers, e.g. vetiver lines as an additional soil conservation measure and source of mulch
- The use of natural fertilizers (compost and animal manure) to boost crop yields and the quantity of biomass needed for effective mulching – as well as increasing soil organic matter
- Where the weed problem is severe, farmers in Zambia and Zimbabwe have been advised to use safe herbicides (e.g. Glyphosate) carefully sprayed on the weeds to reduce labour costs

MAINTENANCE

Maintenance requirements:

- CA requires breaking certain well-established cultural norms with respect to crop production: the most basic is to stop ploughing
- CA methods are most effective when used with skilful management and careful consideration of the many agro-ecological factors affecting production on any given farm or field.
- Since CA is based upon establishing an organic layer; it may take some years before a producer will start to see improved yields.

Definitions:

Minimum tillage – superficial loosening of the soil (5 cm), ripping of planting rows with a ripper tine (chisel plough), or making permanent planting basins by hand, without disturbing the soil between

Zero-till or No-till – direct planting through a mulch layer using a special planter (oxen-drawn) or hand tool (jab planter)

- **Conservation tillage** – any form of reduced tillage techniques.

REFERENCES

Further references:

a. Liniger, H.P., R. Mekdaschi Studer, C. Hauert and M. Gurtner. 2011. Sustainable Land Management in Practice – Guidelines and Best Practices for Sub-Saharan Africa. TerrAfrica, World Overview of Conservation Approaches and Technologies (WOCAT) and Food and Agriculture Organization of the United Nations (FAO)

b. Conservation Farming Unit, Zambia (undated). The practice of conventional and conservation farming in East and Southern Africa. Lusaka, Zambia

c. IIRR and ACT (2005). Conservation agriculture: a manual for farmers and extension workers in Africa. IIRR and ACT, Nairobi and Harare

See also:

Guideline B.1.1.2. Crop rotation and intercropping
Guideline B.1.1.3. Soil cover (mulching)

B.1.1.2. Crop rotation and intercropping

OVERVIEW

Mixing crops by either planting a different crop in each field every season, or by planting a mixture of crops which complement each other can be beneficial. Rotating crops regularly reduces the ability of each crop’s pests to become

B.1.1.2. Crop rotation and intercropping

established in the soil through minimising the available food and habitat for each pest. The variety of crops also increases opportunities for a mixture of pest predators to survive.

Objectives:

- The main concept of intercropping is to obtain increased total productivity per unit area and time, and to ensure judicious utilization of land resources and farming inputs including labour. One of the main reasons for higher overall yields in intercropping is that the component crops are able to use available resources more efficiently than if they were grown separately.
- The most successful and most recommended combination is maize and pigeon pea (Cajanus cajan). Other legumes that can be used include dry bean (Phaeseolus vulgaris), soybean (Glycine max) and cowpea (Vigna unguiculata).

Criteria for application:
This approach is best suited to situations where soil and crops are managed labour intensively.

Benefits:

- Increased returns to cropped land (provided the ratio of maize to pigeon plants is optimal)
- Accumulation of soil nitrogen through the legume's atmospheric nitrogen fixing ability and making soil phosphates more readily available to maize
- Saving in labour and input costs
- Improved weed and disease control
- High-protein food source from seed and pods and leaves serve as a fodder crop
- More biomass for mulching
- Crop rotation and intercropping reduces soil-borne and other diseases and pests

Catchment perspective:
Intercropping is aimed at the individual field level, but over a whole catchment it can bring all round benefits of (for example) reduced pests and diseases, as well as improved soil health (and thus better infiltration of rainfall, etc.).

Funding opportunities:
Not applicable

Legislation:
Not applicable

METHODOLOGY

Methodology:

1. Interplant pigeon pea between every second row of maize at half the intra-row maize seed spacing – giving a maize and pigeon pea population ratio of 4:1
2. Use a dibble stick to make the planting hole for both the maize and the pigeon pea

Variations/Adaptations:
Relay planting: planting another crop into one which is well established to ensure a continuum of crops

Equipment requirements: Hoe

Maintenance requirements: Not applicable

Photos:

Illustrations/ Diagrams: Not applicable

Figure B.1.1.2-1: Intercropping

Figure B.1.1.2-2: Pigeon pea

Seasonal variations:
To prevent the build-up of pests do not plant the same kinds of plants in the same place year after year. Plant different vegetables every year for example:

- Year 1: Legumes (beans, peas)
- Year 2: Leaf (spinach, lettuce, artichokes)
- Year 3: Fruit (tomatoes)
- Year 4: Root (carrots, beetroot, parsnips, onion, garlic) and repeat from Year 1-Year 4

REFERENCES

See also:
Guideline B.1.1.1. Conservation tillage
Guideline B.1.1.3. Soil cover (mulching)

Further references:

a. Agropedia. Feb 2015. Effective drought and desertification mitigation with Pigeon Pea. Accessed 12 August 2015. https://desertification.wordpress.com/2015/02/23/effective-drought-and-desertification-mitigation-with-pigeon-pea/.

B.1.1.3. Soil cover (mulching)

OVERVIEW

B.1.1.3. Soil cover (mulching)

Soil covers and mulches protect the soil from the heating and drying effects of direct sunlight and the physical damage caused by heavy rain. They also reduce evaporation, and moderate soil surface temperatures. Soil covers also slow surface runoff during rainstorms, reducing erosion and increasing infiltration.

Objectives:

- Conservation agriculture requires the establishment of an early dense cover of crops at the beginning of the rains to capture as much rainfall as possible – and to protect the soil surface from the erosive power of rainfall and the loss of water through runoff.
- After the harvest, crop residues and other plant biomass (e.g. weeds/grass) are not burned or removed from the land. Instead, this valuable biomass is retained and distributed over the soil surface. The result is a protective cover on the ground surface to reduce loss of soil moisture and nutrients.
- As the soil cover decomposes it will return nutrients to the soil. Over time this will result in a protective cover on the ground surface that will reduce the loss of soil moisture and nutrients.

Catchment perspective:

- Maintaining soil cover will reduce physical damage to the surface which then limits runoff and erosion, and reduces silting of rivers and wetlands downstream.
- Increasing water infiltration and maintaining soil moisture reduces the water requirement for irrigation and increases groundwater recharge.
- Slowing water movement in fields can reduce flooding impacts downslope.

Benefits:

- Covering the soil prevents evaporation of moisture from the soil surface, which then results in a higher proportion of soil moisture being available to the plants.
- Mulching captures rainfall and enhances infiltration into the soil. This is particularly beneficial where the rainy season is limited to 3-4 months and often occurs in heavy downpours which promote runoff and soil loss/erosion.
- It restores healthy biological activity in the soil which, in turn, increases soil fertility through the gradual breakdown of organic matter and the release of nutrients that can be absorbed by plants.
- The increase in organic matter in the soil improves soil aeration and porosity which enhances root growth. It also increases the water holding capacity of the soil.
- The additional organic matter enhances pH buffering and thus enables the soil to act like a sponge, retaining water and nutrients which are then available to plants.
- It also moderates soil temperature which can improve plant growth and reduce evaporation.

Cover reduces weed growth (but only if in adequate quantities to provide a dense cover that suppresses weed germination).

Criteria for application:

- It is important to exclude plant material with weed seeds in it for covering the soil. Weeds can be used – but only before they develop seeds.
- It can be advantageous to plant leafy plants such as Comfrey or Mexican Sunflower (*Tithonia* sp.) in areas not suitable for cropping to use as a supply of mulch, e.g. steep slopes, rocky soil, borders of fields.

Livelihood opportunities:
Improved water retention and soil fertility improves crop yield, contributing to household food security.

Funding opportunities:
Not applicable

Legislation:
Not applicable

METHODOLOGY

Methodology:

1. Discontinue/ prevent burning of crop residues and weeds prior to planting. The stems of weeds should be broken or cut, leaving the roots in the soil to help bind it and leaving the broken or cut biomass on the soil as cover. As it decomposes it will return nutrients to the soil. The green matter will protect the soil from soil moisture evaporation and erosion.
2. Minimise removal of crop residues for fodder or fuel.
3. Use minimum or zero tillage techniques to retain residues on the surface rather than cultivating them into the soil.
4. Fertilize grain crops adequately to produce good yields and also substantial crop residue – which is the main source of organic mulches.
5. Where crop residues are minimal and if it is practically feasible, permissible and sustainable, the application of plant residues from outside the cropping area will be beneficial to ‘prime’ the system.
6. Where small-scale irrigation is practiced such as with treadle pumps, hand application of organic material will greatly improve irrigation efficiency and provide all the other benefits of mulching described above.
7. The application of animal manure or compost will not only improve the nutrient status of the soil but will contribute to mulching.

Photos:

Illustrations/ Diagrams: Not applicable

Equipment requirements:

- Slashers

B.1.1.3. Soil cover (mulching)

Figure B.1.1.3-1: Soil covered by a grass mulch (Source: S. Braid)

Variations/Adaptations:

- Green manuring is the practice of planting a legume crop not as a cash crop but for incorporation into the soil to increase fertility levels and organic matter content of the soil.
- Areas outside the field also need to be kept covered to prevent erosion. Plant useful plants such as *Tithonia* sp., *comfry, tephrosia* sp. That can be used in other processes on the farm such as composting, green manure.

Seasonal variations:

It is best to apply plant material as a cover well before the planting season so that the bacteria which multiply while helping to decompose material do not compete with the seedlings for nitrogen. The mulch will also be in place before the erosive early rains begin.

MAINTENANCE

Maintenance requirements:

- The opportunity to build significant amounts of biomass mulch. Until a dense mulch of organic matter is achieved, weed infestation will remain a challenge and will require the use of herbicides.
- The use of chemical herbicides is expensive and requires specialist equipment and appropriate training. The effectiveness of some herbicides is reduced by mulch on the surface as high rates of organic matter 'tie-up' many chemicals

REFERENCES

Definitions:

Not applicable

Further references:

Not applicable

See also:

Guideline B.1.1.1. Conservation tillage
Guideline B.1.1.2. Crop rotation and intercropping
Guideline B.2.1. Compost making
Guideline B.2.2. Natural fertilizers
Guideline B.2.5. Agroforestry
Guideline D.1.4. Selecting beneficial trees
Guideline E.3.1. Living fences and wind breaks

B.1.2. Natural farming

B.1.2.1. Designing a natural farming garden

OVERVIEW

Energy can be saved by laying out the farm and household cultivation/ farming beds and plots more efficiently. This guideline outlines how to design an efficient natural farming (permaculture) garden.

Objectives:

- Design food producing systems
- Use resources that are available nearby

Criteria for application:

Applied at the household and village level.

B.1.2.1. Designing a natural farming garden

Catchment perspective:	Benefits:
• A key component is energy, and saving energy. Nutrients enrich the soil and need to be saved where possible to assist in feeding plants. They need to be replenished when plant products are removed from the garden, e.g. by compost, nitrogen-fixing legumes, green manures, fertilizers • Layout of 'sectors' (see diagram) depends on external factors including wind and rain direction, sun and shade, and flow of runoff water (for water harvesting) • Lay the plot out correctly to reduce the negative/ utilise the positive external influences	• Not a lot of money needed to start permaculture, because waste is re-used • Sectors help to manage external influences • Reduce the strength of the wind and also reduce water loss from the garden • Saving energy by putting the things that need work every day (most intensive) in the zones closest to the house • Zones help to manage internal influences • Sectors help deal with external influences **Livelihood opportunities:** A household vegetable garden growing a range of nutritional produce helps ensure household food security, savings from buying foods that can be used for other expenses. Surplus produce can also be sold to supplement household income
Funding opportunities: Not applicable	**Legislation:** Not applicable

METHODOLOGY

Methodology:

1. Divide the land into zones and sectors. Sectors are pie-shaped wedges that radiate out from Zone 1 and help manage external influences such as wind, heavy rain, shade, direction of runoff water, etc.
   a. Determine from which direction the strong winds come from – this will be the wind sector
   b. Once we have identified the direction of wind – that is where to plant windbreak trees and hedges
   c. Similarly, where there is shade, plant shade-loving plants; where there are thieves (including animals!) plant thorny plants or build a fence; and where there is runoff water manage this with vegetative barriers, swales or other water harvesting techniques
2. Once the sectors have been identified it is easier to design the garden if the land being used is now divided into zones
   a. Zones are areas of land and space that are separated out in a special way (e.g. rocks, vegetation barriers, fences, etc.) to make it clear that the use of that space is for specific activities or crops
   b. Zones can be divided for example into Zone 1-Zone 5, with Zone 1 being closest to the home and Zone 5 being furthest.
   c. Zone 1 has activities and services that require it to be visited most often, e.g. the vegetable garden and Zone 5 is normally wild and visited the least often, e.g. "wild lands", forests, wetlands
3. Locate the vegetable and herb garden near the home because that is where vegetables are cooked every day
4. Situate the vegetable garden where it is warm (sun sector) and sheltered from the wind
5. Zones are also about protection. Things that need the most protection, such as vegetable gardens and animals, must be kept as close to the homestead as possible
6. Draw a diagram on a piece of paper or on the ground; fill in what resources are available and the direction of external influences
7. Decide what future work will be done in each zone

Illustrations/ Diagrams: It is easier to design the garden if the land being used is divided into "zones" and "sectors" as described above.

B.1.2.1. Designing a natural farming garden

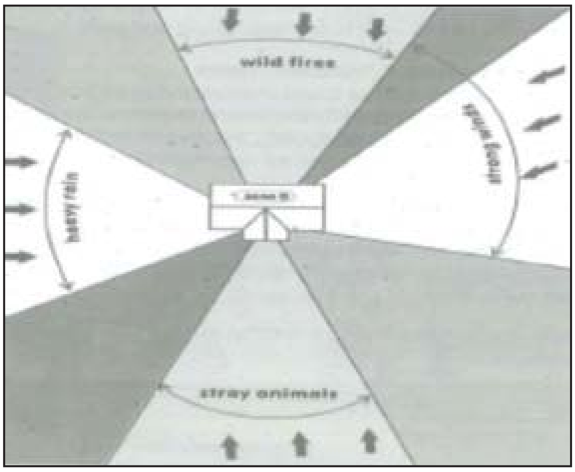


Figure B.1.2.1-1: External influences allocated into sectors. (Source: Food & Trees for Africa)

Identifying the external influences and allocating them into sectors will help with planning how to design and establish each of the zones.

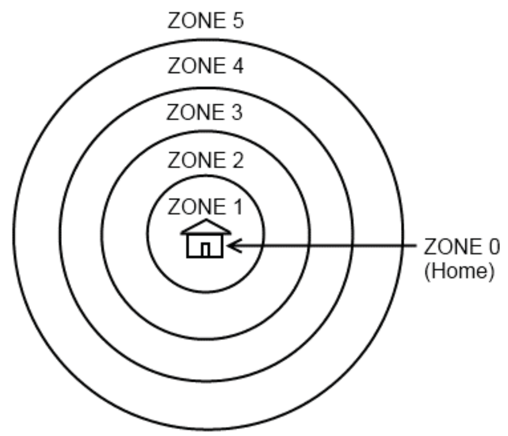


Figure B.1.2.1-2: A typical zone layout: Spinach, tomatoes, herbs, dwarf fruit trees, and other often-used items in Zone 1. Crop rows, berries, useful shrubs, a pond, chickens, and a food forest are in Zone 2. Zone 3 holds larger fruit and nut trees, while Zone 4 is for foraging and firewood. A corner of the yard can be left wild for Zone 5. The inset drawing shows an idealised pattern of concentric zones around a house or other main building. (Source: Deep Green Permaculture)

Equipment requirements:

- Containers and hanging baskets
- Fencing / vegetation barriers, e.g. vetiver grass, napier grass, elephant grass, comfrey
- Hoe
- Shovel

Photos: Not applicable

Variations/Adaptations:

The number of zones can differ, depending on the space available. The example provided is from zone 1-5 but there can be more or fewer zones.

Seasonal variations:

- Plant vegetables according to seasons
- Try "intercropping" (growing different kinds of plants together to improve soil fertility): for example, plant trees with rainfed crops like maize/corn, sorghum, millet, potatoes, sweet potatoes, squashes, pumpkins, cucumbers and cowpeas (imbumba) between.

MAINTENANCE

Maintenance requirements:

- Keep the vegetable garden carefully fenced
- Visit the vegetable garden often
- Maintain channels and trenches
- Should dongas and soil erosion occur (e.g. Zone 4) fix these by making check dams, vegetation barriers, swales or berms to stop the erosion

REFERENCES

Definitions:
Not applicable

See also:
Guideline B.1.2.2. Where to plant what
Guideline B.1.2.3. When to plant what
Guideline E.2.1. Nutrition in the home
Guideline D.1.4. Selecting beneficial trees
Guideline E.3.1. Living fences and wind breaks

Further references:

a. Food & Trees for Africa. Growing Green. www.trees.co.za
b. Deep Green Permaculture. Accessed on: 31 August 2015, online at http://deepgreenpermaculture.com/permaculture/permaculture-design-principles/4-zones-and-sectors-efficient-energy-planning

B.1.2.2. Where to plant what

OVERVIEW

Different types of plants grow better if their planting location is structured according to the plant's specific characteristics. This guideline provides an overview of what plants should be planted where, based on timing, space available and relationship between plants.

Objectives:
Produce a constant supply of fresh, top quality vegetables throughout the year.

Catchment perspective:
Improve yields with a variety of vegetables over several years.

Livelihood opportunity:
Productive and nutritional fruit and vegetables contribute to household food security.

Criteria for application:
- Start with plants that are easy to care for in Zone1
- Several swales should form part of Zone 2
- Choose beneficial trees for Zone 3 which can also be used for fuel wood, fruit and for medicinal purposes (See **D.1.4. Selecting beneficial trees**)

Benefits:
- Save energy by planting the right plants in the right places
- Improved growing efficiency of crops and vegetables

Funding opportunities:
Not applicable

Legislation:
Not applicable

METHODOLOGY

Methodology:

1. Stacking and packing
- Use "stacking" to save space. Stacking is like packing a box carefully. It is the same in a garden. Put short plants under tall ones to pack more plants into a garden rather than spacing all the plants out. Check that the short plants like to grow underneath others – tall growing mustard plants, for example, can protect lettuce from too much sun. Also, planting narrow upright plants like spring onions between more spreading plants saves space. Use climbing plants, trees, short shrubs and then vegetables and flowers to these into a small space. Stake climbing plants with maize stalks.

2. Time stacking
- Plant a few vegetable seeds or planting seedlings each week to make sure that there are always new plants coming up to replace those that are picked and eaten. After every harvest sow again. Mix radish, carrot, lettuce, parsley and parsnip – and sow at the same time. Radishes will come up first and give shelter to the lettuce and carrots. Harvest the radishes to make space for the other plants. Parsley comes up next and last of all, the parsnips.

3. Making plant communities or guilds
- "Guilds" are small groups of plants that help each other. For example, fruit trees like to grow with herbal ground covers, not grasses. Plant comfrey, vetch, lupins, beans or nasturtiums. Plant legumes such as beans, peas and lucerne near other plants because they put food (they "fix nitrogen") into the soil that the other plants can use. Trees / shrubs such as the honey locust, pigeon peas and acacias also make nitrogen available to the plants that grow around them. Some plants, like lucerne and Acacia karroo have very deep roots. They bring nutrients from deep under the soil and make them available for other plants.

Equipment requirements:
- Line level
- Hoe
- Seeds
- Watering equipment

Photos: Not applicable

Variations/Adaptations:
Alter the vegetable or crop types throughout the year, see **Guideline B.1.2.3 When to plant what**

Seasonal variations:
Should wind occur all year round choose trees that keep their leaves the whole year (evergreens).

Illustrations/ Diagrams:

B.1.2.2. Where to plant what

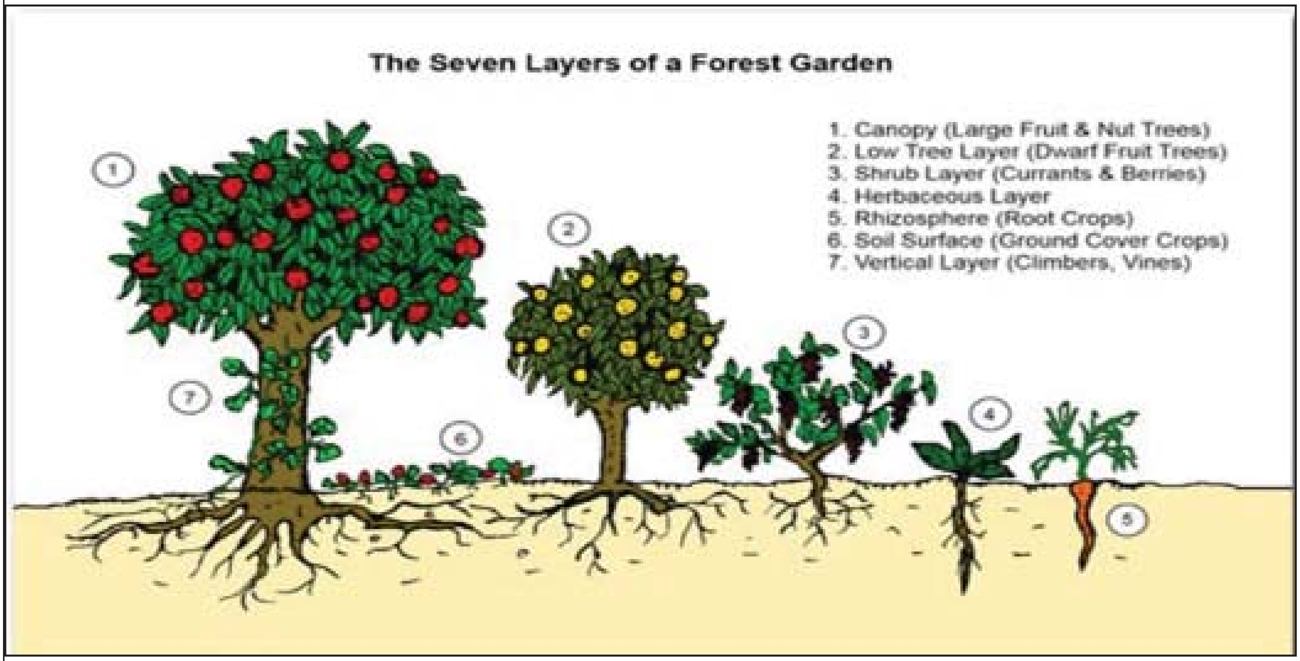


Figure B.1.2.2-1: Example of a plant community. (Source: Deep Green Permaculture)

Figure B.1.2.2.2 Table of companion planting. (Figure inserted on the next page).

Companion planting refers to plants that can help each other when growing together. Some of the ways in which different plants can help each other are:

- Through root secretions: for example, marigold roots secrete a poison that protects the roots of tomatoes and spinach from nematodes (these are also knows as roundworms and are much smaller than the good brown earthworms)
- Aroma/smells from leaves: for example, herbs like rue, worm wood (mlonvane and khakibos) have a strong smell that repels (chases away) insects like aphids and worms from other plants close-by
- Pennyroyal (a type of mint) grows well as a ground cover under brassicas. It is good for repelling mosquitoes and aphids and other insects like ants and termites

MAINTENANCE

Maintenance requirements:

- Once crops are selected, plant the crops and vegetables in the different zones.
- Water the plants/seeds regularly. Monitor the garden.
- Keep soils covered with mulch.
- Break weeds at the stem close to the soil and leave the top growth on the soil, the roots will continue to bind the soil until they decompose. Remove any seeds from the weeds first.
- Dead leaves, cut grass, etc. can be scattered on the ground and over the crop beds to keep the soil covered and moisture in the soil.
- Permaculture beds initially don't look neat and tidy, but it is a much more sustainable practice – so persevere!

REFERENCES

Further references:

a. Food & Trees for Africa. Growing Green. www.trees.co.za.

b. Deep Green Permaculture. *Small Scale Intensive Systems*. Accessed 12 August 2015, online at http://deepgreenpermaculture.com/permaculture/permaculture-design-principles/7-small-scale-intensive-systems/.

See also:

Guideline B.1.1.2. Crop rotation and intercropping
Guideline B.1.2.1. Designing a Natural Farming garden
Guideline B.1.2.3. When to plant what
Guideline D.1.4. Selecting beneficial trees
Guideline E.2.1. Nutrition in the home


COMPANION PLANTING

IN NATURAL ECOSYSTEMS, PLANTS PERFORM FUNCTIONS THAT CAN EITHER HELP OR PREVENT OTHER PLANTS TO GROW. THE SAME IS TRUE IN OUR GARDEMS. THIS CHART WILL HELP YOU UNDERSTAND WHICH PLANTS GROW WELL TOGETHER AND WHICH TO PLANT FAR APART

Plant	Good companions	Bad companions
Beans	Maize, Sunflower, Lavender, Cabbage, Cucumber, Strawberries, Brinjal	Onion, Garlic, Fennel
Beetroot	Beans, Onions, Garlic, Lettuce, Cabbage	No bad companions
Brinjal	Calendula, Marigold, Mint, Peas	No bad companions
Broccoli, Cabbage, Cauliflower, Kale	Aromatic plants, Dill, Sage, Rosemary, Potatoes, Beetroot, Sage, Garlic, Onions, Geranium	Tomato, Pole and runner beans, Peppers
Carrots	Lettuce, Chives, Leeks, Rosemary, Sage, Peas, Wormwood	Strawberries, Fennel, Cabbage
Lettuce	Carrots, Radish, Strawberries, Cucumber, Beans	Celery, Parsley
Maize	Sunflowers, Amaranth, Beans, Peas and other legumes, Pumpkin, Squash, Cucumber, Melons and other Cucurbits, Parsley	Cabbage, Tomato, Celery
Onion /Garlic	Carrots, Beetroots, Strawberries, Tomatoes, Lettuce, Cabbage	Peas, Beans, Parsley, Leeks
Peas	Lavender, Carrot, Turnip, Radish, Cucumber, Maize, Beans. Grows well with most vegetables and herbs	Onion, Garlic
Peppers	Tomatoes, Geranium, Basil, Carrot, Onions	Beans, Kale, Cabbage family
Potatoes	Coriander, Marigold, Beans, Maize, Cabbage family, Brinjal	Pumpkin, Cucumber, Squash, Melons, Sunflower, Tomatoes
Spinach	Strawberries, Broad beans, Peas	No bad companions
Tomatoes	Basil, Oregano, Parsley, Chives, Nasturium, Onions, Carrots, Celery, Calendula, Geranium, Borage	Potatoes, Fennel, Cabbage family
Calendula	Tomatoes - repels tomato worms	General pest deterrent, plant throughout garden
Comfrey	Fast-growing nutrient accumulator Plant along edges & use leaves for mulch	Compost activator, use leaves to make comfrey tea fertilizer
Chili Pepper	Cabbage, Maize	Repels cabbage moth. Plant on borders to keep flying pests away
Marigold	Plant freely throughout the garden - repels soil nematodes aphids, bean beetles & many more	Use marigold leaves to make an organic general insecticide spray
Nasturtium	Tomatoes - improves flavour	Repels white flies and spider mites
Thyme	Cabbage	Deters cabbage worms
Rosemary	Carrots, Cabbage, Sage, Beans	Deters cabbage moth, bean beetles and carrot fly
Wormwood/ Artemesia	Around garden edges	Keep animals out. Also repels white fly
Yarrow	Plant freely throughout the garden - repels soil nematodes aphids, bean beetles & many more	Plant near aromatic herbs to enhance essential oil production

A DIVERSE GARDEN IS AN ABUNDANT GARDEN. HAPPY PLANTING

Figure B.1.2.2-2 Table of companion planting. (Source: Afristar)

B.1.2.3. When to plant what

OVERVIEW

Different crops and plants are suited to being planted during different seasons and months. In order to gain the best growth from the crops they should be planted in their preferred month or season. This guideline provides information on which vegetables are suitable to plant in which season / month.

Objectives: To plant the appropriate fruit and vegetable at its applicable growing time.	**Criteria for application:** Seasonal application.
Catchment perspective: Food security contributes to healthy community, who can then undertake various livelihood and catchment management activities.	**Livelihood opportunities:** Ensuring nutritional food supply throughout the year contributes to household food security **Funding opportunities:** Not applicable
Benefits: Less energy spent growing a low-producing yield out of season.	**Legislation:** Not applicable

METHODOLOGY

Methodology:

1. Plant the crop or vegetable in the appropriate month or season.

Illustrations/ Diagrams: (Figure inserted on the next page) **Figure B.1.2.3-1:** Summer rainfall planting calendar. (Source: Afristar)	**Photos:** Not applicable
Equipment requirements: • Garden tools • Seeds • Plants • Watering equipment	**Variations/Adaptations:** Plant perennial plants and self-seeding plants. **Seasonal variations:** Crops must be planted at the right time of year to make sure that they survive and thrive.

MAINTENANCE

Maintenance requirements:

- Water the plants/seeds regularly
- Monitor the garden
- Keep soils covered with mulch
- Break weeds at the stem close to the soil and leave the top growth on the soil, the roots will continue to bind the soil until they decompose
- Remove any seeds from the weeds first
- Dead leaves, cut grass, etc. can be scattered on the ground and over the crop beds as mulch to keep the soil covered and moisture in the soil

REFERENCES

Further references:

a. Agricultural research (ARC). (2013) Production guideline for summer vegetables
b. Agricultural research council (ARC). (2013). Production guidelines for winter vegetables.
c. Food & Trees for Africa. Growing Green. www.trees.co.za

See also:

Guideline B.1.1.2. Crop rotation and intercropping
Guideline B.1.2.1. Designing a natural farming garden
Guideline B.1.2.2. Where to plant what
Guideline E.2.1. Nutrition in the home
Guideline D.1.4. Selecting beneficial trees

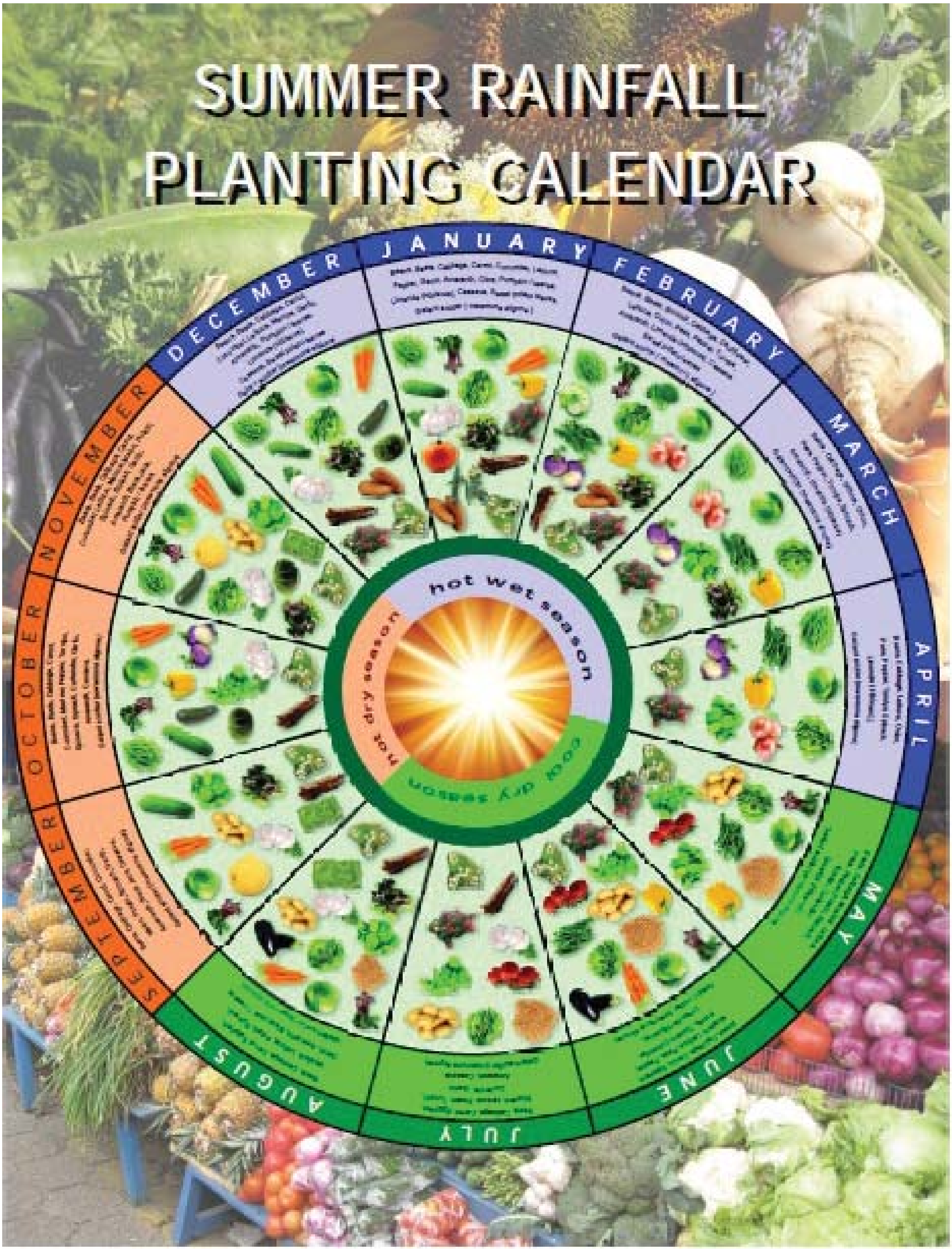


Figure B.1.2.3-1: Summer rainfall planting calendar (Source: Afristar).

B.2 Nutrient management

B.2.1. Compost making

OVERVIEW

Compost helps return nutrients to the soil, reduces reliance on chemical fertilizers, increases soil organic matter, maintains moisture and provides soil cover. This guideline outlines how to make and apply compost.

Funding opportunities: Not applicable	**Legislation:** Not applicable
Benefits: • Cost-effective, valuable fertiliser to apply to high value crops within homesteads • Can be made in the period when labour requirement to fields is low • Diseases, pests, and weed seeds are destroyed by high temperature produced during composting	**Livelihood opportunities:** Improved soil fertility contributes to improved productivity and crop yield which contributes to household food security. **Objectives:** Promote compost making at household level for cost-effective soil fertility improvement.
Criteria for application: Seasonal application.	**Catchment perspective:** Composting is done at the household level. It contributes to improve soil fertility and saves money on expensive chemical fertilizers.

METHODOLOGY

Methodology:

A – Compost

1. Changu (Chinese) method
   a. Measure 11/2 to 2 m (11/2 to 2 spade lengths) diameter circle by using a peg and string
   b. Heap 20-30 cm (foot to spade head) thick layer of composting material over marked area to form compost heap base
   c. Water the heap adequately until moisture just seeps out when the materials are squeezed
   d. Add 3-5 cm (hand width) manure/booster on top and water adequately
   e. Repeat steps 2 to 4 until the heap is 11/2 m (11/2 spade length) high with the diameter of each subsequent layer reducing to achieve a conical shape
   f. Cover heap with grass to reduce evaporation
   g. Insert a stick into compost heap to check if decomposition has started. It should be warm/ hot: if it is not warm, dismantle heap and start process again
   h. Where decomposition has started, turn the heap after 3-4 days and thereafter every 4-5 days to speed up decomposition
   i. During the turning process, remove the outer layer from the heap and separate the middle layer from the inner layer
   j. In the process of rebuilding the heap:
      i. Put outer layer at bottom and water adequately
      ii. Put inner layer in middle and water adequately
      iii. Lastly, put middle layer on top/outside of heap, water and cover heap with grass
   k. Normally the heap will mature within 30-40 days depending upon the nature of composting materials
2. Chimato method (For wet regions)
   a. Follow steps 1 to 7 of the Changu method, except that two cross poles are fixed vertically at the base and a third pole is fixed horizontally at the centre when making the compost
   b. Remove the three poles after piling the compost materials
   c. Smear the compost heap with mud after piling and remove poles leaving the vents open
   d. Cover the heap with grass or plastic to maintain moisture
   e. Close the top vent from the pole that was removed after 2 to 3 days
3. Wooden frame method
   a. Measure out a square of 1.5 by 1.5 m. Construct a frame 1.5 m long by 1.5 m wide and 1.5 m high
   b. Follow steps 2 to 7 of the Changu method
   c. Where decomposition has started, turn the heap every month.
   d. Pile composting material 20-30 cm high and water adequately
   e. The composted material will be ready after 2-3 months depending on composting material used
4. Pit method (for dry regions)

B.2.1. Compost making

a. Measure out a square of 1.5 by 1.5 m. The length may be extended in multiples of 1.5 m
b. Dig a pit of not more than 1.0 m deep. Separate the topsoil from the subsoil
c. Put manure to a depth of 3 to 5 cm at the bottom of pit, and water manure until saturated
d. Fill with composting material to 20-30 cm in thickness and water adequately
e. Repeat steps 3 to 4 till pit is full
f. Cover heap with about 8 cm topsoil and add grass/mulch to reduce evaporation
g. After 1 to 2 weeks check for warmth by inserting a stick. If not warm, dig out heap and start the process again
h. The composted material will be ready after 2-3 months depending on the composting material used
i. The pit method is not recommended during the rainy season because of potential waterlogging conditions

B – **Liquid manure "tea"**

a. Use an old, non-leaking bucket or drum with something that can be used as a lid
b. Put some fresh cow, horse, sheep, goat or chicken manure in an old sock / cloth
c. Alternatively use leaves of Mexican Sunflower (*Tithonia diversifolia*)
d. Knot the bag. Put it in the bottom of the bucket with water and cover it. Leave it for a month. Stir with a stick once a week
e. To use the "tea":
f. Put two tin mugs full of the "tea" into a 5 litre bucket to dilute the "tea"
g. Then fill with fresh water until the mixture looks like weak tea
h. Now give this weak tea mixture to the plants
i. Trees will need one bucketful each
j. This can be used every two weeks in spring and summer to make the trees grow faster
k. Water the soil around the plants with the "tea" – not directly on the plants themselves

Equipment requirements:

- String and pegs
- Shovel/hoes
- Water and bucket for watering / Bucket for liquid manure
- Composting material which includes grass, crop residues, leaves of various plants, green fresh material, leaves from legumes, vegetable/fruit, waste from kitchen
- "Booster" with high nitrogen content (e.g. animal manure) and/or previously made compost
- Log, bricks or stone and small poles for Chimato method
- Old sock or cloth

Illustrations/ Diagrams:

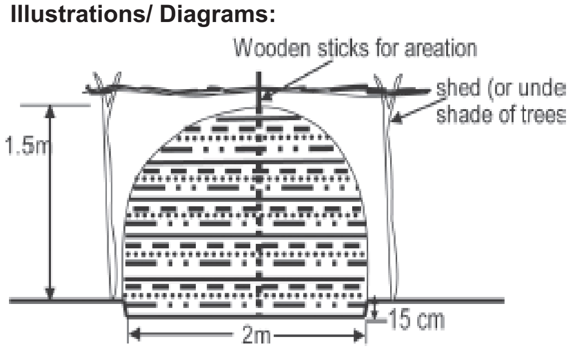


Figure B.2.1-1: Compost making using *Chimato* method

DON'T COMPOST

- Plastic bottles
- Pieces of china/ porcelain plates
- Batteries, light bulbs
- Aluminium, e.g. foil, wrappers, baking trays
- Any kind of plastic, including ear buds, straws, washing powder packets, plastic shoes
- Polystyrene, e.g. meat trays
- Human, cat or dog manure
- Weeds with seed heads

Figure B.2.1-2: Rubbish – Material that should **NOT** be added to the compost. (Source: Food & Trees for Africa)

B.2.1. Compost making

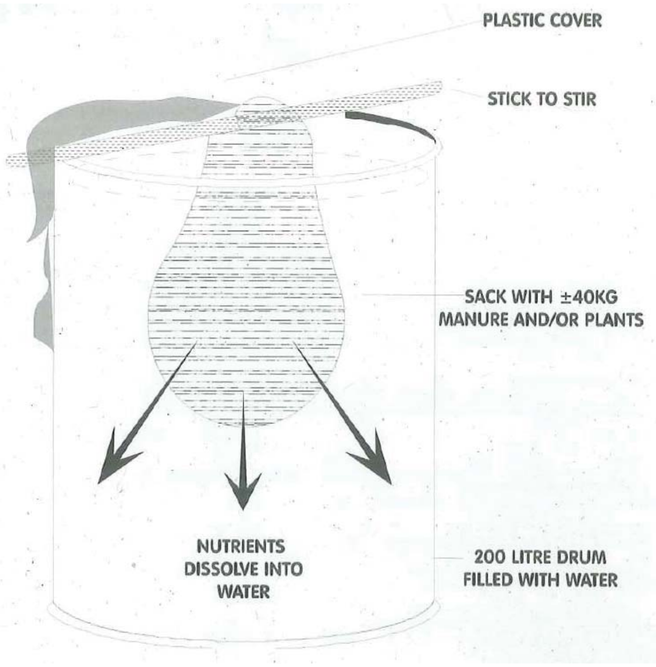


Figure B.2.1-3: Liquid manure "tea". (Source: Food & Trees for Africa)

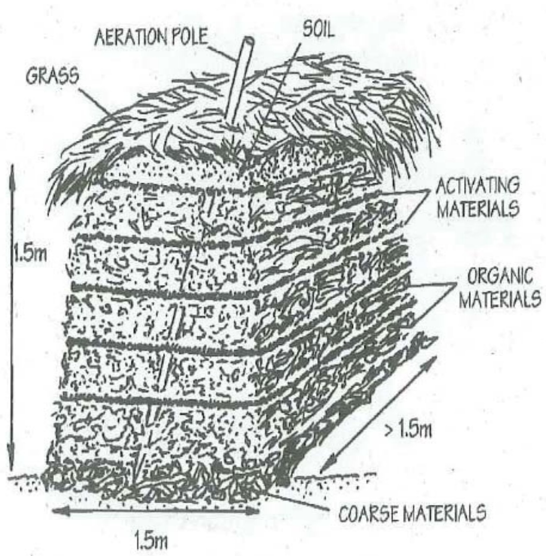


Figure B.2.1-4: Compost heap. (Source: Food & Trees for Africa)

Photos:

Figure B.2.1-5: In-field compost mound (Source: S. Braid)

Figure B.2.1-6: Compost making using pit method. (Source: Critchley W, Di Prima S and Tuyp W.)

Variations/Adaptations:
See methodology for variations

Seasonal variations:
Not applicable

MAINTENANCE

Maintenance requirements:

- Compost heap must be kept relatively moist, but must not be wet. It should feel like a wet sponge
- Heap should be placed in shade or under a shed to prevent it from drying out
- Proper ventilation can be achieved by mixing fine and rough materials. Every point in the heap should be within 70 cm of a ventilation point. Turning over also allows air to enter
- DO NOT use plants that have been attacked by pests or diseases, or weeds that have seed heads. Rather burn these and use the ashes to spread around trees. Do not use coal ash as it poisons rather than feeds the soil.

Potential drawbacks/disadvantages:

- Composting is labour-intensive which can be a limitation if labour is in short supply
- Not enough organic material available
- Composting without manure is difficult
- Compost heap can attract pests if heap is kept in farmyard instead of field

REFERENCES

Definitions:

See also:

B.2.1. Compost making

Not applicable	**Guideline B.1.1.3. Soil cover (Mulching)** **Guideline E.6.1. Household waste management**

Further references:

a. Food & Trees for Africa. Growing Green. www.trees.co.za

b. Critchley W, Di Prima S and Tuyp W. 2012. Sustainable land management in Sub-Sahara Africa information cards. No 9 Integrated Soil Fertility Management. VU University Amsterdam

c. Desta L, Carucci V, Wendem-Agenehu A, Abebe Y. 2005. Community based participatory watershed development: A Guideline. Ministry of Agriculture and Rural Development, Ethiopia

d. Sollod L. 2010. Composting Guide. Accessed online at http://www.organicsforall.org/composting.htm. 14 August 2015

e. Ministry of Agriculture, Irrigation and Food Security. Guide to agricultural production and natural resources management. Agricultural Communication Branch, Ministry of Agriculture, Irrigation and Food Security

f. Environmental Affairs Department. 2005. Community environmental management manual – Soil conservation and fertility improvement

B.2.2. Natural fertilizers

OVERVIEW

In order to improve soil fertility, this guideline outlines how to use inorganic or natural fertilizers in order to restore nutrients into the soil.

Objectives:

Maize is a dominant staple crop in South Africa, because it provides the best edible grain return for the environment. However, continuous cropping without adding soil nutrients will lead to reduced soil fertility, declining yields, and increased food insecurity. There is a limit to the ability of soils to provide available nutrients (particularly macro-nutrients) for continuous crop production without addition from outside sources.

Livelihood opportunities:

Good crop productivity and yield contributes to household food security. Additional yield can be sold to supplement income.

Catchment perspective:

- In densely populated rural areas heavily dependent on subsistence agriculture, land scarcity prohibits the devotion of land to the restoration of soil fertility. Crop rotation and intercropping with legumes contributes significantly to crop nitrogen requirements but does little for replacing phosphates or potassium to the soil.
- A balance of all essential soil nutrients is necessary for healthy plant growth. The application of any one nutrient in a soil with multiple nutrient deficiencies will have limited impact on crop growth. For example, the efficiency of nitrogen uptake is affected by the availability of other nutrients, particularly P, K and S.

Funding opportunities:

Not applicable

Legislation:

Not applicable

Criteria for application:

- The most significant nutrient deficiencies, as a consequence of "mining" arable lands, are nitrogen and phosphorus. Deficiencies of boron, zinc, molybdenum, copper, magnesium and manganese in addition to sulphur have been reported by researchers in recent years.
- Where soils are naturally high in potassium, and consequently fertilizer recommendations for many decades have excluded potassium. However recent research shows that continuous maize cropping is resulting in soil potassium depletion. Trial applications in most maize growing areas have shown significant response to potassium fertilization.
- The essential nutrients for maize (and all other crops) are the macro-elements nitrogen (N), phosphorus (P), potassium (K) and a range of micro-elements such as sulphur (S), boron (Bo), manganese (Mn), iron (Fe), magnesium (Mg), copper (Cu) and zinc (Zn). Of these micro-nutrients, sulphur (S) is required in the largest quantities by crops and is often added to macro-nutrient fertilizers.
- There are effectively only three sources for supplying the key nutrients, particularly nitrogen, in arable farming:
    1. Organic sources recycled from within the cropped area or concentrated from a larger area (mulching, compost, leaf fall; manure) (see **Guideline B.1.1.3 Soil cover (Mulching)** and **Guideline B.2.1 Composting making)**
    2. Biological nitrogen fixation (see **Guideline B.2.5 Agroforestry**)
    3. Mineral (inorganic or chemical) nitrogen fertilizers
- Fertilizer use is an essential component of sustainable and productive maize production for the following reasons:
    - Continuous cropping of maize where soil nutrient extraction consistently exceeds soil nutrient addition has resulted in soil nutrient depletion ("nutrient mining").
    - The intensity of dryland cropping and limited livestock numbers precludes the use of manure as a major source of replacement nutrients for maize production
    - Intercropping and crop rotation with legumes can make a contribution to the soil nutrient requirements for maize but cannot provide all the requirements
    - The positive impact of the Farm Input Subsidy Programme – which includes a fertilizer package – demonstrated conclusively (through the highly significant increase in the national maize harvest), the value of applying inorganic fertilizers to maize

Benefits:

- Improved crop yields through improved soil fertility and nutrients
- Increase yield contributes to increased food security and potential income.
- The production of organic fertilizers could form alternative income generation projects

METHODOLOGY

Methodology:

1. Split application of fertilizer is important to prevent loss of nitrogen by leaching (drained deep by infiltrating rainfall) before fully absorbed by the crop. This is particularly important on sandy (lighter) soils. However split applications of P or K fertilizers or the application of the basal fertilizers P and K after crop emergence will reduce yields significantly and is not recommended.

2. Modest use of fertilizers is therefore strongly encouraged to boost crop yields and increase the quantity of biomass needed to protect the land from runoff and erosion as recommended in the guidelines for conservation agriculture.
3. If resources allow, either through the Malawi subsidy program or from the open market, chemical fertilizers should be applied at an economical rate as follows (this recommendation refers to maize):
   a. Basal Dressing at time of planting: Apply 100 kg (2 bags) of 23:21:0+4S per ha. This provides 23 kg of N/ha, 21 kg of P/ha and 4 kg of S/ha. If potassium deficiencies are suspected, a mixture containing potassium is recommended or a top-dressing of KCl can also be applied
   b. Top Dressing two weeks after planting: Apply 100 kg (2 bags) of Calcium Ammonium Nitrate (CAN) per ha – this provides 25 kg of N/ha or 1 bag/ha of Urea – which provides 23 kg of N/ha.

Variations/Adaptations:

Use of organic fertilizers to replenish soil nutrients is both cheaper and more environmentally friendly than chemical fertilizers. However, where soil nutrients are significantly depleted then chemical (inorganic) fertilizers are required.

Sources of organic nutrients:

Potassium (K)

- Wood Ash: The original source of “potash” fertilizers, hardwood ashes can be used directly as a fertilizer (about a 20 litres bucket per 1000 square metres) or added to your compost pile to increase the potassium content. Wood ash also raises soil pH, so be sure to do regular soil testing to make sure it stays balanced
- Compost: Compost is full of nutrients, including potassium, especially if it is beefed up with banana peels and other fruit and vegetable waste. The potassium compounds in compost are water-soluble, which makes them readily available to plants but also likely to leach out of your compost pile over time

Nitrogen (N)

- Composted Manure: The nitrogen content of manure from grass-eating animals varies, but it is a great source of both nitrogen and organic matter. Because raw manure can burn plants and may contain weed seeds and pathogens, compost it in a hot pile or age it for at least 6 months. To use fresh manure, spread it over the soil in dry months and turn it into the top 6 inches a month before spring planting
- Poultry Manure: Manure from chickens and other poultry is an excellent source of nitrogen, potassium, and phosphate. Fresh manure contains a lot of ammonia and is “hot,” so till it in at least 4 months before planting, or compost it first. (Refer **Guideline B.2.1 Compost making**)
- Blood Meal: This fast-acting fertilizer, made from slaughterhouse waste, is a potent, easy-to-find source of nitrogen. Blood meal can burn plants, especially young seedlings. Mix it with water and apply it through your irrigation system or a watering can, or dig it lightly into the soil before planting
- Feather Meal: Dried chopped chicken feathers contain keratin, a tightly structured protein that’s not easily broken down by soil bacteria, making this an excellent, long-term source of nitrogen. Incorporate into soil before planting
- Alfalfa Meal: This excellent source of nitrogen, phosphorus, and potassium also encourages beneficial microbes. Alfalfa decomposes rapidly, generating heat, so do not use it directly in planting holes or in contact with fragile roots. Scratch it lightly into the soil surface
- Cottonseed Meal: The ground meal from cottonseeds provides nitrogen in a fairly slow-release form and is slightly acidic, so use on plants that require a low pH. Some organic gardeners avoid cottonseed meal because, unless the cotton crop was grown organically, it may have come from a field of genetically modified cotton or contain residues of toxic pesticides. The same can be true of other plant-derived fertilizers
- See also **Guideline B.2.5 Agroforestry** for infield nitrogen fixing and **Guideline B.2.1 Compost making** for green manures, e.g. comfry and Tithonia diversifolia.

Phosphorus (P)

- Bat manure: Guano (manure) from fruit-eating bats is high in phosphate. Application: 1-1.5 kg/10 m^2
- Fish bone meal: Made from steamed, fish bone meal, is readily absorbed by microorganisms and plant roots in the soil. Application: 0.5-1 kg/10 m^2
- Cattle bone meal: Made from steamed, ground cattle bones. P in bone meal is highly plant-available. Great mixed into the planting hole with bulbs. Application: 4.5 kg/10 m^2
- Chicken manure: Good manure source for P and some K. Application: 5-10x 20 litre buckets/10 m^2 in a 1-2.5 cm layer
- Pig manure: Good, balanced manure source of N, P, and K. Note: some pig parasites and pathogens can infect humans, pig manure is not allowed in many organic protocols. If it is used, it must be hot-composted prior to use or only applied to non-edible vegetation. Application: 10x 20 litre buckets/10 m^2 in a 2.5 cm layer

Sulphur (S)

- Soil conditions where S is most likely to be deficient are low organic matter levels, coarse (sandy) texture with good drainage, and high rainfall conditions. However, sulphur requires some time before it is converted to sulphuric acid with the aid of soil bacteria. This conversion rate is dependent on the particle size of the sulphur, the amount of soil moisture, soil temperature and the presence of the bacteria. As a result, it can take several

B.2.2. Natural fertilizers

months to decrease the pH value.

- Naturally occurring sulphur is usually located around hot springs. Application: 20 kg per 100 m^2 to reduce pH from 8.5 to 6.5-6.8 in sandy soils.

Photos:

Figure B.2.2-1: Maize well-fertilized

Figure B.2.2-2: Maize showing nitrogen deficiency (note yellowing of leaves)

Equipment requirements:

- Inorganic fertilizers
- Safe storage areas
- Shovel
- Compost pile
- Bucket
- Water

Illustrations/ Diagrams: Not applicable

Seasonal variations:

- Potassium is water soluble. Supplies of potassium must be kept dry, whether chemical or organic.
- High runoff after application of inorganic fertilizers can lead to contamination and eutrophication of water resources, including groundwater. Ensure fertilizers are well mixed into the soil before the heavy rains.

MAINTENANCE

Maintenance requirements:

- Monitor the health of crops
- Monitor the health of water resources downstream of fields where inorganic fertilizers are applied. If eutrophication appears, reduce dosing with inorganic fertilizer

REFERENCES

Definitions:
Not applicable

Further references:

a. http://www.grow-it-organically.com/

See also:
Guideline B.1.1.2. Crop rotation and intercropping
Guideline B.1.1.3. Soil cover (mulching)
Guideline B.2.1. Compost making
Guideline B.2.5. Agroforestry
Guideline D.1.4. Selecting beneficial trees

B.2.3. Microdosing

OVERVIEW

Microdosing is low-technology precision agriculture technique initially developed by ICRISAT. Small doses of fertilizer applied in the right place has been found to lead to large benefits in yields for the smallholder farmer.

Objectives:
Microdosing involves the application of small, affordable quantities of fertilizer with the seed at planting time or as top dressing 3 to 4 weeks after emergence. This enhances fertilizer efficiency compared to spreading the fertilizer over the field.

Criteria for application:
Applied at plot and catchment scale.

Funding opportunities: Not applicable

Legislation: Not applicable

Livelihood opportunities: Improved soil fertility and crop yield contributes to household food security.

Catchment perspective:
Will improve yields for both grains and vegetables over several years (or sooner).

Benefits:

- Improved crop yields through improved soil fertility and soil nutrients;
- Higher yield contributes to increased food security.

B.2.3. Microdosing

METHODOLOGY

Methodology:

The farmers who use microdosing apply 6 gram doses of fertilizer, about a full bottle cap or a three finger pinch, in the hole where the seed is placed (at the time of planting).

With conservation agriculture farmers dig small holes before the rain starts, then fill it with manure, if available. When rains begin, they put fertilizer and seeds in the hole and the soil provides a moist environment, encouraging root growth, and the water is captured instead of running off the hard-crusted soil. Fertilizer should not be place directly on to the seeds.

Equipment requirements:
Bottle top or bottle cap.

Variations:
A larger amount of fertilizer can be added if it is available. The application method should remain the same.

Illustrations/ Diagrams: Not applicable

Photos:

Figure B.2.3-1: Micodosing fertilizer. (Source: N. Walker)

Photos:

Figure B.2.3-2: Three finger pinch for microdosing fertilizer. (Source: N. Walker)

MAINTENANCE

Maintenance requirements:
Not applicable

REFERENCES

Definitions:
Not applicable

See also:
Guideline B.2.1. Compost making
Guideline B.2.2. Natural fertilizers

Further references:

a. ICRISAT .2009. Fertilizer Microdosing – boosting production in unproductive lands. The International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India.

B.2.4. Weeding

OVERVIEW

A move from conventional farming (i.e. tilling the soil) to conservation farming can result in increased number of weeds. An appropriate weeding strategy is required for successful conservation farming. Weeds lower crops yields due to competition for water, nutrients, light and space.

Objectives:
Weed when small to save time and effort 1 ha can be weeded in 7 days when weeds are 2-3 cm tall, but 14 days to weed when the weeds are 30 cm tall.

Criteria for application:
Can be applied at the plot and village scale.

Livelihood opportunities: Improved soil fertility and crop yield contributes to household food security.

Catchment perspective:
Will improve yields for both grains and vegetables over several years (or sooner).

Funding opportunities:
Not applicable

Benefits:
Will result in higher yields and assists greatly in the transition to successful conservation farming.

Legislation:
Not applicable

METHODOLOGY

Methodology:

1. Hoe weeds when they are small, it is easier than removing large weeds and requires less effort;
2. Weed by hand or with a hand held instrument (i.e. hoe) disturbing the soil as little as possible, simply cutting off the weed at the soil surface;
3. Remove creping grasses by pulling them up and carrying them right out of your field;
4. Don't let weeds set seed in your field.
5. Be precise when planting seed, ensuring a good early canopy to shade out the weeds.

Illustrations/ Diagrams:
Not applicable

Equipment requirements:
Hoe.

Seasonal variations:
Not applicable

Variations/Adaptations:
Weed throughout the season and again at the end of the growing phase.

Maintenance requirements:
Weed throughout the season and again at the end of the growing phase.

Potential drawbacks/disadvantages:
Weeding under conservation tillage more time consuming than under conventional farming. However, will result in higher yields if correct land management is applied.

Photos

Figure B.2.4-1: A standard hoe can be used for the weeding. (Source: N. Walker)

REFERENCES

Definitions:
Not applicable

See also:
Guideline B.1.1.3. Soil cover (mulching)
Guideline B.2.1. Compost making

Further references:
Foundations for Farming. 2014. Weeding information Sheet. Foundations for Farming, Harare Zimbabwe.

B.2.5. Agroforestry

OVERVIEW

Agroforestry is the intentional integration of trees within a cropping system for multiple benefits. It is increasingly recognised as one way of dealing with the lack of space and infertile soils. This guideline provides an outline of how to implement agroforestry.

Objectives:

- To enhance soil productivity and improve crop production through nutrient input (recycling especially of nitrogen through fixation, and other nutrients in leaf litter), and crop protection (shade, windbreaks, etc.).
- To optimise productivity of the land through multiple use.
- To increase overall timber resources providing fuel and other timber products.
- For fodder, fruit and other non-timber forest products.

Criteria for application:

- Almost all croplands can benefit from agroforestry.
- The interaction between crop and tree must be considered. Lack of competition from the tree for crop resources (sunlight, water, nutrients) is important.
- Species selection – there are a number of species recognized as especially useful agroforestry trees. These are discussed below.

Livelihood opportunities:

Agroforestry contributes to soil fertility thereby improving crop yield, which contributes to household food security. It also provides additional food sources that can be sold for additional income, as well as supplying firewood for cooking, thereby contributing to household energy.

Catchment perspective:

- Reduced demand on natural timber resources
- Lower requirements for fertilizer
- Less soil erosion – by wind and water
- Improved all-year infiltration through better soil cover, with little negative impact on the catchment hydrology (water use)

Benefits:

- Improved crop yields through nitrogen fixation, shade, nutrient addition from leaf litter, windbreak protection, improved infiltration
- Soil protection against erosion (water and wind)
- Additional timber and other resources (medicinal, fruit, fodder, etc.)
- Local production of woody products close to homestead without cost in terms of productive land (space)

Funding opportunities:

Not applicable

Legislation:

Not applicable

METHODOLOGY

Methodology:

1. The key methodology is the integration of trees into crop farming
2. Trees are selected for their value as windbreaks, sources of humus and fertilizer (especially nitrogen-fixing trees), shade and sometimes fodder
3. Trees may be evergreen or deciduous – depending on companion crop and primary purpose
4. Agroforestry trees are generally grown in nursery situations for in-field planting. *Faidherbia albida* however should be established directly in-field due to the sensitivity of its tap-root on transplanting
5. Trees are harvested, and new trees planted, when productive benefits decline. This is done on a selective basis

Illustrations/ Diagrams:

Not applicable

Equipment requirements:

Standard farming equipment.

Seasonal variations:

- Select tree species suitable to the area and objectives
- A variety of tree species can be planted to provide different services, i.e. nitrogen-fixing, firewood, fruit, shade, biomass

Variations/Adaptations:

Agroforestry can take a number of different forms:

- Windbreaks
- Fence lines, field edges, contour plantings for erosion control
- Alley cropping – hedges and low shelterbelts with interplanting of food crops
- Mixed intercrop planting – either in widely spaced rows or openly (often randomly) spaced within fields
- Occasional shade or fruit trees

Photos:

Figure A.2.5-1: Agroforestry trees growing in the field, providing nitrogen fixation and shade, amongst other services. (Source: S. Braid)

Maintenance requirements:

- Replacement of trees as they age and end their useful productive lifespan – this is a selective process of occasional tree replacement, dependent on the observation of the individual farmer
- Shelterbelts and contour plantings may need replacing as trees grow too large and begin to dominate to the detriment of crop growth

B.2.5. Agroforestry

	• Protect natural regeneration

REFERENCES

Further references:

a. Bunderson WT, Jere ZD, Hayes IM and Phombeya HSK. 2002. CBommon Agroforestry Species in Malawi.

b. Malawi Agroforestry Extension Project. Publication no 46. MAFE Booklet Series 1

See also:

Guideline B.1.1.1. Conservation tillage
Guideline B.1.1.2. Crop rotation and intercropping
Guideline B.1.1.3 Soil cover (mulching)
Guideline B.2.2. Natural fertilizers
Guideline B.1.2.1. Designing a natural farming garden
Guideline B.1.2.2. Where to plant what
Guideline B.1.2.3. When to plant what
Guideline B.2.1. Compost making
Guideline E.2.1. Nutrition in the home

C WATER STORAGE AND MANAGEMENT

CATCHMENT MANAGEMENT GUIDELINES	ISSUES										CAPACITY					
C. Water efficiency and management	Soil Erosion	Loss of soil fertility	Sedimentation	Water degradation and depletion	Floods	Overgrazing / Deforestation	Threat to biodiversity	Loss of crop yields / Livestock fodder	Risk to infrastructure	Reduced standard of living	Prevention/Rehabilitation	Legislation	Scale	Labour requirement	Complexity	Cost
C.1. Water use efficiency and recycling																
C.1.1. Water use efficiency				■				■		■	Prevention	Other	Household	Single person	Simple	Free to little
C.1.2. Wastewater recycling				■						■	Rehabilitation	NWA/NEMA	Household	Few people	Advanced	Medium cost
C.1.3. Excess water re-use				■						■	Rehabilitation	Other	Household	Single person	Simple	Free to little
C.2. Water harvesting and storage																
C.2.1. Roof runoff and storage				■	■					■	Rehabilitation	Other	Household	Few people	Complex	Medium cost
C.2.2. Water storage tanks - Below ground				■	■					■	Prevention	Other	Village	Few people	Complex	Medium cost
C.2.3. Road runoff	■		■	■	■					■	Prevention	Other	Village	Few people	Advanced	Free to little
C.2.4. Ridging - see **Guideline A.3.1. Contour ridging**	■		■	■	■					■	Rehabilitation	Other	Household	Few people	Simple	Medium cost
C.2.5. Hillside runoff (swales)	■		■	■	■					■	Prevention	Other	Village	Single person	Advanced	Free to little
C.3. Groundwater recharge and infiltration																
C.3.1. Contour bunds	■	■	■	■				■		■	Rehabilitation	Other	Household	Single person	Advanced	Free to little
C.3.2. Zaï planting pits	■	■		■				■		■	Rehabilitation	Other	Household	Single person	Simple	Free to little
C.3.3. Half-moon pits	■	■		■				■		■	Rehabilitation	Other	Household	Few people	Simple	Free to little
C.3.4. Infiltration trenches (Water Absorption Trenches)	■	■	■	■				■		■	Prevention	Other	Village	Few people	Simple	Free to little
C.3.5. Spring protection and management	■		■	■				■		■	Prevention	NWA/NEMA	Village	Few people	Simple	Medium cost
C.4. Small dams																
C.4.1. Stone check dams - see **Guideline A.4.3. Stone check dams**				■						■	Rehabilitation	NWA/NEMA	Village	Few people	Simple	Medium cost
C.4.2. Sand dams	■		■	■						■	Prevention	NWA/NEMA	Village	Few people	Complex	Expensive
C.4.3. Farm dams				■						■	Prevention	NWA/NEMA	Village	Few people	Complex	Expensive
C.5. Small-scale irrigation																
C.5.1. Diversion weirs				■				■		■	Prevention	NWA/NEMA	Village	Few people	Complex	Expensive

KEY: Capacity Icons

Action	Legislation	Scale	Labour	Complexity	Cost
Prevention	Other	Household	Single person	Simple	Free to little
Rehabilitation	NWA/NEMA	Village	Few people	Advanced	Medium cost
		Catchment	Many people	Complex	Expensive

Water is critical to life and to farming. Two key issues affecting water are: access to water, and managing water. Access can be improved through household or community storage of water and resource protection. Access to water is also improved through water efficiency, i.e. using the water wisely to make it last longer; and through recycling water. These guidelines provide techniques on water use efficiency and recycling, water harvesting and storage, groundwater and infiltration, small dams, and small-scale irrigation schemes. By improving access to water, water can also be managed more sustainably, which is beneficial both to the community and to the catchment at large.

C.1 Water use efficiency and recycling

The water use efficiency guidelines provide advice that will help to improve water management in agriculture. By improving water efficiency through suitable crop selection, proper irrigation scheduling, effective irrigation techniques, and using alternative sources of water for irrigation, it will be possible to increase water availability and make the water last longer. These guidelines also address point source protection of water collection points.

C.2 Water harvesting and storage

These guidelines will help to provide access to additional water by harvesting water (collecting runoff) and storing water. By harvesting water, farmers can increase the area they irrigate, grow crops in the dry season, and support livestock. Water storage at the household or village level improves access to water, and reduces the labour burden, by reducing the number of trips to boreholes.

C.3 Groundwater recharge and Infiltration

These guidelines provide information to improve groundwater resources in particular by the infiltration of rainwater into the soil, thereby increasing availability of water stored in the rooting zone and groundwater. Increased water availability in the rooting zone reduces dependence on surface water irrigation, and provides increased potential for cultivation during dry seasons. Increased groundwater feeds the spring and improves surface water flow lower down the catchment as well as the level of water in wells close-by.

C.4 Small dams

These guidelines provide information to help the community to construct small dams to store relatively small amounts of water. Stored water means water retained in the catchment for as long as possible, thereby increasing the time for infiltration and groundwater recharge. This also helps to reduce flooding downstream, and allows for the productive use of otherwise “lost” water.

C.5 Small-scale irrigation

This guideline provides information on techniques for diverting water to irrigation schemes. Water can be used directly in the field, or to fill water storage structures from which supplies can be withdrawn.

C.1. Water use efficiency and recycling

C.1.1. Water use efficiency

OVERVIEW

Where irrigation is used for crops, it is important to make the most efficient use of the water as possible. This is done by reducing the amount of water lost through evaporation, leaks and deep drainage. Drip irrigation is the irrigation method that has the lowest evaporation losses, and this guideline gives instructions on how to install a drip irrigation system.

Objectives:
- To improve water use efficiency (i.e. by reducing water losses).
- To enhance the health of water bodies (rivers, wetlands and lakes).

Catchment perspective:
- Canals and diversion structures are properly constructed.
- All regulations governing water resources management at the field level are being followed.

Funding opportunities: Not applicable

Legislation:
- National Water Act 36 of 1998
- Water Services Act 108 of 1997

Livelihood opportunities: All life needs water. Water is a scarce resource. Efficient use ensures its sustainability.

Benefits:
- Freeing water for on-farm expansion of irrigation
- Generating surplus water to provide additional flows for rivers and wetlands.
- Reducing adverse environmental impacts such as increased salinity and water logging conditions
- Reducing payments for water abstracted
- Indirectly addressing water shortages associated with climate change

Criteria for application:
- Land is ideal for irrigated agriculture.
- Water resources are available in adequate amounts and in good quality to support crop irrigation.
- Climate change impacts are taken into consideration in the development of the irrigation schemes.

METHODOLOGY

Methodology:

General
1. Practicing on-farm sustainable water resources management
2. Adopting efficient technologies such as drip irrigation
3. Adopting best practices as a means of narrowing the range of water use efficiency
4. Utilise drip irrigation where possible

Drip Irrigation
1. Dig a narrow trench through the middle of the vegetable bed, with a slight slope in it
2. Lay the PVC pipe in the trench. Cap/ stopper on one end.
3. Make a small hole in the pipe every 5 cm with a nail
4. Cover the pipe. Leave a portion of the pipe sticking out the ground, to pour the water into. Keep the end covered to prevent mosquitos getting in.

Photos:

Figure C.1.1-1: Irrigation structure. (Source: Suriya Agri Tek.)

Illustrations/Diagrams:

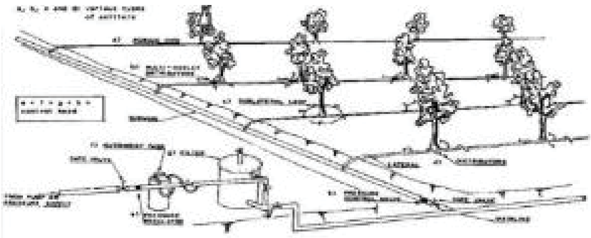


Figure C.1.1-2: Irrigation scheme. (Source: FAO. Irrigation Water management: Irrigation methods)

Equipment requirements:
PVC piping / plastic bottles

Maintenance requirements:
Check for leaks, stagnant water

Seasonal variations:
Not applicable

Variations/Adaptations:
Not applicable

See also:
Guideline C.1.2. Wastewater recycling
Guideline C.1.3. Excess water reuse
Guideline C.2.1. Roof runoff and storage

REFERENCES

Further references:

a. FAO. Irrigation Water management: Irrigation methods. Chapter 6.
b. *Drip Irrigation.* Accessed online at http://www.fao.org/docrep/s8684e/s8684e1g.gif. 19 August 2015
c. Suriya Agri Tek. *Drip Irrigation Products.* Accessed online at http://suryaagritek.tradeindia.com/drip-irrigation-products-1365870.html. 19 August 2015
d. WOCAT 2007. Where the land is greener – case studies and analysis of soil and water conservation initiatives worldwide. Eds, Liniger, H and Critchley, W. pp 325-331.

C.1.2. Wastewater recycling

OVERVIEW

Wastewater recycling is the treatment of wastewater to remove solids and impurities, this water is used in sustainable landscaping irrigation, to recharge ground water aquifers, to meet commercial and industrial water needs and for drinking. The purpose of this process is for water conservation and sustainability (Bischel et al., 2013). Most Wastewater Treatment Plants (WWTP) in South Africa are relatively small systems. In South African Metros typically have a few large WWTPs and are generally well equipped and operated. Specific challenges exist for smaller and poorer communities, these challenges relate to the small scale of operation and having to establish new skills and competencies. The infrastructural, mechanical and electrical maintenance of the plants also present challenges (Snyman et al., 2008).

Objectives:

- To conserve water
- To promote sustainability and reuse of water

Catchment perspective:

- Minimises resource depletion by lowering the extraction of fresh water from rivers and aquifers
- Minimises water pollution by reducing grey water that ends up as effluent in rivers

Funding opportunities:

Not applicable

Legislation:

- National Environmental Management Act 107 of 1998.
- National Environmental Management: Waste Act 59 of 2008. National Water Act 36 of 1998.

Criteria for application:

- If collected using a separate plumbing system from blackwater (wastewater from toilets containing faeces and urine), domestic greywater can be recycled directly within the home, garden or company
- Most cleaning agents contain sodium salts, which can cause excessive soil alkalinity, inhibit seed germination, and destroy the structure of soils by dispersing clay. Soils watered with greywater systems can be amended with gypsum (calcium sulphate) to reduce pH to some extent. Growing legumes in crop rotation may help in sustaining any pH reduction. In most cases high levels of organic matter in the soil help buffer any effects on pH that the addition of greywater may have. Alternatively using alkalinity tolerant species/varieties of crops and pasture can reduce the impact of high pH.

Benefits:

- Wastewater recycling decrease the diversion of water from sensitive aquatic ecosystems
- Reduce discharge to sensitive water bodies
- Reduce and prevent pollution

METHODOLOGY

Methodology:

1. Collect greywater from baths, showers, hand basins and clothes washing machines / washing tubs to separate collection tank
2. Pump or lead this water out to the garden
3. Use a separate plumbing system for blackwater from toilets
4. Domestic greywater can be recycled directly within the home or garden
5. As a safety and health issue, given that greywater may contain nutrients and pathogens, do not use greywater on vegetable gardens if the crop is to be eaten raw or uncooked.
6. •Do not use greywater that has faecal contamination, i.e. from washing nappies, etc.
7. Given that greywater also contains substances that can reduce plant growth or crop yield if present at sufficiently high concentrations, it is very important to store it before use for irrigation purposes. If stored, it must be used within a very short time or it will begin to deteriorate due to the organic solids in the water
8. Regulations change by country and region, but common guidelines for safe usage include not storing the greywater for more than 24 hours, ensuring it cannot pool or runoff, and depositing it with subsurface irrigation.
9. It is essential to put nothing toxic down the drain—bleaches, bath salts, artificial dyes, chlorine-based cleansers, strong acids/alkali, solvents, and products containing boron, which is toxic to plants at high levels

Illustrations/ Diagrams:

C.1.2. Wastewater recycling	

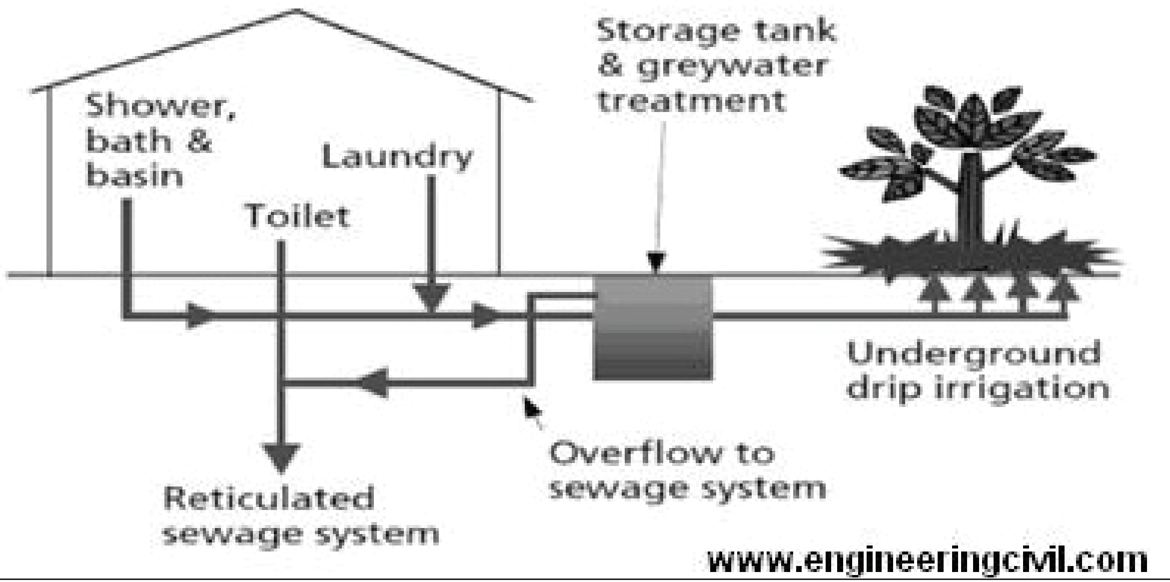


Figure C.1.2-1: Wastewater recycling diagram. (Source: Gupta, A)

Photos:	**Equipment requirements:**
Not applicable	• Small sub soil collection tank with submersible pump, basic filter, float switch, and delivery piping. • Separate plumbing system • Filtration
Seasonal variations:	**Variations/Adaptations:**
Not applicable	• Greywater can be reused for toilet flushing

MAINTENANCE

Maintenance requirements:
Ensure that fat and food waste from kitchen sinks does not contaminate water.

REFERENCES

Definitions:	**See also:**
Aquifer: a body of permeable rock that can contain or transmit groundwater. Greywater: the relatively clean waste water from baths, sinks, washing machines, and other kitchen appliances. Blackwater: wastewater containing faeces, urine and flush water from flush toilets	**Guideline B.1.2.1. Designing a natural farming garden** **Guideline B.1.2.2. Where to plant** **Guideline B.1.2.3. When to plant what** **Guideline C.1.3. Excess water re-use** **Guideline C.2.1. Roof runoff and storage** **Guideline C.3.2. Zaï planting pits**

Further references:

a. Gupta A. *A Step towards sustainable water Management – Greywater Reuse*. Accessed online at http://www.engineeringcivil.com/a-step-towards-sustainable-water-management-grey-water-reuse.html. 19 August 2015

b. Bischel, H.N., Lawrence, J.E., Halaburka, B.J., Plumlee, M.H., Bawazir, A.S., King, J.P., McCray, J.E., Resh, V.H. and Luthy, R.G., 2013. Renewing urban streams with recycled water for streamflow augmentation: hydrologic, water quality, and ecosystem services management. *Environmental Engineering Science*, *30*(8), pp.455-479.

c. Snyman, H.G., Van Niekerk, A.M. and Rajasakran, N., 2006, May. Sustainable wastewater treatment –What has gone wrong and how do we get back on track. In *Proceedings of the water institute of South Africa (WISA) conference, Durban* (pp. 21-25).

C.1.3. Excess water re-use	

OVERVIEW

C.1.3. Excess water re-use

When borehole hand pumps are used, water often spills and the area becomes wet and muddy. The spilt water can be used to water crops by channelling it into a 'fertility pit'. This guideline describes how to construct a fertility pit. Greywater can also be used in this way.

Objectives:
To re-use "lost" water for productive purposes.

Catchment perspective:
- Conservation of water for beneficial crop production rather than wasting it
- Avoid erosion around hand pumps

Criteria for application:
- Used at borehole hand pumps and smallholder fields
- Often planted with water-loving plants, e.g. bananas, pawpaws or sugarcane.
- Can be used in conjunction with greywater

Benefits:
- Increase absorption/infiltration of water into the soil
- Allow for planting of crops with water that would have been wasted
- Improve food security
- Ensure that area around boreholes is kept clean and dry and not muddy
- Improves water quality in the system

Livelihood opportunities:
Improved water efficiency, additional crops can be sold for additional income towards maintenance of borehole or water supply system.

Funding opportunities: Not applicable

Legislation: Not applicable

METHODOLOGY

Methodology:
1. Fertility pits next to borehole hand pumps enable runoff water to be captured and conserved in 1 m deep pits that are filled with organic matter such as compost or manure
2. The organic matter increases the fertility of the soil and minimises the loss of water from evaporation
3. Dig 1 m deep pits
4. Fill with organic matter such as compost or manure
5. Plant crops such as water-loving plants, e.g. bananas, pawpaws or sugarcane
6. Crops can then be sold to earn money to upgrade and maintenance of the tap or borehole.

Illustrations/ Diagrams:

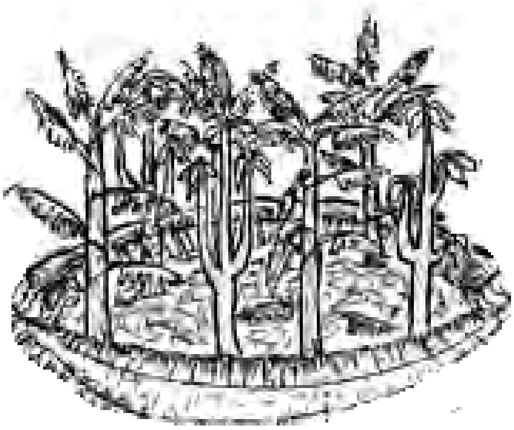


Figure C.1.3-1: Fertility pit. (Source: W. Enright)

Photos:

Figure C.1.3-2: Spilt water from borehole hand pump channeled into a fertility pit. (Source: W. Enright)

Equipment requirements:
- Shovel
- Compost

Variations/Adaptations:
Lends itself as a soakaway around buildings – to absorb greywater.

Seasonal variations: Not Applicable

MAINTENANCE

Maintenance requirements: Not Applicable

REFERENCES

Definitions:
Erosion: removal of surface material from Earth's crust, primarily soil and rock debris, and the transportation of the eroded materials by natural agencies from the point of removal.
Runoff: Runoff can be described as the part of the water cycle that flows over land as surface water

See also:
Guideline B.1.2.1. Designing a natural farming garden
Guideline B.1.2.2. Where to plant what
Guideline B.1.2.3. When to plant what
Guideline C.2.1. Roof runoff and storage
Guideline C.3.2. Zaï planting pits
Guideline C.1.1. Water use efficiency

C.1.3. Excess water re-use	
instead of being absorbed into groundwater or evaporating.	**Guideline C.1.2. Wastewater recycling**

Further references:

a. Denison J, Smulders H, Kruger E, Ndingi H and Botha M. 2011. Water Harvesting and Conservation – Volume 2 Part 1: Technical Manual and Farmer Handouts. Water Research Commission

b. Guidelines for the Safe Use of Wastewater, Excreta and Greywater (WHO, 2006)

C.2. Water harvesting and storage

C.2.1. Roof runoff and storage

OVERVIEW

Rainwater harvesting is the accumulation and deposition of rainwater for reuse on-site, rather than allowing it to run off. Runoff may be harvested from roofs and ground surfaces as well as from intermittent or ephemeral watercourses. In South Africa the practice is mostly common in rural areas and tends to be the primary source of drinking water.

Catchment perspective:

- Giving communities the ability to be more self-sufficient in terms of water during the dry season will reduce pressure on the catchment system as a whole and on nearby wetlands specifically
- Provide an alternative supply of water thereby reducing some pressure on other resource supplies
- Ensure better crop yields
- Reduce runoff and erosion
- Keep the water in the catchment for as long as possible

Criteria for application:

- Preference for installation of water tanks should be given to communities situated at greater distances from safe water sources, both installed and natural, as these communities are at greatest risk from dry spells
- The type and size of tank should take into account the farming practices and likely future community needs
- The sizing of the catchment area is critical in determining and realizing the amount of rainwater to be harvested (listed criteria for application)

Objectives:

- To show communities how to construct an above ground water tank, e.g. from a roof
- Provide an alternative source of water
- Use "lost" water for productive use (domestic use, agriculture, fish farming, livestock use)

Livelihood opportunity:

Stored water at the household level provides improved access to water. Increased access contributes to improved health, crop productivity, and household use.

Benefits:

- Communities will be able to collect and store water giving them access to a water supply during the dry season to water gardens and for domestic use
- Reduce use from other sources
- Diminishes flooding, erosion and the flow to storm-water drain

Funding opportunities:
Not Applicable

Legislation:
Not Applicable

METHODOLOGY

Methodology:

General considerations

1. The tank must always be circular, hemi-spherical or spherical (ball shaped) in order to apply water pressure equally on the tank walls. Square or rectangular tanks are more likely to crack
2. The tank must be covered to prevent evaporation from the sun, keep the water clean and should not be accessible to mosquitoes
3. All inlets (taps, ventilation pipes) must be screened with mosquito-proof mesh
4. Dirty things should not be dipped into the water (hands, clothing, etc.)
5. Place the storage tank near the place of usage (kitchen or garden)
6. Redirect the overflow or spilled water to a nearby garden or orchard

Tank construction

An experienced artisan will follow these steps:

1. Use sun-baked, compressed soil bricks standing on a base of approximately 1.5 m diameter to construct the cylindrical tank
2. Make an exact circle using a wire tied to a vertical pipe erected in the centre of the foundation as a guide. Excavate the circle to a depth of one brick for the foundation (Figure C.2.1-1)
3. Make a level base of bricks on the foundation with the bricks interfiled with cement
4. Build a circular wall of bricks from the edge of the base, to a height of approximately 1 meter (depending on the clearance of the overhanging roof) to make a cylinder. (Figure C.2.1-2)
5. Reinforce tanks built of bricks or blocks with barbed wire, wrapped as a spiral tightly around the exterior tank walls. Tie the first 4 rounds at the foundation, followed by a spiral (spaced 5 cm) for the lower 1 meter of the tank. For the rest of the tank (above 1 m height), continue the spiral with a spacing of 10 cm
6. Plaster the outside of the tank with 2 cm of mortar. Plaster the interior wall and floor with 2 cm of mortar. Apply waterproofing agent onto the mortar with a square steel trowel to waterproof the tank (Figure C.2.1-3)
7. Remember to leave space for an overflow. The area below the overflow should be strengthened and overflow water should be directed by a small swale or berm to a planting pit.

C.2.1. Roof runoff and storage

8. Make the lid from two sheets of corrugated iron, cut to shape with an overlap. Cement one sheet to the tank. Leave the other sheet free so it can be lifted off and water removed. Place bricks on the loose sheet to hold it down so the wind does not blow it off (Figure C.2.1-4)

Gutters

1. Construct gutters using plain galvanized iron, split bamboo or sisal poles
   a. Install gutters on the roof to drain rainwater from roofs to storage tanks. Gutters can be tied to the roof with rope, sticks or hangers made from galvanized wires (Figure C.2.1-5)
   b. Where possible the gutters should be mounted to a splashguard to divert water straight into the gutter (Figure C.2.1-6)
2. Calculating volume of water from roof catchment
   a. Determine the area of the roof in square metres, e.g. 5 m x 4 m = 20 m^2
   b. Determine the average annual rainfall in mm, e.g. 1000 mm = 1 m
   c. Calculate the volume of the water generated, e.g. 20 m^2 x 1 m = 20,000 litres (minus 10% losses)
3. Determine the size of the tank/ reservoir, e.g. a 2,000 litre tank will fill about 9 times

Illustrations/ Diagrams:

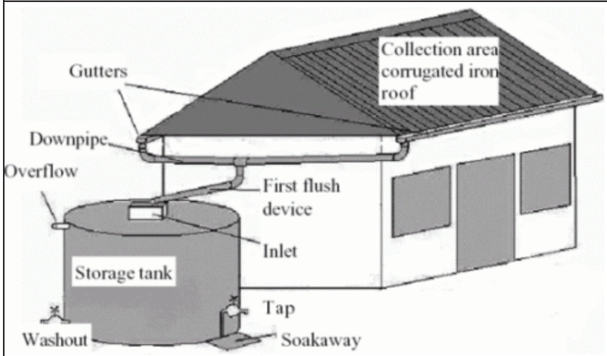


Figure C.2.1-1: Typical Domestic Roofwater Harvesting system in Kenya
(Source: Kenya Water for Health Organisation. 2014).

Key dimensions and material quantities:

A tank of:	Unit	Quantity
Tank diameter	m	1.5
Tank height	m	1
= Storage volume	l	1767
Requires materials:		
Total no of burnt bricks (size 9 x 4 x 3 inches)	No.	380
Total length barbed wire	m	110
Total volume of mortar	m^3	2.5
Corrugated iron sheet	m^2	1.8

Photos: (Source: MDGF. 2012)

Figure C.2.1-2: Rooftop rainwater harvesting tank

Figure C.2.1-3: Rooftop rainwater harvesting tank

Figure C.2.1-4: Foundation of tank

Figure C.2.1-5: Tank walls

C.2.1. Roof runoff and storage

Figure C.2.1-6: Plastering of mortar

Figure C.2.1-7: Fitted roof

Figure C.2.1-8: Steel gutter fitted to roof

Figure C.2.1-9: Splash guard gutter filling tank

Equipment requirements:

- Collection system:
- Catchment (i.e. the roof)
- Conduits, e.g. Split bamboo or sisal pole to serve as a gutter or metal or plastic gutter.
- Storage tank:
- Oven-baked bricks
- Cement
- Waterproofing agent
- Rope
- Barbed wire or building wire
- Corrugated iron sheets or netting to cover the tank and keep debris and mosquitoes out

Seasonal variations:

Construction work should take place in the beginning of the dry season when there is no risk of an unexpected thunder shower that can flood the construction site.

Variations/Adaptations:

- Can make smaller storage tanks for household use, or larger tanks that several buildings can contribute to, e.g. at a school or civic building.
- Can use plastic “Jojo” tanks instead of building a tank, but when these break the storage is lost and a new tank must be purchased, whereas a constructed tank can be repaired.

MAINTENANCE

Maintenance requirements:

- Keep catchment/roof free of debris
- Check gutters and strainers devices at least twice before and after the rainy season. Keep them clean and free of leaves and debris. Before the rain starts, the tank or storage area should be clean
- Clean and maintain filters, including drip filters
- Regularly check the tank to ensure there are no unscreened or damaged openings that allow insects, rodents or animals to get into the tank. Ensure the tank lid is tight
- Check the tank every two years for sludge and have the tank cleaned if there is a thick layer of sludge on the bottom of the tank
- The first direct flush of rainwater should be directed away from the storage, since it contains the dirt from the roof
- The water tank requires periodic emptying, washing, and rinsing with heavily chlorinated water, to prevent the growth of biofilms
- Repair leakage through cracked foundation by constructing a new foundation onto old foundation
- Repair leakage through porous tank walls by sealing or replacing the porous parts with mortar and with waterproofing agent. Should the wall still leak after that treatment, the interior of the tank should be coated with a water proofing agent

C.2.1. Roof runoff and storage

- Repair leakage through cracked walls new tank on the outside of the cracked tank by wrapping reinforcement mesh or wire around the tank and plaster it

Potential drawbacks/disadvantages:

- Unpredictable Rainfall
- Initial High Cost

REFERENCES

Definitions:	See also:
Ephemeral watercourse: An ephemeral watercourse is a wetland, spring stream, river, pond or lake that only exists for a short period following precipitation or snowmelt. **Intermittent watercourse:** watercourse that cease flowing for weeks or months each year.	**Guideline C.2.2. Water storage tanks – below ground**

Further references:

a. Nissen-Petersen E. 2006. Water from Roofs. A handbook for technicians and builders on survey, design, construction and maintenance of roof catchments. ASAL Consultants Ltd. and Danish International Development Assistance (Danida): Kenya

b. MDGF. 2012. *Rainwater Harvesting*. Accessed online at http://wiki.mdgfund.net/Rainwater_Harvesting. 19 August 2015.

c. Kenya Water for Health Organisation. 2014. *Rain Water Harvesting*. Accessed online at http://www.kwaho.org/t-rain-harvest.html. 19 August 2015

C.2.2. Water storage tanks – below ground

OVERVIEW

Underground water storage tanks are used for underground storage of different types of water, e.g. potable water, or rainwater collection, or wastewater.

Objectives:

- To show communities and villages how to construct a below ground water tank to store rainfall from a roof.

Catchment perspective:

- Giving communities the ability to be more self-sufficient in terms of water during the dry season will reduce pressure on the catchment system as a whole and on nearby wetlands specifically
- It will give communities a greater capacity to cope against dry spells and help to ensure better crop yields
- Reduce floods downstream

Criteria for application:

- Due to the complexity of making these tanks, underground tanks should be located at areas where they can serve a larger population rather than a specific household.
- Preference for installation of water tanks should be given to larger villages situated at greater distances from safe water sources, both installed and natural, as these communities are at greatest risk from dry spells.

Benefits:

Communities and villages will be able to collect and store water giving them access to a water supply during the dry season to water gardens and for domestic use.

Funding opportunities:

Not Applicable

Legislation:

Not Applicable

Livelihood opportunity:

Storage of water improves access to water supply, which in turn reduces the time to go and collect water. Improved access to water contributes towards improved health and nutrition.

METHODOLOGY

Methodology:

General considerations

1. The tank **must always be circular, hemi-spherical or spherical (ball shaped)** in order to apply water pressure equally on the tank walls. Square or rectangular tanks are more likely to crack
2. The tank must be covered to prevent evaporation from the sun, keep the water clean and should not be accessible to mosquitoes
3. All inlets (taps, ventilation pipes) must be screened with mosquito-proof mesh.
4. Unclean things should not be dipped into the water (hands, clothing, etc.)
5. The storage tank should be placed near the place of usage (kitchen or garden)
6. Redirect the overflow or spilled water to a nearby garden or orchard

Tank construction

1. Calculating volume of water from catchment roofs:
    a. Determine the area of the roofs in square metres, e.g. 5 m x 4 m x 5 roofs = 100 m^2
    b. Determine the average annual rainfall in mm, e.g. 1000 mm = 1 m
    c. Calculate the volume of the water generated, e.g. 100 m^2 x 1 m = 100,000 litres (minus 10% losses)
2. Determine the size of the tank/ reservoir.
3. Create a circular outline for a tank with a radius of 312 cm is marked on the ground
4. Marked a rectangular shape of 412 cm x 100 cm 90 cm from the tank
5. The excavation for the tank is made in a hemispherical shape using a radius wire of 312 cm tied to a peg in the centre of the tank with the other end showing the side of the wall (Figure C.2.2-1). The peg and its soil pillar are the last to be removed (Figure C.2.2-2). Staircase is dug out
6. The ring beam (20 x 20 cm rim) is made of concrete reinforced with 8 rounds of barbed wire gauge. The ring beam must be made level and kept moist under shade (Figure C.2.2-3)
7. A 60 cm high wall of bricks or blocks is built onto the ring beam with 8 rounds of barbed wire, gauge, are wrapped tightly around the wall and spaced 10 cm apart. The wire is covered with 2 cm mortar of mixture. While in the staircase 10 cm of concrete with weld mesh is compacted onto the floor and ramp (Figure C.2.2-4). A wall of bricks or blocks is built onto the concrete (Figure C.2.2-3)
8. The hemispherical soil excavation and the interior of the ring beam are plastered with a 3 cm thick layer of mortar and thereafter chicken mesh can now be nailed onto the plastered interior of the tank. Thereafter barbed wire gauge is nailed onto the chicken mesh in a spiral starting from the centre of the bottom with a spacing of 20 cm (Figure C.2.2-5)
9. Lines of barbed wire are nailed across the tank from rim to rim with a spacing of 30 cm. The lines of wire must protrude 30 cm above the rim for reinforcement of the dome. The barbed wire and chicken mesh are covered with 3 cm of mortar which is smoothened and coated with NIL. The wall must be kept moist and under shade until the dome is built (Figure C.2.2-4)

C.2.2. Water storage tanks – below ground

10. The outline of the dome is drawn with a radius of 700 cm and the 16 support beams for the roof are cut into the arc (Figure C.2.2-5). The beams are 6"" x 1"" wooden beams nailed onto 4"" x 2"" beams and make a frame (Figure C.2.2-6 and Figure C.2.2-7)
11. A centre column of a 4" PVC pipe filled with two iron rods and concrete and short lengths of pipes for a ladder are erected in the middle of the tank. This supports the wooden frame in the centre while angle irons tied to the lower ends of the wooden frame rest on the circular wall (Figure C.2.2-6)
12. Discharged oil drums or car bonnets are cut into flat iron sheets which are laid onto the frame. These are covered by polythene sheets or old cement sacks and covered with chicken mesh (Figure C.2.2-7). British reinforced concrete (BRC) mesh is cut into sheets and tied together over the chicken mesh
13. The barbed wire sticking out of the circular wall is bent over the BRC mesh and tied
14. Moulds for the manhole and inlets are placed on the dome. A 5 cm thick layer of mortar is compacted onto the dome and smoothened to finish. The dome must be kept moist under shade and without anybody walking on it for 3 weeks
15. A tap attached to a pipe running in the tank at the bottom of the stairs, gravity feeds water from the tank rather than relying on pumps

Illustrations/ Diagrams: Not applicable

Photos: (Source: Nissen-Petersen E. 2006)

Figure C.2.2-1: Measuring the tank and marking with wooden pegs.

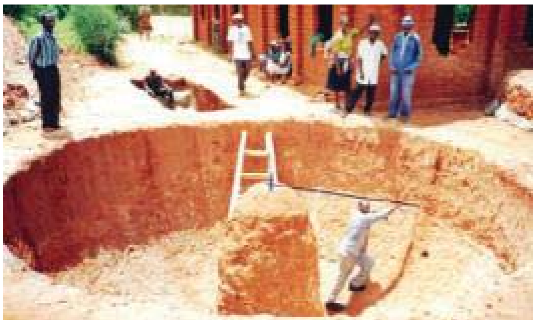


Figure C.2.2-2: Carving the basin of the tank, using a central pivot.

Figure C.2.2-3: Ring beam around the top of the tank

Figure C.2.2-4: Small wall and stairs into the base of the tank

C.2.2. Water storage tanks – below ground

Figure C.2.2-5: Plastering the inside of the tank

Figure C.2.2-7: Covering the roof of the tank with mortar

Figure C.2.2-6: Wooden frame and support for the roof of the tank.

Equipment requirements:

- Sun-baked compressed soil bricks
- Split bamboo or sisal pole to serve as a gutter
- Waterproofing agent
- Cement Chicken mesh
- Corrugated iron sheets
- Barbed wire
- Lime
- Rope
- PVC piping
- Oil-drums, discharged
- Wood boards for frame

Variations/Adaptations:
Not Applicable

Seasonal variations:
Construction work should take place in the dry season when there is no risk of an unexpected thunder shower that can flood the construction site

MAINTENANCE

Maintenance requirements:

- Regularly check the tank to ensure there are no unscreened or damaged openings that allow insects, rodents or animals to get into the tank. Ensure the tank lid is tight
- Check gutters and strainers devices at least twice before and after the rainy season. Keep them clean and free of leaves and debris. Before the rain starts, the tank or storage area should be clean
- Check the tank every two years for sludge and have the tank cleaned if there is a thick layer of sludge on the bottom of the tank
- The first direct flush of rainwater should be directed away from the storage, since it contains the dirt from the catchment area
- The water tank requires periodic emptying, washing, and rinsing with heavily chlorinated water, to prevent the growth of biofilms
- Repair leakage through cracked foundation by constructing a new foundation onto the old cracked foundation.
- Repair leakage through porous tank walls by sealing or replacing the porous parts with mortar and with waterproofing agent. Should the wall still leak after that treatment, the interior of the tank should be coated with a water proofing agent.
- Repair leakage through cracked walls new tank on the outside of the cracked tank by wrapping reinforcement mesh or wire around the tank and plaster it.

Potential drawbacks/disadvantages:

- Unpredictable Rainfall
- Initial High Cost

REFERENCES

Definitions:
Potable water: drinking water

See also:
Guideline B.2.1. Roof runoff and storage

Further references:

C.2.2. Water storage tanks – below ground

a. Nissen-Petersen E. 2006. Water from Roofs. A handbook for technicians and builders on survey, design, construction and maintenance of roof catchments. ASAL Consultants Ltd. and Danish International Development Assistance (Danida): Kenya. http://www.waterforaridland.com/ Books/book7%20Water%20from%20roofs.pdf Accessed 27 August 2015

C.2.3. Road runoff

OVERVIEW

This guideline describes how the runoff from roads can be diverted into channels/canals and then distributed into ditches/basins or farmland. This water can then be used for a variety of purposes, for example: the irrigation of crops and fruit trees, or it can be used for domestic non-potable purposes, especially in rural areas where there is no potable water from taps.

Objectives:

- To slow down runoff
- Prevent erosion in the fields
- To increase water infiltration into the soil for various uses
- To harness road runoff into infiltration pits or basins in order to enhance groundwater recharge for various uses
- To prevent lowering of the water table because of the lessened ground water recharge.

Impacts addressed:

The impacts of not doing road rain water harvesting include those that derail or slow development. Some impacts are:

- The rain water may destroy the road by forming gullies making it impassable
- Unharvested rain water from roads may cause destruction of crops and other infrastructure through flooding in times of heavy rains
- There is little groundwater recharge as the runoff doesn't have adequate time to percolate into the ground

Criteria for application:

Purpose of the water harvested from road catchments should be made clear to avoid inappropriate use since it may contain pollutants that may be harmful.

Benefits:

- Reduced soil loss from uncontrolled runoff from road or poorly constructed mitre drains
- Recharges groundwater
- Improves production, e.g. fruit trees
- Easy to implement: hence can be accomplished by most rural land users with little technical support from external support agents
- Uses simple tools and materials to construct
- Other activities like raising ducks, geese, fish and bees in or near open water reservoirs become possible
- Recharge of hand-dug wells near subsurface dams, weirs and sand dams in riverbeds from where domestic water can be drawn
- Increased agricultural production from fields irrigated by road runoff water
- Watering of cattle and livestock

Catchment perspective:

- Productive use of otherwise "lost water"
- Retain water in the catchment for as long as possible.

Funding opportunities:

Not Applicable

Legislation:

Not Applicable

Livelihood opportunity:

Reducing runoff along dirt roads reduced erosion of the roads, therefore keeping access ways open for transport. Reduced erosion also contributes to reduced sediment in water resources making the resources more usable. The runoff water can be harvested for irrigating fields or for groundwater recharge thereby increasing access to water for food security.

METHODOLOGY

Methodology:

1. Clear the area for channel drains and ditches or basins
2. Excavate channel drains at a slope of 0.2% to lead surface runoff from the road into basins/infiltration pits or farm land.
3. Dig interconnecting ditches of about 1.5 m deep and 1 m wide, and spaced 10-20 m apart to allow overflow of the upper ditches into the lower ditches.
4. The technology is made such that once the first channel gets full, excess water is emptied into the next one below without causing erosion.

Equipment requirements:

- Measuring tape
- Pegs
- Measuring tape Cotton string or home-made rope
- Panga-knife
- Hammer
- Shovel
- Pick / hoe
- Axe
- Line level

Variations/Adaptations:

Water can be directed into a pond or into a borrow pit where materials for road construction were excavated, to temporarily store water for use.

Seasonal variations:

Smaller version can also be applied to walkways and paths, especially on steep slopes.

Vetiver grass can be planted along the outside of the channel to trap silt when the channels overflow into lower channel

Illustrations / Diagrams:

C.2.3. Road runoff

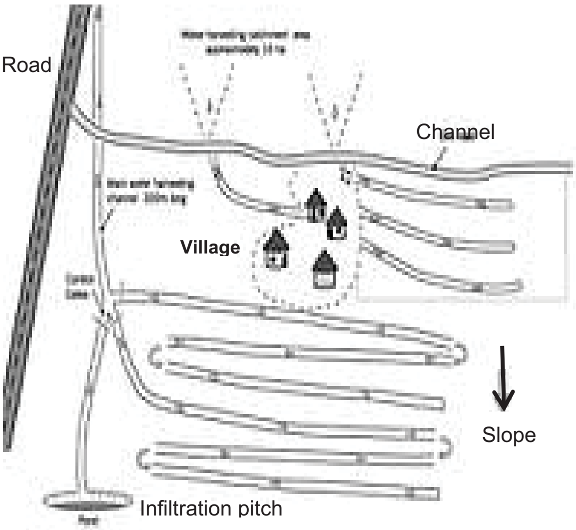


Figure C.2.3-1: Plan of road runoff harvesting system (Source: Mutunga K and Critchley W, 2001)

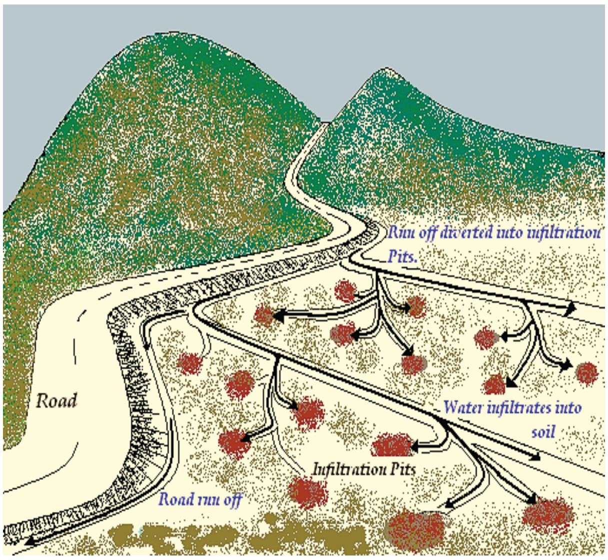


Figure C.2.3-2: Plan of road runoff harvesting system (Source: G. Chavula)

Photos: (Source: G. Chavula)

Figure C.2.3-3: Road water runoff harvested into a pond

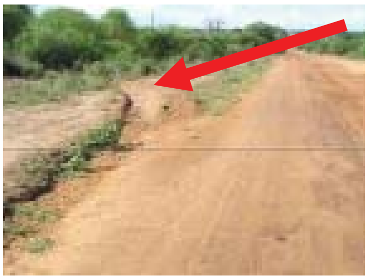


Figure C.2.3-4: Rainwater to be diverted into a ditch through diversion

Figure C.2.3-5: Erosion on the road if no water harvesting mechanism

MAINTENANCE

Maintenance requirements:

- Periodically remove or scoop out sediments from channels, canals and ditches to maintain channel/ basin capacity
- Repair broken sections of channel/canal and embankments
- Stabilize banks with any perennial shrub along the embankment, e.g. Vetiver grass
- Rebuild or repair basin embankments and spillways each time damage occurs
- Frequently replant grass or dried-up fruit trees along the embankment where necessary

REFERENCES

Definitions:
Not Applicable

See also:

Guidelines A.3.1. Contour ridging
Guideline B.1.2.1. Designing a natural farming garden
Guideline B.1.2.2. Where to plant
Guideline B.1.2.3. When to plant what
Guideline C.2.5. Hillside runoff (Swales)
Guideline C.3.2. Zaï planting pits
Guideline C.3.3. Half-moon pits

Further references:

a. Mutunga K and Critchley W 2001 Farmers' Initiatives in Land Husbandry. RELMA Nairobi

C.2.4. Ridging See Guideline A.3.1. Contour ridging

C.2.5. Hillside runoff (swales)

OVERVIEW

This guideline describes how erosion from rainfall on steep slopes can be reduced by creating swales (also known as contour infiltration ditch or graded diversion ditch) A 'swale' is simply a long, shallow depression in the ground, designed to collect or redirect water. The benefit of swales is that they can be used for irrigation purposes.

Objectives:

- Reduce surface erosion by rainfall runoff
- Retain runoff for moisture conservation
- To safely control the flow of water by diverting runoff from upland sloping areas or collection zones to a stable outlet where it can be effectively utilised

Criteria for application:

- This practice applies to steeply sloping sites where surface flow is causing severe erosion and damaging sloping upland or collection zone.

Mode of hillside runoff harvesting:

- Using swales: A channel that has a supporting bund on the lower side, constructed across an eroding slope to address severe erosion.

Catchment perspective:

Maintain water in the catchment for as long as possible, thereby reducing floods downstream, and reducing erosion in the catchment. This also provides for groundwater recharge.

Benefits:

- Increase absorption/infiltration of water into the soil
- Reduce speed of runoff, and therefore erosive power
- Effective moisture conservation leading to potentially improved crop yields
- Easiness in diverting water to cultivated fields that may have been relying on rainfall only

Livelihood opportunity:

The swale helps to recharge groundwater from excessive runoff, this replenishes groundwater supplies thereby allowing them to last longer in the dry season, which contributes to increased water access. Furthermore, stopping the water from running off across the land also reduces soil erosion and protects the land.

Legislation:

- Conservation of Agricultural Resources Act 43 of 1983.

Funding opportunities:

Not Applicable

METHODOLOGY

Methodology:

1. Dig a trench along the contour, to **stop** and **spread** water
2. Fill trench with organic matter to help water **sink** into the earth
3. Put soil from digging the trench as a bund (berm earthen bank or ridge) on the lower side of the trench, to help stop any water from escaping
4. Plant along the bund with strong-rooted, permanent species, preferably food or vetiver / napier grass. Continue planting permanent species, using smaller plants close to the ridge and bigger vegetation like trees or shrubs further down, smaller species placed just below ridge to capture water absorbed by swale

Illustrations / Diagrams:

Figure C.2.5-1: Illustration of a swale. (Source: Mollison, B, 2012)

Photos:

Figure C.2.5-2: Swale with trees planted on swale bund. (Source: permacultureglobal.org)

Equipment requirements:

- Hoe
- Shovels
- Planting material

Variations/Adaptations:

- Planting of shrubs or trees
- Can be applied along footpaths to prevent erosion down pathways

Seasonal variations:

Vegetation cover growth

MAINTENANCE

Maintenance requirements:

- Inspect swales after storms to make sure that rain water has drained and there is no erosion

Potential drawbacks/disadvantages:

- Impractical on steep slopes
- Requires thick vegetation

C.2.5. Hillside runoff (swales)

- Remove sediment and debris from, in and around the swale
- Manually remove any weeds or invasive plants

REFERENCES

Definitions:

See also:

Guideline A.3.1. Contour ridging
Guideline A.4.6. Gully re-shaping
Guideline B.1.2.1. Designing a natural farming garden
Guideline B.1.2.2. Where to plant
Guideline B.1.2.3. When to plant what
Guideline C.2.3. Road runoff
Guideline D.1.4. Selecting beneficial trees

Further references:

a. Mollison B. 2012. *Linear Food Forests along Hugelkultured Swales.* Accessed online at https://midwestpermaculture.com/2012/07/hugelkultured-swale-with-linear-food-forest/. 19 August 2015

b. http://permacultureglobal.org/post_projects/5862 accessed 27 August 2015

C.3. Groundwater Recharge and Infiltration

C.3.1. Contour bunds

OVERVIEW

This guideline describes how to construct stone or earth bunds to harvest water on crop lands, or reduce runoff erosion on degraded rangeland.

Also referred to as:

- Contour ridging (earth bunds)
- Stone lines/banks (stone bunds)

Objectives:

- Stone bunds act as semi-permeable barrier along contour to retain runoff for water harvesting
- Earth bunds to retain all runoff from slope for water harvesting
- Improve crop production and pasture yields
- Reduce hillslope runoff and erosion
- Reduce stream siltation and flooding

Catchment perspective:

- Bunds are suitable for crop, range and degraded land, and soil bunds for cropland
- Bunds and waterways to be planned across individual fields
- Large areas of degraded land (i.e. with surface crusts) can be rehabilitated with stone bunds
- Can be used for infield water harvesting.

Benefits:

- Stone bunds are the simplest contour water harvesting system
- Deposition of eroded soil at stone barrier
- Effect of small errors in contour lines less significant for stone bunds
- No need for spillways for stone bunds
- Stone bunds simple and quick to construct
- Other land practices (Zaï pit) can be incorporated

Criteria for application:

	Rainfall	Soil	Slope	Topography
Stone bunds	200-750 mm/yr	All soil types	<5% preferably 0.5-2%	Does not need to be completely even along contour
Earth bunds	200-750 mm/yr	Deep, well drained, not clayey	<12% preferably 0.5-6%	Must be even on contour

Slope of field (height /distance)	Spacing in between soil bunds	Slope of field	Spacing in between stone bunds
<5% (gentle)	20 m	<1%	20 m
5-12% (moderate)	15 m	1-2%	15 m
>12% (steep)	<10 m	2-5%	10 m

- Distance between stone bunds = (height difference between bunds (m) x 100) / % slope gradient
- Stone bund height of 25-30 cm and base width of 30-40 cm
- Earth bund height of 30-50 cm and base width of 1/2-1 m. Spillway intervals of 20 cm along bund length
- Each bund must have a low point-V or spillway where water can flow over.

Potential drawbacks / disadvantages:

- Stone bunds requires locally available stones
- Stone collection and transport is time-consuming
- Earth bunds labour intensive to construct

Livelihood opportunity:

Reduced soil erosion and increased infiltration to recharge ground water improves quality and availability of water resources.

Funding opportunities:

Landcare

Legislation:

- National Environmental Management Act 107 of 1998.
- Mountain Catchment Areas Act 63 of 1970.
- Runoff management is considered a Schedule 1: permissible use of water in terms of the NWA.

METHODOLOGY

Methodology:

STONE BUNDS

Mark and build contour lines by following steps 1 to 5 for contour ridging (Figure C.3.1-1) – **See** Guideline A.3.1. Contour ridging. The contour interval / distance between bunds are determined according to the formula shown in the criteria:

1. Dig a shallow trench 5-10 cm deep and 30-40 cm wide along marked contour lines (Figure C.3.1-2)
2. Place excavated soil upslope of the trench (Figure C.3.1-3)
3. Place large stones along base of trench and on lower side of slope to create an “anchor” (Figure C.3.1-4)

C.3.1. Contour bunds

4. *Pack smaller stones on upslope side of larger stones and fill gaps in larger stones to act as a filter (Figure C.3.1-5)*
5. *Leave excavated soil on upslope side of stone bund*

EARTH BUNDS

Mark and build contour lines by following steps 1 to 5 for contour ridging) – **See Guideline A.3.1 Contour ridging**. The contour interval depends on the slope of the field as indicated in table and is determined as shown in the illustrations (Figures C.3.1-6 to C.3.1-9):

1. Calculate and mark width and location of spillways over the length of a bund
2. Build the contour line into a bund by digging a channel along the contour and placing the soil downhill of the channel to form an embankment. See criteria for soil bund heights and widths
3. Plant the bunds with grass to strengthen it in case of overtopping
4. Consult land conservation specialist on construction of spillways in the earth bunds
5. Consult land conservation specialist if graded soil bunds are constructed and to plan waterways

Illustrations/ Diagrams: STONE BUNDS (Source: Denison J, Smulders H, Kruger E, Ndingi H and Botha M. 2011)

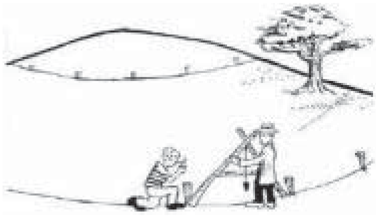


Figure C.3.1-1: Stone bunds – Mark out contour lines

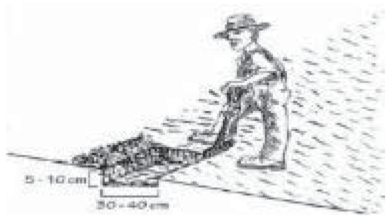


Figure C.3.1-2: Stone bunds – Dig shallow trench along contour line

Figure C.3.1-3: Stone bunds – Place large stones in trench and down-slope side

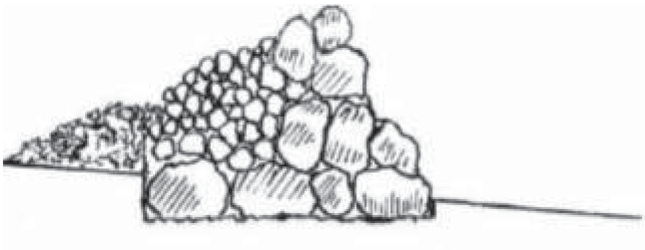


Figure C.3.1-4: Stone bunds – Place small stones up-slope side of large stones

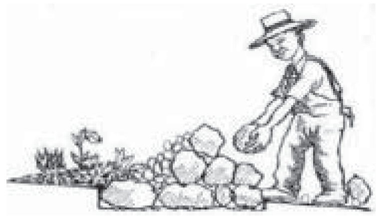


Figure C.3.1-5: Stone bunds – Maintain by filling gaps and tunnels small stone

Illustrations/ Diagrams: EARTH BUNDS (Source: Anschutz J, Kome A, Nederlof M, de Neef R and van de Ven T. 2003)

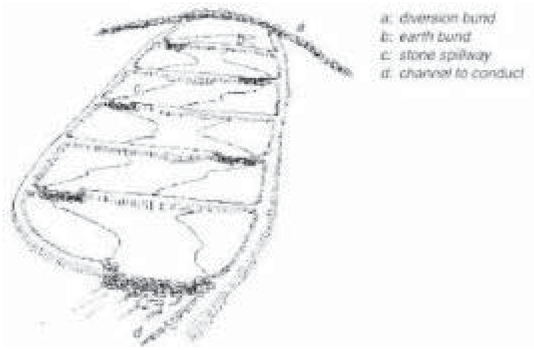


Figure C.3.1-6: Earth bunds – System of earth bunds with stone spillways

Figure C.3.1-7: Earth bunds – Determining distance between soil bunds

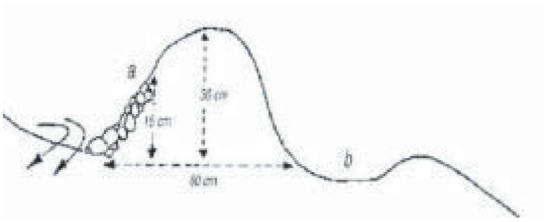


Figure C.3.1-8: Earth bunds – Cross section of a stone-faced soil bunds

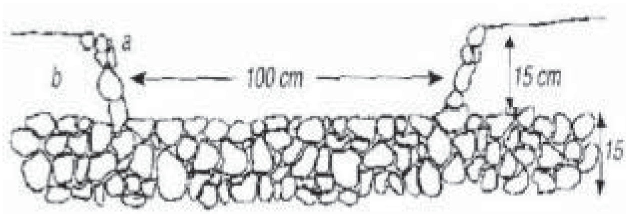


Figure C.3.1-9: Earth bunds – Cross section of a spillway in soil bund

C.3.1. Contour bunds

Photos:

Figure C.3.1-10: Earth bund stabilized with *Phalaris sp.* and combined with zero tillage. (Source: FAO)

Seasonal variations:
- Construct bunds during dry season
- Construct during the period that does not interfere with land preparation

Equipment requirements:
- Pegs and hammer / stone
- Line level / A-frame or Phiri-Lino-frame (See references for details on equipment and use thereof)
- Spade
- Stones of various sizes for stone bunds
- Wheelbarrow

Variations/Adaptations:
- Stone bunds
- Earth bunds with stone spillways
- Stone faced soil bunds (for erosion protection)
- Graded soil bunds (to direct excess runoff to waterways at field boundaries)
- Stone bunds are only suitable where there is plentiful stone available
- Earth bunds not suitable for steep slopes due to excessive erosion with breakage in structure
- Earth bunds not suitable for low permeable / clay soils due to waterlogging in wet periods

MAINTENANCE

Maintenance requirements:
- Plug gaps and tunnels in stone bund with small stone or gravel after heavy rains
- Plant earth bunds with grass for erosion protection in case of overtopping
- Earth bunds can be covered with stone on the upslope side to prevent erosion
- Graded soil bunds must be constructed with spillways and waterways at field boundaries
- Repair breakages in soil bund immediately

Potential drawbacks/disadvantages:
- Not suitable for uneven terrain
- Implementation is more time consuming as construction cannot be mechanised.

REFERENCES

Definitions:
Not applicable

See also:
Guideline A.3.1. Contour ridging
Guideline A.2.2. Prevention and rehabilitating overgrazing
Guideline B.1.2.1. Designing a natural farming garden
Guideline B.1.2.2. Where to plant
Guideline B.1.2.3. When to plant what
Guideline C.3.2. Zaï planting pits
Guideline C.3.3 Half-moon pits

Further references:

a. Environmental Affairs Department. 2005. Community environmental management manual – Soil conservation and fertility improvement.
b. Anschutz J, Kome A, Nederlof M, de Neef R and van de Ven T. 2003. Water harvesting and soil moisture retention. Agrodok 13, Agromisa Foundation.
c. Denison J, Smulders H, Kruger E, Ndingi H and Botha M. 2011. Water Harvesting and Conservation – Volume 2 Part 1: Technical Manual and Farmer Handouts. Water Research Commission.
d. FAO Soils Bulletin 79. Optimising soil moisture for plant production: The significance of soil porosity ISSN 0253-2050. http://www.fao.org/docrep/006/y4690e/y4690e09.htm accessed on 27 Aug 2015

C.3.2. Zaï planting pits

OVERVIEW

This guideline describes how to dig Zaï planting pits to harvest water on individual trees.
Also referred to as: Micro pits; Planting / fertility basin; or Small water harvesting pits

Objectives:
- Act as micro-catchments within fields to retain runoff from the slope for water harvesting

Criteria for application:

Rainfall	Soil	Slope	Topography

C.3.2. Zaï planting pits

- Improve crop production and pasture yields
- Reduce hillslope runoff and erosion
- Reduce stream siltation and flooding
- Rehabilitate degraded, barren and crusted soils

200-750 mm/year Semi-arid climate	Shallow, clayey, poor infiltration, soil with surface crust	preferably <2%	Even topography not required

Catchment perspective:
- Suitable for range and degraded land
- A simple and effective technique that can be widely adopted in catchment
- Large areas of degraded land and land with surface crusts can be rehabilitated

Pit depth	**Pit diameter**	**Distance between pits**	**Distance between rows**
15-20 cm	30-50 cm	30-50 cm	60-75 cm

String length = distance between pits + ½ diameter of pit (i.e. 50 cm + 20 cm = 75 cm string length)

Legislation:
Not Applicable

Funding opportunities:
Not Applicable

Potential drawbacks/disadvantages:
- Digging of pits is labour-intensive
- Not possible to use machinery
- Where soils are already shallow, they become even shallower when pits are dug
- Not recommended on steep slopes
- Manure/compost should be available in adequate quantities

Benefits:
- Simple to construct
- Infiltration of rainwater that would have runoff
- Improves plant production by concentrating runoff around growing plants
- Improves soil fertility and structure when manure/compost is added in pits
- Once prepared, pits can be re-used for up to four crop seasons or two seasons without need to add more manure
- Other measures can be combined with pitting
- Can be used to establish trees and shrubs

Livelihood Opportunity:
The zai pits help with soil nutrition and water harvesting to the crops, this contributes to household food security.

METHODOLOGY

Methodology:
1. Determine length of string according to formula in criteria to mark out position of the pits (i.e. distance between pits + half the width of the pit, e.g. 30 cm distance between pits + 15 cm if pit width is 30 cm = 45 cm length of string).
2. Tie a peg to both ends of string
3. Place one peg in soil at position of first pit, and draw a circle around it. Repeat on the other end of string, draw the second pit.
4. Place the peg in the middle of the second circle, and lay out the string straight along the row, at the end of string draw another pit. **Note:** The end of the string marks the middle of the pit.
5. Pits can be marked in one line or in staggered rows. Continue marking out all pits across hillslope in this way
6. Cut a stick so that its length is equal to the diameter of the planting pit, and another stick to the length of the depth required assisting in digging uniform pits
7. Dig pits according to table in criteria above. Use the excavated soil to create a ridge around the downslope side of the pit. This is used to catch runoff water to infiltrate into the pit.
8. Mix some of the topsoil with one medium size bucket of well-composed manure/compost and return to pit. Ensure that the pit is **not** refilled to the top so there is still space to collect and store runoff.
9. Plant pits with crop seed after the first rains.

Illustrations/ Diagrams:	**Photos:**

C.3.2. Zaï planting pits

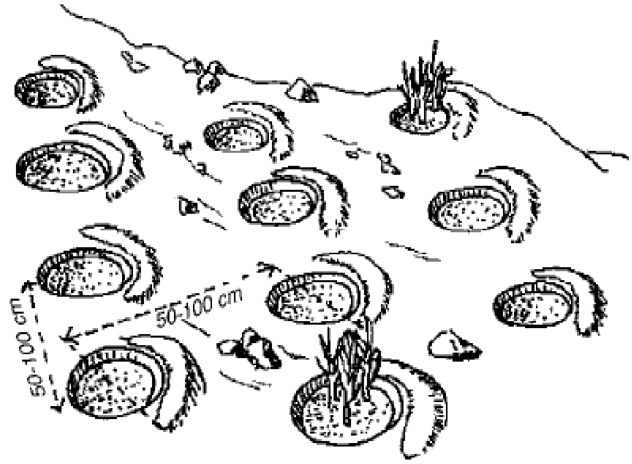


Figure C.3.2-1: Zaï planting pit technique. (Source: Anschutz J, Kome A, Nederlof M, de Neef R and van de Ven T. 2003)

Figure C.3.2-2: Millet growing in Zai Pits. (Source: Echocommunity)

Equipment requirements:

- String and pegs
- Hand hoe
- Manure/compost

Variations/Adaptations:

- Pits in line or in staggered rows
- Combined with stone bunds along contour line
- Zaï pits with soil bunds of grass strips
- Planting on ridge rather than in pit to maximise root depth for shallow soils

Seasonal variations:

- Dig pits during dry season
- Farmers may sow into existing holes in the second year

MAINTENANCE

Maintenance requirements:

- May dig new pits in between existing pits if spacing of pits is wide
- If the aim is to restore fertility of the whole field, it is advisable to dig new pits

Potential drawbacks/disadvantages:

- High labour requirements for construction and maintenance as it cannot be mechanised
- During very wet seasons, water logging is possible. Organic debris placed in the pits may help to soak up excess water
- Already shallow soil gets even thinner where the pits are dug. This may require planting on the top of the ridges

REFERENCES

Definitions:
Not applicable

See also:
Guideline C.3.1. Contour bunds
Guideline C.3.3. Half-moon pits
Guideline D.1.4. Selecting beneficial trees

Further references:

a. Anschutz J, Kome A, Nederlof M, de Neef R and van de Ven T. 2003. Water harvesting and soil moisture retention. Agrodok 13, Agromisa Foundation

b. Critchley W, Di Prima S and Tuyp W. 2012. Sustainable land management in Sub-Sahara Africa information cards. No 6 Zaï planting pits. VU University Amsterdam

c. https://www.echocommunity.org/en/resources/d676d269-5f1f-47f1-812a-ed6d3e253989

C.3.3. Half-moon pits

OVERVIEW

This guideline describes how to dig half-moon pits to harvest runoff water on land to feed individual trees.

Objectives:

- Act as micro-catchments within fields to retain runoff from the slope for water harvesting
- Improve crop production and pasture yields
- Reduce hillslope runoff and erosion
- Reduce stream siltation and flooding
- Rehabilitate degraded, barren and crusted soils

Catchment perspective:

- Suitable for range and degraded land
- A simple and effective technique that can be widely adopted in catchment
- Large areas of degraded land and land with surface crusts can be rehabilitated

Legislation:

Not Applicable

Funding opportunities:

Not Applicable

Livelihood opportunity:

Improved watering of trees and crops by runoff harvesting can contribute to improved crop production which contributes to household food security.

Criteria for application:

For growing trees in areas receiving annual rainfall of at least 150 mm

Rainfall	Soil	Slope	Topography
150 mm/year Dry climate	Shallow, clayey, poor infiltration, soil with surface crust	preferably <2%	Even topography not required

	Pit depth (indication, may be less in harder soils)	Pit width	Distance between pits	Distance between rows
Seed – *may vary on the type / species of the seed*	20-50 cm (Seed type)	4 m	2 m	4 m
Sapling or small tree	1 m x 1 m *(1 spade length wide and deep)*	4 m	2 m	4 m

String length = distance between pits + ½ diameter of pit (i.e. 200 cm + 200 cm = 4 m string length)

Potential drawbacks/disadvantages:

- Digging of pits is labour-intensive
- Not possible to use machinery
- Where soils are already shallow, they become even shallower when pits are dug
- Not recommended on steep slopes
- Manure/compost should be available in adequate quantities

Benefits:

- Simple to construct
- Infiltration of rainwater that would have runoff
- Improves plant production by concentrating runoff around growing plants
- Crops can also be planted in the half-moon around the tree.
- Improves soil fertility and structure when manure/compost is added in pits
- Other measures can be combined with pitting
- Can be used to establish trees and shrubs, especially fruit trees to contribute food sources.

METHODOLOGY

Methodology:

1. Determine length of string according to formula in criteria to mark out position of the pits (i.e. distance between pits + half the width of the pit, e.g. 200 cm distance between pits + 200 cm if pit width is 4 m = 400 cm length of string). See **Guideline C.3.2. Zaï planting pits**
2. Tie a peg to both ends of string.
3. Place one peg in soil at position of first pit, and draw a circle around it. Repeat on the other end of string, draw the second pit.
4. Place the peg in the middle of the second circle, and lay out the string straight along the row, at the end of string draw another pit. **Note:** The end of the string marks the middle of the pit.
5. For the next row, repeat marking out the pits as per steps 3&4 above, however, stagger the pits. This allows these pits to capture the runoff from between the pits above.
6. Dig a hole according to table in criteria above. Use the excavated soil to create a ridge or half-moon crescent around the downslope side of the pit. This is used to catch runoff water to infiltrate into the pit.
7. Holes must be at least half filled with good manure or compost and lots of water so the tree starts growing. Ensure that the pit is **not** refilled to the top so there is still space to collect and store runoff.

C.3.3. Half-moon pits

8. Plant the pits with trees during the wet season so they are regularly watered, and the soil is softened to dig.

Illustrations/ Diagrams:

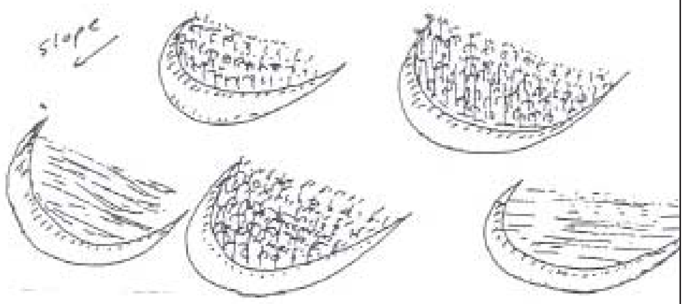


Figure C.3.3-1: Staggered half-moon pits. (Source: Lakew *et al.*, 2005)

Photos:

Figure C.3.3-2: Millet growing in half-moon Pits. (Source: Echocommunity)

Equipment requirements:

- String and pegs
- Hand hoe
- Spade
- Manure/compost

Variations/Adaptations:

- Combined with stone bunds along contour line
- Mulch around the trees, or cover with saw dust to reduce evaporation after rains.

Seasonal variations:

- Dig pits during first rains, to water the trees and soften the soil.
- Farmers may sow into existing holes in the second year

MAINTENANCE

Maintenance requirements:

- Check that the moons are still intact to ensure runoff water is trapped into the pit side.

Potential drawbacks/disadvantages:

- Labour intensive for construction and maintenance as it cannot be mechanised
- During very wet seasons, water logging is possible. Organic debris placed in the pits may help to soak up excess water

REFERENCES

Definitions:
Not applicable

See also:
Guideline C.3.1. Contour bunds
Guideline C.3.2. Zaï planting pits
Guideline D.1.4. Selecting beneficial trees

Further references:

a. Anschutz J, Kome A, Nederlof M, de Neef R and van de Ven T. 2003. Water harvesting and soil moisture retention. Agrodok 13, Agromisa Foundation

b. Lakew Desta, Carucci, V., Asrat Wendem-Ageňehu and Yitayew Abebe (eds). 2005. Community Based Participatory Watershed Development: A Guideline. Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia.

c. Critchley W, Di Prima S and Tuyp W. 2012. Sustainable land management in Sub-Sahara Africa information cards. No 6 Zaï planting pits. VU University Amsterdam

d. https://www.echocommunity.org/en/resources/d676d269-5f1f-47f1-812a-ed6d3e253989

C.3.4. Infiltration trenches (Water Absorption Trenches)

OVERVIEW

Infiltration trenches are shallow excavations with rubble or stone that create temporary subsurface storage of stormwater runoff, thereby enhancing the natural capacity of the ground to store and drain water. Infiltration trenches allow water to exfiltrate into the surrounding soils from the bottom and sides of the trench.

Objectives:

- To dig infiltration pits in areas that receive significant rainfall
- Water will infiltrate into the soil rather than travel overland as sheet flow causing damage
- Doing so will reduce damage to crops and villages from overland flow and increase the underground water table to lengthen the time you can use the village borehole

Benefits:

- Reduces the sheet flow after rain and decreases the damage to crops and homesteads
- Flood risk is reduced when the water infiltrates into the soil
- There is less erosion and river banks are better protected after heavy rain
- Increased water security due to increased ground water which gives longer use of boreholes and recharges the river base flow in the dry months

Criteria for application:

- Areas of high runoff and steep slopes.
- Where cropping is located on slopes above the village.
- It is labour intensive, so where labour to dig the trenches is readily available.

Funding opportunities:

Not Applicable

Legislation:

Not Applicable

Catchment perspective:

- Infiltration trenches can capture sheet flow from a hillside area or concentrated flow from open channels or gullies. This will decrease soil erosion and lead to less sediment in the rivers.
- Having too many trenches, e.g. thousands in small area, will impact the hydrology of the area

Livelihood opportunity:

The trenches catch runoff in high rainfall areas, this holds the water so that it can seep into the ground and recharge groundwater. The reduced runoff and speed of runoff reduces the occurrence of erosion and silt in water bodies don stream. Improved groundwater contributes to improved crop productivity and access to water, which in turn contribute towards household food security and nutrition.

METHODOLOGY

Methodology:

Planning

1. The design of the trenches should be able to handle the largest likely storm each year. This will control water discharge and runoff for the majority of rainfall events

Number of trenches

1. The number of trenches that need to be dug will depend on the area of the hills from which the rain water will drain. If water drains from a hill of 1 hectare (100 meters by 100 meters), only one infiltration trench would be needed. If the hill area is 50 hectares (1000 meters by 500 meters) then you would need roughly 50 trenches
2. Having too many trenches will retain more water in the underground water table and might limit water going elsewhere

Placement

1. Where possible, the placement of trenches should stop direct flow going down the hill and should be spaced evenly across contours if the hill slope is even.
2. The trenches should run across the hillslope and not vertically up the slope, i.e.

3. The trenches should be staggered between rows, i.e. the lower trench catches runoff from the area in between the upper trenches.
4. They should be placed above the village and the area under crop
5. The trenches are not continuous, rather a series of large rectangular holes in rows around the hill slope.

Criteria for trench size

1. Based on slope
   a. If the slope is even, make the trench approximately 5 metres long (around the hill), 1 metre wide and 1-2 metre deep
   b. If the slope makes a channel, bringing the water together, make the trench approximately 3 metres long, 2 metres wide and 1-2 metre deep
2. Based on soil
   a. If the soil has a lot of clay and water infiltrates slowly, the trench should be deeper, up to 4 metres for very clay soil
   b. If water infiltrates fast, having a depth of 1 metre should be sufficient

C.3.4. Infiltration trenches (Water Absorption Trenches)

c. These dimensions serve only as a guide and each trench should be made relative to the slope and soil type

Construction

1. Only start digging trenches once they have been planned out on the village map
2. Making these trenches will take time and will take diggers away from spending time tending to their crop fields. The village will need to act together to support the diggers because they will all benefit from the work they are doing
3. Dig the trenches to the needed size using teams of village volunteers
4. Slope the uphill slide of the trench, so that if animals such as tortoise and snakes fall in the trench, then they can climb out
5. While the diggers are making the trench, other teams should bring large stones and small rocks to the digging site. They should also bring banana leaves
6. Once the trench is dug, put a 30 cm layer of the banana leaves all along the bottom of the trench, with rocks and stones on top.

Illustrations/ Diagrams: (Source: D. Ogier)

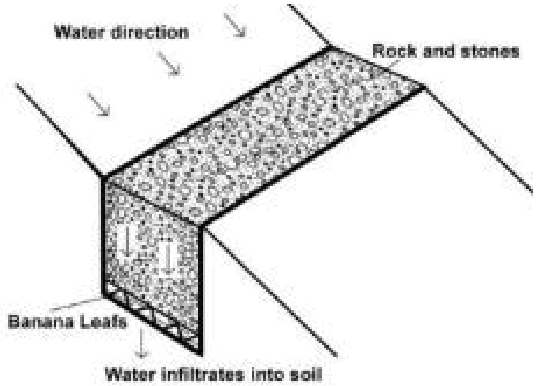


Figure C.3.4-1: Infiltration schematic.

Photos: (Source: D. Ogier)

Figure C.3.4-2: Completed infiltration trench.

Equipment requirements:

- Spade
- Pickaxe / hand hoe

Variations/Adaptations:
Not applicable

Seasonal variations:
Construction and maintenance should be done in the dry months.

MAINTENANCE

Maintenance requirements:

- Each trench should be checked for build-up of leaves and branches once before the wet season and after major storms
- The trench should drain of water between 1 and 3 days. If it still has water in it after 3 days there might be sedimentation in the trench and this should be cleaned out by removing the sediment, or the dimensions of the trench are too small and the trench should be made wider

Potential drawbacks/disadvantages:

- High clogging potential without effective pre-treatment – not for sites with fine particle soils (clay/silts) in upstream catchment
- Build-up of pollution difficult to see
- High historic failure rate due to poor maintenance, wrong siting or high debris input
- Limited to relatively small catchments

REFERENCES

Further references:

a. Metropolitan Council/ Barr Engineering Co. 2001. Minnesota Urban Small Sites BMP Manual. Chapter 3

See also:
Guideline C.3.1. Contour bunds
Guideline C.2.5. Hillside runoff (swales)
Guideline C.2.3. Road runoff
Guideline C.3.3. Half-moon pits
Guideline A.3.1. Contour ridging

C.3.5. Spring protection and management

OVERVIEW

Groundwater use can be a reliable water supply option for meeting daily water needs in rural communities which are located in geographically hard to reach areas. A natural spring provides a reliable and sustainable means of obtaining water compared to formal water supply, which may be limited or non-existent in many areas. The challenges for spring protection and management appears in two ways. The first is through overuse or misuse by the community, and the second is the disregard of springs in water service delivery. These situations lead to the degradation of the spring, even

C.3.5. Spring protection and management

if the community is aware of the benefits it provides. An awareness of the benefits of spring protection and management is needed to ensure that this critical resource is not overlooked in rural areas.

Objectives:

- Understanding of groundwater impacts
- Provide an additional water source
- Reduce erosion/pollution around springs

Catchment perspective:

Groundwater aquifers are recharged by surface water which has filtered through soil and rock. It forms an important part of the water cycle as water is stored in an aquifer before being discharged into a river, wetland, spring or the sea. Many ecosystems are associated with groundwater, and in part are affected by changes in its quality and quantity. In general, the flow of groundwater follows surface topography, therefore contamination upslope from a spring will affect its water quality. In turn over abstraction of a borehole will lead to reduced flow to surrounding springs.

Criteria for application:

- Natural springs occur where groundwater emerges naturally. Rainfall usually seeps into the ground uphill and flows downhill until it is forced out of the ground by natural pressure.
- As spring water is so close to surface there are many ways that it may get contaminated.
- Contamination may occur directly at the spring, or in-directly from areas uphill.
- Potential contamination sources include livestock gathering points, pit latrines and waste disposal sites located upslope from the spring outlet.

Benefits:

- Better spring protection and management
- An understanding of groundwater flow
- Improved water quality and health benefits

Funding opportunities:

Not Applicable

Legislation:

National Environmental Management Act 107 of 1998
National Water Act 36 of 1998.

METHODOLOGY

Methodology:

Set-back distances for springs:

1. Set-back distances for springs are recommended for different hydrogeological types. If unsure of the geotechnical type it is recommended that a specialist be consulted.
2. Geohydrological type:
   - **Sand and gravel**: Large particle sizes such as gravel or sand allows rapid infiltration of runoff into the soil.
   - **Clays and limestone/weathered granite**: Small particle sizes such as clay or solid rock have slow or no infiltration. Weathered rock has pore spaces similar to openings between soil particles.
   - **Limestone fractured, dolomite, granite fractured**: Fractures in rocks allow for pathways for rapid migration of water to the groundwater table.
3. Use of the set-back distance decision chart (Figure C3.4.1) considers the geotechnical type, and the distance of possible contamination. For instance, a pit latrine is located 110 m uphill of a spring. The geohydrological type is weathered granite. This means that the set-back distance should be Zone 3. The recommended protection strategy for Zone 3 should be followed in this example.
4. Set-back Zones:
   - **Zone 1:** This may be considered the NO-GO zone where no potential contaminating activity should be allowed, up to 100 meters upslope of a spring. Any potentially contaminating activities located within this distance, such as cattle kraals, stock watering points and pit latrines should preferably be closed down.
   - **Zone 2:** Is defined as the distance beyond 100 meters, whereby the travel time for contamination is up to 25 days. Alternative options are to (1) Stop the contamination source / activity, or else move it to a safer zone; (2) Install protective measures; or (3) Obtain the input of a specialist. There should be regular monitoring of the water supply for indicator organisms and / or related contaminants, and the water abstracted for potable purposes should be disinfected as a precautionary measure.
   - **Zone 3:** Is the distance outwards, upstream of the spring, beyond protection zone 2, for which the travel time of groundwater is between 25 days and 50 days. Alternative options are to (1) If feasible, move the contamination source / activity to a safer zone; (2) Install protective measures; or (3) Obtain the input of a specialist. The water abstracted for potable purposes should be disinfected as a precautionary measure.
   - **Zone 4:** This is the distance outwards, upstream of the spring, beyond protection zone 3, for which the travel time of groundwater is more than 50 days. Disinfect water used for drinking, especially if sanitary conditions in the home warrant it. If in doubt, install protective measures or obtain the input of a specialist.

Illustrations/ Diagrams:

C.3.5. Spring protection and management

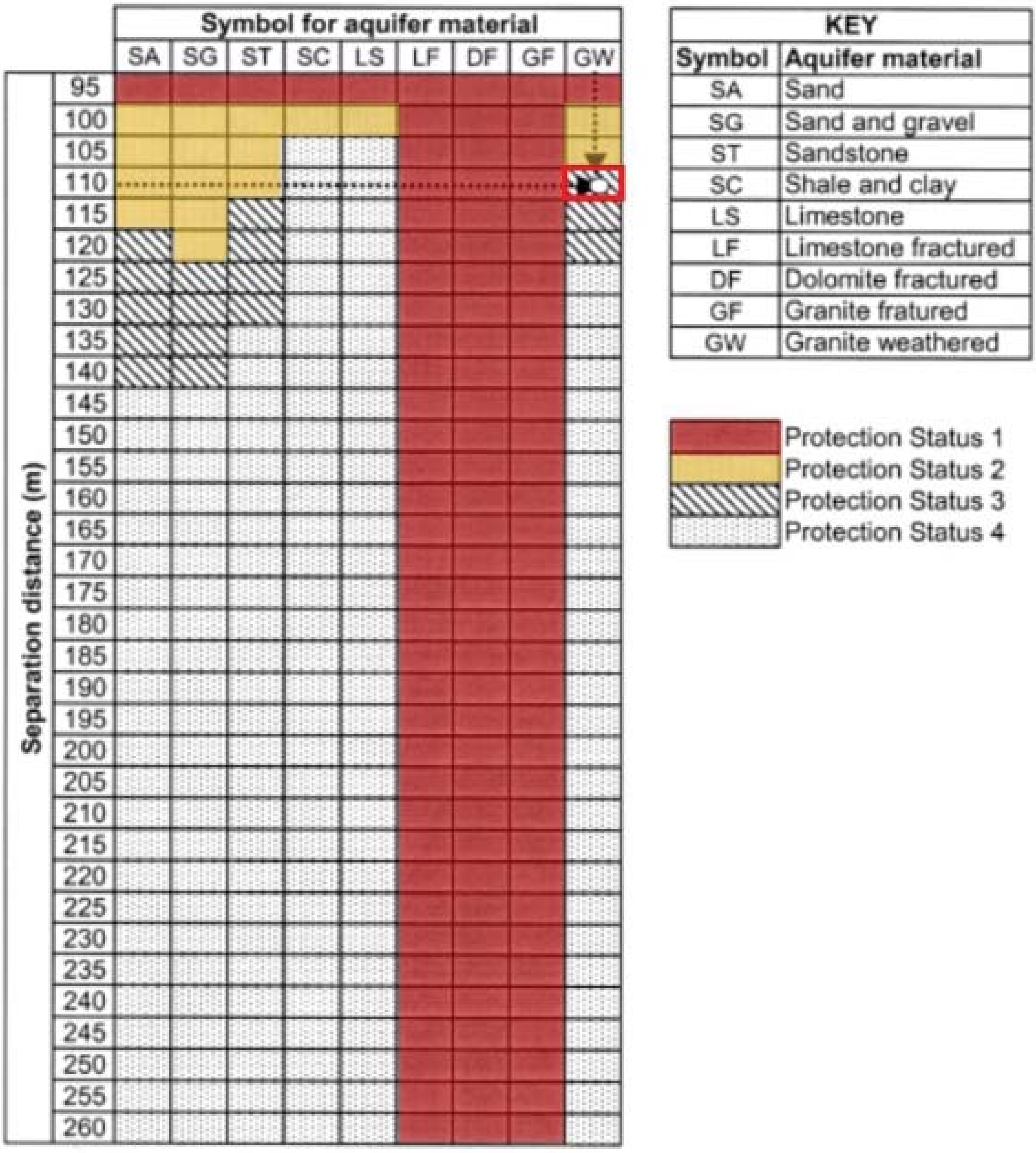


Figure C.3.5-1. Set-back distance chart for springs.

Photos:	Equipment requirements:	Variations/Adaptations:
Not Applicable	Fencing if required to close area around the spring	Not Applicable

Seasonal variations:

- Springflow may be intermittent, reducing drastically or drying up during the dry season.
- Springflow is connected with rainfall and the level of the groundwater table, so any increase or decrease in these will be noticed through the amount of water emerging from the spring.

MAINTENANCE

Maintenance requirements:

- **Zone 1:** Ensure no contaminants occur within this zone.
- **Zone 2**: Regular monitoring of the water supply for indicator organisms/contaminants.
- **All zones:** Water abstracted for potable purposes should be disinfected as a precautionary measure.

Potential drawbacks/disadvantages:

- Springs present special problems for protection area delineation in that the abstraction is governed by natural groundwater flow driven by gravity. The size of the capture area depends on the total flow to the spring, rather than the proportion of the flow actually abstracted.
- This means that flow is dependent on external factors, and that reliance of flow is dependent on climatic factors.
- Spring protection may also be difficult due to groundwater not being "visible", especially if there is contamination.

C.3.5. Spring protection and management

REFERENCES

Definitions:	See also:
Not applicable	Guideline A.2.3. Grazing movement Guideline C.2.5. Hillside runoff (swales) Guideline C.3.1. Contour bunds Guideline D.3.1. Sustainable utilisation of wetlands Guideline D.3.2. Wetland conservation Guideline E.4. Sanitation and latrine management Guideline E.5. Waste management Guideline F.3.2. Cholera response - oral rehydration Guideline F.3.3. Cholera response - food hygiene Guideline F.3.4. Waterborne illness

Further references:

a. Rusinga, F. 2004. Groundwater protection: Guidelines for protecting springs. Department of Water Affairs and Forestry. Pretoria.

b. Foster, S., Garduño, H., Kemper, K., Tuinhof, A., Nanni, M and Dumars, C. 2002. Groundwater Quality Protection: Defining Strategy and Setting Priorities. World Bank Briefing Note 8. World Bank, Washington

C.4 Small dams

C.4.1. Stone check dams See Guideline A.4.3. Stone check dams

C.4.2. Sand dams

OVERVIEW

This guideline describes how to construct a sand dam in a large gully or small river. Sand dams control the spread of sandy sediment, reduce erosion, and increase infiltration of water into the soil.

Objectives:

- Structure placed in a large gully or small river to
- Collect sandy sediment
- Provide sediment control
- Recharge water table
- Provide water source

Catchment perspective:

Retains water in the catchment for as long as possible, thereby increasing the time for infiltration and groundwater recharge. This also helps to reduce flooding downstream. It also allows for the productive use of otherwise "lost" water.

Benefits:

- Increase absorption/infiltration of water into the soil
- Reduced evaporation losses
- Store water in the sandy deposits
- Allows for convenient source for sand harvesting
- Allow for planting of crops once dam is mature Can be used to rehabilitate large areas with erosive damage
- Holds back water during periods of high flow which prevents it from causing damage downstream
- Once mature, a well can be dug to provide access to the water stored in the sand

Criteria for application:

- Can be used in small and large gullies preferably in areas with flat slopes to maximise the sediment collection potential
- Should be built in successive phases or layers. Once a layer has collected all the sand it can, must then place next dam layer
- Water should not percolate / seep through the dam therefore need clay or concrete
- If the dam is well protected the dam can be overtopped
- Strong erosion protection must be provided on the downstream side to prevent undercutting
- It is beneficial to involve an engineer or technician in the initial planning and building these structures
- Limit the final height to 3-4 m (3 to 4 spade lengths). Built in layers of roughly 30 cm (spade head)
- Earthfill can be used instead of the recommended stone masonry but this will not be permanent as it will wash away eventually

Funding opportunities:

Not Applicable

Legislation:

- National Environmental Management Act 107 of 1998.
- National Water Act 36 of 1998.

METHODOLOGY

Methodology:

1. Clear the area underneath the new dam of all topsoil and organic matter
2. Dig a trench across gully or dry river making sure to remove all loose material and dig down to hard material – at least 0.5 m deep and 1 m wide ($^1/_2$ spade deep by 1 spade wide)
3. For masonry dam, the width must be equal to the final height of the dam
4. If earthfill is used, place and compact clay into the trench and build it up to a wide shelf 30 cm (spade head) above the surrounding ground
5. Then place rocks, gravel and sand over and around it
6. Must protect this material from washing away
7. If stone masonry is used, place the stones and the masonry such that the stones touch each other and build them up to 30 cm (spade head) above the surrounding ground
8. Once the dam is full of sand, the next layer of the dam can be built. Thoroughly clean the top of the dam (down to the clay in the case of the earthfill dam) and place the next 30 cm (spade head) layer

Equipment requirements:

- Need large volumes of earth and stone
- Cement/mortar
- Compacting equipment
- Survey equipment

Variations/Adaptations:

- Overflow sand dams using rockfill or gabions
- Permeable rock dams (similar to check dams)

Seasonal variations:

- To be constructed during the dry season
- Regularly repaired during wet season.
- Fix erosion with stones and planting vegetation.

Illustrations/ Diagrams:

Photos:

C.4.2. Sand dams

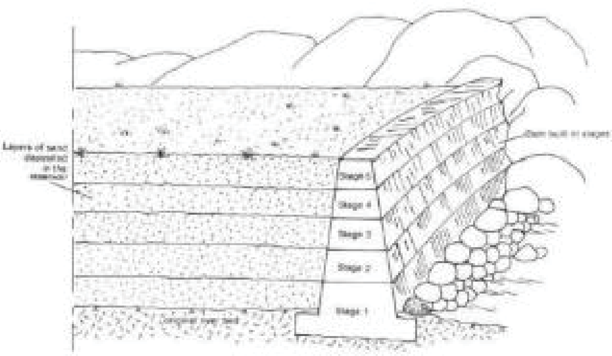


Figure C.4.2-1: Schematic of a sand dam. (Source: Nilsson A., 1988)

Figure C.4.2-2: Sand dam. (Source: Africa Harvest)

MAINTENANCE

Maintenance requirements:

- Check for erosion on the dam and downstream of it, place large stones when erosion occurs
- Do not plant trees on or near the wall – small plants only

Potential drawbacks/disadvantages:

- Sand dams take several years to mature or fill in with sand.
- Sand dam can cause higher rates of erosion downstream and sometimes this has to be maintained when it gets worse.
- It is difficult to control who, and what has access to water in the sand dam

REFERENCES

Definitions:

Sand dam: is a reinforced rubble cement wall built across a seasonal sandy river.

See also:

Guideline A.4.1. Gully prevention
Guideline A.4.2. Gully reclamation (small gullies)
Guideline A.4.3. Stone check dams
Guideline A.4.4. Brushwood check dams
Guideline A.4.5. Vegetation barriers
Guideline A.4.6. Gully re-shaping
Guideline A.4.7. Erosion management along road sides
Guideline A.5.1. Riparian buffer zones
Guideline A.5.4. Gabion baskets
Guideline C.4.3. Farm dams
Guideline C.5.1. Diversion weirs

Further references:

a. Nilsson A. 1988. Groundwater Dams for small-scale Water Supply. London: IT Publications
b. Africa Harvest. *Impact of sand dams on the women of Mulal and Wote in Makueni County.* Accessed online at http://ar2013.africaharvest.org/wp-content/uploads/2014/09/27.jpg. 19 August 2015

C.4.3. Farm dams

OVERVIEW

This guideline describes how to construct a farm dam to capture water during the wet season and store it so that it is available for use in the dry season.

Objectives:

Structure placed in a stream or on a hillslope to

- Collect and store water
- Recharge water table
- Provide water source

Catchment perspective:

- Captures water and stores it for later use
- Prefer as little sediment collection as possible hence these dams should have check dams upstream of them and other soil retention techniques
- Farm dams should not have any latrines or cattle fields upstream, or within 100 m from the bank, of them to prevent pollution or contamination of the stored water

Benefits:

- Store water for use in the dry season
- Increase absorption/infiltration of water into the soil
- Fish farms

Criteria for application:

- It is essential to involve an engineer or technician in the planning and building of these structures
- A suitable site is one where the river valley is narrow which means the dam will also be narrow. Also, the area upstream should be wide to be able to store as much water as possible
- Other aspects that need to be considered are the foundation geology, the hydrological conditions, the available construction materials and the technical knowledge on how to build these dams
- Water should not percolate / seep through the dam therefore need enough impervious clay. Compaction is very important
- One of the flanks of the site should be hard so that the spillway can be placed there
- The spillway must be large enough to remove excess water runoff from the dam
- Under no circumstances should the dam be overtopped

Funding opportunities:

Not Applicable

Legislation:

- National Environmental Management Act 107 of 1998.
- National Water Act 36 of 1998.

METHODOLOGY

Methodology:

1. Earthfill dams are usually built in zones but can be built with a single zone
2. The clay core has the least strength but the highest impermeability
3. The clay is placed in the middle to render the dam watertight
4. General fill, consisting of soil, sand, gravel and cobbles, is placed on either side to provide the strength to make it stand up
5. A filter or rock toe is placed on the downstream toe to drain the dam and keep the downstream side of the dam dry
6. A layer of rip-rap, consisting of large stones, is placed on the upstream face to protect the face from wave erosion
7. The slopes of an earthfill dam are usually 1V:3H on the upstream side and 1V:2H on the downstream side. I.e. 1 vertical measure to each 3 horizontal measures; on the upstream and 1 vertical measure to every 2 horizontal measures on the downstream side
8. A spillway must be provided to remove excess runoff from the dam. The level of the spillway must be a minimum of 1.5 m (11/2 spade lengths) below the crest of the dam. Its width is determined by the size of the floods that will occur.

Equipment requirements:

- Need large volumes of earth and stone
- Earthmoving and compacting equipment
- Survey equipment

Variations/Adaptations:

- Sand dams
- Diversion weirs

Seasonal variations:

- To be constructed during the dry season
- Regularly repaired during wet season
- Fix erosion with stones and planting vegetation

Illustrations/ Diagrams:

C.4.3. Farm dams

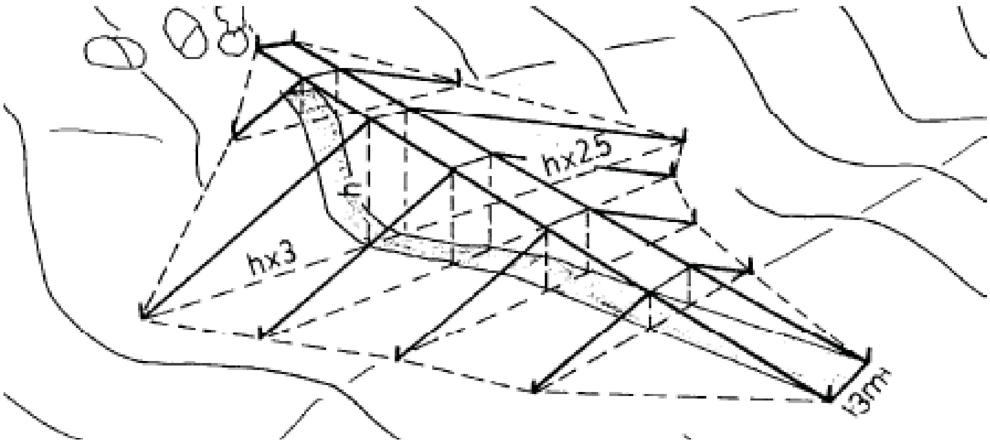


Figure C.4.3-1: Schematic of farm dam. (Source: Nilssen-Petersen E. 2006)

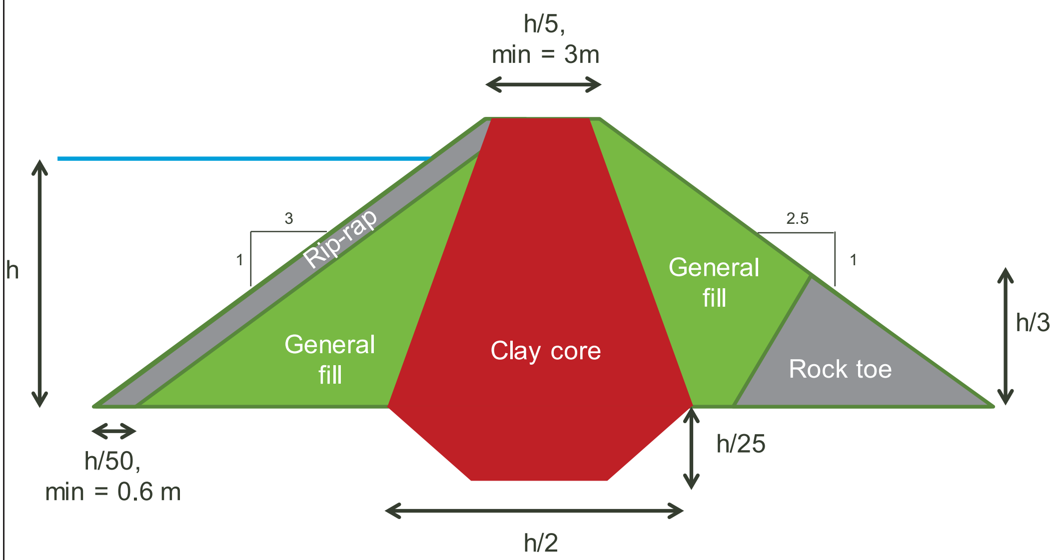


Figure C.4.3-2: Dimensions of earthfill dam. (Source: F. Denys)

Figure C.4.3-3: Slopes of an earthfill dam

Figure C.4.3-4: Construction of a farm dam

MAINTENANCE

Maintenance requirements:

- Check for erosion on the dam, the spillway and downstream of the dam, place large stones when erosion occurs
- Do not plant trees on or near the wall – small plants only. Remove any trees that do grow
- Check for excessive leakage and try to find the source if it occurs

REFERENCES

Definitions:
Not applicable

See also:

Guideline A.4.3. Stone check dams
GuidelineA.4.4. Brushwood check dams
Guideline A.4.5. Vegetation barriers
Guideline A.5.4. Gabion baskets

C.4.3. Farm dams

Guideline B.4.2. Sand dams

Further references:

a. Nilssen-Petersen E. 2006. Water from Small Dams. A handbook for technicians, farmers and others site investigations, designs, cost estimates, construction and maintenance of small earth dams. Danish International Development Assistance.

b. Stephens T. 2010. Manual on small earth dams: a guide to siting, design and construction. Food and Agriculture Organisation of the United Nations. http://www.fao.org/docrep/012/i1531e/i1531e.pdf Accessed 27 August 2015

c. Desta L, Carucci V, Wendem-Agenehu A, Abebe Y. 2005. Community based participatory watershed development: A Guideline. Ministry of Agriculture and Rural Development, Ethiopia

C.5 Small-scale irrigation

C.5.1. Diversion weirs

OVERVIEW

This guideline describes how to construct a diversion weir in a river in order to provide water to a canal or pipeline. This differs from a farm dam in that the diversion weir does not provide water storage.

Objectives:

Structure placed in a river to:
- Raise the water level
- Provide water source by diverting flow into a canal or pipeline
- Providing storage is not its prime purpose

Catchment perspective:
- Diversion placed at an elevation above where the water is needed so the water can flow by gravity
- Preferably select a river that has flow in the dry season
- Be sure not to divert all the flow so that downstream users also have access to water

Benefits:

Divert water for irrigation schemes.

Funding opportunities:

Not applicable

Livelihood opportunity:

Diversion weirs can be used for small-scale irrigation, which contributes to household food security.

Legislation:
- National Water Act, Act 36 of 1998
- National Environmental Management Act, Act 17 of 1998

METHODOLOGY

Methodology:
- Clear the area underneath the new weir of all topsoil and organic matter
- Dig a trench across the river making sure to remove all loose material and dig down to bedrock or very hard material. The trench should be almost as wide as the dam is high. The trench must be longer than the river is wide
- Place concrete or stone masonry in a wall to the desired height making sure to key into the sides of the river

Place concrete or stone masonry in a long apron on the downstream side of the wall to protect against erosion. Length determined by erodibility of downstream material. Ranging from 2 m for rocky soil to 10 m for fine sand

Photos:

Figure C.5.1-1: Example of a diversion weir. (Source: F. Denys)

Illustrations / Diagrams:

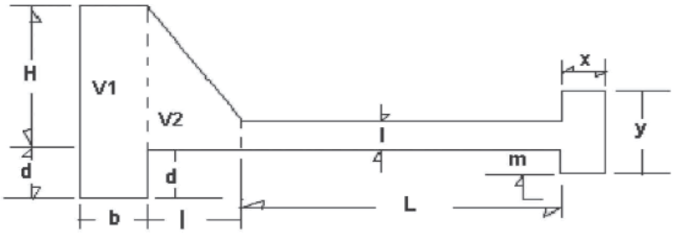


Figure C.5.1-2: Schematic of a diversion weir. (Source: F. Denys)

MAINTENANCE

Maintenance requirements:
- Check for erosion downstream of the weir, place large stones when erosion occurs
- Do not plant trees near the wall

Variations / Adaptations:

Overflow sand dams using rockfill or gabions.

Equipment requirements:
- Cement/mortar
- Stones
- Earthmoving and compacting equipment
- Survey equipment

Seasonal variations:
- To be constructed during the dry season
- Regularly repaired during wet season
- Fix erosion with stones and planting vegetation

See also:

Guideline A.4.3. Stone check dams
Guideline A.4.4 .Brushwood check dams
Guideline B.4.2. Sand dams

REFERENCES

Further references:

a. Nissen-Petersen E. 2006. *Water from Roads. A handbook for technicians and farmers on harvesting rainwater from roads.* Danish International Development Assistance

b. Desta L, Carucci V, Wendem-Agenehu A, Abebe Y. 2005. *Community based participatory watershed development: A Guideline.* Ministry of Agriculture and Rural Development, Ethiopia

D NATURAL RESOURCE MANAGEMENT

CATCHMENT MANAGEMENT GUIDELINES	ISSUES										CAPACITY					
D. Natural resource management	Soil Erosion	Loss of soil fertility	Sedimentation	Water degradation and depletion	Floods	Overgrazing / Deforestation	Threat to biodiversity	Loss of crop yields / Livestock fodder	Risk to infrastructure	Reduced standard of living	Prevention/Rehabilitation	Legislation	Scale	Labour requirement	Complexity	Cost
D.1. Forests																
D.1.1. Sustainable plantation forestry																
D.1.2. Natural forest management																
D.1.3. Protected forest reserves																
D.1.4. Selecting beneficial trees																
D.2. Grasslands																
D.2.1. Sustainable grassland management																
D.3. Wetlands																
D.3.1. Sustainable utilisation of wetlands																
D.3.2. Wetland conservation																
D.3.3. Constructed Wetlands																
D.4. Medicinal plant management																
D.4.1. Sustainable harvesting of medicinal plants																
D.5. Alien and/or invasive plant management																
D.5.1. Controlling alien and/or invasive alien vegetation																
D.5.2. Utilising and controlling Blue Gum trees																
D.5.3. Utilising and controlling Pine trees																
D.5.4. Utilising and controlling Bamboo																
D.5.5. Utilising and controlling Prosopis spp. species																
D.5.6. Utilising and controlling Water weed / Hyacinth																

KEY: Capacity Icons					
Action	Legislation	Scale	Labour	Complexity	Cost
Prevention	Other	Household	Single person	Simple	Free to little
Rehabilitation	NWA/NEMA	Village	Few people	Advanced	Medium cost
		Catchment	Many people	Complex	Expensive

Communities rely on natural resources to live and earn an income. Over utilisation leads to the depletion of natural resources. Therefore, natural resources need to be managed and utilised in a sustainable manner, in order to maximise the goods and services received from them, while still maintaining their function and production capacity. Natural forests, grasslands and wetlands are finite resources that must be managed sustainably; similarly, invasive alien vegetation can provide useful resources but needs to be managed to prevent uncontrollable spread. This section provides guidance on the sustainable and efficient management and utilisation of these various resources.

D.1. Forests

Forests are important to return moisture to the air through evapotranspiration, which then generates rain, as well as to stabilise soils with their root systems; they can also be rich in terms of biodiversity as well as stores of carbon. These guidelines provide information and techniques for the sustainable management of forests both natural and plantation, for reforesting of areas where forests have been removed including the selection of beneficial tree species. Includes guidelines for seed collection, tree nursery establishment, tree transplanting, and natural forest management.

D.2. Grasslands

These guidelines provide techniques for sustainable grassland management and rehabilitation.

D.3. Wetlands

These guidelines aim to assist communities to improve farming practices and grazing in wetlands for more sustainable utilisation and reduced impacts. However not all wetlands should be farmed, the guidelines also provide techniques for the conservation of wetlands.

D.4. Medicinal plants

These guidelines provide techniques for sustainable harvesting of medicinal plants

D.5. Alien and invasive plant management

These guidelines provide information to educate communities on the general approaches to sustainably manage invasive and alien plant species. Invasive alien plant species are a threat to water resources and water availability. By managing them and preventing their further spread, these plants can also provide useful resources and alternatives to rapidly depleting indigenous vegetation.

D.1. Forests

<table>
<tr><td colspan="2">D.1.1. Sustainable plantation forestry</td></tr>
<tr><td colspan="2">OVERVIEW</td></tr>
<tr><td colspan="2">Formal forestry is carried out through plantations. These should be managed in a sustainable manner in order to prevent environmental degradation and provide the greatest rewards both for the communities and plantation companies. This guideline provides an outline to sustainable plantation management, aimed at plantation managers at large scale.</td></tr>
<tr><td>Objectives:
• To optimise productivity and the value of forest products
• To ensure that timber supplies, to meet all requirements, are available to meet national requirements at a sustainable and predictable level.
Catchment perspective:
Alternative supplies of timber reduce the pressure on natural, indigenous timber resources.</td><td>Criteria for application:
• All plantation forestry resources (state, private, communal).
• Plantation forests that are currently being over-exploited must be put under tight controls.
• Plantation forests that are inefficiently utilised must be thinned and pruned, harvested on schedule, and may need to be replanted. Species choice may alter to meet changed local or national objectives.</td></tr>
<tr><td colspan="2">Benefits:
• Wood / energy is available in regular supply
• Forests are no longer progressively degraded
• Sustainable management and harvesting bring stability to national supplies
• The need to seek alternative sources of timber (or energy) is reduced</td></tr>
<tr><td>Funding:
Not Applicable</td><td>Legislation:
• National Forests Act 84 of 1998.
• National Veld and Forest Fire Act 101 of 1998.</td></tr>
<tr><td colspan="2">METHODOLOGY</td></tr>
<tr><td colspan="2">Methodology:</td></tr>
</table>

D.1.1. Sustainable plantation forestry

Sustainable plantation forestry requires the following:

1. Species selection based on market requirements: this can and should be changed at the end of a rotation should the market demand it.
2. An even-aged stand, achieved through progressive planting and maintained by sustainable harvesting.
3. Site: species matching to optimise productivity.
4. An on-site nursery with access to seed and/or modern clonal material.
5. A dedicated management team.
6. Fire protection.

Management actions include:

1. Establishment:
   a. Spacing for most plantation species is typically 3m*3m
   b. Fertilisation on planting is the norm
   c. Coppicing may be practised but replanting is the norm in larger plantations, particularly due to continuous genetic material improvement thus better and more suitable, disease resistant trees
2. Rotation length:
   a. This depends on purpose and on the optimisation of increment
   b. Fast growing eucalypts may be harvested within 5-7 years but are often grown for 10-15 years
   c. Pines may optimise annual volume increment at 20 years but 25-30 years may be necessary for suitable sawlog sizes
3. Thinning and pruning:
   a. These are practised especially for pine plantations, with a first thinning at five years
   b. Pruning first to 2 m and later to 5-7 m is essential if production is for sawn-timber
   c. Thinned and pruned material can be used for mulching, compost or fuel wood
   d. Correct match of species to site reduces risk of pests and diseases
   e. Pests and diseases are a greater risk at plantation scale than for woodlots. Eucalyptus clones are being developed for disease resistance
4. Harvesting
   a. Plantations are generally clear-felled in blocks or compartments – typically 1-10 hectares in size
   b. Harvesting and cross-cutting is by chainsaw
   c. Extraction may be by hand (especially on steep slopes), animal power (oxen or mules), or machine (truck with hydraulic grapple)
   d. Timber is usually moved first to a loading deck where it is sorted and graded
   e. Each block should be marked and entered into an accounting system
   f. Replanting as rains permit

Illustrations/ Diagrams: not applicable

Variations/Adaptations:

- Plantations must be clear-felled and replaced on schedule
- The schedule should not be advanced to meet short-term requirements
- Rotation length will depend on growth rate and the end-user requirement
- In the event of fire damage to plantations, timber can often be salvaged, provided trees have reached harvestable age
- This often means an accelerated harvesting rate
- Fires upset the rotation and future clear-felling regime and require management back towards an even-aged stand

Plantations originally established with softwoods for pulp and paper could be converted to alternative species to meet other current and projected needs

Equipment requirements:

- Forest mensuration equipment: 50 m tape measures, tree diameter tapes, hypsometers
- GPS for positioning resources
- Chainsaws and trained operators
- Loading deck. Log measuring, marking and accounting system

Photos:
Not applicable

Seasonal variations:
Not applicable

MAINTENANCE

Maintenance requirements:

- Any over-exploitation will require additional protection and recovery
- Continuous tree improvement – improved seed, clonal material

D.1.1. Sustainable plantation forestry

REFERENCES

Definitions: Not applicable **Further references:** Not applicable	**See also:** Guideline B.2.5. Agroforestry Guideline D.5.2. Utilising and controlling Blue Gum trees Guideline D.5.3. Utilising and controlling Pine trees Guideline E.3.5. Tree nursery

D.1.2. Natural forest management

OVERVIEW

Natural forests remain in small patches, especially around cultural sites such as graveyards and headwaters of springs or seeps. These forests should be managed in a sustainable manner. Where other natural forests occur, a cooperative approach between the villages and Department of Forestry should be implemented. This guideline provides an outline to this cooperative approach.

Objectives:

- To sustain, preserve and increase the area under natural forest within Malawi.
- To rehabilitate and improve all areas of degraded forest.
- To prevent the further conversion of areas under natural forest for other uses (typically for agricultural land).
- To manage natural forest and woodland so that these resources are able to provide a sustainable and increasing supply of goods and services.
- To increase the yield of timber and other resources from natural forests.
- To optimise use and range of products from natural forest areas.

Criteria for application:

- Natural forests and woodlands should be both protected and managed.
- Natural forests identified as threatened to be given top priority.
- Lands previously under forest and with potential for rehabilitation (i.e. showing some signs of natural regeneration), that are not being beneficially used.
- Degraded forest lands to be prioritised for rehabilitation.

Catchment perspective:

Protection of remaining natural forest is critical to catchment hydrological function (infiltration, production of high-quality water, flood control, flow regulation, erosion and silt management) as well as being rich sites of biodiversity and carbon storage.

Benefits:

- Forests and woodlands are preserved for future generations.
- The supply of goods and services from natural forest areas are increased.

Funding:

Not Applicable

Legislation:

National Forests Act 84 of 1998.
National Veld and Forest Fire Act 101 of 1998.

METHODOLOGY

Methodology:

1. Local communities to engage with the situation – assessing the resource (area, species, condition), demands on the resource (uses), land ownership / tenure situation, threats and opportunities, and prospects participatory forest management.
2. Implement immediate protection from unsustainable harvesting.
3. Identify other threats to natural forests (e.g. clearing for agriculture, grazing, fire) and develop strategies for each situation.
4. Demarcate all natural forest areas. Proclaim management status.
5. Provide a sustainable utilisation and harvesting plan so that forests can continue to be utilised and basic needs met.
6. Support measures for the provision of alternative sources of wood / energy (through plantations and woodlots) to reduce the pressure on natural forests.
7. Proclaim the benefits of natural forests and work towards a national culture of value and protection. This must go hand in hand with utilisable benefit.
8. Local management systems and authority (participatory forest management).
9. Provide technical support through forestry extension services. Replanting of degraded areas, management towards re-establishing best (and most productive) species mix.
10. Research to improve growth rates and product mix for multiple uses.

Illustrations/ Diagrams: Not Applicable

Photos:

Equipment requirements:

- Tape measure for planting spacing
- Diameter tape
- Bow-saws

Variations/Adaptations:

Not Applicable

Seasonal variations:

Not applicable

D.1.2. Natural forest management

Figure D.1.2-1: Natural forest (Source: S. Braid)

MAINTENANCE

Maintenance requirements:

- Forestry extension officers
- Mensuration equipment to assess and monitor stock
- Seed or nursery stock for enrichment planting where required

REFERENCES

Further references:

a. Department of Forestry, Ministry of Energy and Mines: Government of Malawi, 2008. Guideline for co-management of forest reserves in Malawi. (Supplement to the 2005 Standards and Guidelines for Participatory Forest Management in Malawi)

See also:

Guideline B.1.2.1. Designing a natural farming garden
Guideline B.1.2.2. Where to plant what
Guideline B.1.2.3. When to plant what
Guideline D.5.1. Controlling alien and/or invasive vegetation
Guideline D.5.2. Utilising and controlling Blue Gum trees
Guideline D.5.3. Utilising and controlling Pine trees
Guideline D.5.4. Utilising and controlling Bamboo
Guideline D.5.5. Utilising and controlling Prosopis species
Guideline D.5.6. Controlling water weed/Hyacinth
Guideline E.3.4. Sustainable woodlot management
Guideline E.3.5. Tree nursery
Guideline F.1.3. Firebreaks

D.1.3. Protected forest reserves

OVERVIEW

Protected forest reserves occur throughout rural areas in South Africa, but they are threatened by the pressure for fuelwood, and farm/urban expansion. This guideline provides an outline to the management of these protected forest areas by Department of Agriculture, Forestry and Fisheries, as well as communities.

Objectives:

- To prevent further destruction, degradation and encroachment of existing Protected Forest Reserves.
- To manage land which is liable to serious degradation if not immediately protected for purposes of soil and water conservation.

Criteria for application:

- All steep terrain on watersheds and headwaters
- All fragile unprotected hill slopes

Funding:
Not Applicable

Benefits:

- Enhanced conservation of water for downstream utilization.
- Control of erosion and flooding.
- Maintenance of climatic conditions in the interests of agriculture and fisheries.

Livelihood opportunity:
Natural forests provide habitat for fauna and flora, including honey, mushrooms and medicinal plants, as well as protecting headwaters of streams and preventing soil erosion. This contributes towards water availability and food security.

Legislation:

- National Forests Act 84 of 1998.
- National Veld and Forest Fire Act 101 of 1998.
- National Environmental Management: Protected Areas Act 57 of 2003.
- National Environmental Management: Biodiversity Act 10 of 2004

Catchment perspective:

- All watersheds and headwaters to be protected.
- Future land use planning of Protected Forest Reserves to be integrated / multi-sector.
- While formally implemented by Department of Forestry (DoF), local villages and communities can be involved through co-management agreements.

METHODOLOGY

Methodology:

1. Annual boundary maintenance
2. Improved and intensified forest patrols
3. Improved and robust extension services around Protected Forest Reserve
4. Appraise suitability / feasibility of each Protected Forest Reserve for Co-management agreements with communities
5. Enforce joint / integrated land use planning for Protected Forest Reserves
6. Declare all fragile steep slopes and hills as protected Forest Reserves
7. Controlled early bush burning
8. Appraise afforestation programmes especially with regard to site/species/water requirements

Illustrations/ Diagrams: Not Applicable

Photos:

Figure D.1.3-1: Forest cleared for crop land. (Source: S. Braid)

Equipment requirements:

- Forest Guard Uniforms
- Surveying / Geographical Information Systems (GIS) Technology
- Global Positioning Systems Devices (GPSs)

Variations/Adaptations:
Co-operative management agreements with Village Natural Resource Management Committees should be established in a fair and equitable manner.

MAINTENANCE

Maintenance requirements:

- Using satellite imagery and ground patrols
- Check for signs of encroachment

Check for negative changes in forest cover on a regular basis (annually)

Seasonal variations:

- Fire breaks should be burnt before the hot dry season.

Definitions:
Not applicable

REFERENCES

Further references:

a. Forests and Water, FAO Forestry Paper No 155, United Nations Rome, 2008

See also:

Guideline E.3.5. Tree nursery
Guidelines E.3.4. Sustainable woodlot management
Guideline E.5.1. Energy efficient stoves and ovens

D.1.4. Selecting beneficial trees

OVERVIEW

In order to combat deforestation and land degradation, afforestation projects have been, and should be more widely established in South Africa. However, tree species for these projects must be suitable and applicable to the objective of the afforestation project. This guideline provides a list of the applicable trees for different afforestation objectives.

Objectives:

- Protect the catchment in order to reduce flash flooding and erosion
- Protect stream and river banks from erosion
- Reduce siltation in rivers, and thus reduce the risk of floods
- To provide fuelwood, poles and fibre
- To provide forest products, including wild mushrooms, wild fruits, medicinal plants, and honey

Criteria for application:

- It is the communities themselves, and the individuals in that community, who will decide which tree species they will plant and where.

Benefits:

- Increase absorption / infiltration of water into the soil and restore the groundwater
- Reduce runoff and erosion
- Increase availability of fuelwood, poles and fibre for the needs of the community

Catchment perspective:

- Afforestation of the catchment is fundamental to its function of collecting, storing and supplying water to the watershed.
- Afforestation of the catchment maintains the level of rainfall in the catchment area.

Funding:
Not Applicable

Legislation:
National Forests Act 84 of 1998.
National Environmental Management: Biodiversity Act 10 of 2004.

METHODOLOGY

Methodology: for management methodologies see **Guideline B.2.5 Agroforestry**

Natural regeneration of the indigenous woodland:

- Afforestation of a catchment can be accomplished by protecting the regrowth of the indigenous saplings, by preventing their destruction, and by protection from fire. This requires strict management by the community.
- Direct seeding is recommended where possible in that it reduces labour and the costs incurred in raising seedlings in a nursery and then transplanting them, which may also involve transport.

Illustrations/ Diagrams: Not Applicable

Photos: Not Applicable

Equipment requirements: Not Applicable

Variations/Adaptations: Not Applicable

Seasonal variations: Not Applicable

MAINTENANCE

Maintenance requirements:

- Try select indigenous trees, or no invasive trees.
- When first planted, keep trees well-watered.
- Keep trees safe from goats and other livestock eating their leaves, e.g. tree basket

REFERENCES

Definitions: Not Applicable

See also:
Guideline B.2.5. Agroforestry
Guideline E.2.1. Nutrition in the home
Guideline E.3.5. Tree nursery
Guideline E.3.1. Living fences and wind breaks
Guideline E.4.2. Constructing an arbourloo

Further references:

D.2. Grasslands

D.2.1. Sustainable grassland management

OVERVIEW

Livestock need grasslands for food, and communities need grasslands to protect the soil so that the catchment provides plenty of clean water. Therefore, grasslands should be managed to provide enough food for the animals and enough cover to prevent soil erosion. In areas where there is bare soil and where the grasslands have been degraded, rehabilitation needs to take place to bring the grasslands back. These guidelines provide (i) an outline on how to increase the production of grasslands in communal areas, and (ii) an outline on ways to stop soil erosion and increase the grass cover to provide, food and water from village to catchment scale.

Objectives:

- To increase production of communal grasslands for livestock
- To increase grassland cover to reduce soil erosion and increase water infiltration

Catchment perspective:

The vegetation in most of South Africa's catchments is grassland. Since South Africa is a water-scarce country, sustainable grassland management in these catchment areas is necessary for water production. This will involve appropriate management of the existing grasslands, and active rehabilitation of degraded grasslands.

Criteria for application:

- Grassland in poor condition with low production
- Degraded grasslands with few palatable species
- Severely degraded grasslands with extensive bare soil and erosion gullies (dongas)
- Eroded catchments that silt up waterways and dams
- perennial streams no longer have water all year round

Benefits:

- Adequate fodder for livestock for improved livelihoods of communities.
- Increased vegetation cover will increase the amount of productive land.
- A sustainable production of water for communities living in catchment areas as well as for down-stream users and for national water supplies.
- Good quality water for domestic and commercial use.
- Reduced soil erosion will reduce costs of dredging dams below degraded catchments.

Funding opportunities:

- Potential funding through payment for ecosystem services.
- Potential national funding opportunities from national government to offset costs of dredging dams for South Africa's water storage schemes.

Legislation:

Selection of species for rehabilitation must adhere to National Environmental Management: Biodiversity (NEMBA) regulations for Invasive Species.

National Environmental Management: Biodiversity Act 10 of 2004.

National Veld and Forest Fire Act 101 of 1998.

METHODOLOGY

D.2.1. Sustainable grassland management

D1 Increased production of existing grassland requires the following:

1. Rest:
   a. Resting is the most critical part of a grazing management programme
   b. Rest grassland for different periods to allow the grasses to recover, grow and reproduce after grazing
   c. The season of rest has different benefits in sweetveld (where the quality of forage is good in winter) and sourveld (where the quality of forage is poor in winter)
   d. Rest for a short period (e.g. spring) allows regrowth and leaves to accumulate
   e. Rest for a full growing season will have the greatest benefit as it allows shoots to develop and seed production which is important in sweetveld.
   f. In communal areas, rest can be implemented through herders keeping livestock off part of the grazing area .

2. Alternative fodder:
   a. Provide alternative feeds to reduce grazing on grassland
   b. Alternative feeds (e.g. crop residues or stover, legumes, Napier fodder) can be planted on marginal land.

3. Licks:
   a. In sourveld give livestock a nutrient or salt lick in winter to help digestion of low quality grass

4. Fire
   a. Fire applied in the correct season (dormant period and early spring before significant green growth) promotes the vigour and growth of grasses, provides palatable foliage and controls invasive plants
   b. Patch burning can be used to control the distribution of livestock across an open grazing area
   c. Fire must not be applied during the growing season
   d. The frequency of fire depends on the fuel load. In sourveld burning every 2-3 years maintains the vigour of the grasses. In sweetveld fire frequency is reduced or absent due to the heavy grazing pressure and low fuel accumulation as a result of low and erratic rainfall.

D2 Rehabilitation of degraded grassland requires the following:

5. Selection of sites:
   a. Identify sites to be rehabilitated.
   b. Develop of a land-use management plan with communities in which the most severely eroded areas are identified.
   c. Assess distance of the site, severity of erosion, area of erosion, time required for rehabilitation and material costs.
   d. Costs include purchase of seed, vegetative material (e.g. vetiver grass), fertilizer, lime, etc.; payment of tractor drivers to transport stones; payment of taxi fares to transport community members to distant rehabilitation sites

6. Training
   a. Where possible arrange cross-visits for community members to visit successfully rehabilitated sites
   b. Organize on-site training of different techniques by experts
   c. Training must also include the specific advantages and disadvantages of each technique to enable community members to select the most appropriate technique for different sites.

7. Knowledge of rehabilitation techniques which includes physical or vegetative structures:
   Physical
   a. A **swale** is a combination of a ditch and a bank constructed along a contour line. It slows down the water running down the slope. The ditch and the bank should be approximately one metre wide, and have a height of one metre from the floor of the ditch to the top of the bank. Swales need to have overflows designed and constructed. The bank of the swale should be planted with vegetation to stabilize the loose soil.
   b. **Stone lines** are placed on slopes along the contour to prevent erosion. A trench is dug along the contour line 30 cm wide and 10 cm deep. Large stones are placed on the lower side of the slope and smaller stones were used to fill in the spaces. This enables water to seep through the stones and the soil to deposit above the trench.
   c. **Stone packs** are used in erosion gullies (dongas) to slow runoff. A stone barrier is formed by digging a trench across the donga and packing stones close together. Keying in the stones along the bottom and sides of the donga prevents water from eroding underneath and around the sides.
   An apron of stone is built below the stone pack so that overflow hits the stone and does not cause erosion. The centre of the stone pack should be the lowest point to form a weir so that water is discharged down the middle of the structure. Stone packs should be built at wide parts of the donga so that the force of the water is lower.
   d. **Creosote pole barriers** across cattle paths slow down runoff. Creosote poles one to one and a half shovels long (100-150 cm) are keyed into a shallow trench dug across the slope at a 45° angle. The poles are pegged in place with droppers cut in half and bent to form a U-shape. If the path is very wide, additional poles could be added across the slope, ensuring that the ends overlap. These are kept in place with a wooden frame (45

cm) laths hammered into the ground adjacent to the ends of the poles. The laths are tied together with wire in the form of a figure 8. If the path is so badly eroded that the poles are not flush with the soil surface, large stones need to be lodged in below the poles and the spaces filled in with soil and smaller stones. The critical part of path construction is the siting and construction of drains which take the runoff away from the path.

Vegetative

e. **Plant trees** in a micro-catchment to form a barrier against overland flow. The micro-catchments are formed by placing a circle of rocks around the tree and covering the soil surface with grass which forms a mulch which retains moisture for the growth of the tree.

f. Indigenous grass seeds
Indigenous grasses are ideal for rehabilitation as they occur naturally in the area. However, they are difficult to re-establish once they have been lost from the system because of their poor seed germination. The seed of some indigenous grasses (e.g. *Hyparrhenia, Chloris, Digitaria Paspalum* and *Melinus*) can be purchased and established in speedling trays. The seedlings or seeds are planted into shallow furrows containing fertilizer and lime. They must be watered regularly during establishment.

g. **Exotic grasses**
Since indigenous grasses are difficult to propagate in eroded areas, rehabilitation programmes often utilize exotic grasses that are not invasive. A mix of grasses that (i) spread over the soil surface and (ii) have deep roots is best. **Kikuyu** is an exotic grass that spreads rapidly through vegetative shoots called stolons. Vegetative material can be collected from around homesteads and replanted in eroded areas. The application of lime and fertilizer is recommended to facilitate establishment of the grass. **Vetiver** is a non-invasive tufted grass that has deep roots which bind the soil. It should be planted early in the wet season. The roots of the plants are trimmed to about half a hand width (5 cm) and the shoots to one hand width (10 cm). Slips of 2-3 shoots (tillers) are planted 10-15 cm apart in a furrow about one hand length (20 cm) deep with fertilizer and lime. The crown of the plant is buried 6-7 cm below the soil surface. Distance between vertical rows is about two shovel lengths (2 m). The slips should be watered for the first 2 weeks after establishment.

8. Implementation of rehabilitation technique
   a. No single technique can be recommended for rehabilitation – selection will depend on the extent and type of erosion, availability of material, etc. Initially experts must train community members to select the most appropriate technique until they are able to select and implement the rehabilitation techniques independently.

Variations/Adaptations:
- The most suitable grass species for rehabilitation will vary between areas with different rainfall and temperatures. Where possible, select local species.
- Adapt the height of the stone structures to the local conditions. For example, in areas with high intensity storms increase the height.
- Document the rehabilitation process with 'before' and 'after' photos to monitor the progress.

Equipment requirements:
- Tape measure for planting spacing
- GPS for positioning rehabilitation sites
- Shovels
- Fire-fighting equipment

Seasonal variations:
A general guide is to implement the physical structures during the dry season and the vegetative structures during the wet season.

Photos

Figure D.2.1-1: Full season rest in the foreground. (Source: T. Everson)

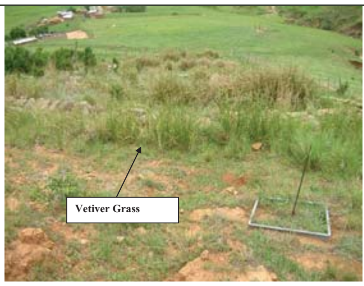


Figure D.2.1-2: Vetiver grass on a contour line. (Source: T. Everson)

Figure D.2.1-3: Stone line on eroded slope. (Source: T. Everson)

MAINTENANCE

Maintenance requirements:
- Continuous maintenance of physical structures is essential since runoff can damage the stone structures.
- If runoff damages the stone packs where they are keyed into the donga wall this must be fixed immediately as it can result in severe erosion.
- A community nursery to grow and maintain plants suitable for rehabilitation.

D.2.1. Sustainable grassland management	
Potential drawbacks/disadvantages: • Availability of stones	
REFERENCES	
Definitions: Not Applicable	**See also:** Guideline A.2.1. Rotational resting of rangeland Guideline A.2.2. Prevention and rehabilitating overgrazing Guideline A.2.3. Grazing movement Guideline A.2.4. Cattle paths up slopes Guideline A.4.6. Gully re-shaping
Further references: Not Applicable	

D.3. Wetlands

D.3.1. Sustainable utilisation of wetlands

OVERVIEW

The sustainable management of wetland systems on a catchment level will enhance the capacity of a wetland for water security and provide direct benefits to agriculture and economic development.

Objectives:

To introduce sustainable wetland management practices and their associated benefits to communities.

Criteria for application:

Applicable where wetlands exist, in order to protect, sustain and, where possible, restore the biodiversity of wetland habitats.

Catchment perspective:

- Promoting the sustainable management of wetland systems on a catchment level will further enhance the capacity of a wetland for water security and provide direct benefits to agriculture and potential economic development on the local level. Functioning wetlands retain water in the catchment for longer.
- The correct use of drainage ditches in wetlands prevents waterlogging during the wet season and allows crops to grow.
- But if drainage ditches are too deep they may lower the water table so it is too dry for cropping in the dry season.
- The cultivation in the centre of the wetland creates gullies by fast moving water.
- The planting of water hungry plants such as sugar cane and Eucalyptus trees in wetlands reduces the water supply.
- Communities should compile their own integrated management plans to help them see the linkages between integrated catchment and wetland management and how they contribute, Figure D.3.1-2.

Benefits:

- Improved soil fertility for cultivation and crop value.
- Decreased siltation and enhanced infiltration of water in the rainy season leads to improved water security and capacity to store and release water for irrigation in the dry season, for livestock, irrigation of vegetable crops to supply local markets.
- Healthy wetlands create a safety net for communities by overcoming food shortages created by poor rain fed harvests in the catchments.
- Healthy wetlands are a development resource to increase income and generate surplus income for the establishment of new business opportunities.
- Healthy wetlands assist with flood moderation and recharging of wells.
- The sustainable management of wetlands ensure domestic water supply in wells and increases community perception of wetlands and encourages better community management of water resources.

Funding opportunities:

- Working for Wetlands

Legislation:

- National Environmental Management Act 107 of 1998.
- National Water Act 36 of 1998.

METHODOLOGY

Methodology:

1. Village Natural Resource Management Committees should facilitate the integrated sustainable management of wetlands that require communities to not only manage the wetlands through land use planning but also the surrounding catchments that sustain and impact the wetlands, Figure D.3.1-1.
2. Wetlands must be clearly zoned with a 50 m buffer of protected natural vegetation to act as an infiltration zone and blocker of sediments/runoff reaching the wetland and should have fire protection, Figure D.3.1-2. Cultivation in the wetland should be limited to small plots or beds surrounded by natural vegetation closer to the edge of the wetland, with no development at the core of the wetland. This will limit erosion and gully formation. Erosion and increased sedimentation can be further limited through managed grazing practices.
3. Correctly utilised drainage ditches will give crops space to grow, move water away to prevent waterlogging (wet season), be well placed to limit erosion, not be dug to deep/have excessive drainage which would lower the water table (dry season) and lead to gully development (flash flood event).
4. Organic compost improves water infiltration close to the roots of the crops. Water hungry plants such as sugar cane and Eucalyptus that reduce the water supply should not be planted in wetlands. In the catchment agroforestry trees reduce sedimentation, improve infiltration, and stabilise and improve soil fertility. It also reduces the removal of natural vegetation for fuel wood and building materials which is a problem.
5. Wetlands must be clearly zoned to ensure communities manage it sustainably.
6. The wetland core must be clearly demarcated and natural vegetation must be protected to prevent erosion, Figure D.3.1-2.
7. Community wells should not be located in the core of the wetland because they can become focal point for gully formation. They should be placed closer to the edge of the wetlands, Figure D.3.1-2.

Illustrations/ Diagrams:

D.3.1. Sustainable utilisation of wetlands

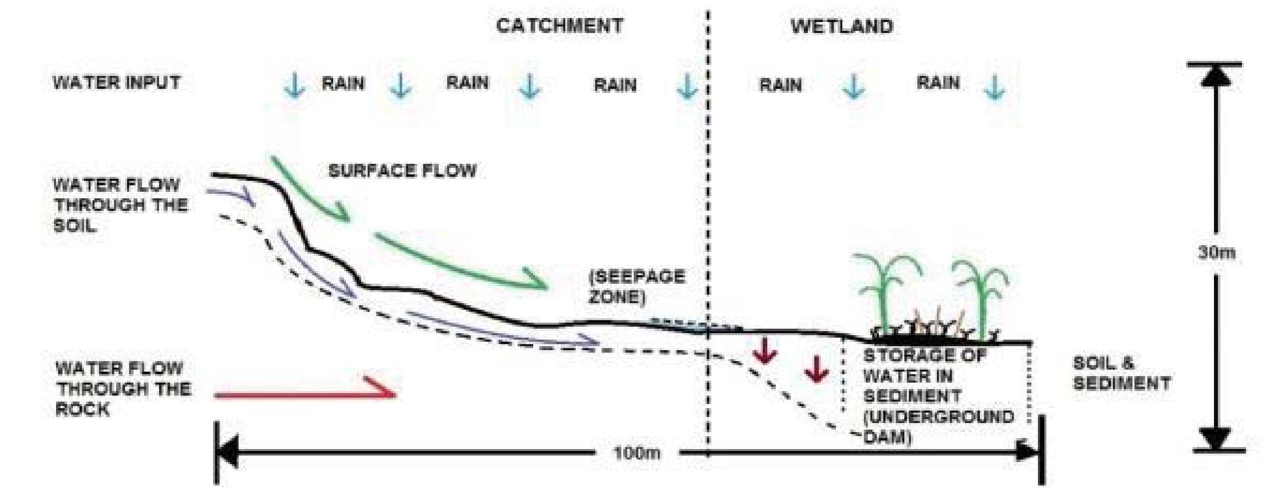


Figure D.3.1-1: How water flows from the catchment to the wetland.

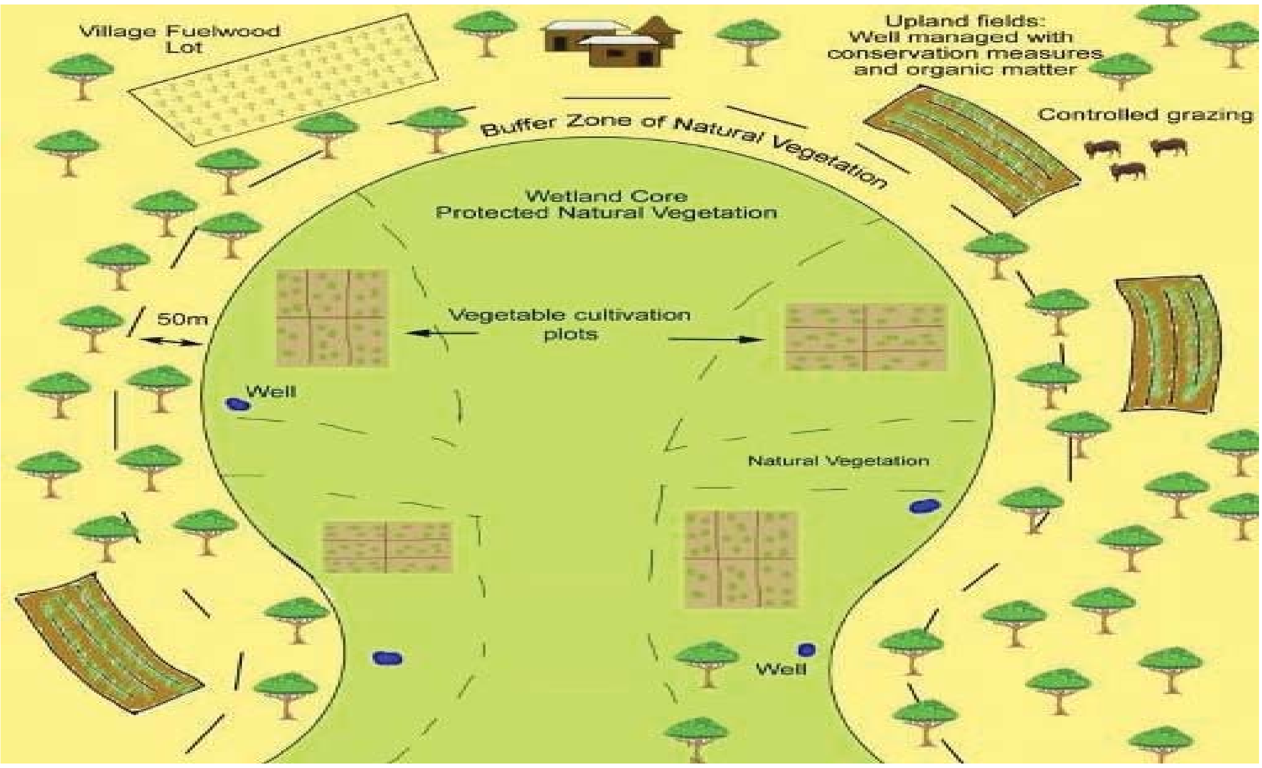


Figure D.3.1-2: The integrated management of wetlands.

Photos:

Figure D.3.1-3: Raised planting beds.

Equipment requirements:
Not applicable

Variations/Adaptations:
Not applicable

Seasonal variations:

- During the early dry season when the water table is high planting beds should be slightly raised to avoid waterlogging, Figure D.3.1.3.
- In the late dry season the beds should be depressed below the surface, Figure D.3.1.4, to get access to ground water and use irrigation water efficiently.
- Plants should be spaced according to the recommendations for the different varieties to ensure good quality crops.

D.3.1. Sustainable utilisation of wetlands

Figure D.3.1-4: Depressed planting beds.

MAINTENANCE

Maintenance requirements:

- Maintain natural wetland core area through community self-regulation
- Maintain fire belts protecting the wetland buffer area

REFERENCES

Definitions:
Not Applicable

Further references:

a. Wood, A.P. & Thawe, P. (2013) "Catchment and wetlands: a functional landscape approach to sustainable use of seasonal wetlands in central Malawi."

b. Wood, A.P., Dixon, A.B. & McCartney, (eds.) (2013) Wetland management and sustainable livelihoods in Africa

See also:

Guideline B.2.1. Compost making
Guideline B.1.1.3. Soil cover (mulching)
Guideline B.1.1.2. Crop rotation and intercropping
Guideline B.1.2.1. Designing a Natural Farming garden
Guideline B.1.2.2. Where to plant what
Guideline B.1.2.3. When to plant what
Guideline B.2.5. Agroforestry
Guideline D.5.1. Controlling alien and/or invasive vegetation
Guideline D.5.2. Utilising and controlling Blue Gum Trees
Guideline D.5.3. Utilising and controlling Pine trees
Guideline D.5.4. Utilising and Controlling Bamboo
Guideline D.5.5. Utilising and Controlling Prosopis species
Guideline D.5.6. Controlling Water weed/hyacinth
Guideline D.1.4. Selecting beneficial trees
Guideline E.3.1. Living fences and wind breaks
Guideline F.1.3. Firebreaks

D.3.2. Wetland conservation

OVERVIEW

Wetlands are an important source of water and nutrients necessary for their rich biological diversity and often support livelihoods of rural communities.

Objectives:
To identify wetlands that should be conserved in a natural state and introduce sustainable wetland conservation practices to communities and their associated benefits.

Catchment perspective:
Participatory sustained conservation of wetland systems on a catchment level will enhance water security, quality and provide direct benefits to biodiversity.

Benefits:

- Decreased siltation and enhanced infiltration of water in the rainy season leads to improved water security and capacity to store and release water for irrigation in the dry season, for livestock, irrigation of vegetable crops to supply local markets.
- Healthy wetlands assist with water filtration, flood moderation and recharging of wells.
- The conservation of wetlands ensures domestic water supply in wells and improves community perception of wetlands, and encourages better community conservation of water resources.
- It provides a habitat for wildlife and leads to increase in biodiversity of water birds which can enhance eco-tourism and/or income/food from sustainable hunting, Figure D.3.2-1.

Criteria for application:
Continued increase in population and the increasing need for cultivation will put pressure on all wetlands for agricultural development. A balance needs to be reached and maintained as to which wetlands are developed for agriculture and which are conserved and/or rehabilitated. It is understood that the criteria below would be subject to the local context of an area, but act as a guideline to consider.

Wetlands that should be considered for conservation:

- wetlands close to settlements that feed boreholes
- wetlands in flood prone areas (particularly near settlements) – long duration of waterlogging
- wetlands featuring a high level of biodiversity
- wetlands that have been previously undisturbed
- larger wetlands
- wetlands with large game (e.g. hippos)
- wetlands consisting predominantly of peat lands

Wetlands more suitable to development for agriculture:

- wetlands that have been previously disturbed
- wetlands that do not feed borehole used by a settlement
- smaller wetlands
- wetlands in less flood prone areas – shorter water logging periods
- wetlands closer to transport route
- wetlands with lesser biodiversity

Funding opportunities:

Legislation:
National Environmental Management Act 107 of 1998.
National Water Act 36 of 1998.
National Veld and Forest Fire Act 101 of 1998.

METHODOLOGY

Methodology:

- Wetland Resource Management and conservation committees should identify the wetlands that should be fully conserved and those in which sustainable agriculture can take place.
- These should be made known and agreed to with the local community.
- Where conservation is set to take place the wetlands should be marked (surrounded by red stones) to eliminate any misunderstanding of the purpose and conservation status of the wetland.
- Cognisance should be taken of the catchment system as a whole and how the conservation of a wetlands will impact on the catchment as a whole, Figure D.3.2-1.
- The committee should check the unutilised/undisturbed status of the wetland periodically (every few months); additionally, where large game (such as hippos) uses the wetland, anti-poaching patrols should take place.
- If any agriculture or destruction or damage has been inflicted to a wetland, every effort should be made to identify/punish the offender and more regular checks of the wetland should take place.

Illustrations/ Diagrams:

D.3.2. Wetland conservation

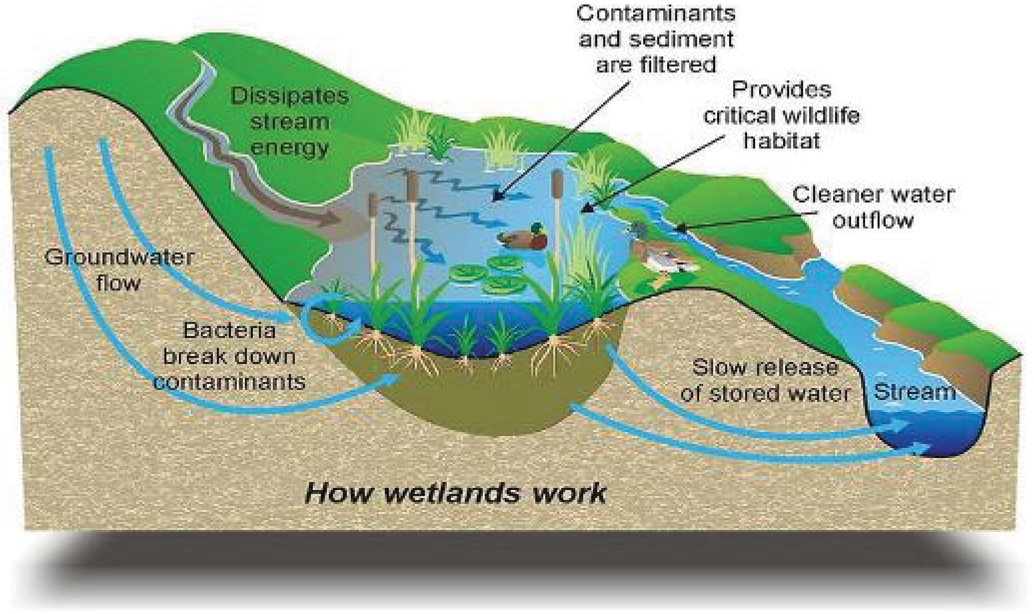


Figure D.3.2-1: Biodiversity of conserved wetlands

Photos: not applicable	**Equipment requirements:** Not applicable
	Variations/Adaptations: Not applicable
	Seasonal variations: Not applicable

MAINTENANCE

Maintenance requirements:

- Maintain natural wetland area through committee assessment in both the dry and wet seasons and implement accountability measures for offenders.
- Maintain fire belts protecting the wetland buffer area.

REFERENCES

Definitions: Not Applicable	**See also:** **Guideline D.1.1. Sustainable Plantation Forestry** **Guideline D.1.2. Natural Forest Management** **Guideline D.1.3. Protected Forest Reserves** **Guideline D.1.4. Selecting beneficial trees** **Guideline D.1.5. Tree transplanting** **Guideline D.3.1. Sustainable utilisation of Wetlands** **Guideline F.1.3. Firebreaks**

Further references:

a. Wood, A.P. & Thawe, P. (2013) “Catchment and wetlands: a functional landscape approach to sustainable use of seasonal wetlands in central Malawi.”

b. Wood, A.P., Dixon, A.B. & McCartney, (eds.) (2013) Wetland management and sustainable livelihoods in Africa

D.3.3. Constructed wetlands

OVERVIEW

Constructed wetlands (CWs) are engineered systems that mimic natural wetlands in order to achieve wastewater treatment through a combination of biological, physical and chemical processes.

Objectives

To motivate for and provide useful general guidance on the implementation of successful constructed wetlands for wastewater treatment.

Catchment perspective

Constructed wetlands are an effective, low-cost technology to intercept and treat point source pollution discharge and thereby preserve catchment water quality.

Benefits

- Simple design and implementation
- Low capital cost
- Non-technical maintenance
- No energy or additives required
- Pleasant appearance
- Provide habitat for wildlife
- Increase biodiversity of water birds
- Can enhance eco-tourism, see Figure D.3.2.1.

Criteria for application

Like all wastewater treatment technologies, constructed wetlands are applicable to certain contexts and not to others:

Wastewater source?

- ✓ Domestic wastewater
- ✓ Brewery/Dairy effluent
- × Industrial wastewater

Context:

- Sufficient space? 5 m^2/capita is a common conservative estimation of the space required for domestic wastewater treatment
- Volume of wastewater? 2 ML/d is an approximate maximum threshold, larger than which CWs become less cost-effective compared with conventional WWTWs. Forced aeration may be used to improve efficiency (and reduce cost) of larger systems.
- Location? EIA required if <32 m from river, or <500 m from natural wetland

Funding opportunities

Not Applicable

Legislation

National Environmental Management Act 107 of 1998.
National Water Act 36 of 1998.
National Veld and Forest Fire Act 101 of 1998.

METHODOLOGY

Primary treatment is required to prevent clogging of constructed wetlands; therefore, a description of an effective primary treatment method, the Anaerobic Baffled Reactor, is here included. Gutterer, et al (2009) from BORDA, Germany, produced an excellent practical guideline which provides strong basis for the following guideline.

Anaerobic Baffled Reactor

An Anaerobic Baffled Reactor (ABR) is a simple, effective primary treatment for organic and TSS reduction. It is resilient to hydraulic and organic shock loads with dependable organic removal of 65-90%

- An ABR consists of 4-6 chambers in series with basic connecting pipework to cause the flow path shown below. Treatment performance increases with number of chambers, to a maximum of 6 chambers.
- Typical Hydraulic Retention Time (HRT) 1.5 days
- Important for design is maintaining an 'up-flow velocity' through each chamber < 1 m/h
- To distribute inflow evenly, chamber length is kept < 50% of the depth at outlet
- For various reasons, chamber depth is most often chosen as 1.5 m or similar
- The chamber width is the dimension altered to vary HRT and maintain up-flow velocity < 1 m/h
- A settling chamber with HRT = 1.5 h is commonly included as the first chamber to allow for maintenance
- Total suspended solids (TSS) content entering the wetland should be < 10 mg/l

Constructed Wetland

Constructed wetlands achieve treatment through a complicated combination of biological, physical or chemical processes. As a result, following experience-based recommendation of suitable design is more effective for common contexts (10-500 m^3/d wastewater) than attempting to describe and predict each process. Some key design recommendations:

Basic Principles

- Design to avoid opportunities for clogging
- Short-circuiting through the gravel media drastically reduces HRT – ensure even spread of flow
- Hydraulic loading should be maintained < 100 l/m^2 and organic load (BOD) should not exceed 10g BOD/m^2/d
- Hydraulic Retention Time (HRT) depends on climatic conditions, water quality and aeration, but will typically be between 5 and 10 days.

Components

- The base of wetland should be water-tight either with an HDPE liner, geosynthetic clay liner (GCL), puddle clay or possibly concrete lined for small wetlands.
- Wide inlet zone – inlet flow to be spread evenly across the width with perforated pipe and a rock bank of 50-100 mm stones
- The outlet should enable at least 100-200 mm variation in operating water level, including opportunity to drain the wetland when required for maintenance.
- Filling material should be 13 mm if smooth/rounded, or 16-19 mm if broken/jagged edged, washed stone.

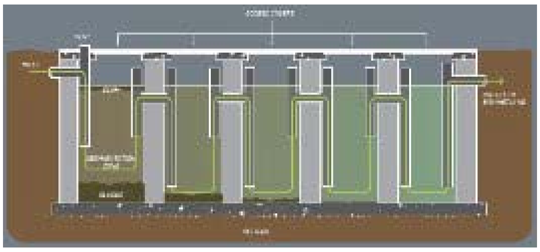
D.3.3. Constructed wetlands

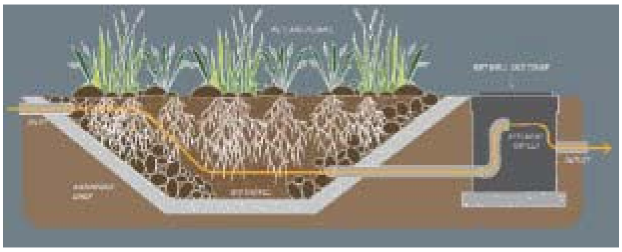
- Most wetland plants will grow well in wastewater, but selecting a diversity of species will promote biodiversity in microorganisms, insects and ultimately birdlife. **Avoid invasive species such as *Typha capensis*.**

Dimensioning

- Area: a common rule is 5 m^2 wetland area/capita served for domestic wastewater
- Depth: shallow wetlands of 600 mm depth are more effective – plant roots don't grow much deeper and oxygen dissolves from the surface in the upper 150 mm, both factors relate to treatment performance.
- Length: to reduce short circuiting, every 10 m of wetland length should have a re-distribution zone
- Width: if flow can be completely distributed across the width, CWs can have widths 1.5-2 times their length
- Slope: to control hydraulic loading and erosion, a bottom slope of 1% inlet to outlet is ideal

Illustrations/ Diagrams





Primary treatment: Anaerobic Baffled Reactor
Secondary Treatment: Constructed Wetland

Figure D.3.3-1: Schematic of a constructed wetland system. (Source: J. Harris)

Photos

Figure D.3.3-2: Anaerobic baffled reactor. (Source: J. Harris)

Figure D.3.3-3: Constructed wetland. (Source: J. Harris)

Equipment requirements

Wastewater flow of 0-25 m^3/d:

- Engineer/Technologist with basic experience in wastewater treatment
- Design reference material (see below)
- Contractor competent in basic earthworks, sewer pipework and simple masonry/concrete structures

Variations/Adaptations:

This guideline presents the most common form of constructed wetland, horizontal subsurface flow. However, there are a number of variations such as vertical flow wetlands, aerobic ponds, trickle filters and hybrid systems which can achieve better performance in treatment of selected parameters specific to a certain wastewater context.

Seasonal variations:

Temperature significantly affects the performance of biological treatment systems, and thereby design is often based on the lowest inlet temperature. Constructed wetlands function well in temperate and tropical regions where this value may be approximately 17°C. In cold climates, temperature variation in winter requires additional consideration in the design.

MAINTENANCE

- ABR De-sludging and vegetation cut-back once every 18-24 months
- Monthly visual samples of inlets and outlets, 6-monthly outlet water quality sample testing by laboratory
- Reactive maintenance as required

REFERENCES

Further references:

Gutterer, B., Sasse, L., Panzerbieter, T. & Reckerzgel, T., 2009. *Decentralised Wastewater Treatment Systems (DEWATS) and Sanitation in Developing Countries.* Bremen: Water, Engineering and Development Centre.

See also:

Guideline D.3.1. Sustainable utilisation of Wetlands
Guideline E.4.1. Constructing a composting toilet
Guideline E.4.3. Closing a filled pit latrine

D.4. Medicinal plant management

D.4.1. Sustainable harvesting of medicinal plants

OVERVIEW

Medicinal plants are an important aspect of the daily lives of many people and an important part of South African cultural heritage. In particular in rural areas the use of medicinal plants is a viable alternative in areas where there are limited healthcare provisions.

Objectives:

- Sustainable use of natural resources
- Enhancing cultural traditions

Catchment perspective:

- Sustainable harvesting of medicinal plants requires a catchment perspective as it is important to understand the linkage of plant populations across large spatial scales.
- Important plant populations which are considered rare in the area must be maintained and managed accordingly to allow for future harvesting.

Benefits:

- Important medicinal plants are sustained.
- Cultural and heritage resources are maintained.
- Natural resources are effectively managed.

Funding: Not Applicable

Criteria for application:

- As populations move into urban centres there is a change in socio-economics with the likely result being an increased demand for medicinal plants both locally and inter-provincially.
- Trade in medicinal plants will increase and pressure on the plant populations will increase.
- Medicinal plant populations need to be managed sustainably in order to preserve the important cultural heritage of traditional medicine.

Legislation:

- National Forests Act 84 of 1998.
- National Environmental Management: Biodiversity Act 10 of 2004.
- Draft Protection, Promotion, Development and Management of Indigenous Knowledge Systems Bill (the "2016 IKS Bill).

METHODOLOGY

Methodology:

Plant parts used:

- **Underground parts:** Harvesting of parts of plants that grow underground can be very destructive, as usually the whole plant is removed. The parts that are usually used are:
  a. **Roots**: i.e. Devils claw (Harpagophytum procumbens) and uzara (Xysmalobium undalutum)
  b. **Bulbs**: i.e. Inguduza (*Scilla natalensis*) and sekanama (*Urginea sanguinea).*
  c. **Rhizomes:** i.e. Ubani (Agapanthus spp.), bulrush (Typha capensis), piles root (Sansevieria hyacinthoides) and ikathazo (Alepidea amatymbica).
  d. **Tubers**: i.e. Isidakwa (*Dioscorea dregeana*) and imfingo (*Stangeria eriopus*).
- **Bark:** High concentrations of active ingredients are found in bark. Numerous trees such as pepper-bark (*Warburgia salutaris*) and unukari (*Ocotea bullata*) are used in traditional medicine. It is possible to harvest bark sustainably, without causing permanent damage to the tree.
- **Leaves, stems and flowers**: Leaves and twigs are rarely separated, with flowers sometimes being included too. Thick stems or the wood itself is rarely used (i.e. sneezewood (Ptaeroxylon obliquum)) and in some cases the flowers are considered an essential part of the medication (i.e. honeybush tea (*Cyclopia* species)).
- **Fruits and seeds:** Fruits and seeds are rarely used for medicinal purposes. Examples are fruits of fennel (*Foeniculum vulgare)* and kukamakranka (*Gethyllis spp*.); and nuts of the castor oil plant (*Ricinus communis*) and purging nut (*Jatropha curcas*).
- **Gums, exudates and nectar:** Gum sometimes flow from a damaged stem as a plants defence mechanism. This gum/exudate can be used as is or dried for medicinal purposes. Examples are the Cape gum (*Acacia karoo*) and aloe (*Aloe ferox*). Nectar may be used as a syrup to mask the unpleasant taste of medicine, for example the sugarbush (*Protea repens*) is used in this way.

Sustainable harvesting:

- **Selective harvesting:** Usually only through experience and knowledge will medicinal plants be selectively harvested. This involves the guidance of an ancestral spirit before embarking on a collecting trip. Supernatural guidance is supplemented with an understanding of environmental factors such as seasonality, aspect on slope, soil type and moisture and time of day. It is important to encourage this "selective process" as it allows for plant populations to recover.
- **Conservation measures:** Traditions and taboos can also aid in allowing plant populations to recover. For example *Alepidea amatymbica* is generally only collected in the winter, ensuring that the plant is only harvested when colds and flu are prevalent. A Shangaan taboo states that when *Elephantorrhiza elephantine* is harvested it is necessary to cover the remaining root system or treatment will not work. Other conservation measures used to counteract increasing demand have been the cultivation of rare and valuable medicinal plants such as buchu (*Agathosoma betulina*), pepper-bark (*Warburgia salutaris*) and wild ginger (*Siphonochilus aehiopicus*).

D.4.1. Sustainable harvesting of medicinal plants

- **Storage:** Some whole plants can be dried and stored, although it is considered unacceptable to leave the dried plants exposed to sun, shade, wind or the possible contact with strangers. Proper warehousing facilities for herbal remedies marketed in urban centres may be required.

General harvesting:

1. **WHEN to harvest:** Determine the correct time for harvesting, depending on the plant species. Collect when the plants are at an optimum condition, and high efficacy and medical quality. Determine the best time for collection, i.e. the season, time of day, to ensure the best possible quality of raw material. Harvest under the best possible climatic conditions to avoid desiccation or mould growth.
2. **WHAT to harvest:** Identify the plants you want to harvest without doubt. Choose healthy, well developed plant material. Do not choose plant material that is infected with fungal growth or insects. Ensure the plants you want to pick have not been sprayed with fertilizers or chemicals (especially near farm fields, roadsides or industries).
3. **HOW to harvest:** Gather only plants that are abundant in that area and be sure to leave a healthy population behind. Take special care with leaves and flowers, which may be more sensitive to damage. Try to harvest material without too much damage, as this may result in unwanted quality changes. Put different plant material in different containers.

Specific harvesting:

1. **Root harvesting:** The important thing about root harvesting is to allow the plant to survive and continue growing for future harvesting. It is recommended that the following rules be followed when harvesting roots:
   a. Dig the root at a considerable distance (at least 30 cm) from the main stem or tap root.
   b. Avoid severing the tap root.
   c. Collect lateral roots
   d. After digging cover the hole to ensure protection from pests and infection.
2. **Bark harvesting:** There are common unsustainable bark harvesting techniques such as ring barking, or over-harvesting. It is recommended that the following rules be followed when harvesting bark:
   a. Peel the bark from the tree in small pieces, leaving most of it intact on the East and West side of the tree.
   b. Remove the bark in long vertical strips using a thin flexible blade.
   c. Do not practice ring barking.
   d. Remove the bark in small sections and leave some inner bark to protect the wood.
   e. Do not cut the edges of the strip with an axes, this causes the remaining bark to lift and the wood to dry out.
   f. Use “tree seal” (a piece of wet cow-dung) to the bark wound. This will prevent the wound from drying out.
3. **Leaf harvesting:** Although leaf harvesting is not generally considered destructive, collection methods such as removing all the leaves from the tree or cutting down branches are not recommended. It is recommended that the following rules be followed when harvesting leaves:
   a. Pluck individual leaves instead of leaf stripping. Also avoid sharp pruning shears.
   b. Regularly prune branches to improve quality and quantity of leaves.
4. **Fruit harvesting:** Commercial harvesting of fruits can affect resource regeneration and quality of the resource in an area. This is particularly true if the small and rotten fruits are left to regenerate**.** It is recommended that the following rules be followed when harvesting fruit:
   a. Do not collect all the good looking, high quality fruit, but leave some on the ground so that some more good quality plants can germinate.
   b. Only collect fruit from some trees and leave others completely.

Illustrations/ Diagrams:

D.4.1. Sustainable harvesting of medicinal plants

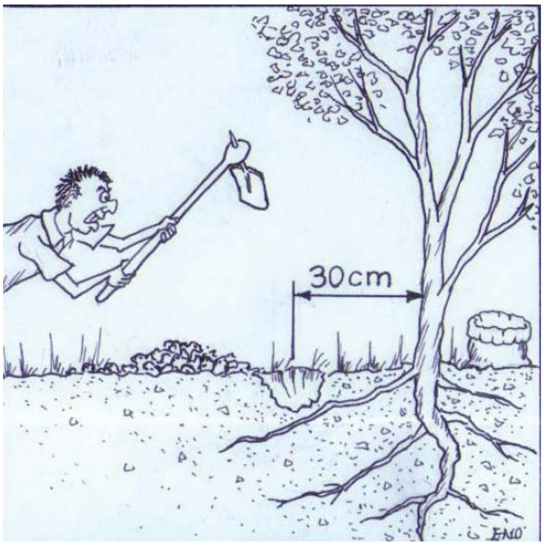


Figure D.4.1-1: Dig the root at a considerable distance[c].

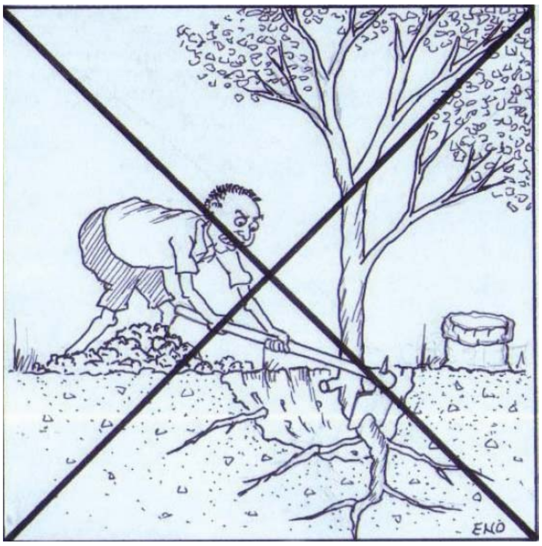


Figure D.4.1-2: Avoid severing the tap root[c].

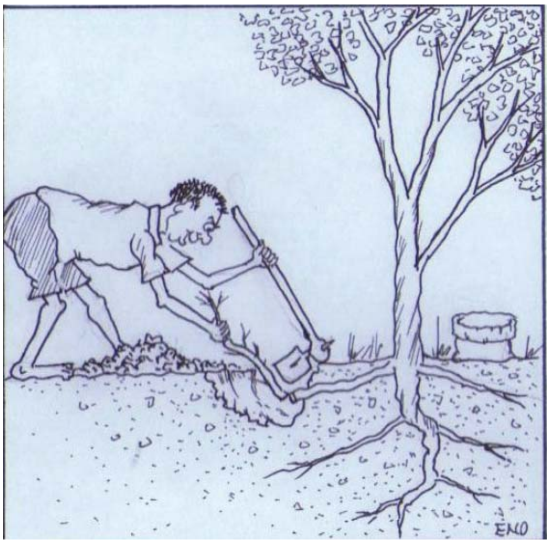


Figure D.4.1-3: Collect only lateral roots[c].

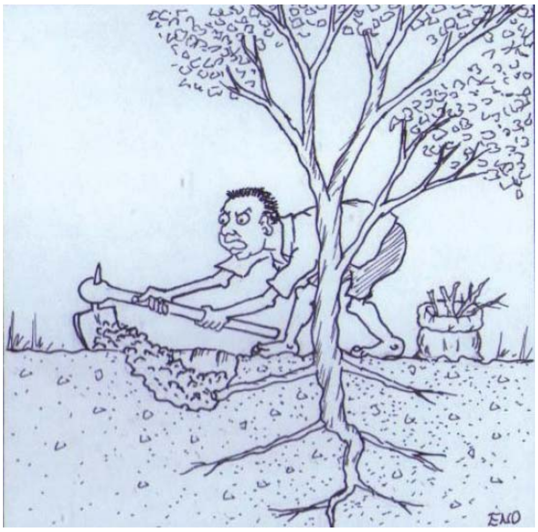


Figure D.4.1-4: Cover the hole once you have harvested underground plant material[c].

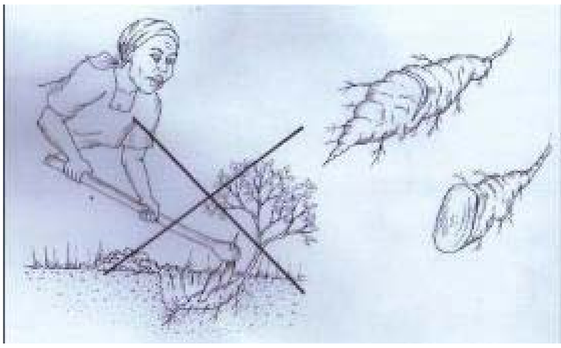


Figure D.4.1-5: Do not sever or damage bulbs[c].

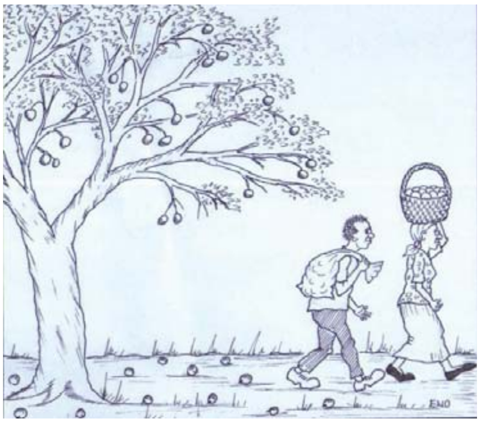


Figure D4.1-6: Do not collect all the good looking fruits, leave some on the ground[c].

D.4.1. Sustainable harvesting of medicinal plants

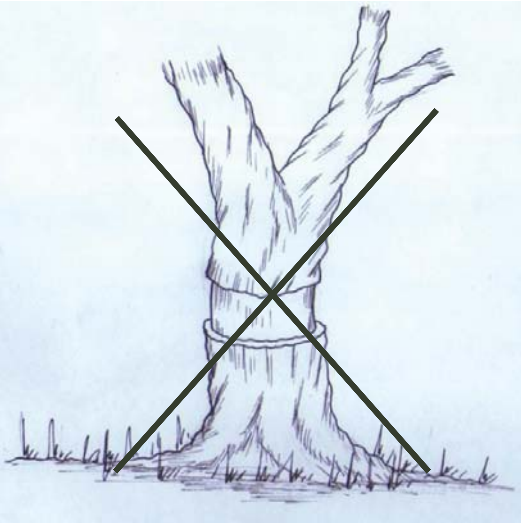


Figure D.4.1-7: Do not ring bark trees[c].

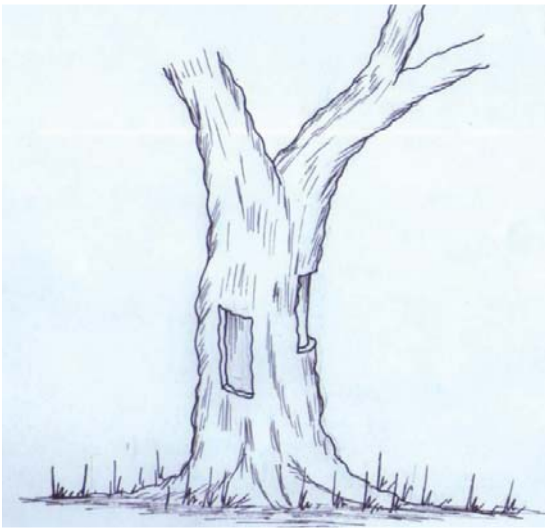


Figure D.4.1-8: Remove bark by vertical stripping[c].

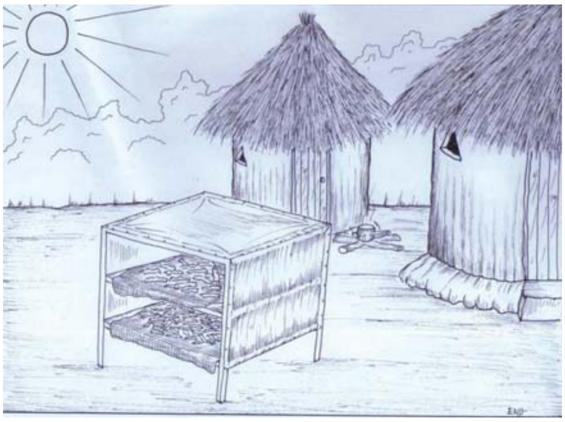


Figure D.4.1-9: Dry plant material in the sun on sheets above the ground[c].

Figure D.4.1-10: Keep dried plant material in an aerated storeroom[c].

Variations/Adaptations:	**Seasonal variations:**
Not applicable	Take note of the optimum season for harvesting for specific plant species.

Photos: Not applicable

Equipment requirements:

Keep all equipment used clean and free of any remains for previously harvested plants. If plastic containers are used make sure to pay attention to any moisture which would lead to fungal growth. When containers are not in use, keep them in dry conditions away from pests. Make sure to keep an eye on over-harvesting signs, especially if the plants you want to collect are in a worse condition. These signs could be:

- Distance you have to walk to collect plants increases
- Plants are in a bad condition and are infected by pests
- Some plants can't be found locally anymore

MAINTENANCE

Maintenance requirements:

After harvesting the fresh plant material undergoes a variety of processes. Once harvesting is done the following rules should be followed to ensure a high quality:

- As soon as you arrive at the place for drying or processing unpack the plant material. Do a visual inspection for foreign matter and quality assurance.
- Ensure that the building you use for drying is clean, well aerated and never used for animal keeping.

D.4.1. Sustainable harvesting of medicinal plants

- Ensure that the drying conditions are appropriate to the type of pant material. In the case of air drying place the plant material in a thin layer a sufficient distance from the ground for air flow.
- Place dried plant material in bags or containers allowing air exchange in order to reduce risk of pest attacks. Do not store material in closed unventilated containers (i.e. plastic bags).

Potential drawbacks/disadvantages:

An increase in demand for medicinal plants may result in increased harvesting. It must be stressed that over harvesting is a short term solution to increased demand, but sustainable harvesting is a long term solution with multiple benefits both for the community and environment.

REFERENCES

Definitions: Not applicable	**See also:** Not applicable

Further references:

a. Van Wyk B-E., van Oudtshoorn, B. and Gericke, N. 2005. Medicinal plants of South Africa. Briza Publications, Pretoria.

b. Dold, A.P. and Cocks, M.L. 2002. The trade in medicinal plants in the Eastern Cape Province, South Africa. *South African Journal of Science*, 98: 589-597.

c. Khumalo, S.G., Frode, A. and Sola, P. 2008. Guidelines for the sustainable harvesting of traditional medicinal plants in Zimbabwe, for the Ministry of Environment and Tourism. SAFIRE, Harare.

D.5. Alien and/or invasive plant management

D.5.1. Controlling alien and/or invasive vegetation

OVERVIEW

Invasive alien plant control relies on four main methods – manual, mechanical, chemical and biological control. Long-term success of any programme is best achieved through a combination of these. This is called an integrated control approach.

Objective:	Criteria for application:
To educate communities on the general approaches to managing invading alien plant species.	Invasive alien vegetation, if left unmanaged, will invade and replace indigenous vegetation by monopolising the water resources.

Catchment perspective:

Invading alien plants use much more water than indigenous trees and plants – and doing so they grow faster. They prevent rainwater from reaching rivers and deprive people and ecosystems of much needed water. Invasive alien plants can displace indigenous species and thereby reduce biodiversity. Invading alien plants also increase fuel loads making the area vulnerable to devastating fires that destroy infrastructure and damage soils. By damaging the soils, important indigenous seed banks are destroyed and may be eliminated from the area.

Benefits:

Controlling invading alien plants:

- especially along waterways, can increase water supply
- reduces the risk of devastating fires and the replacement of indigenous vegetation
- can reduce the risk of biodiversity loss, thereby protecting important indigenous vegetation

Funding opportunities:

Working for Water

Legislation:

National Environmental Management: Biodiversity Act 10 of 2004.
Agricultural Pests Act 36 of 1983.
Conservation of Agricultural Resources Act 43 of 1983.

METHODOLOGY

Methodology:

General considerations:

- Always start at the highest point and work downwards, i.e. downhill or downstream
- Start from the edge of the infestation and work towards the centre
- Ensure all root material is removed from site
- The following methods can be used to remove larger hardwood invading alien plants
  a. **Ring barking:** (Figure D.5.1.1)
     i. The bark must be removed in a 30 cm band around the stem at a height of 50 cm
     ii. All bark must be removed until only the wood is visible
     iii. Beat the bark with a sturdy log or the blunt end of an axe to loosen the bark
     iv. Ring barking prevents food reaching the leaves of the plant
  b. **Strip barking:** (Figure D.5.1.4)
     i. Strip off all the bark from waist height to below the surface of the soil
  c. **Hand pull**: (Figure D.5.1.2)
     i. Grip the young plant or seedling low down and pull out by hand
     ii. Remove the plant and roots
     iii. Shake the excess soil from the plant

Invasive alien plants come in many different shapes and forms and therefore different species may have different control mechanisms which are more effective than others. Please see the following sections for specific measures to Bamboo, Pine and Blue Gum trees. For further information on species not mentioned in this guideline, refer to the Global Invasive Species Programme as mentioned in the reference section.

Illustrations/ Diagrams:

Figure D.5.1-1: Ring barking

Figure D.5.1-2: Strip barking

Figure D.5.1-3: Hand pulling

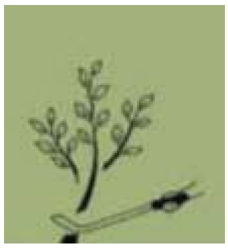


Figure D.5.1-4: Slashing

D.5.1. Controlling alien and/or invasive vegetation		
Equipment requirements: • bow saw • slasher • axe • shovel	**Seasonal variations:** When flowers are in seed, cover the flowers to prevent the spread of seeds. Do not compost while in seed.	**Variations/Adaptations:** Not Applicable

MAINTENANCE

Maintenance requirements: Regular follow-up of treated plants and areas are required to ensure the successful control of the relevant species	**Potential drawbacks/disadvantages:** If clearing is not followed up, the spread of invading species could be worse than before

REFERENCES

Definitions:	**See also:** **Guideline D.5.2. Utilising and controlling Blue Gum Trees** **Guideline D.5.3. Utilising and controlling Pine trees** **Guideline D.5.4. Utilising and Controlling Bamboo** **Guideline D.5.5. Utilising and Controlling Prosopis species** **Guideline D.5.6. Controlling Water weed/hyacinth**

Further references:

a. Akobundu, I.O. and Agyakwa, C.W. 1998. A Handbook of West African Weeds. International Institute of Tropical Agriculture, Nigeria. Page 304.

b. Encyclopedia of Life: online resource http://eol.org/

c. Henderson, L. 2001. Alien Weeds and Invasive Plants: A Complete Guide to Declared Weeds and Invaders in South Africa, Including another 36 Species Invasive in that Region. Plant Protection Research Institute.

d. Mwanyongo, M.K.M., Maulana, T.H.H. and Kamwendo, J.S. 2002. Malawi. IN: Macdonald, I.A.W., J.K. Reaser, C. Bright, L.E. Neville, G.W. Howard, S.J. Murphy & G. Preston (eds.). 2003. Invasive alien species in southern Africa: national reports & directory of resources. Global Invasive Species Programme, Cape Town, South Africa.

e. Quattrocchi, U (ed.) 1999. CRC World Dictionary of Plant Names: Common Names, Scientific Names, eponyms, Synonyms and Etymology. CRC Press, Florida.

f. Wittenberg, R. and Cock, M.J.W (eds). 2001. Invasive Alien Species: A Toolkit of Best Prevention and Management Practices. CAB International, Wallingford, Oxon, UK, xvii-228.

D.5.2. Utilising and controlling Blue Gum trees

OVERVIEW

Many species of eucalyptus (Blue Gum) have been of great benefit to the economy. The species are amenable to physical and herbicidal control, but their readiness to re-grow and the propensity for coppiced trees to grow back, and seedlings to germinate once exposed to sunlight necessitates repeated attention and herbicide application.

Objective: To introduce the concept of and educate communities to the potential invasive nature of Blue Gum trees while managing and utilising the trees. **Catchment perspective:** Invading alien plants use much more water than indigenous trees and plants – and doing so they grow faster. They prevent rainwater from reaching rivers	**Criteria for application:** • Blue Gum trees, if left unmanaged, will invade and replace indigenous vegetation by monopolising the water resources. Application of invasive species management should be done throughout the catchment, but a particular focus should be given to areas closer to settlements, areas near smaller non perennial rivers and areas known to have an elevated fire risk. • Do not use for brushwood check dams.

D.5.2. Utilising and controlling Blue Gum trees

and deprive people and ecosystems of much needed water. Invasive alien plants can displace indigenous species and thereby reduce biodiversity. Invading alien plants also increase fuel loads making the area vulnerable to devastating fires that destroy infrastructure and damage soils. By damaging the soils, important indigenous seed banks are destroyed and may be eliminated from the area.

Funding opportunities:
Working for Water

Legislation:
National Environmental Management: Biodiversity Act 10 of 2004.
Agricultural Pests Act 36 of 1983.
Conservation of Agricultural Resources Act 43 of 1983.

Benefits:

- Maintaining a controlled stock of Blue Gum trees provides timber for construction, fencing, poles, pulp, furniture and oils
- Knowing the invasive potential of Blue Gum will allow the community to effectively manage a plantation and help control the unwanted spread of trees
- Managing Blue Gum plantations reduces the risk of devastating fires and the replacement of indigenous vegetation
- Maintaining a stable volume of Blue Gum in a controlled area limits the potential for the trees to use excess water

METHODOLOGY

Methodology:
Managing plantations
Managing of plantations has two sides: the growth of the Blue Gum trees in the plantation area and the affect caused on the surrounding areas. The most significant area in terms of the invasive nature of the Blue Gum is on the periphery of the plantation where spread of Blue Gum and loss of species may occur. Areas on the edge of plantation at the highest risk include wetlands/rivers (through water loss), grassland (biodiversity/habitat loss) and indigenous forests (biodiversity/habitat loss). Good management will try to conserve these of natural habitats. On the edge of the plantations, steps should be taken to remove the immature trees/saplings (see below)
Growing management

- Plantations are managed on a 10 to 30 year rotation period
- Saplings are then planted in a grid of 2.7 m by 2.7 m, not fertilisers are used
- After about 5 years, thinning (removing every third or fourth or fifth row of trees) is done to allow for the dominant trees to develop faster
- The trees removed are normally used as pulp and wood chips, and can be used for fuel wood, compost and mitigation measures
- If this is not done, trees will compete for water
- The lower branches are trimmed and pruned to remove potential knots from the timber
- When the trees number 300 per hectares, they should be allowed to grow until they are fully mature at between 20 and 30 years
- While they are growing, they should be protected against fires, competition with weeds, pests and tree diseases
- At the mature stage, the trees are mature and ready for harvest. All remaining trees are felled, delimbed, and taken to be processed
- The ground is cleared, and the cycle is repeated

Removal of invading and spreading plantations
General considerations:
Always start at the highest point and work downwards, i.e. downhill or downstream
Start from the edge of the infestation and work towards the centre
Ensure all root material is removed from site
Once ring barked trees are dead they can be cut down
Ring barking: (Figure D.5.2.1)

- The bark must be removed in a 30 cm band around the stem at a height of 50 cm
- All bark must be removed until only the wood is visible
- Beat the bark with a sturdy log or blunt end of an axe to loosen it
- Ring barking prevents food reaching the leaves of the plant

Strip barking: (Figure D.4.2-3)

- Strip of all the bark from waist height to below the surface of the soil
- Hand pull: (Figure D.5.2.2)
- Grip the young plant or seedling low down and pull out by hand
- Remove the plant and roots

D.5.2. Utilising and controlling Blue Gum trees

- Shake the excess soil from the plant

Utilisation of Blue Gum trees

Fast-growing alien trees cater for the demand for wood products and fuelwood and often do well as they are not susceptible to insects and plant diseases which affect the trees in their country of origin. The supply of wood, wood fuel and wood products from plantations prevents over-exploitation and ultimate destruction of indigenous forests.

Illustrations/ Diagrams:

Figure D.5.2-1: Ring barking

Figure D.5.2-2: Strip barking

Figure D.5.2-3: Hand pulling

Equipment requirements:

- Panga, bow saw, slasher, chainsaws, axe and shovels
- Log carriers and truck transport

Seasonal variations: Not applicable

Variations/Adaptations: **Not applicable**

MAINTENANCE

Maintenance requirements:

- Regular follow-up of immature plants is needed to ensure the young trees make it to the mature phase
- Checking and maintenance of the edge areas of the planation to ensure there is no spread into other areas. This should be done on a yearly basis. More frequent checks will ensure the tree is still small and easily removable
- Plan the thinning and harvesting of trees as far in advance as possible
- Maintain adequate fire breaks around the plantation

See also:

Guideline B.2.1. Compost making

Guideline F.1.3. Firebreaks

REFERENCES

Further references:

a. Wittenberg, R. and Cock, M.J.W (eds). 2001. Invasive Alien Species: A Toolkit of Best Prevention and Management Practices. CAB International, Wallingford, Oxon, UK, xvii-228

b. Timber Plantations, http://www.botany.uwc.ac.za/ – accessed 2014-11-14

c. Sabie, http://www.sabie.co.za/about/forestry/ – accessed 2014-11-14 Henderson, L. 2001. Alien Weeds and Invasive Plants: A Complete Guide to Declared Weeds and Invaders in South Africa, Including another 36 Species Invasive in that Region. Plant Protection Research Institute.

d. Mwanyongo, M.K.M., Maulana, T.H.H. and Kamwendo, J.S. 2002. Malawi. IN: Macdonald, I.A.W., J.K. Reaser, C. Bright, L.E. Neville, G.W. Howard, S.J. Murphy & G. Preston (eds.). 2003. Invasive alien species in southern Africa: national reports & directory of resources. Global Invasive Species Programme, Cape Town, South Africa.

e. Quattrocchi, U (ed.) 1999. CRC World Dictionary of Plant Names: Common Names, Scientific Names, eponyms, Synonyms and Etymology. CRC Press, Florida.

f. Wittenberg, R. and Cock, M.J.W (eds). 2001. Invasive Alien Species: A Toolkit of Best Prevention and Management Practices. CAB International, Wallingford, Oxon, UK, xvii-228.

D.5.3. Utilising and controlling Pine trees

OVERVIEW

Pine trees are widely planted for timber but their ability to grow quickly with short juvenile periods allows them to outcompete many native species while their small seeds with wings aids in their dispersal.

Objective:

To introduce and educate communities to the potential invasive nature of pine trees while managing and utilising pine trees.

Catchment perspective:

Invasive plants such as pine trees use much more water than indigenous species. As such they prevent rainwater from reaching rivers and deprive people and ecosystems of much needed water. Invasive alien plants can displace indigenous species and thereby reduce biodiversity. Invading alien plants also increase fuel loads enhancing the potential intensity of fires that destroy infrastructure and damage soils. However, as they are fast growing trees they are useful for afforestation projects, they must however be carefully managed in order to prevent uncontrollable spread through the catchment.

Criteria for application:

Pine trees, if left unmanaged will invade and replace indigenous vegetation by monopolising the water resources. Application of invasive species management should be done throughout the catchment, but a particular focus should be given to areas closer to settlements, areas near smaller seasonal rivers and areas known to have an elevated fire risk

Funding opportunities:

Working for Water

Benefits:

- Maintaining a controlled stock of pine trees provides timber for fuel wood, furniture or housing.
- Knowing the invasive potential of pine will allow the community to effectively manage a plantation and help control the unwanted spread of trees.
- Managing pine plantations reduces the risk of devastating fires and the replacement of indigenous vegetation.
- Maintaining a stable volume of pine in a controlled area limits the potential for the trees to use excess water.

Legislation:

- National Environmental Management: Biodiversity Act 10 of 2004.
- Agricultural Pests Act 36 of 1983.
- Conservation of Agricultural Resources Act 43 of 1983.

METHODOLOGY

Methodology:

Managing plantations

Managing of plantations has two sides: the growth of the pine trees in the plantation area and the affect caused on the surrounding areas. The most significant area in terms of the invasive nature of the pine is on the periphery of the plantation where spread of pine and loss of species would occur. Areas at the highest risk include wetlands/rivers (through water loss), grassland (biodiversity/habitat loss) and indigenous forests (biodiversity/habitat loss). Good management will try to conserve these of natural habitats. On the edge of the plantations, steps should be taken to remove the immature trees/saplings (see below)

Growing management

- Preparing: ground is prepared by burning existing plants, herbicide spraying and cultivation. Saplings are then planted a few meters from each other
- Caring: First few years (until tree canopy closes), the saplings are looked after through fertiliser/pesticide dusting/spraying
- When the tree canopies are touching (pole stage): the plantation is now very dense and trees are competing for water
- Thinning: When the diameter of the canopy is less than 1/3 of the tree height, thinning is needed by removing every third (or fourth or fifth) row of trees. These trees are normally used as pulp and wood chips.
- If the trees become too dense again after a few years, thinning is needed again. Wood used for pulp and chips
- After 10 years (varies according to water supply and pine type) the pine trees are mature and ready for harvest. All remaining trees are felled, delimbed, and taken to be processed
- The ground is cleared, and the cycle is repeated

Removal of invading and spreading plantations

- General considerations:
  - Always start at the highest point and work downwards, i.e. downhill or downstream
  - Start from the edge of the infestation and work towards the centre
  - Ensure all root material is removed from site
  - Once ring barked trees are dead, they can be cut down
- Ring barking/stripping (Figure D.4.3-2, D.4.3-5):
  - The bark must be removed (stripped) from below ground level of the stem to a height of 0.75-1.0 m

D.5.3. Utilising and controlling Pine trees

- All bark must be removed until only the wood is visible
- Beat the bark with a sturdy log or blunt end of an axe to loosen the bark
- Ring barking prevents food reaching the leaves of the plant and kills the tree

- Hand pull (Figure D.4.3-3):
  - Grip the young plant or seedling low down and pull out by hand
  - Remove the plant and roots
  - Shake the excess soil from the plant
- Felling and slashing (Figure D.4.3-4):
  - Cut, slash or saw the plant down as low as possible to the ground

Utilisation of Pine trees

Fast-growing alien trees cater for the demand for wood products and often do well as they are not susceptible to insects and plant diseases which affect the trees in their country of origin. The supply of wood and wood products from plantations prevents over-exploitation and ultimate destruction of indigenous forests.

Illustrations/ Diagrams:

D.5.3-1: Ring barking

Figure D.5.3-2: Strip barking

Figure D.5.3-3: Hand pulling

Figure D.5.3-4: Slashing

Equipment requirements:

- Bow saw, slasher, chainsaws, axe and shovels
- Log carriers and truck transport
- Fertilisers and herbicide for growth management

Photos:

Figure D.5.3-5: Pine trees (Photo: S. Braid)

Variations/Adaptations:

Not Applicable

Seasonal variations:

Not Applicable

MAINTENANCE

Maintenance requirements:

- Regular follow-up of immature plants is needed to ensure the young trees make it to the mature phase
- Checking and maintenance of the edge areas of the planation to ensure there is no spread into other areas, this should be done on a yearly basis. More frequent checks will ensure the tree is still small and easily removable
- Plan the thinning and harvesting of trees as far in advance as possible
- Maintain adequate fire breaks around the plantation

REFERENCES

Further references:

a. Wittenberg, R. and Cock, M.J.W (eds). 2001. Invasive Alien Species: A Toolkit of Best Prevention and Management Practices. CAB International, Wallingford, Oxon, UK, xvii-228

b. Timber Plantations, http://www.botany.uwc.ac.za/

c. Sustainable management of Pinus radiata plantations, Donald J. Mead

See also:

Guideline B.3.1. Compost making

Guideline F.1.3. Firebreaks

D.5.4. Utilising and controlling Bamboo

OVERVIEW

There are many types of bamboo but in general they can be divided into either clumpers or runners. The clumping species are non-invasive and can be used for building materials or stabilising soil erosion. Running bamboo species can be become very invasive and must be controlled.

Objectives:

- To introduce the concept of controlling bamboo as an invasive species
- To educate communities how to control bamboo
- To give options on how to utilise bamboo and stop it from spreading further

Legislation:

- National Environmental Management: Biodiversity Act 10 of 2004.
- Agricultural Pests Act 36 of 1983.
- Conservation of Agricultural Resources Act 43 of 1983.

Criteria for application:

Management of bamboo resources should be done not only to decrease their impact but also to utilise the potential positive benefits. The areas particularly impacted on include: areas closer to settlements, areas near water courses and areas suffering from soil loss and erosion.

DO NOT use invasive spreading bamboo for brushwood check dams or riparian buffers.

Funding opportunities:

Working for Water

Catchment perspective:

- Invading alien plants – including bamboo – use significantly more water than indigenous trees and plants. If left unmanaged, these plants could be invasive and out-compete other plants for water. They could ultimately decrease biodiversity and put pressure on existing water resources. Management of these resources is therefore vital across the whole catchment.

Benefits:

Knowing the invasive potential of bamboo will allow the community to effectively manage bamboo stocks and help control the unwanted spread of plants.

Maintaining a stable volume of bamboo in a controlled area limits the potential for the plant to use excess water, unnecessarily.

Managed farming of bamboo can provide a number of benefits and products:

- Erosion control in degraded areas
- Soil stabilization along river banks
- Windbreaks protecting crops
- Wood industry (e.g. flooring, particle board, etc.)
- Pulp and Paper Industry (e.g. newsprint, toilet tissue, etc.)
- Energy (charcoal, biofuel)
- Textile Industry
- Food
- Construction (e.g. scaffolding)

METHODOLOGY

Methodology:

Managing plantations

Bamboo is able to grow dense without very much intervention provided it is given sufficient water. Management is focussed on reducing the spread of bamboo from the controlled area. If the bamboo does spread, control should be undertaken to remove the young plants/saplings (see below).

Growing management

- Bamboo grows best in slightly acidic soil. Where soil is very acidic lime can be added to tilled and overturned soil to prepare the soil. Both new and existing plantations should be demarcated and secured to prevent unwanted spread (See Trenching and Barriers below.)
- Bamboo trees can be grown from seeds or shoots/cuttings.
- Any shoots outside the demarcated areas should be pulled out manually, Figure D.5.4-1.
- Watering: if the bamboo is not next to a water source, it should be watered once or twice a week for the first few months.
- Cutting and pruning the bamboo as it grows results in longer, straighter stems.
- The first harvest can be done when the bamboo is mature – after about 6 years. Cuttings from these plants can be used to grow more bamboo in other secured areas until you are able to do an annual harvest.
- Harvesting can be done by slashing, Figure D.5.4-2. This is often used for the bamboo that it more difficult to get to.

D.5.4. Utilising and controlling Bamboo

Removal of invading and spreading plants

General considerations:

- Start from the edge of the infestation and work towards the centre
- Ensure all root material is removed to stop regrowth
- Many types of clumping bamboo species (Fargesia spp or Campbell bamboo) exist that do not spread like running bamboo (most Phyllostachys spp bamboo types – Yellow Groove or Solid Stem) and can be used for building materials or stabilising soil erosion

Trenching: (Figure D.5.4-3)

- Dig a 50 cm (knee high) deep trench around the stand of bamboo
- Inspect the trench regularly and cut (shovel, slasher) or break bamboo rhizomes that appear in the trench
- Creeping root barrier: (Figure D.5.4-4, D.5.4-5)
- Dig a 50 cm (knee high) deep trench around the stand of bamboo
- Insert a 30 mm thick plastic sheet barrier in the trench and make sure that there are no gaps in the plastic
- The barrier can be slanted outward at the top to guide rhizomes upward instead of allowing them go down and under the barrier
- Once the sheet has been installed, fill the trench
- Leave the plastic sheet sticking out above ground for a few centimetres to prevent rhizome going over and to indicate where the barrier edge is

Utilisation of Bamboo

Due to the water supply, bamboo grows rapidly along river banks. The roots can stabilise the banks, especially in areas where active erosion is occurring. It must be strictly managed/utilised along the banks of water resources as it will spread quickly. Harvested bamboo can be used to make crafts, screens, furniture, etc.

Illustrations/ Diagrams:

Figure D.5.4-1: Hand pulling[a].

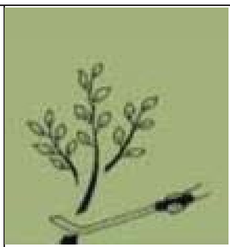


Figure D.5.4-2: Slashing[a].

Photos:

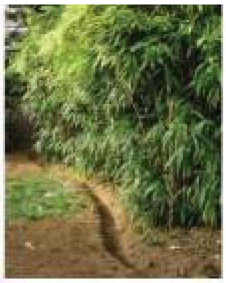


Figure D.5.4-3: Trench around stand of bamboo[b].

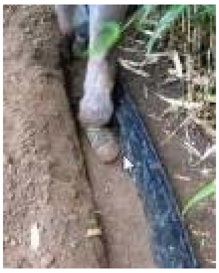


Figure D.5.4-4: Plastic barrier being installed in trench[b].

Equipment requirements:

- Panga, slasher, axe and shovel
- Lime to prepare the soil
- Plastic barriers

Seasonal variations:

- Not applicable

Variations/Adaptations:

Not applicable

MAINTENANCE

Maintenance requirements:

- Regular follow-up (monthly) of demarcated and trench areas are required to ensure the successful control of the bamboo.
- Maintain the open trench around a stand of bamboo.

REFERENCES

Definitions:

Not applicable

See also:

Guideline B.3.1. Compost making
Guideline F.1.3. Firebreaks
Guideline A.4.5. Vegetation barriers

Further references:

a. Wittenberg, R. and Cock, M.J.W (eds). 2001. Invasive Alien Species: A Toolkit of Best Prevention and Management Practices. CAB International, Wallingford, Oxon, UK, xvii-228.

b. Haiti, Jérémie.1999. Hazard Mitigation & Vulnerability Reduction Plan, USAID. Accessed online: http://www.oas.org/cdmp/document/jeremie/exsum.htm

c. Use of Bamboo for Land Stabilization, Soil Erosion Control, Water Catchment Rehabilitation, and Effluent Treatment in Citarum River Basin, Asian Development Bank: accessed online: http://www.bamboobotanicals.ca/html/bamboo-care/controlling-bamboo-spread.html and http://www.bamboogarden.com/barrier%20installation.htm

D.5.5. Utilising and controlling Prosopis spp. species

OVERVIEW

Prosopis spp. also known as mesquite, is a dominant groundwater dependent invasive alien species found in the arid and semi-arid areas. Hybridization between the dominant species, Prosopis velutina and Prosopis glandulosa var. torreyana are very invasive.

Objectives:
To introduce the concept of and educate communities regarding the control of Prosopis plants as invasive species and to give options for utilisation to prevent detrimental infestation.

Catchment perspective:
Invading alien plants including Prosopis use significantly more water than indigenous trees and plants. If left unmanaged, it would be invasive and out-compete other plants for water and ultimately decrease biodiversity and put pressure on existing water resources. Management of these resources is therefore vital across the whole catchment.

Funding opportunities: Working for Water

Criteria for application:
Prosopis has the ability to replace natural vegetation and use excess water. Management of Prosopis as a resource should be done to not only decrease their impact but also to derive the many benefits. This could be done particularly in areas closer to settlements, areas near smaller seasonal rivers and areas suffering from soil loss and erosion.
DO NOT use plants with seed pods for brushwood check dams or riparian buffers.

Legislation:

- National Environmental Management: Biodiversity Act 10 of 2004.
- Agricultural Pests Act 36 of 1983.
- Conservation of Agricultural Resources Act 43 of 1983.

Benefits:

- Balancing the benefits of using the prosopis plants (such as Prosopis glandulosa – Figure D.5.5-1) against the potential invasive potential nature has often not been achieved.

If managed correctly, the plants can be a sustainable source of:

- Fodder (Figure D.5.5-2)
- Shade
- High quality fuel/fire wood/charcoal (Figure D.5.5-3)
- Honey, dye and fibre
- Hard wood for very high-quality timber, poles and posts
- It can further help to safeguard the existing natural vegetation from over-exploitation caused by the increasing human populations
- Reducing water and wind erosion
- It is resilient and can grow under conditions where few other tree species can survive.
- Go. However if left uncontrolled to invade, the impacts of prosopis can be severe due to its aggressive water usage
- Limiting/eliminating/replacing the growth of natural vegetation and reduce biodiversity
- Altering ecosystem hydrology
- Results in very thick stands of vegetation and hinders domestic and wild animal movement
- The thorny branches are able to cause injury and the pollen causes breathing problems

METHODOLOGY

Methodology:

Managing plantations

- Plantations should be located away from vital river tributaries and agricultural areas, where possible, due to their high water demand. As such a resilient plant, prosopis require little active intervention to keep plantations growing.
- Harvesting of the plants should be done in a circular fashion along the edges of the plantation as this is the most assessable area. This also limits the invasive potential of the plants.
- Moving around the plantation give the most recently harvested area time to recover and grow before harvesting occurs again.
- The roots should not be removed to allow regrowth of the plant. (root removal is required when the plant is to be permanently removed).
- Maintenance is required to keep the plantations from spreading beyond the desired areas. Due to the strength and density of the plants, removal of established plantations is difficult and therefore intervention against invasive spreading should be done when the plants are small and more easily managed.
- This requires monitoring and clearing of immature plants saplings (see Figure D.5.5-4 and Figure D.5.5-5) in the areas surrounding the existing plantations.
- Seed pods are indigestible to animals and therefore spread through the animal droppings.
- Where plants are more mature and slashing or pulling are not an option, ring and strip barking (Figure D.5.5-6 and Figure D.5.5-7) can be an effective way of killing the tree.
- Any active maintenance on the plants should be undertaken with care due to the thorns and the inhalation problems caused by the pollen.
- When completely removing an invading cluster of plants, start from the edge of the infestation and work towards the centre.
- Ensure all root material is removed to stop regrowth.

Utilisation of Prosopis

D.5.5. Utilising and controlling Prosopis spp. species

The supply of prosopis products from these controlled areas prevents over-exploitation and ultimate destruction of indigenous forests. Additionally, the benefit of reducing losses from flooding or soil erosion. Harvested prosopis plants can be used to make fodder, high quality burning fuels, honey, dyes, fibres and very high-quality timber, poles and posts from the hard woods of the plants. These uses have created a small industry for local populations who can sell their goods in a sustainable way without impacting on the natural vegetation.

Photos:

Figure D.5.5-1: Honey mesquite: Prosopis glandulosa (Photos from reference 4)

Figure D.5.5-2: Cattle feeding on seed pods (Photos from reference 2)

Figure D.5.5-3: Making charcoal from prosopis hard wood (Photos from reference 2)

Illustrations/ Diagrams:

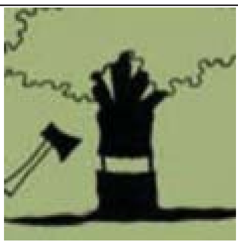


Figure D.5.5-4: Ring barking

Figure D.5.5-5: Strip barking

Figure D.5.5-6: Hand pulling

Figure D.5.5-7: Slashing

Equipment requirements:

- Panga, slasher, axe and shovel.

Seasonal variations:
Not Applicable

Variations/Adaptations:
Not Applicable

MAINTENANCE

Maintenance requirements:
Regular follow-up and monitoring of plantation and surrounding areas to ensure no spread of the prosopis plants. Harvesting should be done in a circular pattern around the edges of the plantation for ease of access and to maintain the buffer between natural and invasive species.

See also:
Guideline B.2.1. Compost making
Guideline E.3.4. Sustainable woodlot management
Guideline F.1.3. Firebreaks
Guideline A.2.2. Prevention and rehabilitating overgrazing
Guideline A.4.5 Vegetation barriers

REFERENCES

Further references:

a. Wittenberg, R. and Cock, M.J.W (eds). 2001. Invasive Alien Species: A Toolkit of Best Prevention and Management Practices. CAB International, Wallingford, Oxon, UK, xvii-228

b. Prosopis: A despised tree that is a key resource for communities in Baringo – Agri cultures – accessed 2014-11-14, http://www.agriculturesnetwork.org/magazines/east-africa/62-trees-farming/prosopis

c. How to remove invasive plants – Invasive Species South Africa, accessed 2014-11-14, http://www.invasives.org.za/resources/control-methods/item/392-how-to-remove-invasive-plants.html

d. Honey mesquite – Invasive Species South Africa, accessed 2014-11-14, http://www.invasives.org.za/invasive-species/item/313-honey-mesquite-prosopis-glandulosa.html

D.5.6. Utilising and controlling Water weed/Hyacinth

OVERVIEW

Water hyacinth, Eichhornia crassipes (Mart.) Solms-Laubach (Pontederiaceae) is a perennial, herbaceous, free-floating aquatic plant that is widely recognized as one of the world's worst invasive weeds.

Objective:
To introduce and educate communities regarding the hazard of water weed and water hyacinth, and give them the knowledge to combat the spread of the weed.

Catchment perspective:
Water hyacinth infestation is a symptom of broader catchment management and pollution problems. It calls for a concise national and transboundary water hyacinth policy designating the plant as noxious weed to aquatic systems. Water weeds and hyacinth are perennial grade 1 weeds and as such should be controlled or removed from the natural environment. Reducing the water weeds and hyacinth will provide a better quality of water down stream of lakes and water bodies. Removal will also allow better movement of water and transport for humans through the waterways.

Criteria for application:
Water weeds and hyacinth occur in nutrient-rich lakes and slow flowing rivers. Often, they are not anchored and therefore are moved by winds and water flow. An area with a strong infestation of water hyacinth is very difficult to clear and they are fast acting to establish in a new environment once introduced. They are often brought to new areas because of their ornamental beauty by people not educated in their harmful impacts.
Training requirements:
Anyone undertaking biological or chemical control methods should have proper training in the use of the chemical/biological agents. Additionally, they must have a strategic plan in place over several years to ensure that the process in successful and the system doesn't relapse into an infestation state.

Benefits:

- Will decrease water loss through evapotranspiration,
- Increase light penetration and plankton growth
- Help alleviate biodiversity loss and animal/fish death through excessive oxygen usage and will increase the quality of water
- Opening the water ways for transport for both humans and animals through the lakes/rivers and increased ability of casting of fishing nets (Figure D.5.6-1)
- The decay of the plants has negative health effects on users of the water
- Reduced siltation of rivers, and will lessen the pressure on reservoirs and waterways

Funding opportunities:
Not Applicable

Legislation:

- National Environmental Management: Biodiversity Act 10 of 2004.
- Agricultural Pests Act 36 of 1983.
- Conservation of Agricultural Resources Act 43 of 1983.
- National Water Act, Act 36 of 1998

METHODOLOGY

Methodology:

- Due to the nature of the spread of water hyacinth, dealing with its negative impacts requires a planned approach and several options for control. Re-infestation occurs easily either from vegetative growth or from the seed bank
- Control should aim at managing infestations to acceptable levels of about 10% cover rather than targeting it for complete eradication
- Management techniques include physical removal, application of herbicides, utilisation for commercial/subsistence purposes, and the importation and release of biological control agents
- Communities can get involved in removing small infestations by hand-pulling but it is extremely labour intensive process and thus largely ineffective for very large weed infestations. Once on the shore, it should be disposed of or utilised such that the seeds can't return to the water (Figure D.5.6-3)
- Large infestations can be controlled through mechanical control methods that involves the water hyacinth involve drainage of the water body or using large machines like weed harvesters (Figure D.5.6-2). Mechanical control is very expensive and requires coordination and funding from relevant government departments
- Herbicides such as glyphosate can also be sprayed on large infestations but require coordination and funding from relevant government departments
- Biological control remains the most cost-effective and environmentally friendly technique for the sustainable control of water hyacinth but requires coordination from relevant government departments.
- Water hyacinth can be utilised as a fertilizer, fodder, paper and a fibre source

Illustrations/ Diagrams: not applicable

Photos:

D.5.6. Utilising and controlling Water weed/Hyacinth

Figure D.5.6-1: Fishing boats trapped by water hyacinth (Source: Theuri, 2013)

Figure D.5.6-2: Harvester boat extraction

Figure D.5.6-3: Manual removal of water hyacinth by community (Source: Enanga, 2014)

Equipment requirements:

For manual removal:

- Boats, lifejackets, nets, rakes, slashers

For mechanical removal:

- Weed cutter boat (refer Figure D.4.6-2)

For biological removal:

- Weevils such as Megamelus scutellaris, Neochetina eichhorniae and Neochetina bruchi

Variations/Adaptations:

Not applicable

Seasonal variations:

Not applicable

MAINTENANCE

Maintenance requirements:

Mechanical, chemical and biological controls are ongoing until an area is clear of the weeds. However, monitoring should take place thereafter to ensure the controls were effective.

REFERENCES

Definitions:

Not applicable

See also:

Guideline B.2.1. Compost making
Guideline E.3.4. Sustainable woodlot management
Guideline F.1.3. Firebreaks

Further references:

a. Wittenberg, R. and Cock, M.J.W (eds). 2001. Invasive Alien Species: A Toolkit of Best Prevention and Management Practices. CAB International, Wallingford, Oxon, UK, xvii-228

b. Prosopis: A despised tree that is a key resource for communities in Baringo – Agri cultures – accessed 2014-11-14, http://www.agriculturesnetwork.org/magazines/east-africa/62-trees-farming/prosopis

c. How to remove invasive plants – Invasive Species South Africa, accessed 2014-11-14, http://www.invasives.org.za/resources/control-methods/item/392-how-to-remove-invasive-plants.html

d. Honey mesquite – Invasive Species South Africa, accessed 2014-11-14, http://www.invasives.org.za/invasive-species/item/313-honey-mesquite-prosopis-glandulosa.html

E SUSTAINABLE HOUSEHOLDS

CATCHMENT MANAGEMENT GUIDELINES	ISSUES										CAPACITY					
E. Sustainable households	Soil Erosion	Loss of soil fertility	Sedimentation	Water degradation and depletion	Floods	Overgrazing / Deforestation	Threat to biodiversity	Loss of crop yields / Livestock fodder	Risk to infrastructure	Reduced standard of living	Prevention/Rehabilitation	Legislation	Scale	Labour requirement	Complexity	Cost
E.1. Money management																
E.1.1. Household budgeting										■	Prevention	Other	Household	Single person	Simple	Free to little
E.1.2. Loan repayments / Debt management										■	Prevention	Other	Household	Single person	Advanced	Medium cost
E.1.3. Group savings (and credit) schemes										■	Prevention	Other	Village	Few people	Advanced	Medium cost
E.2. Nutrition																
E.2.1. Nutrition in the home								■		■	Prevention	Other	Household	Single person	Simple	Free to little
E.3. Plot management																
E.3.1. Living fences and wind breaks	■	■	■	■		■	■	■	■	■	Prevention	NWA/NEMA	Household	Single person	Simple	Free to little
E.3.2. Borehole pump maintenance				■				■	■	■	Prevention	Other	Village	Few people	Advanced	Medium cost
E.3.3. Improved grain storage								■		■	Prevention	Other	Household	Single person	Simple	Free to little
E.3.4. Sustainable woodlot management	■	■	■	■		■	■				Prevention	Other	Household	Single person	Simple	Free to little
E.3.5. Tree nursery	■			■		■	■				Prevention	NWA/NEMA	Village	Few people	Advanced	Free to little
E.4. Sanitation and latrine management																
E.4.1. Constructing a composting toilet		■		■		■				■	Prevention	NWA/NEMA	Village	Few people	Complex	Expensive
E.4.2. Constructing an arborloo latrine				■		■				■	Prevention	Other	Household	Few people	Advanced	Free to little
E.4.3. Closing a pit latrine				■		■				■	Prevention	Other	Household	Single person	Simple	Free to little
E.4.4. Operating and maintaining a Ventilated Improved Pit (VIP) Latrine				■						■	Prevention	Other	Household	Single person	Simple	Free to little
E.5. Energy, efficiency and alternatives																
E.5.1. Energy efficient stoves and ovens						■				■	Prevention	Other	Household	Single person	Simple	Free to little
E.5.2. Heat retention cooker						■				■	Prevention	Other	Household	Single person	Simple	Free to little
E.5.3. Solar cooker						■				■	Prevention	Other	Household	Single person	Simple	Free to little
E.5.4. Solar electrification						■				■	Prevention	Other	Household	Single person	Advanced	Medium cost
E.5.5. Solar borehole pump				■		■				■	Prevention	NWA/NEMA	Village	Few people	Complex	Expensive
E.5.6. Wind pump						■				■	Prevention	NWA/NEMA	Village	Few people	Complex	Expensive
E.5.7. Micro hydropower						■				■	Prevention	NWA/NEMA	Village	Few people	Complex	Medium cost
E.5.8. Biogas digester						■				■	Prevention	Other	Household	Few people	Complex	Medium cost
E.5.9. Solar turtle						■				■	Prevention	Other	Village	Few people	Complex	Expensive
E.6. Waste management (solid)																
E.6.1. Household waste management	■	■		■			■			■	Prevention	Other	Household	Single person	Simple	Free to little
E.6.2. Ecobricks	■	■		■			■			■	Prevention	Other	Household	Single person	Simple	Free to little
E.6.3. Village waste management	■	■		■			■			■	Prevention	NWA/NEMA	Village	Few people	Advanced	Medium cost
E.6.4. Buy back centres				■			■			■	Prevention	NWA/NEMA	Catchment	Few people	Complex	Expensive

KEY: Capacity Icons

Action	Legislation	Scale	Labour	Complexity	Cost
Prevention	Other	Household	Single person	Simple	Free to little
Rehabilitation	NWA/NEMA	Village	Few people	Advanced	Medium cost
		Catchment	Many people	Complex	Expensive

In order to ensure that catchment management activities and resource protection activities can be implemented, it is important that activities around the household, farm and village are also sustainable and of a high standard. These include activities such as basic money management, nutrition, farm management, sanitation management, energy, waste management and risk management.

E.1 Money Management
As a result of living day to day off the land, rural groups of people do not generally practice a culture of saving financially. It is difficult to inspire people and communities to take responsibility for their environment when they are poor and in debt. This guideline provides some ideas on money management principles. These are also important for income generation activities and grant/fund management for catchment management implementation.

E.2 Nutrition
Healthy families are happy families. A major contributor to health is good nutrition. These guidelines provide a summary of good basic nutrition and what to eat accordingly. By having good nutrition leads to reduced illness and more strength and energy, better attendance at school.

E.3 Plot management
These guidelines assist farmers with activities around the house and farm (plot of land) to improve sustainability, efficiency and resource availability.
E.4 Sanitation and Latrine Management
Good sanitation improves health and hygiene. Having a healthy family, community and village means there can be more productive labour and income generation. Good sanitation reduces illness and mortality rates and reduces contamination of available water resources. These guidelines set out and describe techniques to improve sanitation and maintain systems.

E.5 Energy, efficiency and alternatives
This set of guidelines provides instructions to build devices which promote the use of renewable sources of energy to generate electric power for use in the household, or community, as a replacement for the burning of wood or charcoal. These guidelines also promote energy efficient use and reduce the release of noxious gases that have adverse health and environmental effects.

E.6 Waste management (solid)
Litter and solid waste can contribute to the spread of vector diseases such as *E. coli*, e.g. rainwater trapped in thrown away plastic bags provides ideal breeding grounds germs, and other illnesses including contamination of water resources. Therefore, it is important to manage the disposal of waste both at the household/farm level as well as at the village. One of the best methods of waste management is to recycle or reuse waste products, e.g. cans, glass bottles, paper, cardboard and plastics can be recycled and/or reused, and organic waste can be used in compost. These guidelines give guidance to improved management of waste including ideas for recycling, upscaling, reuse of litter.

E.1. Money management

Financial inclusion goes beyond the provision of financial services (credit, savings, insurance) but includes empowering individuals with the necessary information and knowledge to make better financial decisions. Financial literacy goes hand in hand with household well-being. One of the most important steps of financial literacy involves developing a household budget. By providing a breakdown of income and expenses, will assist a household in prioritizing spending, diverting money towards savings and reducing debt.

E.1.1. Household Budgeting
OVERVIEW
A household budget is a useful tool for managing household income. Essentially, a budget is a monthly "plan" for your money, based on the household's current earnings and both current and future expenses. If income is seasonal or

E.1.1. Household Budgeting

irregular, it is extremely important to make provision for these future expenses. In this sub-theme, we provide a step-by-step guide on how to draw up and use a household budget.

Objectives:

Within the overall objective of providing money management guidelines, this sub-theme focuses on providing a step-by-step guide for households around developing a household budget.

It is often the case that households are forced to solve short-term monetary problems (for example, covering monthly expenses) with decisions that have long-term and detrimental consequences (for example, borrowing money at a high interest rate). In this context, one of the ways in which budgeting improves financial well-being is through helping households to both identify and plan for daily and future expenses (ranging from monthly necessities to annual expenses such as the purchase of school uniforms and agricultural inputs needed during the planting season). Saving for future expenses is particularly important for households with irregular income as it will facilitate consumption smoothing in times when households are not earning an income and ensure money is available for unplanned expenses.

Criteria for application:
Any individual/household can develop e budget.

Benefits:

- Awareness of spending habits
- Prioritizing specific expenses
- Planning for future and unexpected expenses through monthly savings
- Consumption smoothing in times of no income

Debt reduction through prioritizing the paying off of debt, and even avoiding debt by rather saving for future expenses.

Catchment perspective: Not applicable

Funding opportunities: Not applicable

Legislation: Not applicable

METHODOLOGY

Methodology:
This is a step-by-step guide on how to draw up a budget.[15] This process has been broken down into six steps:

Step 1: Tracking your spending

Think about everything that your household spends money on. All household members will need to sit down together to make this list. When making the list:

Include the items that your household buys on a monthly basis: for example, food, water, electricity, fuel for cooking. These are your *regular monthly expenses*.

Also include expenses that aren't regular: for example, buying agricultural inputs or buying a bus ticket to visit family over the festive season. These are important purchases, but because they aren't regular monthly expenses, we tend not to plan for them. These are your *expected future expenses.*

Step 2: Make a list of all your needs and wants

Once you have a list of all the items that the household spends money on, divide the list of items into "needs" and "wants".

"Needs" are items that the household can't do without. For these items, when budgeting, you need to make sure your income covers these expenses first! This list of items will be different for each household. Examples of "needs" might include food, water, electricity, savings, debt repayment, fuel for cooking, school fees, school uniform, clothes, agricultural inputs and medicine. As households need to save each month to cover future "needs" (i.e. future expenses), savings are also included as a "need" (this is discussed in more detail below).

"Wants" are also important, but these are expenses that can be delayed until you have met your most important expenses (your "needs"). For example, cigarettes, furniture, entertainment or a renovation to your house.

Dividing up your expenses into "needs" and "wants" helps to clarify what expenses need to be prioritised. Every month, first pay for your "needs". Any money left over can then be used to pay for "wants".

Step 3: Save every month for irregular and unplanned expenses

a. In step 1, you made a list of all your regular and future expenses. These future expenses might be planned (for example, buying school uniforms) or unplanned (needing to visit a sick relative). It is important to plan ahead

15 The information in the section draws from the material of the Consumer Education Department of the Financial Services Board, which oversees the non-banking financial services industry in South Africa (Financial Services Board 2015, My Life My Money [date unknown]).

for these unexpected future expenses by putting money aside each month for them. By planning ahead, you can ensure there is money available for these expenses without having to take out expensive loans.

b. Your household needs to agree on an amount of money to save every month. You will include this amount, under savings, in your budget every month.

Step 4: Save every month for times when you are not earning an income

a. If your income is seasonal, you will only earn money during certain times of the year. Alternatively, if your job is not permanent, you might have a period between jobs where you are not earning a salary. Think about how many household members have an income that is not regular. If much of your household income is not regular (for example, if working household members are only employed in the harvesting season), you need to make sure there is enough money to cover your expenses in times when you are not earning an income. You need to make sure that your savings will cover:

b. The households' *regular monthly expenses* (monthly "needs") in times when household members are not earning an income.

c. The households' *expected future expenses* in times when household members are not earning an income.

d. The household's *unplanned expenses* when members of the household are not earning an income.

e. Think about the amount of money your household has decided to save each month (in step 3). Will this be enough to cover your expenses in times when household members are not earning a salary? If your household is able to, increase the amount of money you are going to save each month. Alternatively, once you pay off a debt, redirect this money to savings. Financial advisors recommend that households should work towards building up an emergency saving fund to cover 8 months-worth of living expenses. Thus, should there be a loss in family income due to unemployment, one has funds available to cover one's regular monthly expenses in the short-term until a new job has been found.

f. Importantly, before taking on a new debt, think about how your household will repay the debt when members of the household are not earning a regular salary. If possible, delay making purchases that require you to take out a loan and rather save up for the item.

Step 5: Start drawing up your household budget. This will be divided into five parts:

a. Part 1: List of fixed expenses (fixed costs)
   - This is a list of monthly expenses that stay the same across months (for example, rent, school fees and savings). Calculate the TOTAL spent each month on fixed costs.
   - Note: fixed expenses include monthly savings.

b. Part 2: List of changing expenses (variable costs)
   - These are expenses that you usually pay every month, but the amount spent varies from month to month. This might include electricity, water, groceries and cooking fuel. Calculate the TOTAL spent each month on variable costs. While this amount might change from month to month, the household will soon get a good idea of what the variable expenses are.

c. Part 3: Total expenses for the month
   - Add the fixed and changing costs together to calculate total monthly household expenses.

d. Part 4: Total income for the month
   - This is the total money that your household will earn in this particular month. In other words, this is the amount of money that you have available to spend.

e. Part 5: Money left over OR amount needed to cover shortfall
   - Subtract your total expenses (fixed and variable) from your total household income. If your income is greater than your expenses, you are able to cover your expenses and have money left over to spend or to save (see example in Figure 1). If your expenses are greater than your income, your income is not sufficient to cover all your expenses (See example in Figure 2).

An example of a household budget is provided below:

Figure E.1.1-1: Example of budget (where income covers expenses)

Household monthly budget November 2016	
Fixed Expenses	
Savings	R30
School fees	R50
Crèche fees	R30
Total fixed costs	**R110**
Changing Expenses	

Figure E.1.1-2: Example of budget (where income does not cover expenses)

Household monthly budget November 2016	
Fixed Expenses	
Savings	R30
School fees	R50
Crèche fees	R30
Total fixed costs	**R110**
Changing Expenses	

Debt: payment to savings group	R100
Food	R200
Water	R50
Electricity	R30
Cooking fuel	R30
Total changing costs	**R410**
Total monthly income	**R540**
Total expenses	**R520**
Left to spend	**R20**

Debt: payment to savings group	R100
Cigarettes	R40
Food	R200
Water	R50
Electricity	R30
Cooking fuel	R30
Total changing costs	**R450**
Total monthly income	**R540**
Total expenses	**R560**
Left to spend	**-R20**

Step 6: Making a plan if your income does not cover your expenses

a. If your income is not covering all your expenses, go back to your list of needs and wants (step 2) to see which expenses can be reduced. As “needs” are things that the household needs to spend money on to survive, first look at your household’s "wants" list to find areas that can be reduced or cut out completely. The budget will allow you to see all your expenses.

b. For example, in Figure 2, the household is paying R40 per month on cigarettes. If cigarettes were identified as a “want” in the list of needs and wants, the household can halve the number of cigarettes they buy each month which will reduce their expenses by R20 so that their income just covers their expenses. Alternatively, assume a household has a loan with a furniture store. Once the debt is repaid, the amount being spent each month to service the debt can rather go towards covering the income shortfall. However, this money is only freed up if the household does not purchase more items on credit or get another loan.

c. In the following subsection, we replicate some of the material from the Financial Services Board’s financial literary booklet (*Make the most out of your money*) in order to illustrate how this kind of information can be presented in both a simple and engaging way.

Illustrations/ Diagrams:

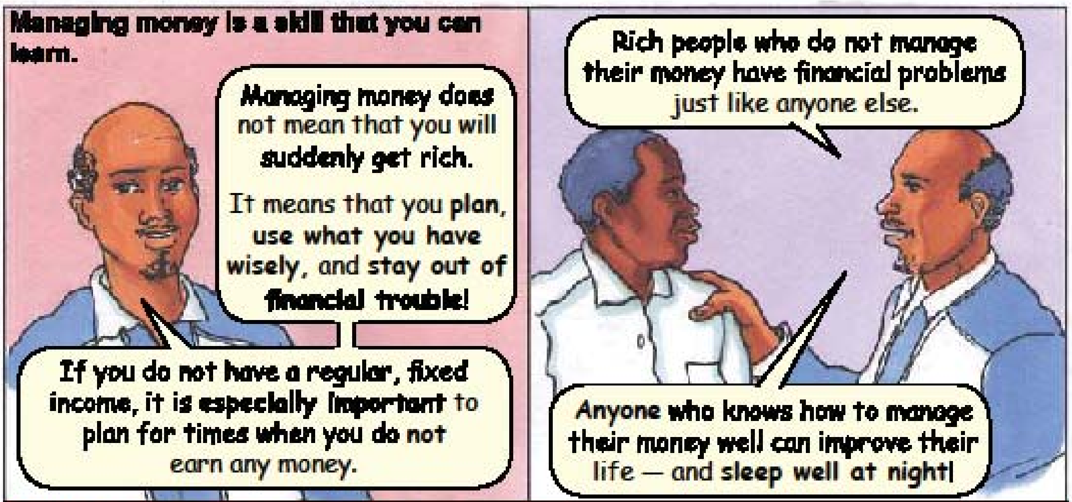
Managing your money

This book explains how to manage *your* money

Do you have a pension or a grant?
You can manage your money better.

Do you have a low-paying job?
You can manage your money better.

Do you get only piece work?
Then you are earning money.
You, too, can manage your money better.



We can all have a better life if we:

- think about what we are doing;
- identify the things we are doing wrong; and
- take steps to change our behaviour.

2

Let me show you my budget for last month ...

Thobelo's Budget

FIXED COSTS	
rent	R350
insurance policy	R 50
car repayment	R100
savings	R 50
TOTAL FIXED COSTS	R550
CHANGING COSTS	
debt: furniture shop	R100
groceries	R260
electricity	R 60
telephone	R 60
petrol/repairs	R100
toiletries	R 60
entertainment	R 60
medicine	R 40
TOTAL CHANGING COSTS	R740
TOTAL COSTS	R1 290
TOTAL INCOME	R1 450
LEFT TO SPEND OR SAVE	R160

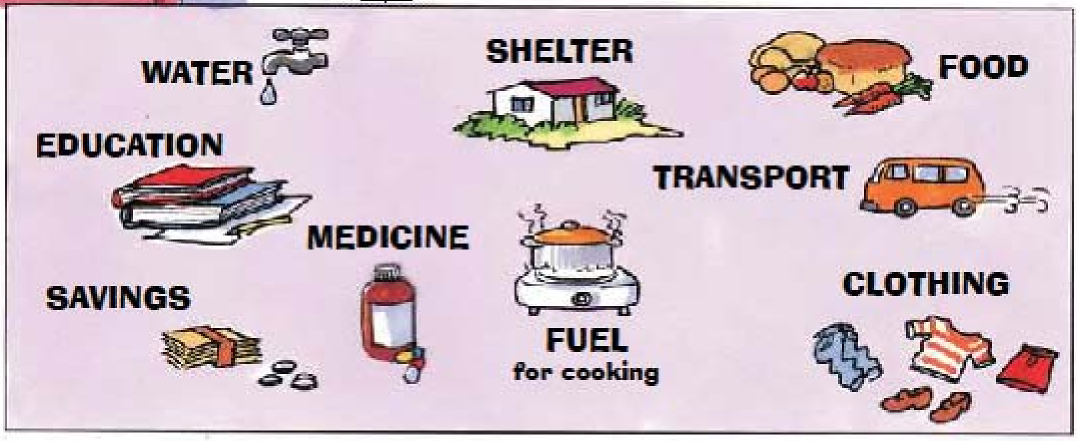
Find out about Fixed Costs and Changing (Variable) Costs on pages 12 and 13.

How to plan your budget

Your budget will be different from anyone else's.

That is because your needs and wants are not exactly the same as mine — or anyone else's! Each person or family's needs and wants are a bit different. For example, you are a single parent with a child — I have a partner, but no children. And we do not have the same money to spend! Some people do not even have a regular income.

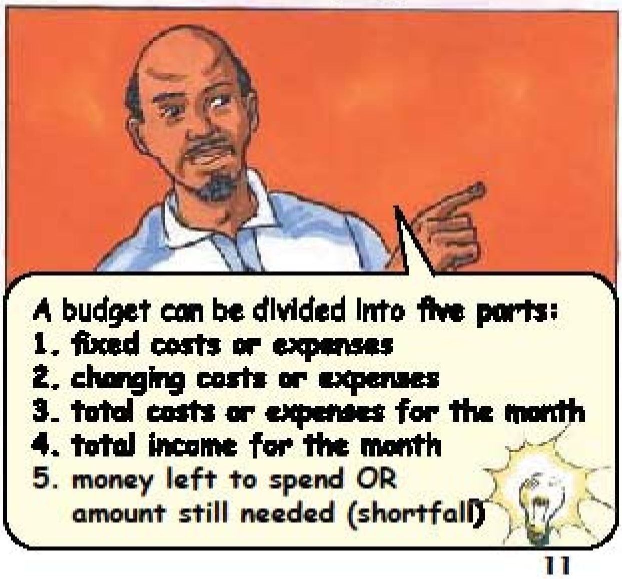
Things we need



Our needs are the things we **cannot do without**. We must make sure we have money to pay for these things **every** month **first**.

Sit down with your family and make your list. Write down everything you can think of!

Let's look at Thobelo's budget again.



THOBELO'S BUDGET

FIXED COSTS	
rent	R 350
insurance policy	R 50
car repayment	R 100
savings	R 50
TOTAL FIXED COSTS	R 550
CHANGING COSTS	
debt: furniture shop	R 100
groceries	R 260
electricity	R 60
telephone	R 60
petrol/repairs	R 100
toiletries	R 60
entertainment	R 60
medicine	R 40
TOTAL CHANGING COSTS	R 740
TOTAL COSTS	R1 290
TOTAL INCOME	R1 450
LEFT TO SPEND	R160

Step 2: Changing (variable) costs

Changing or variable costs are things that you usually pay or buy *every* month, but the *amount changes* from month to month.
Below "changing costs", write down what you think your *changing costs* will be.
Don't forget to add them up.

Step 3: Total costs

Add the ***total for fixed costs*** and the *total for changing costs* together. Write down the answer.

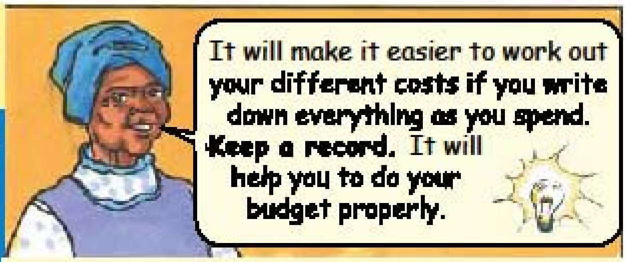
Step 4: Total income

This is the amount of *money you have available to spend* each month.

Step 5: Money left over OR still needed (shortfall)

Subtract the smaller amount from the bigger amount.

If *costs* are *bigger*, you are *spending more* money than you have. If *income* is *bigger*, you have *money left over*!



Vicky's Budget

FIXED COSTS	
rent	R200
money for mother	R100
crèche fees	R50
transport (to and from work)	R90
TOTAL FIXED COSTS	R440
CHANGING COSTS	
debt:	
Edwards	R60
furniture shop	R110
clothing shop	R50
credit provider	R50
groceries	R300
electricity	R50
telephone	R55
toiletries/cosmetics	R70
take-aways, etc.	R30
TOTAL CHANGING COSTS	R775
TOTAL COSTS	R1 215
TOTAL INCOME	R1 100
STILL NEEDED	**R115**

13

Photos: not applicable

Seasonal variations: Not applicable

E.1.1. Household Budgeting	

Variations/Adaptations:
Savings initiatives, such as savings groups (covered in sub-theme E1.3), would complement this money management intervention by providing an informal vehicle for monthly saving. However, saving can take place independently of any formal or informal structure.

In addition, the envelope budgeting system can also assist households in keeping to their budget. At the start of the month, think of all the expenses you will need to pay during the month. Allocate an envelope for each one of these expenses. For example, your household might have an envelope for food, an envelope for electricity and an envelope for taxi fare.

Because of your budget, you will know how much money you wish to allocate to each of these expenses. When you receive your income, divide it up according to your budget and place the money in the designated envelope. For example, the money for food will go in the "food envelope".

The envelope approach provides a tangible way to ensure that one's money is physically allocated according to one's spending intentions. It also allows one to see whether one's budget was realistic, for example, if the money in the "food envelope" does not last until the end of the month, one may have to increase the food budget or think about the food purchases one is making

Equipment requirements:
Household member will require pen and paper in order to:

- Make a list of needs and wants
- Keep track of the amount of money spent on various expenses
- Write up the budget

MAINTENANCE

Maintenance requirements:
The household budget should be reviewed regularly, for example, on a monthly basis, to ensure it accurately reflects spending patterns of the household.

REFERENCES

Definitions:

- ***Household(s):*** this refers to the all the occupants of a house as a single unit.
- ***Consumption smoothing***: keeping your usage (or consumption) of goods and services regular and consistent. So even when you are not earning an income, you are able to afford your day-to-day expenses.

See also:
Guideline E.1.2. Loan repayments / Debt management
Guideline E.1.3. Group savings (and credit) schemes

Further references:

a. Financial Services Board. (2015). *Consumer Education*. [ONLINE] Available at: https://www.fsb.co.za/Departments/consumerEducation/Pages/foundation.aspx. [Accessed 4 August 2016].
b. Lundberg, M., Mulaj, F. (2014). Overview. In: Lundberg, M., Mulaj, F. ed. *Enhancing Financial Capability and Behaviour in Low- and Middle-income Countries*. The World Bank, Washington DC.
c. Cole, S., Zia, B., Abel, M., Crowley, L., Pauliac, C., Postal, V. (2014). Evaluation of Old Mutual's On The Money Programme: Financial Literacy in South Africa. In: Lundberg, M., Mulaj, F. ed. *Enhancing Financial Capability and Behaviour in Low- and Middle-income Countries*. The World Bank, Washington DC.
d. My Life My Money. [Date unknown]. *Financial Literacy*. [ONLINE] Available at: https://www.mylifemymoney.co.za/Consumer/Financial/Pages/default.aspx. [Accessed 4 August 2016].
e. Struwig, J., Roberts, B., Gordon, S. (2013). Financial Literacy in South Africa: Results of a *2012 national survey update*. Report prepared by the Human Sciences Research Council on behalf of the Financial Services Board. Pretoria: Financial Services Board.
f. Orman, S. (2015) 'Emergency Fund 101', Available online at: http://www.suzeorman.com/blog/emergency-fund-101

As financial inclusion has improved, South African households have become heavily indebted. People borrow money (take out a loan) for many different reasons, for example, to fund an emergency shortfall in cash, start up a business, pay for a house or to fund personal expenditure. While the National Credit Act has put legislation in place to better protect consumers, many borrowers enter into loan agreements without an understanding of the costs involved and find themselves in a vulnerable position where, instead of the loan improving financial well-being, it traps them into a cycle of debt. Against this backdrop, this sub-theme serves as an educational tool around borrowing money. Specifically, the core determinants of the cost of loans are unpacked. More specifically, why higher interest rates and repayment periods lead to higher total repayment values.

E.1.2. Loan Repayments / Debt management

OVERVIEW

There are different ways to borrow money. Individuals might obtain loans from formal institutions (such as commercial banks and retail stores) or from informal lenders. For example, sub-theme E.1.3 provides information about an informal savings group that facilitates short-term loans.

The person or institution providing (or loaning) the money is called the lender while the person receiving the money is called the borrower. The money lent to the borrower is the loan and is also called credit. Despite the manner in which loans are often advertised, they are not free money. Lenders provide loans because they will receive a fee in return for lending out their money. This fee is called the interest rate and is paid by the borrower. The person borrowing the money thus has to pay back both the original amount borrowed as well as the interest. As such, when borrowing money, it is important to understand how the repayment of the loan works, or, in other words, what the loan will cost you. This means that, before taking out the loan, you must have a good sense of *how much money you will be paying back every month and for how long*.

Households sometimes cannot afford to repay their loan. This could then result in them taking out another loan to meet the payments on the first loan. This cycle of taking out a loan to pay off another loan is known as a debt trap and is highly destructive to a family's financial wellbeing. By knowing in advance whether you can afford to repay the loan, you can avoid such a debt trap.

The information provided in this sub-theme illustrates how the cost of borrowing increases by three elements of the loan, namely:

1. The interest rate
2. The amount of money you borrow,
3. The amount of time you have to repay the loan,

This intervention is conducted at the individual or household level. By working through the information provided in this sub-theme, individuals will have a better understanding of how loans work. By using this information, household members can decide whether a prospective loan is affordable and avoid getting into debt that they won't be able to repay.

Objectives:
This sub-theme is part of a broader series around money management. This particular sub-theme focuses on loan repayment and the cost of borrowing money.

By working through these examples, households will have insight into why:

- Higher interest rates increase the cost of borrowing money
- A higher principal amount increases the cost of borrowing money
- Longer repayment periods increase the cost of borrowing money.

Armed with a better understanding of how much a prospective loan actually costs, households will be able to make better decisions about debt.

Criteria for application: Not applicable

Catchment perspective: Not applicable.

Funding opportunities: Not applicable

Legislation: Not applicable

E.1.2. Loan Repayments / Debt management

Specifically, whether it is realistic that the loan will be able to be repaid.

Benefits:

Specific benefits:

- A better understanding of financial terms, such as interest rate, principal amount and repayment period.
- Better understanding of why the interest rate, repayment period and principal amount all work to increase the repayment amount of the loan.
- A better understanding of how much a prospective loan actually costs.

General benefits:

- Greater financial literacy. An understanding of financial terms and principles and the ability to calculate the cost of a loan are extremely important when borrowing money. Without this information, households are unable to make informed decisions.
- Making better financial decisions by avoiding loans with excessive interest rates.

Making better financial decisions by avoiding unaffordable loans: households can compare the monthly repayment value with their household budget (sub-theme E1) to assess whether the loan is affordable

METHODOLOGY

Methodology:

Step 1: clarifying financial principles

a. You are able to borrow money by taking out a loan. The amount that you borrow is called the *principal* amount. If you borrow R100 from your local savings group to buy fertilizer, the R100 is the *principal*.

b. When you borrow money, you are charged interest. Interest is really the cost (or price) of borrowing money. When you repay your loan, you pay back the principal amount (the actual amount that you borrowed) as well as the interest. That is why it is also cheaper to save up beforehand and purchase the item with cash. That way, you avoid having to pay interest.

c. The interest rate is a percentage of the principal amount and is charged for a specific period of time. For example, if you are charged a rate of 10%, you need to determine whether this is 10% per year or 10% per month. If it is 10% per month, it would be a lot more expensive. So, the interest rate must have a time period associated with it. In our worked examples below we assume the interest rate is charged per year.

Step 2: calculating the interest on a loan

a. To calculate the total interest paid on a loan:

b. $Interest = principal \times interest\ rate \times time$

Amount of money you

Amount of time you will have the

c. We immediately notice three things:

- The higher the principal (i.e. the more money you borrow), the more interest you will pay on your loan
- The higher the interest rate, the more interest you will pay on your loan
- The longer you have the money (the longer your repayment period is), the more interest you will pay.

Step 3: Worked examples

E.1.2. Loan Repayments / Debt management

a. Example 1: The higher the interest rate, the higher the cost of borrowing money

- Let's assume the following:
  - Your household needs to buy fertilizer for the next planting season. The fertilizer costs R500. Your household decides to take out a loan to finance the purchase of the fertilizer. The conditions of the loan are as follows:
  - You borrow **R500** (this is the principal amount)
  - You are charged an **ANNUAL** interest rate
  - The repayment period is one year (your household has a year to pay back the loan)
  - In the table below, there are three examples of three different interest rates to illustrate how a higher interest rate results in a higher total cost of borrowing over the term of repayment:
  - When the interest rate is **5%,** you will pay back the **R500** you borrowed, **plus** R25 in interest
  - When the interest rate is **20%,** you will pay back the **R500** you borrowed, **plus** R100 in interest
  - When the interest rate is **40%**, you will pay back the **R500** you borrowed, **plus** R200 in interest. This is nearly half the value of the loan just in interest.
-
  - So, the higher the interest rate, the greater the repayment amount.
  - Usually, the total repayment is divided up into monthly instalments. This is discussed later (under step 4). For now, we are focusing on the total repayment as this clearly indicates the impact that each of the underlying factors (interest rate, principal and repayment period) has on the total cost of the loan.

Table E.1.2-1: The cost of borrowing money at different interest rates

Principal amount	Interest rate	Time	Total Interest charged	Total repayment
R 500	5%	1 year	R 25	R 525
R 500	20%	1 year	R 100	R 600
R 500	40%	1 year	R 200	R 700

b. Try these examples for yourself. Remember, you work out the interest as follows:

- Interest = principal x interest rate x time
- So in the example where the interest rate is 5%:
- Interest = principal x interest rate x time (in years)
- = R500 x 0.05 x 1 year
- = R25

c. Example 2: The higher the principal amount, the higher the cost of borrowing money

  - In table 2 below, we keep the interest rate unchanged at 5%, but vary the principal amount (the amount that is borrowed). In the first example, we assume, as before, that the household borrows R500 at an annual interest rate of 5%. In the second example, we increase the principal to R1000. In the third example, the principal increases to R1500.
  - You can see from Table E.1.2.2:
  - When the principal amount is R500, you will pay back the R500 you borrowed, **plus** R25 in interest.
  - When the principal amount is R1000, you will pay back the R1000 you borrowed, **plus** R50 in interest
  - When the principal amount is R1500, you will pay back the R1500 you borrowed, **plus** R75 in interest.
  - So, the higher the principal amount, the greater the repayment amount.

Table E.1.2-2: The cost of borrowing money with different principal amounts

Principal amount	Interest rate	Time	Total Interest charged	Total repayment
R 500	5%	1 year	R 25	R 525
R 1 000	5%	1 year	R 50	R 1 050
R 1 500	5%	1 year	R 75	R 1 575

d. Example 3: The higher the repayment period, the higher the cost of borrowing money

  - In Table E.1.2.2 below, we keep the interest rate unchanged at 5% and the principal amount at R500, but vary the repayment period (the amount of time you keep the money). In the first example, we assume that your household keeps the money for 1 year. This increases to two years in the second example. Finally, in the third example, we assume your household keeps the money for three years.

- You can see from Table E1.2.3:
- When the repayment period is **1 year**, you will pay back the **R500** you borrowed, **plus** R25 in interest.
- When the repayment period is **2 years**, you will pay back the **R500** you borrowed, **plus** R50 in interest.
- When the repayment period is **3 years**, you will pay back the **R500** you borrowed, **plus** R75 in interest.
- So, the longer your household takes to repay the money (the longer the repayment period), the greater the repayment amount.

Table E.1.2-3: The cost of borrowing money with different repayment periods

Principal amount	Interest rate	Time	Total Interest charged	Total repayment
R 500	5%	1 year	R 25	R 525
R 500	5%	2 years	R 50	R 550
R 500	5%	3 years	R 75	R 575

Step 4: Calculate what the monthly loan repayment amounts will be

a. As the examples have shown, you start off by borrowing an amount of money, but, because you are being charged interest, you end up repaying MORE than you borrowed.

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• Let's once again assume the following:
  - Your household needs to buy fertilizer for the next planting season. The fertilizer costs R500. Your household decides to take out a loan to finance the purchase of the fertilizer. The conditions of the loan are as follows:
  - You borrow R500 (this is the principal amount)
  - You are charged an ANNUAL interest rate
  - The repayment period is one year (your household has a year in which to pay back the loan)
  - Table E.1.2.4 (a repeat of Table E.1.2.1) is now familiar to you:
  - When the interest rate is 5%, you will pay back the R500 you borrowed, **plus** R25 in interest
  - When the interest rate is 20%, you will pay back the R500 you borrowed, **plus** R100 in interest
  - When the interest rate is 40%, you will pay back the R500 you borrowed, **plus** R200 in interest.

Table E.1.2-4: The cost of borrowing money at different interest rates

Principal amount	Interest rate	Time	Total Interest charged	Total repayment
R 500	5%	1 year	R 25	R 525
R 500	20%	1 year	R 100	R 600
R 500	40%	1 year	R 200	R 700

How will paying back the money actually work?

- The lender will not wait an entire year for the money. Rather, you will have to pay back portions of the money every month over the year. Thus, in the simplest way, the total repayments are divided by 12 months. From Table 5, you can see:
- When the total repayment amount is R525, you will pay back R44 every month
- When the total repayment amount is R600, you will pay back R50 every month
- When the total repayment amount is R600, you will pay back R58 every month
- So, as the total repayment amount increases, so will the monthly repayment amounts. This will mean less money available to spend on other household expenses.

Table E.1.2-5. Monthly repayment amounts

E.1.2. Loan Repayments / Debt management

Principal amount	Interest rate	Time	Total Interest charged	Total repayment	Monthly repayment
R 500	5%	1 year	R 25	R 525	R 44
R 500	20%	1 year	R 100	R 600	R 50
R 500	40%	1 year	R 200	R 700	R 58

When considering taking out a loan, think about your monthly household budget (sub-theme E1.1). Does your monthly income cover the extra expense of the monthly repayment? If it does not, you have an opportunity to re-evaluate whether the loan is feasible. You don't want to get into the debt trap where you need to borrow more money to make your monthly repayments… getting yourself into more and more debt.

Step 5: Consider whether this is a good loan

a. Before taking out a loan, evaluate whether the loan is a good idea.

b. Borrowing money to create wealth is generally a good idea, for example, borrowing money to buy a house, farming inputs or to finance education. These debts will pay for expenses that will usually earn you, or save you, money in the long run. For example, paying a loan for a house means that, once the home loan is paid off, you will not have to pay rent. Furthermore, you will generally be able to sell the house for more than you bought it. Other examples include taking a loan for farming materials, which could result in a more productive harvesting season and thus a higher income and, finally, taking out a student loan – with education being a platform to a higher earning potential in the future.

Importantly even when a loan can be justified as a good idea it still needs to be affordable.

When is borrowing money not a good idea? When the items one is wishing to purchase on credit are not income generating. Often these items are "wants". For example, luxury clothing and shoes. Interest will be paid on these items, even though they lose value the moment you put them on (i.e. you couldn't sell them for the same price at which you purchased them).

Illustrations/ Diagrams: Not applicable

Photos: Not applicable
Variations/Adaptations: Not applicable
Seasonal variations: Not applicable

Equipment requirements:
Pen, paper and calculator to go through the worked examples.

MAINTENANCE

Maintenance requirements: Not applicable

Potential drawbacks/disadvantages: Not applicable

REFERENCES

Definitions:

- *Household(s):* this refers to the all the occupants of a house as a single unit.
- *Smoothing consumption*: keeping your usage (or consumption) of goods and services regular and consistent. So even, when you are not earning an income, you are able to afford your day-to-day expenses.
- *Interest/interest rate*: when you borrow money, you re charged interest, Interest is the cost of borrowing money. When pay back the loan, you pay back the amount you borrowed plus interest.
- *Principal*: The amount that you borrow is called the *principal* amount. If you borrow R100 from your local savings group to buy fertilizer, the R100 is the *principal*.
- *Needs*: Essential items that the household can't do without, for example, food, water, electricity and medicine.

Wants: There are items that you can delay purchasing until you have paid for your most important expenses. For example, entertainment or home renovations.

Further references:

a. FinScope Consumer Survey. (2015). FinScope South Africa 2015. FinMark Trust. Available online: http://www.finmark.org.za/wp-content/uploads/2016/03/Broch_FinScopeSA2015_Consumersurvey_FNL.pdf.

See also:

Guideline E.1.1. Household budgeting
Guideline E.1.3. Group savings (and credit) schemes

E.1.3. Group saving (and credit) schemes

OVERVIEW

An informal saving group that meets at regular monthly intervals to save money. The core function is to provide a framework for short-term savings but it can also be used to offer short-term loans for group members. Each saving group sets up their own rules (such as minimum monthly contributions, when the annual pay-out will be, the terms of a loan and the interest to be charged on loans). The group also elects a management committee. All transactions are recorded and occur in the presence of all members to ensure transparency and facilitate trust in the group.

Membership of a group is voluntary and the decision to participate in a group saving scheme is made at the individual level. Group sizes typically range between 15-30 people. There can be multiple saving groups within a village. The benefits of the saving group accrue to the members and, by extension, their households, with no direct benefit to the rest of the village. While a saving group can consist of any number of people, successful saving groups are found to have between 15-30 members. Any larger and the administration burden becomes too great. The time frame for saving groups is a 12-month cycle with meetings occurring once a month.

Setting up a group savings scheme is relatively simple. Some basic maths ability and the help of a calculator is required to work out the loan repayments and payouts. Some basic training and help with the facilitation of meetings is useful when getting started. The organisation SaveAct offers this service (http://saveact.org.za/). There is a once-off cost in purchasing the equipment necessary for setting up the saving group. Equipment is not expensive and should be readily available at a general dealer or hardware store. This cost gets divided across all group members as a once-off joining fee.

Objectives:
The saving group assists members to manage their money by providing a structure and incentive for short-term savings.
The short term loan facility provides an easily accessible means of borrowing for group members. It also allows members to receive end-of-cycle pay-outs larger than their own contribution.

Criteria for application:
Individuals decide for themselves if they wish to be part of a saving group or not. Usually a few people get together to start saving and invite friends that they trust to join them.

Funding opportunities: Not applicable

Legislation: Not applicable

Benefits:
Direct benefits:

- Increased personal savings.
- Easier to plan one's finances by knowing when the annual pay-out will be.
- Flexible (as the rules are established by the groups themselves).
- Transparent:
  - Every transaction happens in front of the group members at the regular meetings.
- Secure:
  - Four people are required to open the money box which increases the level of confidence and trust amongst group members.
- Simple
  - The rules of how the savings and loans are conducted are straightforward.
  - No hidden costs.
- Cheap
  - Besides the once-off joining fee to cover the equipment costs there are no other costs to saving.
- Accessible and cheap short-term loans
  - No pre-requisites for borrowing (e.g. minimum earnings or permanent employment).
  - No admin fees. The only cost is the interest charged.

Indirect benefits:

- Develop a supportive community network which can be relied on in times of financial hardship.
- Small business development is encouraged through the saving mechanism as well as the availability of low-cost credit.
- Learning from other group member's experience.

Catchment perspective:

While a saving group can consist of any number of people, successful saving groups are found to have between 15-30 members. Any larger and the administration burden is too great.

Smaller groups may not be able to generate the funds necessary to be able to offer loans and thus lose out on the possibility for earning interest.

The time frame for saving groups is a 12-month cycle with meetings occurring once a month.
Setting up a group savings scheme is relatively simple requiring some basic maths literacy by those on the management committee.

METHODOLOGY

Methodology:

E.1.3. Group saving (and credit) schemes

Stage 1: Setting up the saving group

a. Groups of between 15-30 people are formed through self-selection, i.e. people choose whether they wish to be a part of the saving group.

b. Groups write their own constitution which details the rules of how the saving group is to operate, such rules should include:
   - The date of regular meetings, e.g. the first Wednesday of each month.
   - When the annual pay-out will be, e.g. in January.
   - Decision on minimum amount to be saved by each member each month, e.g. R100. These minimum contributions are called ‘shares’.

c. Selection of management committee:
   - 1 Chairperson: the person who will run the meetings.
   - 1 Record keeper: person who writes down each person’s monthly contributions.
   - 1 Box keeper: the person who keeps the money box and record books.
   - 2 Money counters: these people count the money that is coming in and going out of the fund to ensure it is correct.
   - 3 Key keepers: these people each have a key for one of the three padlocks on the money box. There is one key on the box itself, and two extra padlocks on two chains securing the box.

d. Decisions regarding the rules for taking out and repaying loans (see stage 4 below).

e. Extra rules can include:
   - Non-members will not be allowed to attend meetings.
   - If a member dies their contributions will be paid out to their family.
   - Members need to pay a once-off joining fee to cover the cost of equipment. The total cost of the necessary equipment is divided by the number of group members.

Stage 2: Order of regular meetings

a. Start of meeting:

- The meeting is run by the chairperson and all activities and transactions take place in the presence of all members. The meetings start with the money box being opened by the three key keepers in view of all members.

b. Saving contributions:

- Each member decides how many shares they want to save. The minimum saving is 1 share per month and the maximum contribution is 5 shares per month. The amount of money in the savings fund is called the capital fund.

c. Record keeping:

- The record keeper records how many shares each member saves.
- In addition, each member has their own record book in which they record the amount saved every month by recording the number of shares saved. If members have low literacy and numeracy levels, then a stamp can be used to indicate the number of shares contributed, where three stamps mean three shares were saved that month (indicated by a * in Table E.1.3.1 below).

Table E.1.3-1: Example of monthly record keeping of savings contributions

Saving contributions by members Month: February 2016			
	Member name	**Shares**	
	A	**	2
	B	*	1
	C	****	4
	D	*	1
	E	*	1
	F	*	1
	G	*****	5
	H	*	1
	I	*	1
	J	**	2
	K	*	1
	L	***	3
	M	***	3
	N	*	1

	O	*	1
	P	**	2
Total shares contributed:			30
Value of each share:			R 100
Total value of shares contributed for February:		**R 3 000**	

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d. Loans:

- After savings contributions have been made, the meeting then moves on to loans. First, loans that are due are repaid with interest (see stage 3 below) and then members who are needing loans can take out loans from the available capital fund (the amount of money in the savings fund).
- All loans taken out and repayments are recorded in the group record book. Individuals also record their own loans in their personal record books.

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e. Close of meeting:

- Any money left over in the capital fund after loans are taken is kept in the money box with the record book. The money box is locked with three padlocks (and the keys held by the three key holders). The box is kept by the box keeper until the next meeting.

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Stage 3: How the loan facility of the saving group works

a. Members can take out loans from the capital fund (which consists of the group's combined savings). Some guidelines for setting up rules regarding loans include:
b. The interest rate charged on loans is decided by the group at the initial setting up meeting
c. Interest is charged monthly as a percentage of the original loan (e.g. 5% per month).
d. Thus, the quicker the money is paid back, the cheaper is the loan.
e. See Table E.1.3.2 below, which shows how a loan of R600 (the principal amount) is paid back over 4 months with interest:

Table E.1.3-2: Example of how a loan works

Principal (P) = R600 **Term = 4 months** **Interest rate =5%**					
	Month 1	**Month 2**	**Month 3**	**Month 4**	
Loan (R600) divided by number of months of repayment (4)	R150	R150	R150	R150	
Interest per month 5%	R30	R30	R30	R30	
Total monthly repayments:	**R180**	**R180**	**R180**	**R180**	
Total interest charged					**R120**
Total loan borrowed					**R600**

f. Loans should not be greater than three times the value of what has been previously saved, i.e. if person C has contributed 5 shares of R100 each in this cycle (R500), then he/she can borrow up to R1500 (3 x R500).
g. The term of the loan is recommended to be no more than 4 months. But in mature groups that have gone through several cycles together, the repayment period can be extended to 6 months.
h. Members can take out only one loan at a time.
i. A record of loan allocations and loan repayments is kept in the personal and group record books.

See an example of how to keep a record of loans and repayments in Table E.1.3.3 (at the end of the sub-theme).

Stage 4: Payouts

E.1.3. Group saving (and credit) schemes

a. Payouts occur at the end of a 12-month savings cycle. The end-date of the cycle is decided by group members at the initial set up meetings. Usually the date chosen precedes a time where member's benefit from having extra cash available. For example, in January, before the start of the school year where money is needing for tuition, books and school uniforms. Alternatively, the payout could be set to coincide with the agriculture planting season, a time when members need money available to pay for fertilizer and other inputs.

b. The group's capital from their saving contributions, together with any interest earned during the cycle, is shared out amongst members. The share-out that each member receives is in proportion to the number of shares saved throughout the cycle (See outs for an example of calculating payouts). Thus, someone who saved more during the year will receive a larger payout than someone who saved less.

Steps to calculate individual payouts:

1. Work out the total number of shares saved over cycle from all group members:
   e.g. 360 shares
2. Calculate the total earnings from saving shares over cycle:
   e.g. R 36 000
3. Calculate the total earnings from interest on loans taken over cycle:
   e.g. R1700
4. Add the earnings from shares and interest to get the **Total Earnings over cycle**:
   e.g. R 37 700
5. Divide the total earnings over cycle by total no. of shares over cycle to get the payout per share: e.g. R 37 700 ÷360 = R 104.72
6. Work out the payout for each member by multiplying the number of shares saved by the payout per share:
   e.g. For person A: 24 shares x R 104.72 = R2513.28.
   e.g. For person B: 12 shares x R 104.72 = R1256.64

Table E.1.3-3. Example of calculating end of cycle pay-outs

	Member name	**Total shares saved over 12-month cycle**	**Payout per member** (total shares per member x pay-out per share)
	A	24	R 2 513.28
	B	12	R 1 256.64
	C	48	R 5 026.56
	D	12	R 1 256.64
	E	12	R 1 256.64
	F	12	R 1 256.64
	G	60	R 6 283.20
	H	12	R 1 256.64
	I	12	R 1 256.64
	J	24	R 2 513.28
	K	12	R 1 256.64
	L	36	R 3 769.92
	M	36	R 3 769.92
	N	12	R 1 256.64
	O	12	R 1 256.64
	P	24	R 2 513.28
Total no. of shares over cycle:		360	
Value of each share:		R 100	
Earnings from savings (shares):			R 36 000
Earnings from interest on loans[16]			R1700

[16] This amount is taken from the example in Table E.1.3.3

E.1.3. Group saving (and credit) schemes

Total Earnings over cycle:			**R 37 700**
Payout per share (total earnings over cycle divided by total no. of shares over cycle)		R 104.72	

Stage 5: Starting a new cycle

a. At the end of a 12-month cycle (after payouts), members can decide to start a new saving cycle.
b. The start of a new cycle is the time for any changes to be implemented: for example, new members can join, members wishing to leave can do so, new people can be selected for management and rules can be adapted if necessary.
c. New members are required to pay the once-off joining fee which is then used by management to purchase new equipment if necessary.

Illustrations/ Diagrams: not applicable

Photos:

Figure E.1.3-1: Counting out the end of cycle payouts

Equipment requirements:

- Money box
- Chain for box
- 3 padlocks with keys
- Record book for group
- Record books for each member
- Stamp and stamp pad
- Calculator
- Pen

Variations/Adaptations:

Extensions of basic saving group

The saving group framework described here can be extended to address a specific need shared by group members, for example:

- Payouts can be combined and go towards the purchase of shared farming equipment.
- Payouts can be used toward bulk discount purchases such as groceries our housing materials.

Longer-term savings schemes can also support families for financing funeral expenses.

Groups can set up rules for social funds to provide resources to members in times of financial emergencies. In this case, rules need to be clearly defined at the outset to ensure consistency. For example, if an emergency occurs, members could borrow money interest free. In this case, it would be important to be clear on what is considered an emergency.

Seasonal variations:

- Not applicable

MAINTENANCE

Potential drawbacks/disadvantages:

- Safety of the money box and the record book are supremely important and, with an informal saving group, there is no insurance against fire or theft.
- Thus, every effort needs to be put in place to
- (1) ensure the money is safe and
- (2) that there is no misconduct by the management committee in terms of stealing or falsifying records.
- To deal with these important concerns:
- - The money box is only opened at group meetings and in front of all group members.
- - The money box requires 4 people to open the box (1 box keeper and 3 key keepers). Thus, any tampering with the money box would require the collusion of 4 people.
- - The box keeper must also ensure the moneybox is kept in a safe place.

Maintenance requirements:

- Over time, some of the equipment will need to be replaced. If there are new members, their once-off membership fee can be used to purchase new materials. Otherwise this cost will have to be spit over the group members.

E.1.3. Group saving (and credit) schemes

REFERENCES

Definitions:

- ***Household(s):*** this refers to the all the occupants of a house as a single unit.
- ***Share(s)***: A 'share' is the minimum monthly saving contribution. Members can contribute between 1 and 5 shares per month. The value of the share is decided by group members at the first meeting. For example, 1 share = R100
- ***Capital fund***: This is the total amount of money that has been collected in the saving group at any point. It comprises the individual savings contribution as well as any interest collected from loan.
- ***Loan***: An amount of money that is borrowed and needs to be paid back with interest over an agreed period of time.
- ***Credit***: In this context, the term 'credit' is synonymous with a 'loan' and refers to money being borrowed that needs to be paid back over an agreed period with interest.
- ***Term***: This is the agreed period over which the loan is repaid, for example, 4 months.
- ***Interest***: The cost of a loan, i.e. the fee one is charged for the use of a loan.
- ***Constitution***: The rules or fundamental principles that govern how the group operates.
- ***Payout***: A payment of money.
- ***Principal***: This refers to the original sum of money taken as a loan (in other contexts it can also refer to the original sum of money invested).

Further references:

a. Delany, A., Storchi, S. (2012). SaveAct Savings and Credit Groups and Small Enterprise Development. FinMark Trust

See also:

Guideline E.1.1. Household budgeting

Guideline 1.2. Loan repayments / Debt management

E.2. Nutrition

Healthy nutrition is recognized as a vital component of wellbeing and health promoting behaviours; however, it becomes more complex in environments where food security is not guaranteed. Since 1994, both food security and the nutritional health of all South Africans has been on the national health agenda. Food security is defined as a condition that 'exists when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life' (FAO 2010). While progress has been made in certain aspects, 50% our country still experiences or are at risk of experiencing hunger. In addition, children are still considered at highest risk with up to 30% being stunted due to chronic energy malnutrition.

E.2.1. Nutrition in the home

OVERVIEW

Nutritional vulnerability affects the livelihoods of many rural communities. This guideline aims to ensure adequate energy and nutritional intakes while protecting against the development of chronic diseases and assist in improving the food security as well as food choices within a household, especially in a rural or low socio-economic household.

Catchment perspective: In order to carry out household work to support livelihoods and activities to protect and management the catchment requires the community members to be healthy and have energy for the work. By Ensuring appropriate nutritional intake will contribute to a stronger and healthier working capability.

Objectives:

- To improve the nutritional intake of all South Africans
- To improve household food security with practical, cost-effective strategies
- To ensure the complimentary frameworks of nutrition, agriculture and social welfare

Criteria for application:

- For the Nutritional Supplementation program – growth faltering children, adults with >10% weight loss over 3 months (including HIV/SIDS patients).
- School feeding programs as per school/crèche

Benefits:

- Improvements in nutritional status of South Africans will contribute to lower morbidity and mortality, especially those in high-risk groups, e.g. children, someone infected with HIV/AIDS, those with NCD's.
- Improved water and food safety will decrease risk of illness and malnutrition due to intestinal parasites.
- Any decrease in morbidity and mortality will decrease the burden on the public health system, especially in rural areas.
- Improved household food security will contribute to positive outcomes in nutritional status.

Funding opportunities: Not applicable

Legislation: Not applicable

METHODOLOGY

Food based Dietary guidelines of South Africa:

1) Enjoy a variety of foods. Populations consuming a diet of low dietary diversity are nutritionally vulnerable.
   Practical aspects:
   - Aim to have a variety of foods on your plate at meals times, i.e. include more than 2 food groups (food guide) on your plate, e.g. Breakfast: include some fresh fruit with your grain cereal/pap/toast and milk rather than juice; Lunch: include fresh/tinned vegetables or salad when possible. You can use legumes rather than meat or chicken. Supper: ensure there are colourful foods on the plate. Ideally vegetables should occupy 50% of the plate, e.g. green (spinach), pumpkin (orange), white (potato).
   - If you have a food garden, grow a range of vegetables types (tuber, leaf, different colours) as the season and the landscape allow.
   - Eat regular meals with your family. Sit and eat in a calm environment.
   - Sub guideline for children: to include a variety of foods as part of complimentary feeding from 6 months and to provide a positive eating environment
2) Be active! Be physically active in your lifestyle, including manual tasks and walking.
3) Make starchy foods part of most meals. These foods are energy dense and nutritious.
   Practical aspects:
   - Vary your household use of grains/maize/tubers in meals, e.g. use sweet potato (orange or white), corn, pumpkin, rice, pap, butternut, carrot, beetroot, etc. in meals as part of the energy rich foods.
   - Include orange coloured tubers/vegetables when possible to increase the vitamin A content of the meal. Add a small amount of oil to these foods to improve absorption. These are especially important if there are children in the house.
   - Add indigenous grains of pearl millet, sorghum, cowpea and mung bean to the seed/crop selection

- If land use is restricted for growing, black bags/refuse bags can be used for tuber plants (see below)
- If you do not access the government fortified staple foods (wheat, maize, salt) – it is important to make more of an effort to improve the quality of the diet.
- If you buy bread, you should buy higher fibre breads (wholewheat, brown) that are fortified.

4) Eat plenty of vegetables and fruit every day. Vegetables and fruit contribute to micronutrient intake and decrease the risk of chronic diseases.

   Practical aspects:
   - Keep your vegetables crunchy and use less fuel by cooking them for only a short time – specifically your green vegetables (e.g. leaves, green beans). You can use other fuel-efficient methods (hay box) as well, and add the vegetables last.
   - Peel as few vegetables as possible, e.g. don't peel potatoes, carrots, sweet potato, and butternut – if they are well cooked you can eat the skins. These increase the fibre content. (make sure they are well washed).
   - Use any non-digestible offcuts/peels from your vegetable's preparation in your compost.
   - If you have a garden, rotate your crop selection (see below) to improve your soil quality, nutrient quality and yields.
   - You can pickle and bottle vegetables or fruit to keep them once a season is over (see below).
   - Invest in indigenous green leafy vegetables (Agriculture Research Council)
   - Any extra vegetables grown in excess can increase income potential of the house.
   - If possible, vegetables should occupy 40-50% of the plate at meal times

5) Eat dry beans, split peas, lentils and soya regularly.

   Practical aspects:
   - Use dry or tinned legumes in your meals, e.g. lentils, kidney beans or sugar beans. They are ideal for bulking up and adding nutrients to stews/soups and are a nutritional alternative to animal protein foods.
   - Include these foods as part of a cost-effective budget, as they are cheaper alternatives to animal protein-rich foods.

6) Have milk, mass or yogurt every day. Use fresh dairy as part of your daily intake, to ensure adequate calcium and protein intakes.

   Practical aspects:
   - If you have access to animals, ensure you pasteurise raw dairy (goat/cow/sheep) for improved food safety. This is vital for any individual who has a compromised immune system or young child.
   - Sub guideline for children: it is vital to protect and promote breastfeeding for infants. This includes women who are HIV positive. In rural areas, due to the inconsistent supply of clean water, all women are recommended to exclusively breastfeed for a minimum of 6 months. However, this decision should be discussed with the clinic sister at the nearest clinic.

7) Fish, chicken, lean meat or eggs can be eaten daily. Include these foods when the budget allows. Bulk up with legumes to extend these meals.

   Practical aspects:
   - Use tinned fish regularly, e.g. pilchards or tuna
   - Check the expiry date on tins that you buy to ensure safe foods.

8) Drink lots of clean safe water

   Practical aspects:
   - Ensure that any water that is not clean is boiled/sanitized (see below). This may be more important after large rainfalls.
   - Choose water to drink instead of any juices/pre-mix sugar syrups, excessive coffee and tea, fizzy drinks
   - Have a recipe for Oral Rehydration Solution in the house for any incidences of gastrointestinal illness in children or adults (see below).

9) Use fats sparingly. Choose vegetable oils rather than hard fats

   Practical aspects:
   - Use a small amount of oil in cooking and do not reuse the oil multiple times. Use the portion guide to estimate better portion sizes (see below) (end of your thumb)

10) Use sugar and foods and drinks high in sugar sparingly

    Practical aspects:
    - Choose healthier options rather than sweets, chocolates, fizzy drinks. Limit sugar in your tea and coffee.
    - Sub guideline for children: to improve oral health of children under 5 years limit sugar containing beverages and choose more nutritious food-based options. Practice good oral hygiene practices, and brush teeth daily.

11) Use salt and foods high in salt sparingly

E.2.1. Nutrition in the home

- Use herbs in cooking rather than stock cubes. This will improve the taste and nutrient profile of the meal.
- Grow herbs in plastic ice cream containers/ cut 2 litre cooldrink bottle (length ways).

Additional practical aspects:

1) Keep a consistent body weight. Adults should limit any drastic weight gain or loss during their adult life. Large weight loss or weight gain (>10% of body weight) should be referred to a health professional.
2) Children should have growth monitoring at the clinic until 5 years of age. This is once a month until 2 years, and then every three months till 5 years.
3) Ensure good food hygiene and food safety in the house, especially for children.
4) Wash your hands regularly, and especially when you are preparing food. Create easy hand washing access (e.g. tippy bottle) in the house if there is no running water in the house.
5) If there is good food availability, portion sizes of different food groups should be considered in meal composition. Use the food guide to estimate the portions of these food groups (the size in the picture is in relation to the proportion of these foods in your intake.
6) Locate and register at your local clinic. Check all the essential services available. For infants, this includes: Immunisations, vitamin A supplementation, multivitamin supplementation, and national supplementation program (NSP) for individuals with TB/HIV and severe malnutrition/weight loss in both adults and children.
   - Access to information about social welfare grants
   - Growth monitoring for children
   - Access to any non-governmental organisation (NGO) or other interventions in the area
7) Growing potatoes in black bags (or similar low space requiring vegetable interventions)
   - Prepare potatoes by letting them sprout several days before planting. Cut large seed potatoes into smaller pieces that have several sprouts in each piece.
   - Place the trash bag in a sunny place in your garden, patio or other growing spot.
   - Roll down the sides of the trash bag.
   - Cut holes in the bottom of the bag for drainage.
   - Fill the bottom of the bag with soil mix.
   - Plant potatoes about 8-10 cm deep in little hills with sprouts facing up.
   - Cover potatoes with soil mix and water.
   - Mulch with dry leaves or straw.
   - Keep plants watered, but not wet.
   - When the leafy shoots are about 15-20 cm tall, roll the trash bag up a bit and add soil mix to cover all but the top few leaves.
   - As the plants grow, repeat this process, keeping the potatoes buried and mulched; keep soil watered, but not soggy.
   - When the leaves on the plants turn yellow and the foliage starts to dry, stop watering so the potato skins can dry.
8) To harvest potatoes, carefully cut the side of the trash bag and remove potatoes
9) Add a teaspoon of oil: to red/orange vegetables to promote beta carotene (Vitamin A) absorption.
10) Pickle: some vegetables to keep them for longer

Illustrations/ Diagrams:

E.2.1. Nutrition in the home

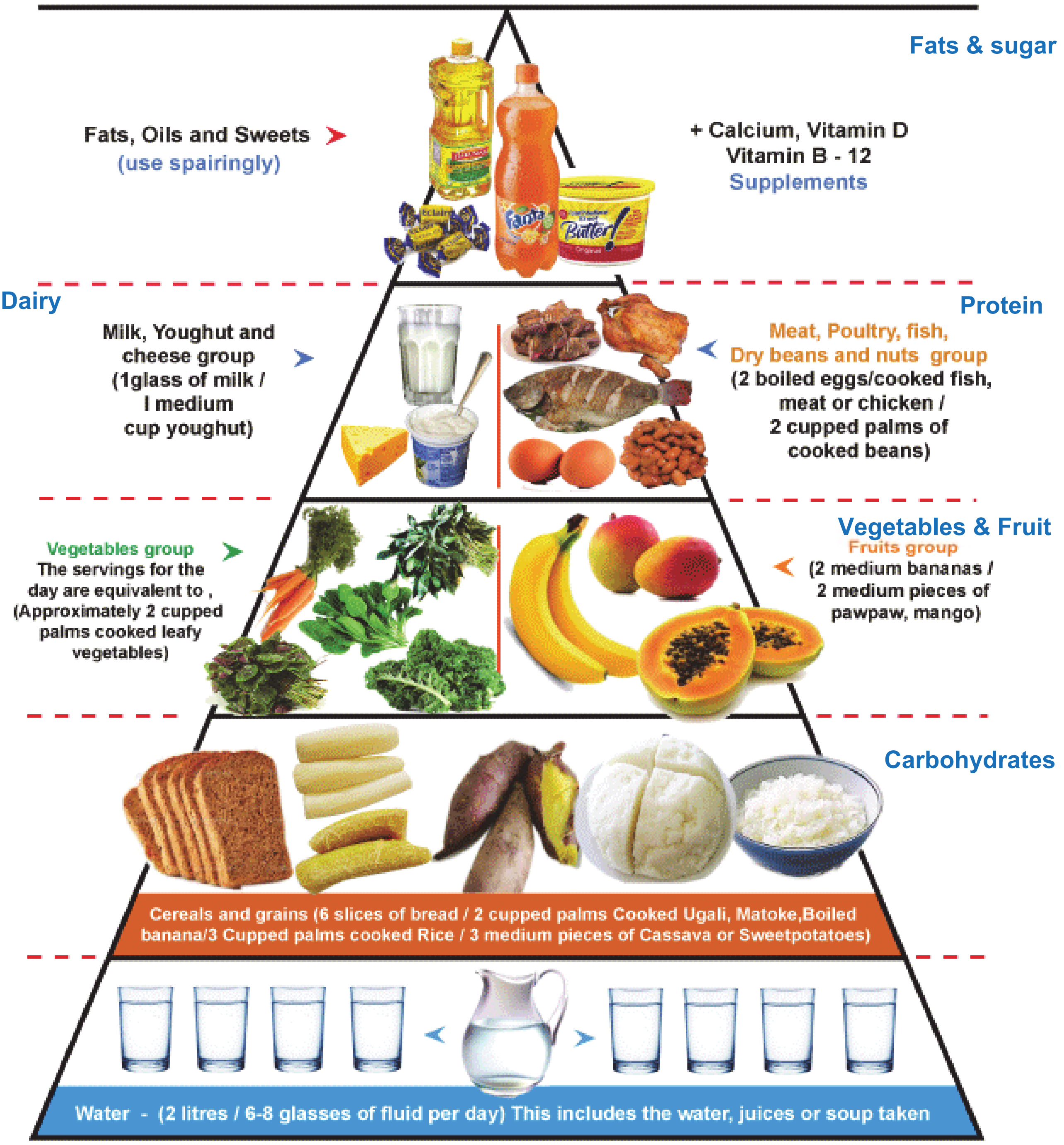
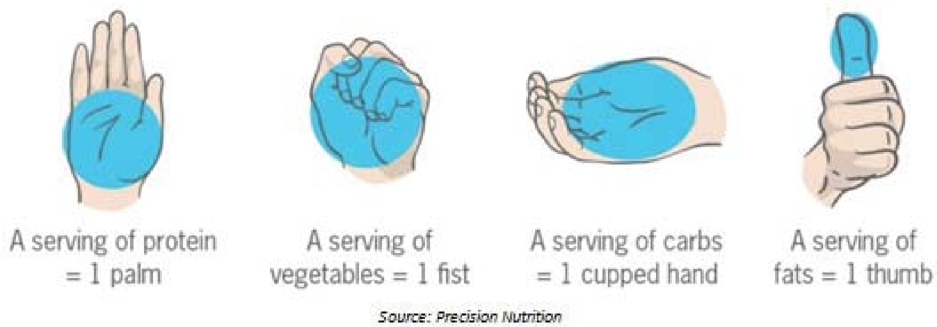


Figure E.2.1-1: Daily Food intake/ serving guide

Portion ideas:



Photos: Not applicable

Equipment requirements:

E.2.1. Nutrition in the home

Variations/Adaptations: Not applicable **Seasonal variations:** Important to recognize different seasonal changes in vegetable availability, water availability	• For education-based interventions, materials, posters, pamphlets, etc. can be sourced from the Department of Health. • For practical interventions, materials are generally low cost and common to most shops

MAINTENANCE

Maintenance requirements: Not applicable	**Maintenance requirements:** Not applicable

REFERENCES

Definitions:

***Food availability**:* effective or continuous supply of food at both national and household level. It is affected by input and output market condition, as well as production capabilities of the agricultural sector.

***Food access or effective demand*:** ability of nation and its household to acquire sufficient food on sustainable basis. It addresses issues of purchasing power and consumption behaviour.

Reliability of food: utilisation and consumption of safe and nutritious food.

Food distribution: Equitable provision of food to points of demand at the right time and place. This spatial/time aspect of food security relates to the fact that a country might be food secure at the national level, but still have regional pockets of food insecurity, at various periods of the agricultural cycle.

***Nutritional vulnerability**: the presence of risk factors for malnutrition*

See also:

Guideline B.1.1.2. Crop Rotation and intercropping
Guideline B.1.2.3. When to plant what
Guideline E.4.4. Operating and maintaining a VIP Latrine
Guideline F.3.4. Waterborne illness
Guideline F.3.3. Cholera response – Food hygiene
Guideline F.3.2. Cholera response – Oral rehydration

Further references:

a. World Health Organisation (WHO): Protecting Surface Water for Health. 2016, 1-196.
b. Agricultural research (ARC). (2013) Production guideline for summer vegetables
c. Agricultural research council (ARC). (2013). Production guidelines for winter vegetables.
d. Poster for five keys to food safety: WHO [27]
e. Department of Agriculture, Forestry and Fisheries. (2014) The National Policy on Food and Nutrition Security for the Republic of South Africa
f. Department of Health: Food based dietary guidelines 2003. Revised 2013.
g. ARC. African Green leafy vegetables. http://www.arc.agric.za/arc-vopi/Pages/Crop%20Science/Indigenous-Crops.aspx

E.3. Plot management

E.3.1. Living fences and wind breaks

OVERVIEW

When planted as living fences or windbreaks, trees help protect crops and the soil from heavy winds and rain, preventing soil erosion. Trees may also be a source of forage, wood, fruit, and medicine. This guideline gives instructions on how to establish living fences and windbreaks.

Objectives:

To introduce the establishment of live fences that serve as windbreaks and boundary fences around crops and homesteads

Catchment perspective:

- Protection against the wind, rain and sun
- Prevention of soil erosion
- Shelter livestock and crops
- Control of livestock movement
- Economic value added by producing fruit, timber and fuelwood
- Create wildlife habitat

Benefits:

- Reduced wind and increased retention of moisture
- Protect houses and crops against strong wind
- The leaves shed by trees return organic matter to the soil, increasing its structural stability, erosion resistance and capacity to store water
- Nitrogen fixing by leguminous trees – Mexican lilac
- Create strong and impenetrable fences – Jatropha tree
- Provide oil that can be used for biofuels or turned into soap – Jatropha tree
- Provide food (fruit trees)
- Medicinal benefits – Neem tree
- Provide sustainable fire wood – Neem tree

Criteria for application:

- Plan the planting to fit the available space
- Allow ample room for good tree and shrub growth
- If the purpose is to contain livestock, selected plants must not be poisonous or hazardous to the animals and should attain a size adequate to create a barrier to contain livestock or humans, as needed
- Locate the windbreak where it will be most effective: along the boundary, preferably against the prevailing wind direction
- Windbreaks are most effective when oriented at right angles to the prevailing winds
- Plants selected must be suited and adapted to the soils and climate
- Trees and shrubs require careful handling prior to planting and post-planting care
- It is necessary to provide adequate moisture, by rainfall or good irrigation methods
- Protect the plants from weeds for at least 3 to 5 years after planting
- Protect the plants from livestock and other grazing animals
- Undertake periodic inspection for insect, rodent, and disease damage

Funding opportunities:

Not applicable

Legislation:

- Subdivision of Agricultural Land Act (Act 70 of 1970).
- National Environmental Management: Biodiversity Act No 10 of 2004.

METHODOLOGY

Methodology:

General considerations:

1. Trees should not be planted to close to houses because brittle branches or trees blowing over can damage houses or injure people
2. Roots penetrating under a house may damage the foundations
3. Trees for living fences should be acquired from the tree nursery to ensure the sustainable use of tree resources and limit exploitation of the natural forests. Furthermore, selecting saplings of similar size and growth rate will give a more homogeneous defensive fence

Living fence planting site preparation:

1. The location and type of trees in a living fence is determined by the benefit to be drawn from the fence itself, i.e. for firewood, windbreaks, and barriers
2. Measure and demarcate the potential planting site and establish the area in square meters
3. Work out the quantity of seedlings to be planted. This will give the quantities of tree seeds to be provided and seedlings that need to be raised in the nursery
4. All grass should be removed from the planting site
5. It is very important that the seedlings are planted in straight lines and are spaced correctly per species planted.
6. Knots are tied in a rope at the required planting interval and this can be stretched from one end of the planting site to the other and held by a peg at each end. Alternatively, the distance can be measured by steps (Figure E.3.1.7)
7. A peg (a 60 cm / foot to above knee length stick) is fixed into the ground at each knot to indicate where planting pits must be dug
8. A planting pit is at least 30 cm long by 30 cm wide by 60 cm deep, but can be up to 60 cm x 60 cm x 60 cm.
9. The first 30 cm (wrist to elbow length) of topsoil is removed and placed on the left-hand side of the pit
10. The bottom 30 cm of subsoil is placed on the right-hand side of the pit

E.3.1. Living fences and wind breaks

11. The pit is now left open until planting time. (Figure E.3.1.8)

Planting of tree seedlings:

1. Seedlings should be carried using the basins ensuring minimal soil loss. The tree seedlings are then placed by each planting station, ready for planting.
2. Planting out must be done either early in the morning or late in the afternoon to avoid the midday heat.
3. The topsoil from the left-hand side of the pit is placed in the bottom of the pit, and the subsoil is placed on top.
4. The topsoil is placed at the bottom of the pit as there are more nutrients and humus in it. When the tree grows, the roots will naturally grow down into this soil and benefit from it.
5. Dig out a hole by hand in the middle of the pit to the same depth as the soil around the seedling.
6. Remove the seedling carefully from the plastic tube (if present), (Figure E.3.1.9)
7. The root ball of the tree seedling is then placed in the hole, and the top of the soil around the tree seedling must be at the same level as the top of the soil in the pit. The soil around the tree is then firmed down by foot.
8. Form a basin of soil 60 cm in diameter around the tree seedling. This will hold extra water for a longer period which will help the tree seedling to grow. If it is on a slope, make the basin a half-moon shape to catch the runoff from the slope.
9. Save the plastic tubes that held the seedling for the next planting season. Each tube can be used for two planting seasons at least.
10. Newly planted trees need to be protected against livestock and fire
11. A live fence, to be used as a windbreak, should be planted at right angles to the prevailing wind (Figure E.3.1.4)
12. It can either consist of a single line of trees with a spacing of 1.5-2.0 m, or two lines with a spacing of 4-5 m within the line and 2-4 m between the lines.
13. In addition to one or two lines of trees, a line of shrubs spaced at approximately 1 m can be planted on the side facing the prevailing wind.
14. Planting should be completed by the end of January at the latest to give them a good start.

Equipment requirements:

- Watering cans
- Basins
- Rope
- Wooden planting pegs (60 cm)
- Hoes
- Slashers
- Shovels and rakes

Variations/Adaptations:

- Change the type of tree
- Choose the appropriate function for the fence

Seasonal variations:

- All planting sites must be prepared in good time, preferably during the dry season, so that tree seedlings can be planted out early
- Grass slashing of the planting sites should be done by the end of September, and all marking, pegging and pitting must be finished by the end of October
- Planting out should be carried out after the start of the rainy season in wet soil, ideally from early December to the end of January: that will encourage good root development

E.3.1. Living fences and wind breaks

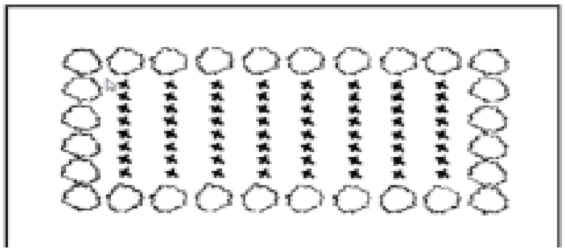


Figure E.3.1-1: Trees planted around a crop field

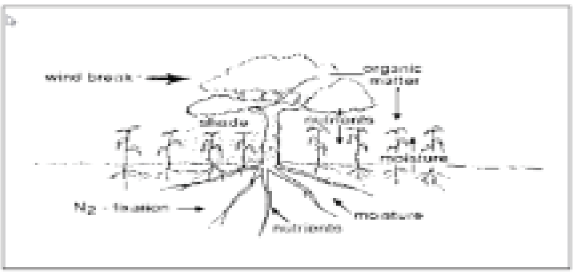


Figure E.3.1-2: The benefits of trees with crops

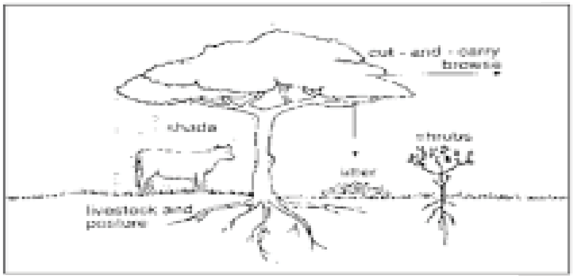


Figure E.3.1-3: The benefits of trees with crops and livestock.

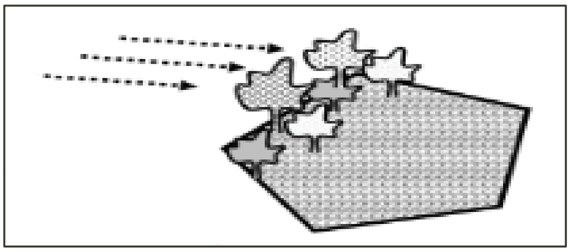


Figure E.3.1-4: Windbreaks must be planted at right angles to the prevailing wind. (Source: Tengnas B. 1994)

Figure E.3.1-5: 18-month-old *Senna spectabilis* windbreak

Figure E.3.1-6: Mature live fence

E.3.1. Living fences and wind breaks

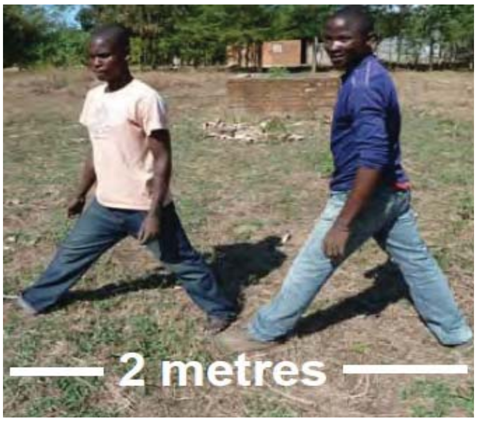


Figure E.3.1-7: Measuring planting gap

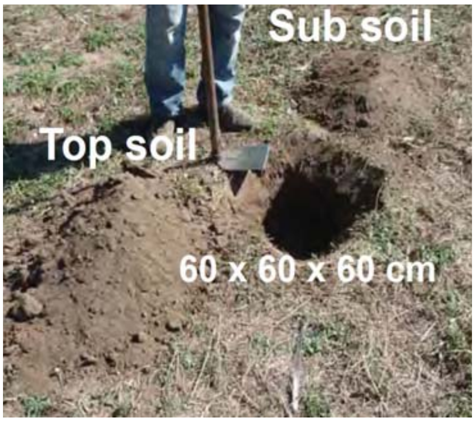


Figure E.3.1-8: A ready planting pit

Figure E.3.1-9: Planting seedling in planting pit

Figure E.3.1-10: A spaced out living fence starting

MAINTENANCE

Maintenance requirements:

- tilling and mulching around the newly planted trees, ensuring the soil around each tree is formed into a basin to catch water, and creating fire breaks around the planted site (photo 6)
- Weeds must be removed from each planting station once during the rainy season. Till the soil around the tree seedling when weeding
- Later the trees may need pruning or pollarding to maintain a suitable density and to minimize the shading effects on crops
- Dead seedlings or trees that have been blown over must be replaced
- After the basin has been made, place mulch (cut grass and/or tree leaves) in the complete basin, leaving a space of 15 cm around the stem of the tree (if the mulch is too close to the tree stem, it will attract termites). This will preserve soil moisture and provide nutrients for the tree from the decay of the grass and leaves
- Living grass at the planting site must be slashed every three months up until the end of July and left to form mulch (not burnt)
- In July/August, create 4 m wide fire breaks around the planted site by slashing the grass

REFERENCES

Definitions:	See also:
Not applicable	Guideline A.3.2. Contour vegetation rows Guideline B.2.5. Agroforestry Guideline C.3.2. Zaï planting pits Guideline D.1.4. Selecting beneficial trees Guideline E.3.5. Tree nursery Guideline F.1.3. Firebreaks

Further references:

a. Tengnas B. 1994. Agroforestry extension manual for Kenya. Nairobi: International Centre for Research in Agroforestry

E.3.2. Borehole pump maintenance

OVERVIEW

E.3.2. Borehole pump maintenance

Boreholes and wells become useless when the pumps are not maintained or fixed when they break down, thereby cutting off an important access to water. This guideline gives basic instructions regarding maintenance and minor repairs of borehole pumps.

Criteria for application:
- Availability of teaching manuals, e.g. the Implementation Manual, Groundwater Technical Manual
- Availability of committed members of Water Point Committees

Catchment perspective:
To build capacity in villages for repairing Afridev pumps local communities to improve access to water.

Funding opportunities:
Not applicable

Legislation:
Not applicable

Objectives:
- To build capacity in rural areas for maintaining Afridev pumps.
- To ensure that minor repairs for borehole pumps are done by local communities as soon as the pumps break down in order to avoid interruptions in water supply services by long delays in repair works

Benefits:
- Reduced cases of pump breakdown
- Reduced delays in repairing pumps
- Sustaining the water supply system by carrying out routine maintenance of pumps

METHODOLOGY

Methodology:
1. Conduct training sessions to cover theoretical aspects of pump maintenance
2. Conduct practical training sessions to cover aspects of pump maintenance
3. Monitor the performance of the trained personnel in making sure that boreholes are functional at all times

Illustrations/ Diagrams:

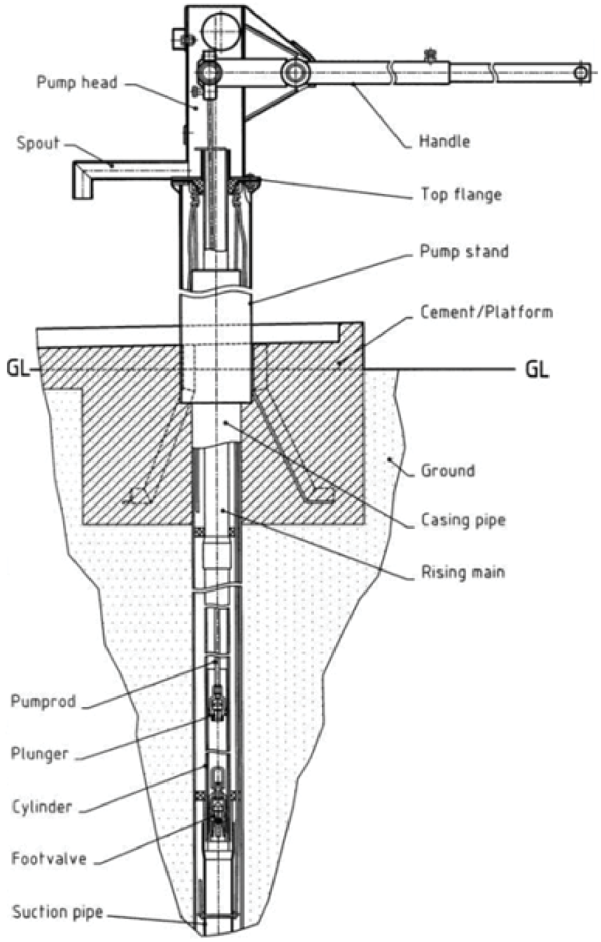


Figure E.3.2-1: Borehole pump. (Source: SKAT – RWSN)

Photos:

Figure E.3.2-2: Borehole pump

Figure E.3.2-3: Borehole pump. (Source: Joissam Ghana Ltd. 2015)

Equipment requirements:
Borehole Spare parts

Variations/Adaptations: Not applicable

Seasonal variations: Not applicable

MAINTENANCE

Maintenance requirements:
- Committed local communities conducting weekly Checks

E.3.2. Borehole pump maintenance

- Annual check by a technician
- Check that the flange bolts and nuts are tight
- Check that the Fulcrum pin nuts and Hanger pin nuts are tights

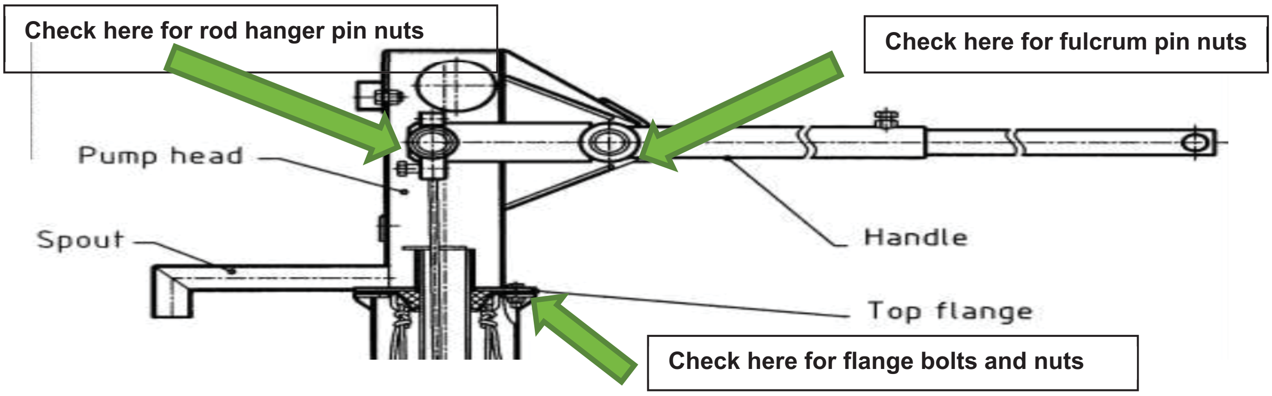


Figure E.3.2-4: Borehole pump detail. (Source: IND-TECH Services. 2015)

Figure E.3.2-5: Fulcrum Pin Nuts – Check that these nuts are tight. (Source: Joissam Ghana Ltd. 2015)

Figure E.3.2-6: Rod Hanger Pin Nuts – Check that these nuts are tight. (Source: Joissam Ghana Ltd. 2015)

Figure E.3.2-7: Flange Bolts and Nuts – Check that these nuts are tight. (Source: Joissam Ghana Ltd. 2015)

Monthly Checks: Check if any fasteners or parts in the pump head are missing

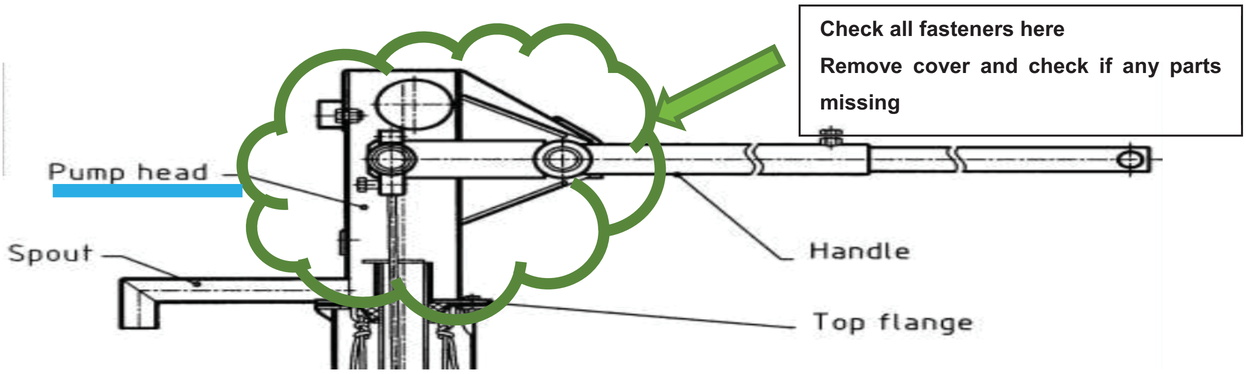


Figure E.3.2-8: Borehole pump detail. (Source: IND-TECH Services. 2015)

NOISE: Check for any strange noises and if you can find the source, correct it if possible or replace the part that is making the noise. This will typically be at bearing surfaces or any surface where movement takes place. Look specifically at the fulcrum joint, hanger joint to pump rod joints. Bearings are located at the fulcrum joint and the rod hanger joint. These can be replaced if required

Bearings can be a source of noise and can be replaced.

Figure E.3.2-9: Bearings. (Source: Joissam Ghana Ltd. 2015)

CASING: Check if the stand is loose. If the stand is loose, first determine why. It may be that the casing is broken and if that is the case, it should be fixed by the manufacturer. It may also be that the stand has come loose from the cement in which it is encased. If that is the case, fix it by securing the stand again by cementing it in place. If the casing is not grounded in cement but rather fixed to the ground by bolts, these may have come loose. Tighten the nuts if applicable or replace the bolts and nuts if required

E.3.2. Borehole pump maintenance

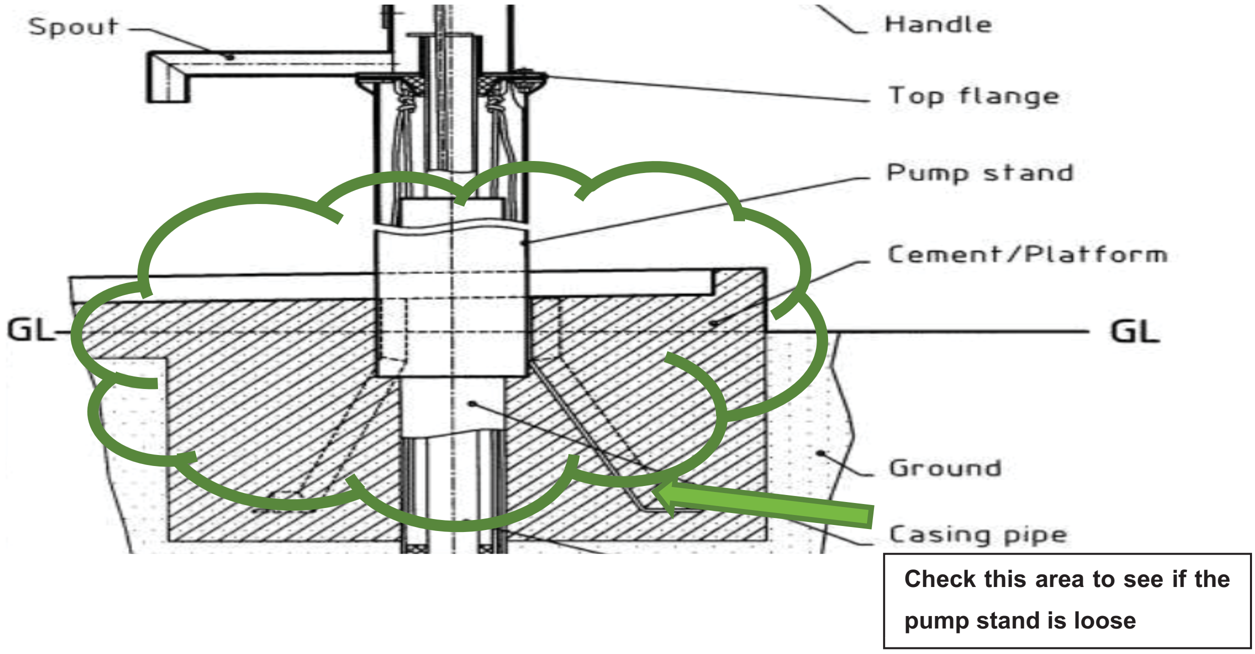


Figure E.3.2-10: Borehole pump detail. (Source: IND-TECH Services. 2015)

LEAKS: Check if there is a leakage in the pump. If more than 5 strokes are required before water comes out from the spout, it means the pump is leaking beyond an acceptable limit. The leak may be caused by either a faulty bobbin / footvalve O-ring or U-seal or there may be a leak in the pipe down the hole. Replace the bobbin if required. Replace the seals every month even if there is no leak. If the bobbin and seals have been replaced and the problem is not gone then there may be a leak in the pipe. The pump and pipe should then be removed to find the broken piece of pipe and replace it

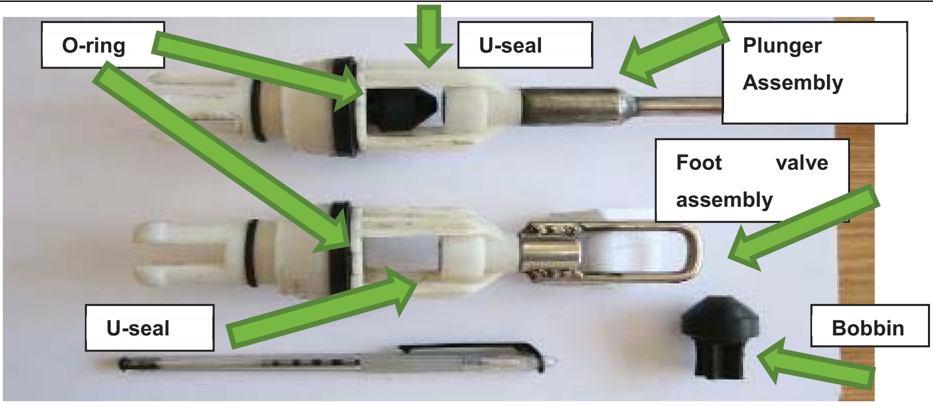


Figure E.3.2-11: Borehole pump parts. (Source: JICA. 2013)

REFERENCES

Definitions:	See also:
Not applicable	Guideline C.1.3. Excess water re-use Guideline E.5.5. Solar borehole pump Guideline E.5.6. Wind pump

Further references:

a. Joissam Ghana Ltd. 2015. http://www.joissamghana.com/ 20 August 2015
b. SKAT – RWSN. 2007. Installation and Maintenance of the Afridev Handpump http://www.waterforcameroon.com/PDF/Installation%20and%20Maintenance%20Manual.pdf
c. IND-TECH Services. 2015. http://indtechservices.co.in/index.php/gallery/. 20 August 2015
d. JICA. 2013. Ethiopia Water Technology Center Project. http://www.ewtec.org.et/phase2/image/img_afridev01.JPG 20 August 2015

E.3.3. Improved grain storage

OVERVIEW

E.3.3. Improved grain storage

Storage involves significant costs and risks, however if storage systems are adapted to local conditions it is possible to reduce losses from grain storage. This guideline gives instructions on how to build an improved grain storage bin.

Objectives:

- To store grain safely for future use
- To cope with the current and future demand for food grains
- To reduce the loss of seeds during and after harvest

Catchment perspective:

- Grain safely stored over longer periods reduces losses and improves efficient use of crops
- Dependency on larger cultivated areas is reduced

Criteria for application:

- It should provide maximum possible protection from ground moisture, rain, insect pests, moulds, rodents, birds, fauna, etc.
- It should provide the necessary facility for inspection, disinfection, loading, unloading, cleaning and reconditioning.
- It should protect grain from excessive moisture and temperature favourable to both insect and mould development.
- It should be economical and suitable for a particular situation.

Benefits:

- Seeds can be stored for varying periods to ensure proper and balanced public distribution throughout the year.

Funding opportunities:
Not applicable

Legislation:
Not applicable

METHODOLOGY

Methodology:

1. Ensure the maize is harvested early before the husks open which allows water, weevils and moths to enter the maize cobs.
2. The maize store should be properly cleaned. Remove undesired grains, cobwebs, and any other material in the store where pests can hide.
3. Sort the maize before storage to remove any cobs that may be infested with weevils or moths.
4. Shelled maize should be sun-dried (direct sunlight) for 3-4 days to bring the moisture content to 12 per cent, which is safe for long-term storage. Farmers need to watch their maize when it is drying in the field.
5. At this point tephrosia leaves (grown on the farm) should also be dried and pounded into powder in order to mix it with the grain.
6. Mix the powder with the grain and put it into the container.
7. Preferably, the shelled maize should be stored in airtight containers, to prevent pests from getting into the maize and destroying it.

Illustrations/ Diagrams:

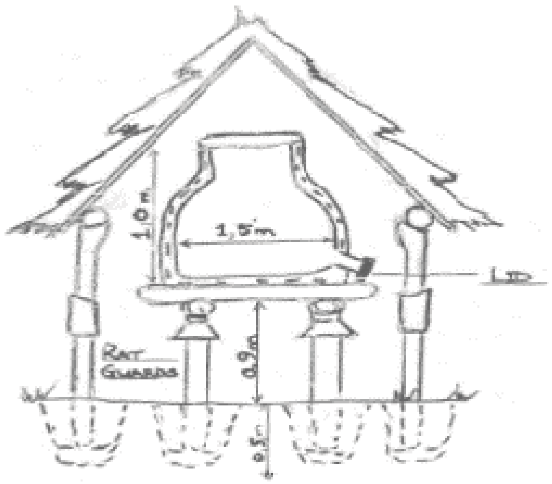


Figure E.3.3-2: Improved traditional bin**.** (Source: adapted from FAO)

Photos:

Figure E.3.3-1: Improved traditional bin. (Source: W. Enright)

Equipment requirements:

- Floor must be raised from the ground to avoid it getting wet
- Supporting legs of hardwood made 90 cm long and equipped with baffles to keep rats away
- Instead of mud the walls may be plastered with cement or mud mixed with cement/lime
- Inlets and outlets should be made with airtight and lockable covers
- Thatched roof to protect the bin from rain and strong sun

Variations/Adaptations:

- Underground pits
- Brick-walled silo
- Reinforced concrete silos
- Steel bins

Seasonal variations:

- Ensure cover is rain-proof
- Check for leakage after rains

E.3.3. Improved grain storage

MAINTENANCE

Maintenance requirements:

- Keep the area around the storage bin clean
- Ensure aeration where necessary
- Inspect for insects, rats and mites at fortnightly intervals
- Watch for advancement in deterioration, if any

REFERENCES

Definitions:	See also:
Not applicable	**Guideline B.1.2.2. Where to plant what** **Guideline B.1.2.3. When to plant what** **Guideline F.4.1. Community emergency response** **Guideline F.4.3. Community emergency response - Drought** **Guideline F.4.2. Community emergency response - Flood**

Further references:

a. www.kusamala.org

b. FAO: http://www.fao.org/docrep/015/i2433e/i2433e10.pdf

E.3.4. Sustainable woodlot management

OVERVIEW

This guideline gives some basic principles of good woodlot management in order to supply households with regular wood and prevent deforestation in the catchment.

Objectives:

- To ensure that timber supplies, to meet all requirements, are available year on year
- To avoid a progressive decline in the quality and productivity of woodlots
- To take pressure off natural vegetation and especially forests

Criteria for application:

- Established stands of exotic trees, existing areas of indigenous woodland, and all trees utilised for household or productive purposes (e.g. curing of tobacco, cooking)
- All rural households have the opportunity to grow some timber
- Villages, schools, community woodlots, fence lines, agroforestry

Catchment perspective:

Household woodlots reduce the need to harvest wood from natural forests. Forests are maintained in better condition, and catchments are consequently protected.

Legislation:

National Forests Act 84 of 1998.
National Veld and Forest Fire Act 101 of 1998.

Funding opportunities: Not applicable

Benefits:

- Wood for multiple purposes, including energy, is available in regular supply
- The forest resource is no longer progressively degraded
- Sustainable use brings stability to households and communities
- The need to seek alternative sources of wood is reduced.

METHODOLOGY

Methodology:

Optimal and sustainable woodlots, even at the smallest scale, require thoughtful and intensive management. All of the steps applicable to large-scale plantation forestry also apply to the small timber grower and owner of a household woodlot. These steps are outlined below:

1. Selection of appropriate species for the expected use – poles, firewood, laths, etc. The ability of a tree to coppice (i.e. to sprout again after being cut back) may be key in decision-making
2. Site selection. Trees are commonly placed on land of lesser agricultural value but still require good soils, and sites should not be waterlogged
3. Establishment. The key decision in planting trees is spacing. This too depends on the species and on purpose. Spacing may vary from 1.5m*1.5m to 3m*3m, with 2m*3m a common choice for small woodlots. Close spacing provides for natural early weed suppression. Fertiliser gives trees an early boost and weeding is essential until trees outcompete weed growth
4. Closely planted timber must be thinned to reduce competition for light and water. Selective thinning is most common in woodlots – with the removal of weaker trees, and this wood utilised as and when required. Typically, every third tree may be marked for removal, but with selective thinning this can be a progressive process. The closer the initial spacing the earlier and more intensive the thinning required. Successive selective thinning can be practised over the lifespan of the stand and has the advantage of providing a regular supply of timber to the land-holder as the woodlot develops
5. The need for pruning is also species-dependent. Pruning opens the stand, bringing access and light, and provides a useful source of timber. Pruning is best done with a dedicated pruning saw, which can be mounted on a pole to reach higher branches. Prune as close to the stem as possible or dead knots will form around branch stumps, weakening the timber. Pruned / trimmed material can be used for mulching, compost or fuel wood
6. Pollarding is a drastic form of pruning, with trees cut at head-height and allowed to sprout. New growth provides for sticks, laths or fodder. Senna siamea and eucalypts (blue gum) are commonly pollarded
7. Felling should be done using a bowsaw rather than an axe. A low, clean horizontal cut minimises wastage and provides for best coppicing. Cross-cutting by saw also wastes far less wood than does an axe
8. Chainsaws are costly, dangerous, and require regular sharpening and maintenance. Breakeven is only achieved with large woodlots or in a communal situation. A single operator should be responsible for chainsaw maintenance
9. Most trees (pines and some acacias are important exceptions) will coppice after being felled and this is a common form of regeneration. Several generations of felling and coppicing may be allowed before replanting, but the trees will lose vitality with age. Coppice shoots should be removed to allow space for growth (leaving typically four shoots in the case of eucalypts) and the growing coppice stems harvested progressively as the stand develops
10. A change in use requirements, or the advent of new clones or hybrids may require that the woodlot be replanted, even if coppicing is possible

E.3.4. Sustainable woodlot management

11. Sustainability in forest production depends on a regular mix of age classes. If trees are felled at age 10 years it would be ideal if the land-holder could replace or regenerate 1/10th of the stand of trees each year. A single-aged stand can be progressively managed towards this ideal

Photos:

Figure E.3.4-1: Small woodlot close to the house. (Source: S. Braid)

Figure E.3.4-2: Small woodlot (Source: S. Braid)

Illustrations/ Diagrams:
Not applicable

Seasonal variations:
Not applicable

Equipment requirements:
- Tape measure for planting spacing
- Diameter tape
- Bow-saws

Variations/Adaptations:
- Selective thinning and felling should be practiced in natural forests, but with an eye to maintaining species mix and biodiversity
- Do not advance the thinning or clear-felling schedule to meet short-term requirements
- Optimal clear-felling age will depend on growth rate and the end-user requirement

MAINTENANCE

Maintenance requirements:
- Re-establishment with new or improved species as these become available
- Weeding, thinning, pruning, coppice stem selection, and replanting are all standard management practices essential for optimal productivity and stand maintenance
- Protection from grazing and from fire damage

REFERENCES

Definitions: Not applicable

Further references: www.kusamala.org

See also:
Guideline B.1.2.1. Designing a natural farming garden
Guideline B.1.2.2. Where to plant what
Guideline B.1.2.3. When to plant what
Guideline D.5.1. Controlling alien and/or invasive vegetation
Guideline D.5.2. Utilising and controlling Blue Gum trees
Guideline D.5.3. Utilising and controlling Pine trees
Guideline D.5.4. Utilising and controlling Bamboo
Guideline D.5.5. Utilising and controlling Prosopis species
Guideline D.5.6. Utilising and controlling Water weed/Hyacinth
Guideline E.3.5. Tree nursery
Guideline E.3.1. Living fence and windbreaks

E.3.5. Tree nursery

OVERVIEW

This guideline gives instructions on how to establish a tree nursery in order to improve the community's livelihood while replenishing forests and woodlots.

Objectives:

- To introduce the establishment of tree nurseries
- Promote afforestation
- Promote agroforestry
- Alternative income generation through the sale of tree saplings

Criteria for application:
Where exotic and potentially invasive trees are planted, these must be strictly managed in order to ensure they do not spread uncontrollably. (See **Guidelines D.5.** on invasive alien vegetation management).

Catchment perspective:
Tree nurseries increase the capacity of communities to sustainably use and manage forest resources leading to reduced environmental degradation and increased market opportunities to generate income.

Legislation:
National Environmental Management: Biodiversity Act No 10 of 2004.

Funding opportunities: Not applicable

Benefits:

- The planting of nursery trees in degraded communal areas improves water infiltration and increases ground and surface water supplies.
- Communities derive tree-based benefits from trees such as fruits, timber, forage, medicines and oils.
- Good firewood trees include cassias (e.g. Senna siamea). A cassia tree can be grown for firewood within three to five years. The tree can then be coppiced, with each tree producing one large bundle of firewood.
- Blue gum trees for poles can produce, after three years, poles which can be harvested for building and selling.
- Provide food (fruit trees)

METHODOLOGY

Collect seeds from the trees in the catchment during flowering/seeding season.

Tree nursery:

1. A permanent supply of water must be close to the nursery
2. A fence made from grass and poles should be constructed around the nursery site to the height of a person. There also needs to be an entrance with a door. The fence will keep out animals and people, and will shield the seedlings from the wind, Figures E.3.5-1 & E.3.5-2
3. The size of the nursery will depend on the number of seedlings to be planted. Typically, an area of 10 metres by 10 metres will provide sufficient space for 5,000 tree seedlings and a suitable area for tube filling, seed beds, piles of compost manure, soil and sand
4. There should be good quality soil available nearby, either from a wet area or forested area
5. The ideal soil will be light and sandy, well-drained, and free of weed seeds and stones
6. Heavy clay or waterlogged, soils must be avoided
7. The nursery needs to be located on flat ground which will not be exposed to flooding and running water. Nurseries can be located on slopes if the areas are terraced
8. East-facing nursery sites must be avoided so that seedlings are not exposed to morning sun that can kill them.
9. A structure of poles with thatching grass should be erected to provide shade for the delicate tree seedlings.

Planting tubes:

1. Polythene tubes should be available in quantities equal to the estimated number of trees required. Old milk cartons, juice bottles, yoghurt tubs can also be used as planting tubes – be sure to pierce 2-3 holes in the bottom for drainage.
2. The tubes can be used for two years and must be carefully saved after planting out.
3. Seeds are supplied in plastic bags according to the calculated number of trees required.
4. Tube filling:
5. Take two buckets of compost, two buckets of forest or damp soil, one bucket of sand, and mix together thoroughly with one watering can of water, Figure E.3.5-3. This is the mixture to be used for tube filling
6. Fill soil to a depth of 6 cm in each tube, Figure 4, and firm down strongly with your fingers to create a soil plug in the bottom of the tube, Figure E3.5-5
7. Fill the rest of the tube to the top with the compost mix
8. The filled tubes should be arranged in groups of 200, i.e. 20 tubes by 10 tubes that will simplify the counting of the seedlings
9. The groups of tubes should be arranged in lines with gaps of 60 cm between them for ease of watering and weeding, Figure E.3.5-3

10. When the tubes have been filled and arranged, they must be watered thoroughly
11. The tubes should be filled one month before seed sowing
12. Once the tubes have been watered, weeds will be stimulated to grow. These should be removed as early as possible as the weeds will consume the nutrients from the compost mix in the tube.

Seed sowing:

1. Tree seeds need to be sown at the correct time
2. If they are sown too early, they will overgrow and produce weak tree seedlings when planted out. If they are planted too late, the trees will be very small when planted out and are less likely to establish and survive
3. Slow-growing trees need to be sown into tubes in July; Large can be sown directly into the polythene tubes. Small sized seed species should be sown in the seedbed.
4. Sow small to medium-sized species on the surface of the medium and then cover them with a thin layer of soil (with a depth of approximately 2-3 times the diameter of the seed)
5. Space the seeds 1-2 cm apart to prevent over-crowding
6. Transplanting of seedlings from the seedbed should be done early in the morning or later in the afternoon to avoid mid-day heat
7. Protect the newly transplanted seedlings with shade made of grass or leaves
8. Tree seedlings that grow quickly in the nursery, for example Mthethe and Gliricidia need to be sown into tubes in August
9. Tubes which have been filled some time beforehand need to be thoroughly watered two days before sowing
10. Tubes which have only just been filled can be sown immediately and watered afterwards
11. Once the tubes have been sown, they should all be watered
12. For different tree species, varying quantities of seeds are sown per tube, see Table E.3.5-1

Illustrations/ Diagrams:

Table E.3.5-1 Number of seeds per tube for selected species. (Source: Bunderson WT., *et al*. 2002)
(A – indicate alien species; I – indicates indigenous species; N – indicates naturalized species)

Tree Species	Seeds per Tube	Seed sowing			
		July	August	September	October
Senna siamea **(cassia) – Iron wood (A)**	**3**	**-**	**Tube**	**-**	**-**
Senna spectablis **(cassia) – Spectacular Cassia (A)**	**3**	**-**	**Tube**	**-**	**-**
Albizia adianthifolia **– Flat-crown (I)**	**3**	**Seed bed**	**-**	**Tube**	**-**
Khaya anthotheca **– Red Mahogany (N)**	**5**	**Tube**	**-**	**-**	**-**
Faidherbia albida **– Acacia (I)**	**2**	**-**	**Tube**	**-**	**-**
Afzelia quanzesis **– Pod Mahogany / Lucky Bean Tree (I)**	**-**	**Seed bed**	**-**	**Tube**	**-**
Papaya (A)	**3**	**-**	**-**	**-**	**Tube**
Guava (A)	**-**	**Seed bed**	**-**	**Tube**	**-**

Photos:

Figure E.3.5-2: Seedlings in planting tubes

E.3.5. Tree nursery

Figure E.3.5-1: Village nursery with tree seedlings in polythene tubes

Figure E.3.5-3: Watering seedlings in nursery

Figure E.3.5-4: Filling planting tubes

Figure E.3.5-5: Making planting hole for seeds

Figure E.3.5-6: Basket-fence protecting young tree from goats, chickens and children (Photos: S. Braid)

Figure E.3.5-7: Ensure tree still receives light for growing. (Photos: S. Braid)

Variations/Adaptations:

- Wildlings as alternatives to seeds
- Wildlings are seedlings that are dug up from the forest and cultivated in the nursery. Forest trees produce vast number of surplus seedlings, most of which die, so digging some of them for transfer into the nursery can do no harm
- Producing planting stock from wildlings is advantageous when seeds are not available and also when germination and or seedling survival are problematic
- Small wildlings are more delicate than larger saplings and are more easily damaged during transportation
- Labels should be made to identify the tree species in each group
- These can be made from empty packets, as these are waterproof, and can be written on with a ball point pen

Equipment requirements:

- Planting tubes / old bottles
- Seeds
- Watering can
- Tree basket

Seasonal variations:

- Trees planted early in the dormant season tend to survive and have higher survival rates than trees planted later in the growing season
- The plants must be watered if they are transplanted during the dry season

E.3.5. Tree nursery

- The labels should be placed with each group of tree species

MAINTENANCE

Maintenance requirements:

- All the tree seedlings in tubes need to be watered twice a day – early morning and late afternoon – until the seedlings are 4 weeks old, Figure E.1.5-3
- After 4 weeks, watering should be reduced to early mornings only
- On average one full watering can is needed for every 200 tree seedlings
- If it is very hot and or windy it may be necessary to water twice per day
- Remove weeds from all tubes as soon as they are seen
- Till the top surface of the soil in the tubes with a stick every two weeks
- This will allow water and air to penetrate, providing better growth for the seedling
- When the tubes with two or more germinated seedlings have reached a stage of having two leaves, normally after two months, the extra tree seedlings can be transplanted into the ungerminated tubes
- There must not be more than one tree seedling in each tube
- Regularly remove any weeds from the nursery
- Because the tubes are open at the bottom, the roots will grow down into the soil. Roots need to be pruned after the tree seedlings have grown four leaves
- This is done by carefully cutting the roots using a phanga knife or some thin wire. The best method is to use a piece of wire about 1½ metre long and, with two people, drag this underneath a group of 200 tubes
- Alternatively, one person can drag a phanga knife underneath half the tubes in a group at a time
- Once root pruning has started, it needs to be carried out every two weeks until the tree seedlings are planted out

REFERENCES

Further references:

a. Bunderson WT, Jere ZD, Hayes IM and Phombeya HSK. 2002. Common Agroforestry species in Malawi. Malawi Agroforestry Extension Project. Publication no. 46.

b. Elliott, S.D.D. Blackesley and K. Hardwick, 2013. Restoring Tropical Forests: a practical guide. Royal Botanic Gardens, Kew

c. Tengnas B. 1994. Agroforestry extension manual for Kenya. Nairobi: International Centre for Research in Agroforestry.

d. Ripple Africa. 2003. Why conserve and manage the trees. Accessed online at http://www.rippleafrica.org/environment-projects-in-malawi-africa/tree-planting-africa. 20 August 2015.

e. www.kusamala.org

f. www.sdnp.org.mw/frim/

See also:

Guideline B.1.2.1. Designing a natural farming garden
Guideline B.1.2.2. Where to plant what
Guideline B.1.2.3. When to plant what
Guideline B.2.1. Compost making
Guideline B.2.5. Agroforestry
Guideline D.1.4. Selecting beneficial trees
Guideline E.3.1. Living fences and wind breaks
Guideline E.4.2. Constructing an arborloo latrine
Guideline E.3.4. Sustainable woodlot management

E.4. Sanitation and latrine management

Water is life, sanitation is dignity. Access to suitable sanitation is important not only for human development and personal dignity, but for the sustainability of the environment as well. The combination of the water scarcity and sanitation backlog in South Africa demand that we understand that sanitation is not all about flushing. The key issues related to sanitation are ensuring that each person has a system, which enables them to dispose of human excreta in a manner that is dignified, does not compromise human health, and does not damage the environment.

This section provides guidelines on the construction and maintenance of latrines at household or school level, in a manner that will ensure that human dignity is maintained, health is not compromised, and the environment is protected.

E.4.1. Constructing a composting toilet

OVERVIEW

Pit latrines are one of the oldest forms of formal sanitation in the world. They can be built by using local materials and skills. This guideline gives instructions on how to construct a composting latrine.

Objectives:

- To improve household and institutional sanitation
- To improve soil fertility and food production

Catchment perspective:

- Localised production of rich organic material that can help restore soil fertility
- Design does not require quarry stone, protecting rocky outcrops
- Eliminates contamination of groundwater

Funding opportunities: Not applicable

Legislation:
National Water Act, Act 36 of 1998

Criteria for application:

- Willingness to work with human manure
- Skilled and experienced builder
- Ability to access / source necessary materials.
- Chambers must be north facing for maximum sun exposure

Benefits:

- Reusable latrines rather than rebuilding once full
- Provides valuable organic manure
- Cleanliness
- Separation of urine and solid waste
- Eliminates ground water contamination
- Reduces spread of disease from open defecation

METHODOLOGY

Methodology:

1. To build the composting latrine (one unit of two adjacent latrines) builders need to gather resources: – Sand, 3,800 bricks, 21 bags cement, 1 roll 150 mm brick force wire, 2 rolls 80 mm brick force wire,100 x 25 mm planks & 4 mm plywood for arch framework. 5 corrugated tin sheets 3.0 m long, 4 m of 40 mm pvc pipe, 6 x 40 mm elbows, 2 wooden doors, 50 x 75 mm and 50 x 100 mm softwood timber each 6.0 m long, 12 m of 10-gauge wire
2. Dig foundations ½ m (1/2 spade length) deep according to the plan
3. Lay 3 courses of 345 mm brick work as foundations to the longitudinal walls / sides of the arches. Build on with 220 mm walls to150 mm above ground level. Refill and compact soil to make chamber floor
4. Build-up 220 mm walls to take arched chamber with brickforce wire every 5 courses
5. Build arch leaving 2 holes 200 mm diameter in the top of each arch (formed with 5 litre bucket)
6. Place shower waste, pvc pipes & fittings to take urine waste
7. Fill between arch and walls with compacted soil
8. Place door frame in position with nails to anchor into walls
9. Continue walls 100 mm / ½ brick thick with brickforce wire every 5 courses
10. Place 6 wire ties to hold roof timbers
11. Nail on tin sheets with larger overhang on lower side
12. Finish floor and urine basin
13. Close up arch with bricks and mud mortar so this can be easily opened once full of manure

Illustrations/ Diagrams:

E.4.1. Constructing a composting toilet

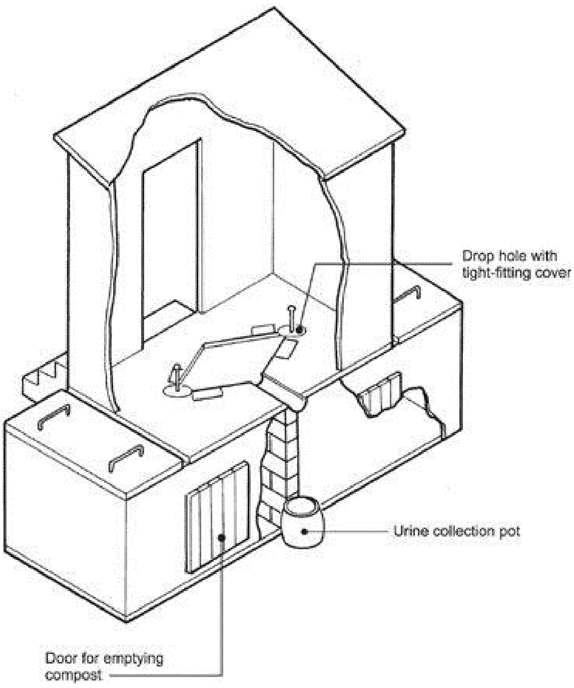


Figure E.4.1-1: Double-vault composting latrine

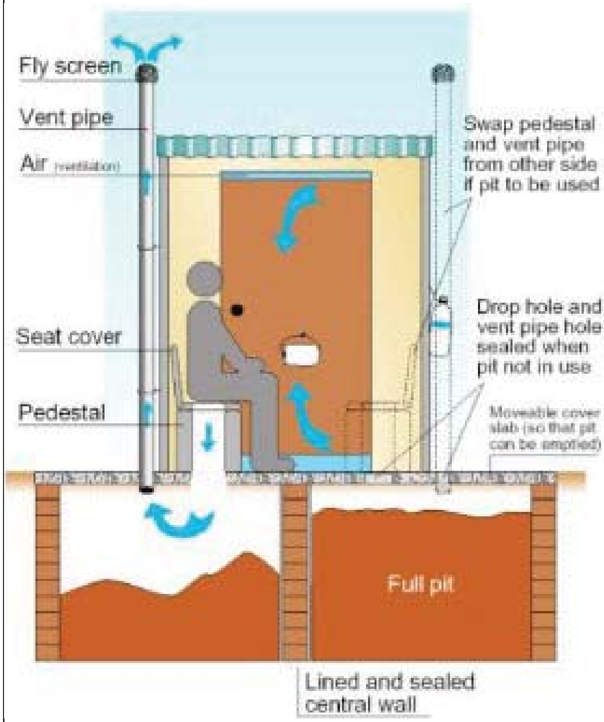


Figure E.4.1-2: Ventilated Improved Pit (VIP)

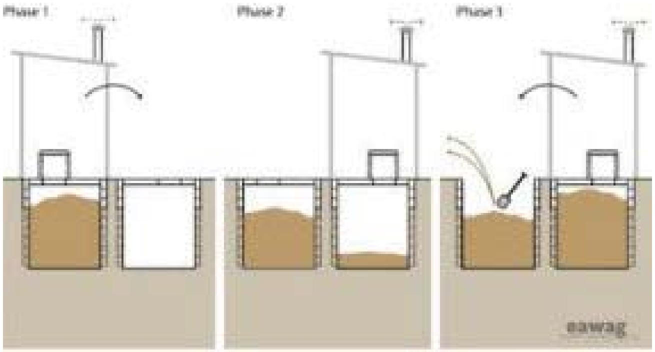


Figure E.4.1-3: Alternate use of chambers

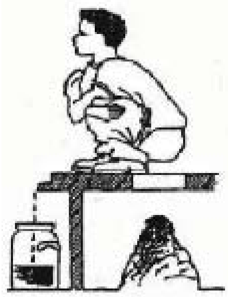


Figure E.4.1-4: Skyloo


Figure E.4.1-5: Constructing a composting toilet


Figure E.4.1-6: Constructing a composting toilet


Figure E.4.1-7: A composting toilet

E.4.1. Constructing a composting toilet

Figure E.4.1-8: Inside a composting toilet

Figure E.4.1-9: A notice inside a composting toilet

Figure E.4.1-10: Inside a composting toilet. (Photos: T. Mahoney)

Variations/Adaptations:

- Could be built with sundried mud bricks
- Could be built from small cement bricks
- On sloping ground steps could be reduced / removed and access to chambers from the side

Equipment requirements:

- Shovel, hoe, spirit level, trowel, hammer, woodsaw
- Jerry cans for urine collection.
- Wheelbarrow and shovel for moving waste

Seasonal variations: Not applicable

MAINTENANCE

Maintenance requirements:

- Ash and dry soil required to add after each use
- Dry storage for manure between cropping seasons
- Wash hands with soap and clean water after using the toilet

REFERENCES

Definitions: Not applicable

See also:
Guideline E.5.8. Biogas digester
Guideline E.4.2. Constructing an arborloo latrine
Guideline E.4.3. Closing a pit latrine

Further references:

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b. Michiel Verweij & Richard Nyirishema, A School Challenged by an ECOSAN Pilot Project: ECOSAN 2010. Accessed online at http://www.susana.org/es/recursos/biblioteca/details/709

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E.4.2. Constructing an arborloo latrine

OVERVIEW

Pit latrines are one of the oldest forms of formal sanitation in the world. They can be built by using local materials and skills. This guideline gives instructions on how to construct a shallow pit latrine which need not be emptied as when it is filled up, the pit is covered with soil and a tree is planted on site.

Objectives:

- To improve household and institutional sanitation
- To improve soil fertility and food production

Catchment perspective:

- Contributes to afforestation projects
- Beneficial trees of many types can be grown on filled pit latrines
- Eliminates contamination of groundwater

Funding opportunities: Not applicable

Legislation: Not applicable

Criteria for application:

- Social, educational status, etc.
- Local skills in building and gardening
- Ability to access / source necessary materials
- Sufficient space to move the Arborloo every 6 to12 months
- Access to a communal tree nursery or sufficient space to set up a tree nursery
- Latrines should be placed at more than 100 m away from ground and surface water sources (sanitation policy requirement)
- Wash hands with soap and clean water after using the toilet

Benefits:

- Cleanliness
- Eliminates groundwater contamination.
- Reduces spread of disease from open defecation
- It is easy to construct and cheap to build
- Replaces the conventional pit latrines with a positive end use – planting a beneficial tree
- Every year the household has a new tree, which gives fruits or timber and excess products can be sold for extra income

METHODOLOGY

Methodology:

1. The Arborloo is made up of 4 parts: the pit; the ring beam, the concrete slab, and the toilet house
2. The pit:
   a. Pits are dug shallow, flexible size but usually 60 cm diameter x 1-1.5 m deep
   b. The small-sized pit is easy to dig, even for women and children
   c. The pit should not be lined as the lining would prevent the tree or plant from growing properly
3. The ring beam: is needed to protect the pit that will be dismantled when shifting the Arborloo to a new location
   a. Mark a circle on the ground with the diameter required for the pit and lay burnt or sun-dried bricks around the circle
   b. Make a good mortar of ant hill soil and water
   c. Add the ant hill mortar between and above the bricks
   d. Add another two courses of burnt bricks in the same way (joints of layer 1 and 2 not above each other!)
   e. Add extra mortar above course three to get levelled surface
   f. Make sure the shape of the ring beam is correctly shaped with a width of about 15 cm
4. The concrete slab: sits on the ring beam and is movable
   a. The circular slab has a diameter of the pit size plus 10 cm, to allow for 5 cm overlap at all sides
   b. Usually the thickness of the slab is 40 mm made of coarse river sand and fresh cement, but if quality of sand and/or cement is poor, 45-50 mm to be on the safe side in order to avoid a slab collapsing with someone ending in the pit
   c. The mould can be made of bricks with the height required for the slab thickness. Making a circular timber or metal mould is attractive and worthwhile if the expected number of slabs to be produced is high
   d. To avoid soiling and urine splashing on the slab, the squatting hole should have an appropriate shape and size (as small kids may fear to fall in the 'dark' hole) A common shape is the key-hole (see figure C.2.2-6). The mould for the squatting hole can be made of an empty paint tin or a small bucket, or a pan; and a smaller round object (diameter 10 cm)
   e. For more permanent moulds, one could use a timber, metal or masonry shaped mould. Always apply some used engine oil to the mould to prevent the concrete sticking to the mould
   f. The slab usually weighs only about 30 kg and thus can be moved by one or two people
5. The toilet house: (superstructure) provides privacy inside the latrine and is also movable and it can be simple or more elaborate to provide the level of privacy and portability desired by the family
   a. Poles and grass, papyrus, palm leaves or banana leaves are cheap and easy to transfer or replace

E.4.2. Constructing an arborloo latrine

   b. The poles must be put in the ground outside the ring beam by digging/boring small diameter holes (preventing the pit from caving in)
   c. Timber or metal frame with grass, papyrus, palm leaves or banana leaves has the advantage of being easily be transferred to new Arborloo, but are more expensive because of cost of timber or metal frame
   d. Fully made of timber is more expensive and heavier but still transferable
   e. Poles and mud is a cheap option though heavier and not easily transferable
   f. Fully made of burnt bricks are not recommended for the Arborloo since these are heavy and expensive. This requires a full lining of pit otherwise the pit will collapse quickly!
   g. Roofing material can be any in principle, that is, corrugated sheet (expensive but durable), papyrus (cheap if available), grass (cheap), palm or banana leaves (cheap)
6. Before the pit is used, a layer of leaves must be put into the bottom of the pit
7. When the Arborloo pit is full, the slab and ring beam are moved to another place and a thick layer (30 cm thick) of soil and leaves is placed over the pit contents, and the pit is topped up with a least 15 cm of good topsoil
8. If water is not freely available the young tree is best planted at the start of the rainy season
9. A young tree is planted in this soil and is watered and cared for and also protected against animals
10. The topsoil should be watered down before a tree is planted
11. A hole is made near to the centre of the pit and a young beneficial tree planted there
12. The roots of the tree must not come anywhere near the waste material initially though the roots will gradually penetrate the waste
13. The tree is watered and the soil covered with mulch (leaves, grass cuttings, compost or other decomposing vegetable matter) to protect the soil from direct sun and helps to conserve moisture in the soil reducing the amount of water needed
14. It is very important to protect the tree against animal attack like goats and chickens
15. The end result is a “sanitary orchard”

Variations/Adaptations:

- The pit shape can be circular (best solution in loose soils and high groundwater tables) or square (as an alternative in more stable soils with deeper/low groundwater tables)
- Other plants such as tomatoes and pumpkins can also be planted on top of the pit if trees are not available
- Slab production can be encouraged as a business in the community

Equipment requirements:

- Shovel
- Hoe
- Spirit level
- Trowel
- Hammer
- Wood saw

Figure E.4.2-2: The mould for a circular slab

Figure E.4.2-3: The mould and slab casting for a circular slab

Figure E.4.2-4: Ring beam (circular brick collar)

Figure E.4.2-5: Ring beam (circular brick collar)

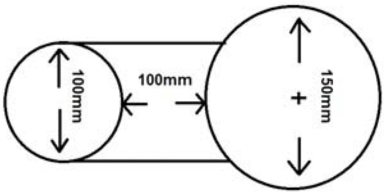


Figure E.4.2-6: Squatting hole drawing

Figure E.4.2-7: Basic Arborloo unit. (Photo: Peter Morgan)

E.4.2. Constructing an arborloo latrine

Figure E.4.2-8: Installing small slab on ring beam for Arborloo (Photo: Peter Morgan)

Figure E.4.2-9: Completed Arborloo (Photo: Peter Morgan)

Figure E.4.2-10: Completed Arborloo

Figure E.4.2-11: Young tree planted and protected against animals

Figure E.4.2-12: Portable superstructure of an Arborloo

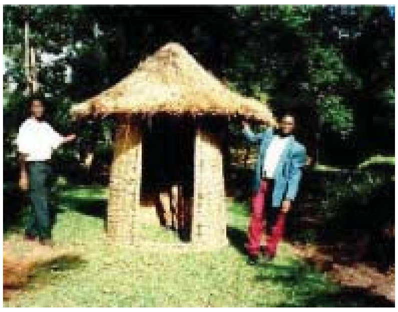
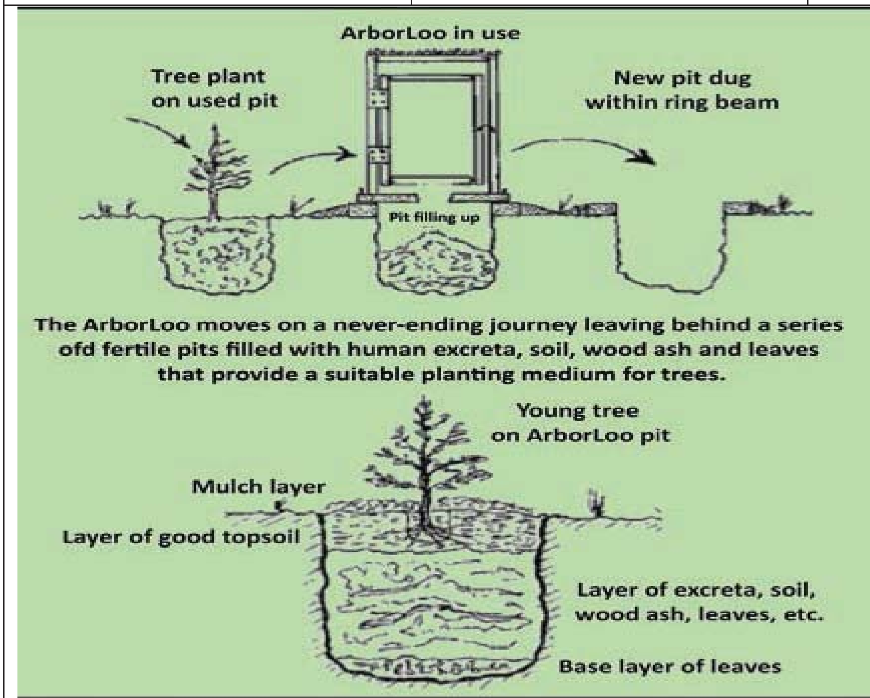


Figure E.4.2-13: Portable superstructure of an Arborloo



Illustrations/ Diagrams:

Figure E.4.2-1: Arborloo life cycle drawing by Peter Morgan

MAINTENANCE

Maintenance requirements:

- Ash, dry soil and leaves required to add after each use and on a daily basis in order to accelerate the composting process and also helps to control flies and smells.
- **DO NOT** put garbage or other wastes in the pit, since this method should not be used to dispose of things that will not break down, such as cans, bottles, plastic.

See also:

Guideline B.2.1. Compost making
Guideline B.2.2. Natural fertilizers
Guideline D.1.4. Selecting beneficial trees
Guideline E.3.5. Tree nursery
Guideline E.4.1. Constructing a composting toilet
Guideline E.4.3. Closing a pit latrine

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E.4.3. Closing a pit latrine

OVERVIEW

When an old used pit latrine is filled up, it needs to be emptied or closed and relocated. This guideline gives instructions on how to close a filled pit latrine.

Objectives:

- To avoid people, mainly children, or animals falling into large diameter openings and become trapped
- To avoid that the pit is used as a dump site

Criteria for application:

- Willingness to work with human manure
- Skilled and experienced builder
- Ability to access / source necessary materials.
- Chambers must be north facing for maximum sun exposure

Benefits:

- Cleanliness
- Reduce spread of disease from open defecation
- Eliminates the abandoned pit holes and replaces the hole with a positive use – planting a beneficial tree
- Reduces the potential for underground contamination of water by preventing the infiltration of pollutants into the surrounding soil

Catchment perspective:

- Localised production of rich organic material that can help restore soil fertility
- Design does not require quarry stone, protecting rocky outcrops
- Eliminates contamination of groundwater

Funding opportunities:
Not applicable

Legislation:
Not applicable

METHODOLOGY

Methodology:

1. Examine the pit – Do not enter a pit if uncertain about its stability or air quality. The walls of some pits may be unstable and subject to collapse or, in some instances, the air in a pit may have decreased oxygen content or contain toxic gasses, **DO NOT** light a flame if there is gas.
2. Users need to gather resources: The pit needs to be topped up with a good layer of soil to cover the waste, and on top a layer of 30 cm thick of fertile soil or compost.
3. Do not put garbage or other wastes in the pit, since this method should not be used to dispose of things that will not break down, such as cans, bottles, plastic.
4. The soil layer should be piled up above ground level, as the contents of the pit will reduce in volume during composting process and the soil level will drop. Additional soil may be needed to level the ground.
5. The pit can then be left to settle until the rains arrive. If water is not freely available the young tree is best planted at the start of the rainy season.
6. The topsoil should be watered down before a tree is planted
7. A hole is made near to the centre of the pit and a young beneficial tree planted there.
8. The roots of the young tree must not reach into the waste material.
9. The tree is watered and the soil covered with mulch (leaves, grass cuttings, compost or other decomposing vegetable matter) to protect the soil from direct sun and helps to conserve moisture in the soil reducing the amount of water needed
10. It is very important to protect the tree against animal attack like goats and chickens
11. The end result is a “sanitary orchard”

Photos:

Figure E.4.3-1: Tree nursery

Figure E.4.3-2: Growing fruit trees in old pits

E.4.3. Closing a pit latrine

Figure E.4.3-3: Pawpaw tree with a fence to protect the tree against goats, chickens and children

Figure E.4.3-4: Most trees will grow well in abandoned toilet pits if cared for and watered

Variations/Adaptations:

- Could be built with sundried mud bricks
- Could be built from small cement bricks

On sloping ground steps could be reduced / removed and to access chambers from the side

Equipment requirements:
Wheelbarrow and shovel for carrying the soil

Seasonal variations:
Additional watering during the dry season

MAINTENANCE

Maintenance requirements:

- Watering – When the trees are young, they need to be watered regularly, especially if the rains are poor or if the trees are not planted in the rainy season. As the roots penetrate more deeply, they rely less on watering. If a tree shows signs of dying it should be replaced
- Protection from termites – If there is early evidence of termite presence the trees should be treated with chemicals. The application of wood ash may help. Dead trees should be removed and the soil treated and new trees planted
- Protection from goats – Goats can eat trees and suitable protection should be provided if goats roam the area
- Replanting – If for any reason the young tree does not become established, it should be replaced. If the plant struggles for a period of 3-4 months then it is best to take the tree out and replant with a new tree or to take out the soil from the pit and, loosen and mix up and reapply to the pit; replant the same tree or preferably a new tree repeating the planting procedure

REFERENCES

Definitions:
Not applicable

See also:
Guideline B.2.5. Agroforestry
Guideline B.2.1. Compost making
Guideline D.1.4. Selecting beneficial trees
Guideline E.3.5. Tree nursery
Guideline E.4.1. Constructing a composting toilet

Further references: Not applicable

E.4.4. Operating and maintaining a Ventilated Improved Pit (VIP) Latrine

OVERVIEW

The Ventilated Improved Pit Latrines (VIP) has been constructed in many areas throughout South Africa to address the sanitation backlog. This guideline gives instructions on how to maintain a VIP latrine.

Objectives:

- To avoid the rapid filling up of VIP latrines
- To avoid repulsive odours and flies in the latrine, which can make the use of the latrine unpleasant
- Ensure that groundwater is protected

Catchment perspective:

- Eliminates groundwater contamination
- Extends the lifespan of VIP latrines

Benefits:

- Cleanliness
- Reduces the possibility of overflowing latrines therefore making the use of the latrine more pleasant
- Reduces the spread of diseases linked to sanitation practices
- Increases the lifespan of the latrine
- Reduces bad odour from and flies in the latrine

Criteria for application:

- The VIP latrine must be constructed at least 100 m away from ground and surface water resources, e.g. boreholes, streams, springs, wells, etc.
- Air must be allowed to flow either through an air space above the door frame, through a space above and below the door; or through the ventilation pipe.
- Consistent monitoring of the state of the latrine
- Availability of the correct cleaning materials
- Ability to access an alternative waste disposal site

Funding opportunities:

Not applicable

Legislation:

Not applicable

METHODOLOGY

Methodology:

1. When the toilet is not in use, ensure that the door is closed at all times, minimizing the amount of sunlight that enters the toilet
2. To allow air flow into the pit and up the ventilation pipe (hence reducing bad odour in the latrine), do not cover the toilet seat during the day.
3. **DO NOT** throw household or other waste into the latrine. Only human waste.
4. Clean the walls, seat and walls of the toilet regularly.
5. Clean the ventilation pipe and the fly screen regularly. Pour water down the vent pipe at least once a month to wash away anything could block the vent pipe and fly screen.
6. Do not put any plastic, cans, glass, rubber, stones, bricks, oil, and sanitary towels in the toilet pit.
7. Wash your hands with soap and water after using the toilet.
8. Do not throw any chemicals such as Jik, Domestos and Jeyes Fluid into the toilet pit.
9. Do not throw dirty water into the pit
10. If the fly screen is broken, replace it.
11. Keep some soap and clean water near the latrine to wash hands after using the latrine, to improve hygiene and health.

Illustrations/ Diagrams:

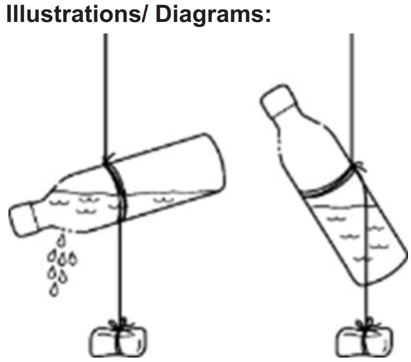
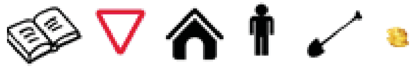


Figure E.4.4 – 1: Tippy tap design

Tippy Tap – to wash hands after using the toilet

1. Full a plastic bottle with clean water.
2. Tie some string around the middle of the bottle, that holds the bottle. Leave some string above and below the bottle.
3. Tie some soap to the bottom end of the string. Make a hole in the soap and thread the string through it, and tie together.
4. Use the top end to tie to bottle and soap next to the toilet, e.g. branch, stick, or nail.
5. Poke 1 small hole near the lid of the bottle on the topside – for air.
6. Poke a few small holes also near the lid, on the underside, this is where the water pours out.
7. When not in use, bottle should hang upright so water doesn't leak out.

E.4.4. Operating and maintaining a Ventilated Improved Pit (VIP) Latrine



Photos:

Figure E.4.4-2: Tippy Tap on a VIP Latrine, Bergville. (Source: S. Braid)

Equipment requirements:

- Bucket
- Cloth
- Soap
- Ladder or steps for cleaning the ventilation pipe and fly screen
- Tippy tap: plastic bottle, string, soap, clean water.

Variations/Adaptations:
Not applicable

Seasonal variations:
Not applicable

MAINTENANCE

Maintenance requirements: Not applicable

REFERENCES

Definitions: Not applicable	**See also:** Guideline E.4.3. Closing a pit latrine Guideline E.5.8. Biogas digester Guideline E.4.1. Constructing a composting toilet

Further references: not applicable

E.5. Energy, efficiency and alternatives

Access to energy is a basic need required for heating, lighting and cooking applications. Currently in South Africa, many households in rural areas do not have access to the electricity grid and therefore use paraffin, gas and charcoal as their main source of energy. With climate change and the development of global legislation, further strain is placed on the South African government to not only provide every household with access to energy, but to also ensure that the energy source is clean, relatively cheap, convenient and sustainable. Where houses are connected to the National grid, the cost of increase electricity tariffs may be too expensive for households.

This guideline therefore provides alternative energy options that may be implemented in rural areas within South Africa to provide access to alternative, cleaner energy sources for all citizens.

E.5.1. Energy efficient stoves and ovens

OVERVIEW

Improved efficiency of traditional wood stoves can be achieved by enclosing the fire within **insulating** clay, earth or rocks. This results in a hotter fire with the need for less fuel.

Objectives:

- The formation of a rock oven or earth oven for the production of heat for cooking purposes
- Enhances the ability of rural villagers to access efficient, healthy, and affordable cooking technology
- To promote energy efficient cooking stoves with a focus on rural areas
- To minimise or replace the use of charcoal for cooking purposes by using natural resources
- Limiting the release of **noxious** gases that have adverse health effects

Catchment perspective:

- Reduced deforestation and degradation of surrounding forests, as less wood will be needed to cook
- Reduces the pressure placed on local forests by reducing the amount of wood the stoves consume
- Additionally, the money a family spends on wood or charcoal translates into less money being available to be spent on food, education, and medical care; therefore, reduced reliance on charcoal should make household money more available for other expenses
- An improved cooking stove is seen as a way of boosting a family's income

Criteria for application:

- This is beneficial to both urban and rural settlements. Skills development training in group forums inclusive of practical training is key.
- A suitable site is one where an open spaced area is available close to the homes in the rural areas. Size variations mean that these can be used at an individual or community (e.g. school) level.
- In the areas prone to rainy conditions for longer periods of time, may be necessary to build shelter structures over these ovens to prevent damage thereof.
- Steel plating, if available can be placed as a surface area for cooking on the upper area of the clay/earth oven serving as a grill area and allowing for more foods to be cooked at a time.
- Rock Ovens work well only if used with the correct heat retaining types of rocks. If the incorrect rocks are used, they may explode. It is therefore important to involve an individual with knowledge of the local geology in rock selection if rocks are to be used.

Legislation:

Not applicable.

Funding opportunities:

- The 'Greenfund'[a] established by the Department of Environmental Affairs (DEA) and implemented by the Development Bank of Southern Africa (DBSA).
- Renewable Energy forms part of the Low Carbon Economy (LCE) window of the 'Greenfund'.
- This window is open to proposals from the private sector (including small and medium enterprises), research and non-governmental organisations.

E.5.1. Energy efficient stoves and ovens

Benefits:

- Easily adaptable to the people due to its familiar cultural methods of cooking
- Reductions in CO_2 emissions associated with the reduction of the **combustion** of wood and charcoal derived from non-renewable biomass
- Replace or minimise the use of charcoal (from indigenous trees) with wood (from sustainable woodlots) for the fire
- Reduced poverty, as the efficient wood stove will reduce annual expenditure on cooking fuels
- Reduced cooking and wood collection time, which will allow more time to attend to other household tasks and supervise children
- Reduced risk of attacks on firewood collectors (mainly women) in the remote areas generally used for firewood collection
- Reduction in burns and injuries as the stove is safer to cook on
- Increased local human capacity via education and employment in the distribution, production and maintenance of cook stoves
- Economically viable as there are no high costs involved in building these structures. Can be built or a pit can be dug for the “construction” thereof thus making materials easily available. No need to incur additional costs

METHODOLOGY

Methodology:

Method 1: Energy Efficient Stove

1. Mould a stove from clay or mud, incorporating a combustion chamber to contain the fire
2. Make sure the wood is dry or “seasoned.”

Method 2: Cob/Clay Oven

1. Prepare a brick base for the oven. Rock can be used here as well. Create a square opening which can be used for storage of wood or vegetation.
2. Thereafter, make a pile of damp sand, and pat into a dome shape.
3. Cover the pile and frame with a clay mixture and mould evenly into shape.
4. Leave an opening at the bottom of the dome to ensure that the sand can be removed once the mould has dried.
5. Allow to dry thoroughly.
6. Cover with another layer of smooth clay, mud mixture to recoat the mould.

Method 3: Earth Oven

1. Dig a pit into the ground in stable soil.
2. Leave an opening to provide access for starting a fire, in order to heat the pit.
3. Once fire is made cover the opening with vegetation to retain heat within the pit.
4. Heating rocks in the fire will ensure heat retention allowing cooking to continue long after the fire has been extinguished.

Method 4: Rock Oven

1. Use rocks, placed in a table structural shape, neatly stacked on top of each other to ensure that there are minimal spaces in between.
2. Leave an opening at the front, or on the top, for access into the centre of the oven.
3. Cover the opening with a steel sheet or wood panel to ensure that the heat of the rocks is **encapsulated** inside the oven.
4. Rocks can be painted black on the outside to attract heat and increase temperatures within the oven.

Variations/Adaptations:

- A solar rock oven could be used as an alternative. Rocks painted black and left in the sun to heat up can provide the heat source in all three oven designs. The hot rocks are placed in the oven replacing the need for a fire.
- Bricks or other alternate materials can be used.

Equipment requirements:

- Earth, stone and/or clay
- Cement is optional for holding the structure together. Also good for heat retention
- Can use a mould structural frame made of steel mesh or bamboo sticks
- Wood & easily obtainable vegetation readily available within the surroundings

E.5.1. Energy efficient stoves and ovens

- The stoves or ovens can be built above or below the ground

Seasonal variations:

- To be constructed during the dry season
- Build shelter during rainy season if necessary

Illustrations/ Diagrams:

1. Fire is started at the front opening of the oven.
2. Once fire roars, it is moved to the back to allow the heat to circulate and penetrate into the roof of the oven
3. Excess smoke & heat is released

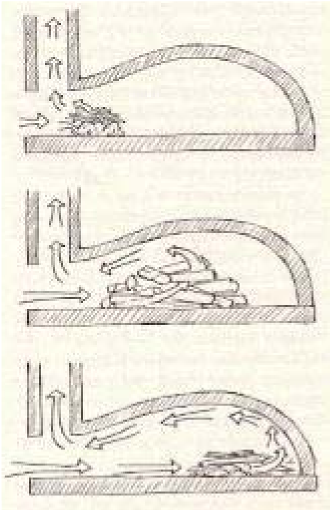


Figure E.5.1-1: Diagram of an energy efficient stove

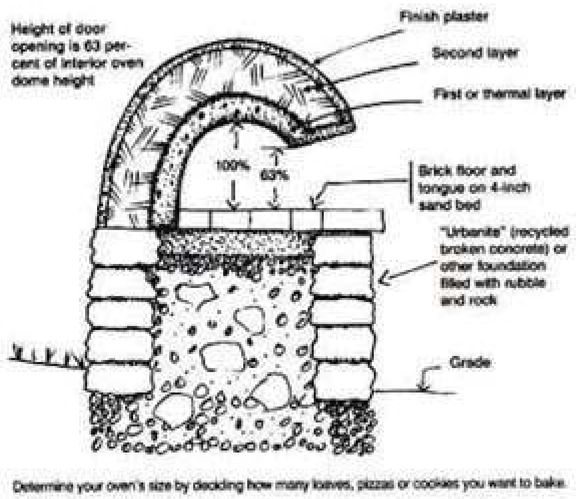


Figure E.5.1-2: Diagram of a cob oven

Photos:

Figure E.5.1-3: Energy Efficient Stove (S. Braid)

Figure E.5.1-4: Energy Efficient Stove (S. Braid)

Figure E.5.1-5: Energy Efficient Stove (S. Braid)

Figure E.5.1-6: Earth Oven [b]

Figure E.5.1-7: Rock Oven [b]

Figure E.5.1-8: Clay Oven [b]

MAINTENANCE

Maintenance requirements:

- Stoves should be kept clean and swept regularly to remove ash. Ash quantities are generally very low (<1% of fuel volume), but it is still needed to empty the ash bin of a wood burning stove. A log fire requires ash removal before every use. The wood ash can be used for **mulching**, compost and keeping termites away from crops
- Ensure that the soil is stable for long term standing
- Keep in an open space for optimal benefit of solar energy

Potential drawbacks/disadvantages:

- Charcoal and wood are still required for starting fires although a smaller quantity is required.
- Using unsuitable rocks could pose a danger for the user.

E.5.1. Energy efficient stoves and ovens

- Maintenance of cracks in the clay over time. Reseal with clay at a later stage if needed

REFERENCES

Definitions:

- Insulating – Applying a material that prevents the loss or movement of heat,
- Noxious – Harmful or poisonous.
- Geology – Physical structure and substance of the Earth.
- Hydrological – Movement and distribution of water on Earth.
- Combustion – The process of burning a material.
- Encapsulated – To be completely covered.
- Mulching – The process of applying a protective covering usually made up of organic matter.

See also:

Guideline B.1.1.3. Soil cover (mulching)
Guideline B.2.1. Compost making
Guideline B.1.2.1. Designing a Natural Farming garden
Guideline B.1.2.2. Where to plant what
Guideline B.1.2.3. When to plant what
Guideline E.5.3. Solar cooker
Guideline E.3.4. Sustainable woodlot management
Guideline E.3.5. Tree nursery

Further references:

a. https://www.environment.gov.za/projectsprogrammes/greenfund
b. Outdoor Earth Ovens – inspiration green
c. Cooking Options in Refugee Situations. A Handbook of Experiences in Energy Conservation and Alternative Fuels. Report of UNCHR.1 http://en.wikipedia.org/wiki/Biomass_Cook_Stoves
d. www.aprovecho.com
e. http://bioenergylists.org/
f. www.repp.org
g. www.hedon.info//Category:ImprovedStoves
h. www.hedon.info/goto.php/BoilingPoint
i. www.practicalaction.org

E.5.2. Heat retention cooker

OVERVIEW

A simple, easy to construct, box or bag with a layer of **insulation** can be used to reduce cooking time over a fire. A pot of food is heated over a fire or in an energy efficient stove and then placed inside the heat retention cooker where it will continue to cook with no further heat source.

Objectives:
To reduce the time required for cooking over a fire, thereby reducing the volume of biomass fuels (charcoal, wood, etc.) required for burning.

Catchment perspective:
Reduced dependence on charcoal as a fuel supply, thereby reducing deforestation in the catchment and reduces respiratory illnesses.

Criteria for application:
- Consists of an outer bag/box and an inner space with a layer of insulation in between
- Can be constructed using a variety of materials depending on local availability and local skills
- Insulation layer can be cloth scraps, hay, straw, rice hulls, corn husks, etc.

Benefits:
- Reduced carbon emissions from domestic cooking
- Reduce indoor smoke and fumes from burning fuels resulting in a potential health benefit
- Reduced deforestation as the use of wood and charcoal can be reduced
- Heat retention allows food to be kept warm for long periods so it does not require reheating
- Limited change from conventional cooking
- Easily built with local materials and skills
- Used in conjunction with conventional cooking methods and energy efficient stoves

Funding opportunities:
Not applicable

Legislation:
The heat retention cooker as detailed in this guideline does not trigger any legislative requirements

METHODOLOGY

Methodology:
1. Construct, sew or weave an outer structure. This can be a wooden box, a basket, a large bag or something similar. It must be large enough to accommodate the cooking pot and a thick layer of insulation material
2. Fill with a layer of insulation 5-10 cm (hand width on the sides and hand length on the top) thick
3. Wrap the cooking pot to be used in the lining material, tie it at the top and place it in the centre of the box/basket
4. Densely pack the space between the lining and box/basket with insulation material, making sure there are no large air gaps. The insulation layer should be at least 5 cm thick all the way around
5. Untie the lining layer from the pot and sew/secure to the rim of the box/basket to contain the insulation
6. Make a lid for the box/basket using the lining fabric and fill with insulation material. This layer of insulation should be thicker than the rest of the insulation as heat rises upwards
7. To use the heat retention cooker, start the cooking process over the fire as normal, cook for 10-15 minutes and then place the pot into the cooker with the lid
8. For longer heat retention, a tray of hot sand from the fire can be placed in the bag, in a ceramic dish underneath the pot but this is not necessary for the cooking process to continue

Illustrations/ Diagrams:

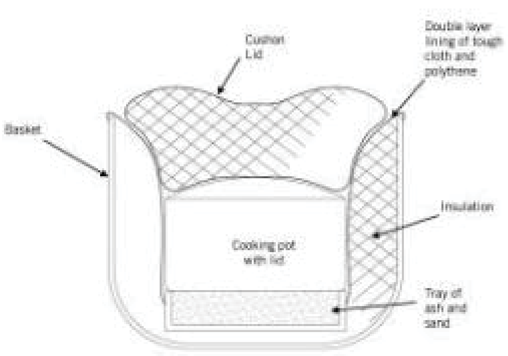


Figure E.5.2-1: Diagram of a fireless cooker

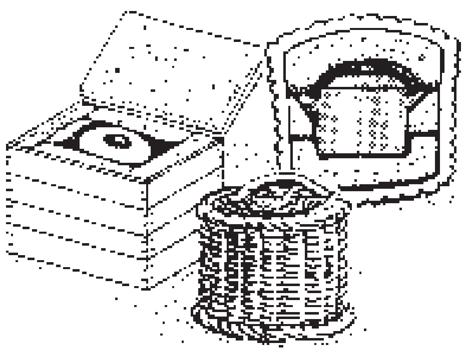


Figure E.5.2-2: Drawing of Fireless Cookers

Photos:

E.5.2. Heat retention cooker

Figure E.5.2-3: Fireless Cooker [a]

Figure E.5.2-4: Fireless Cooker [a]

Variations/Adaptations:

Commercially manufactured variations are available.

Seasonal variations:

Cooking is possible indoors and outdoors, ambient temperatures will have a negligible effect on cooking times.

Equipment requirements:

- Outer structure can be a woven basket, a wooden box, a fabric bag or something similar
- Sacking or strong fabric to be used as lining
- Adhesive or needle and thread to secure lining to outer structure
- Insulation material, cloth scraps, rice hulls, corn husks, straw, barley, etc.

MAINTENANCE

Maintenance requirements:

- Ensure that any fabric/material used is cleaned regularly to avoid bacteria build up and **contamination**.

Potential drawbacks/disadvantages:

Still requires an alternative method of cooking to initially heat up the pot.

REFERENCES

Definitions:

- Insulation – A material used to prevent heat from entering or leaving a specific area.
- Contamination – The act of making something impure.

See also:

Guideline E.5.1. Energy efficient stoves and ovens
Guideline E.5.3. Solar cooker

Further references:

a. Practical Action – Fireless Cooker
b. www.practicalaction.org
c. Solar Cookers International Network
d. www.solarcooking.org
e. www.solarcookers.org

E.5.3. Solar cooker

OVERVIEW

This guideline details the concept of a **solar cooker**, which can be procured or self-built, and could be used for cooking in place of, or as a supplement to traditional fire burning stoves.

Objectives:
To use solar energy as a replacement for the burning of biomass fuels, e.g. charcoal for cooking

Catchment perspective:
Reduced dependence on charcoal as a fuel supply, thereby reducing deforestation in the catchment and reducing respiratory illnesses.

Criteria for application:

- Must be placed in sunny locations
- Solar cooker kits can be bought and distributed
- Can also be self-built (requires access to reflective material, e.g. tin/aluminium foil, to **concentrate** the solar energy in order to achieve temperatures suitable for cooking)
- Design can be selected based on local preference and access to suppliers and/or available material

Benefits:

- Reduced **carbon emissions** from domestic cooking
- Reduce indoor smoke and fumes from burning fuels resulting in a potential health benefit
- Free fuel source
- Minimise time spent in collecting fuel
- Reduced deforestation as use of wood and charcoal can be reduced
- Portable

Funding opportunities:
The Solar Cooker can serve as an educational tool and may be funded through Educational funding initiatives.

Legislation:
The solar cooker as detailed in this guideline does not trigger any legislative requirements

METHODOLOGY

Methodology:

1. Cut cardboard to the template shown in Figure E.5.3-1: The "CooKit" Foldable Family Panel Plan. (Note: This should be made big enough for the preferred pot to sit on the flat section as shown)
2. Using **adhesive**, line one side with reflective material, e.g. tin / aluminium foil.
3. Fold along the lines shown so that the **reflective material** faces inward towards the pot.
4. Place in a sunny location with the open side facing the sun.
5. Place food, in the preferred pot with a lid in the cooker.
6. A clear plastic bag placed around the cooking pot will increase **efficiency** as it creates a **greenhouse effect** but is not necessary.
7. Rice will cook in approximately 1.5 hours; beans will take about 2 hours to cook.

Illustrations:

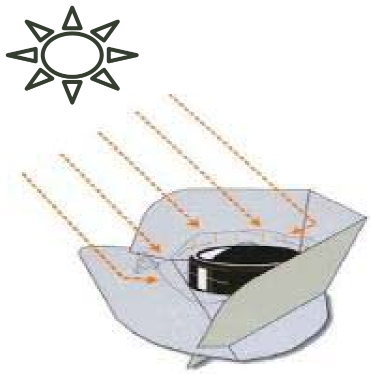


Figure E.5.3-1: Folding the panel allows extra sunlight to be captured, increasing the heating potential. (Source: Solar Cookers International Network)

Equipment requirements:

- Cardboard
- Aluminium foil or other reflective material
- Scissors or craft knife or cutting tool
- Adhesive (e.g. glue)
- Transparent plastic bag (optional)

Seasonal variations:

- The cooker will reach temperatures suitable for cooking even if the **ambient temperature** is low.
- If cardboard has been used for construction, the unit should be protected from rain/wet conditions
- Cooking time will be longer in cloudy conditions

Variations/Adaptations:

- For a more permanent solution the oven can also be constructed out of wood lined with reflective material
- A number of design variations are available; these include the insulated double box and **parabolic designs** shown in the photographs in this guideline.
- Procurement and distribution from one of many commercial suppliers is an alternative to a self/ community build option

E.5.3. Solar cooker

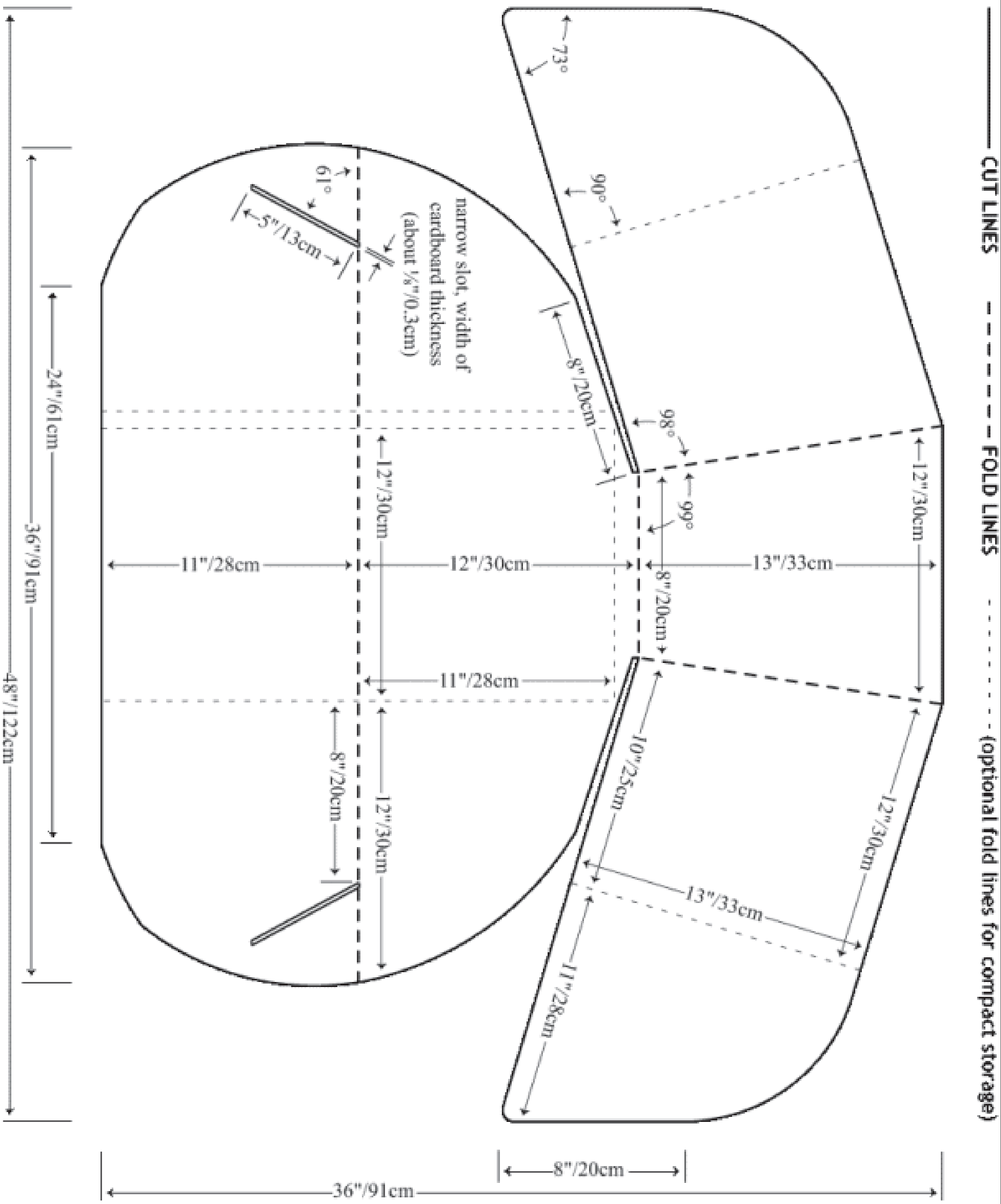


Figure E.5.3-2: The "CooKit" Foldable Family Panel Plan. (Source: Solar cooker)

E.5.3. Solar cooker

Photos:

Figure E.5.3-3: Parabolic cooker

Figure E.5.3-4: Box-style cooker

Figure E.5.3-5: Panel-style cooker

MAINTENANCE

Maintenance requirements:

- Ensure the reflective surface is kept dust free
- Keep dry

Potential drawbacks/disadvantages:

- The Solar Cooker cannot be used during cloudy or rainy conditions.
- Cooking takes a longer time than conventional methods.
- Solar Cookers are not as efficient as conventional cooking devices for retaining heat.
- A backup gas or electric cooker may be required.

REFERENCES

Definitions:

- **Solar Cooker** – A cooking stove which makes use of the sun to generate heat (instead of wood/charcoal, etc.)
- **Concentrate** – To gather something (e.g. energy) in a common location or to make something stronger.
- **Carbon emissions** – The release of Carbon dioxide (CO_2) gas into the atmosphere.
- **Adhesive** – A substance used to stick or join objects together.
- **Reflective material** – A material that causes the sunlight, to be reflected in order to concentrate it on the pot in the middle
- **Efficiency** – An indication of how much of the incoming energy is used by the Solar Cooker.
- **Greenhouse effect** – The warming up of the earth due to the Sun's energy being trapped in the earth's atmosphere.
- **Parabolic designs** – A design that uses a parabola shape (u-shape).
- **Ambient temperature** – The temperature of the surrounding environment.

See also:

Guideline E.5.2. Heat retention cooker
Guideline E.5.1. Energy efficient stoves and ovens

Further references:

a. Solar Cookers International Network www.solarcooking.org; www.solarcookers.org
b. Solar Cooker. Wisions of Sustainability. www.wisions.net

E.5.4. Solar electrification

OVERVIEW

The sun provides a free abundant energy resource, which can be harnessed by solar panels and converted to electrical energy. This electrical energy can then be utilised to provide lighting, heating, run a television or charge a mobile phone.

Objectives:
Solar Panels generate electrical power for use in a home, community or village thereby reducing the need for paraffin or charcoal and providing electrical charging capability otherwise only available from a diesel generator or battery

Catchment perspective:
Reduced dependence on charcoal as a fuel supply, thereby reducing deforestation in the catchment and risk of fires in the house.

Legislation:
Environmental Impact Assessment (EIA) and other relevant permits may be required for large scale systems.

Criteria for application:

- Must be located in a sunny location that will receive minimal shading, the panels must face north.
- Should be installed as close as possible to the load (where the energy is used)
- For small farm or village grids, it is essential to involve an engineer or an individual with experience in the planning and building of these structures
- Solar panels/kits may be available at village markets, these vary considerably ranging in price from R2000 for low power systems up to approximately R45000 for systems capable of powering 1 or 2 houses entirely.[b]

Benefits:

- Convenient source of energy for lighting, cooking and heating and charging of electrical devices such as mobile phones.
- Clean and free energy from the Sun producing no emissions.
- Requires very little maintenance.
- Can be installed independently from the electrical grid with or without using battery storage.

Funding opportunities:

- World Bank and International Finance Corporation (FC) initiatives such as Lighting Africa and Lighting global.
- The 'Greenfund'[c] established by the Department of Environmental Affairs (DEA) and implemented by the Development Bank of Southern Africa (DBSA).
- Renewable Energy forms part of the Low Carbon Economy (LCE) window of the 'Greenfund'.
- This window is open to proposals from the private sector (including small and medium enterprises), research and non-governmental organisations.
- The Industrial Development Corporation's (IDC) Green Energy Efficiency Fund (GEEF).
- Solar Electric Light Fund[d].

METHODOLOGY

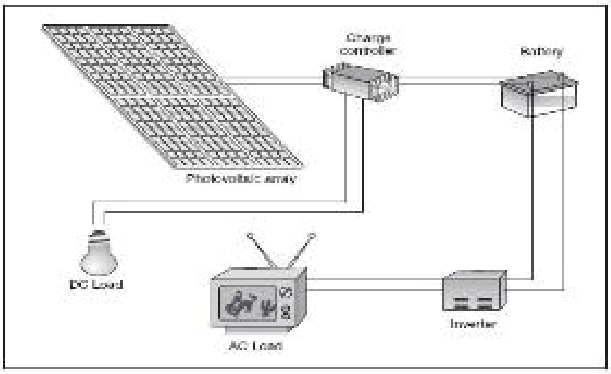
Methodology:

1. Purchase a solar panel
2. Find a suitable location where the Solar Panels will be exposed to maximum sunlight, must be north facing and as little shade as possible.
3. Determine a suitable size for the system. This is dependent on the expected demand on the system. A typical 200 Wp rated solar module installed in the Eastern Cape or Kwa-Zulu Natal, where the **insolation** value ranges between 4.9-5.5kWh/m^2 per day, will produce approximately 830Wh-950Wh. While the same module installed in the Northern Cape, where the insolation ranges from 5.5-6kWh/m^2 per day, will produce approximately 950Wh-1020Wh. This is enough energy to light a 100W light bulb for 8-10 hours or boil approximately 8-10 kettles of water.
4. It is recommended that the Solar Modules be installed on a structure at a suitable height off the ground to prevent damage by animals.
5. Connect the solar panels to the battery via a charge controller.
6. DC loads such as a heating element and light bulbs can be connected directly to the battery.
7. An **inverter** must be included in the system if AC loads such as a television, mobile phone charger are to be connected.
8. Normal safety practices for working with electricity must be adhered to.

Illustrations/ Diagrams:

Photos:

E.5.4. Solar electrification



Components of a typical off-grid PV system *Solar electricity can be used for many purposes, either directly, or by storing in batteries for use when the sun is not shining.*

Figure E.5.4-1: Components of a typical off-grid PV system
Source: Practical Action – Solar-photovoltaic-energy

Figure E.5.4-2: Solar panels
Source: Practical Action – Solar-photovoltaic-energy

Equipment requirements:

- Solar modules (Panels)
- Battery
- Charge controller
- Suitable cables
- If AC electrical loads are to be connected then an inverter is also required

Variations/Adaptations:

- Solar PV can be used for creating mini or micro-grids with a larger solar array, powering batteries and connecting multiple homes within a community or village
- Solar PV can also be used as part of a **hybrid micro-grid** system
- Solar **PV tracking systems** can be implemented to increase energy output although more-costly

Seasonal variations:
Electricity generation will be lower in cloudy conditions. This can be addressed by having larger/multiple panels and batteries.

MAINTENANCE

Maintenance requirements:

- Cleaning of solar panels may be required. Be careful not to scratch the glass. Use a soft damp cloth to clean.
- Battery maintenance
- Tracking system maintenance (if implemented)

Potential drawbacks/disadvantages:

- Initially requires a significant amount of funding.
- Adverse weather conditions (cloudy or rainy conditions) will reduce the power output of the system.
- Solar panels need to be placed in an area where there are no obstructions causing shading on the panels.
- Requires battery storage to generate electricity at night which is quite costly.

REFERENCES

Definitions:

- Insolation – The amount of solar radiation (energy) reaching a certain area.
- Inverter – A device which converts direct current into alternating current.
- Charge Controller – A device which limits the rate at which electric current is added to or drawn from batteries.
- Hybrid – Combining two or more different elements such as solar PV with micro-hydro.
- Micro-grid – A small group of interconnected loads and distributed energy resources which is independent from the main electrical grid.
- PV tracking systems – A solar PV system that tracks the movement of the Sun during the day from East to West to increase its energy output.

See also:
Guideline E.5.5. Solar borehole pump

Further references:

a. Practical Action – Solar-photovoltaic-energy International Energy Agency Solar Photovoltaic Power Systems Programme
b. http://www.sustainable.co.za/
c. https://www.environment.gov.za/projectsprogrammes/greenfund
d. http://self.org/request-information/

E.5.5. Solar borehole pump

OVERVIEW

This guideline details how the sun can be used to power a borehole pump, providing a local source of water, reducing the need to fetch or manually pump water. This guideline considers the application for a new borehole however this could also be retrofitted to an existing borehole.

Objectives:

Structure built adjacent to the home or within a village or community:

- To provide a source of clean water for human consumption
- To replace more labour-intensive hand pumps

Criteria for application:

- It is important to involve an engineer or an individual with experience in the planning and building of these structures
- **Aquifer** or water table of suitable water quality at an accessible depth
- Sunny location

Catchment perspective:

- Reduce the need to carry water long distances
- Replace dependence on labour-intensive hand pumps to obtain water for consumption

Benefits:

- Local/community water supply
- Water for livestock
- Irrigation
- Low maintenance

Legislation:

National Water Act 36 of 1998.

A person does not need any permission to drill any borehole. However, once the borehole has been drilled and water found, the registration of the water use, which in this case is groundwater, must be done depending on the ultimate usage.

Funding opportunities:

- The 'Greenfund'[f] established by the Department of Environmental Affairs (DEA) and implemented by the Development Bank of Southern Africa (DBSA).
- Renewable Energy forms part of the Low Carbon Economy (LCE) window of the 'Greenfund'.
- This window is open to proposals from the private sector (including small and medium enterprises), research and non-governmental organisations.

METHODOLOGY

Methodology:

1. Determine the local demand for water. This will be based on the size of the local community and their water needs
2. Determine the available water supply including depth and well recovery rate. The borehole should be sited appropriately, e.g. 50-100 m away from pit latrines and waste dump sites.
3. Based on the above information, size the system and its subcomponents appropriately. This process must take into account:
   a. Storage requirements (reservoir size)
   b. The required head of water (depth of borehole and height of **reservoir**)
   c. Pump type and size to meet the lifting requirements
4. Solar panel **array** to meet the electrical requirements of the pump
5. Carefully dig/drill the well
6. Construct a support structure to support the solar panels – this should be located so the panels receive maximum sunlight during the day
7. Connect the pump to the solar panels via a suitable controller
8. Install the pump and required water pipes as well as any water **filters** if required.

Equipment requirements:

- Solar panels & a support structure
- Pump (typically a **submersible** low-volume, high-lift types)
- Electrical cables and a controller
- Reservoir or storage tank
- Water pipes
- Filters (optional)

Variations/Adaptations:

- Pump size and type will depend on the system size
- Wind can also be used as a power source for water pumps (windmills)
- A tracking solar panel can increase the water output by 25-30% although it is more-costly and requires maintenance
- Mobile solar water purifiers can be purchased or constructed to supply clean water at a smaller scale although this may be more-costly

Seasonal variations:

- Lower output in cloudy weather
- Dependent on the level of the water table

Illustrations/ Diagrams:

Photos:

E.5.5. Solar borehole pump

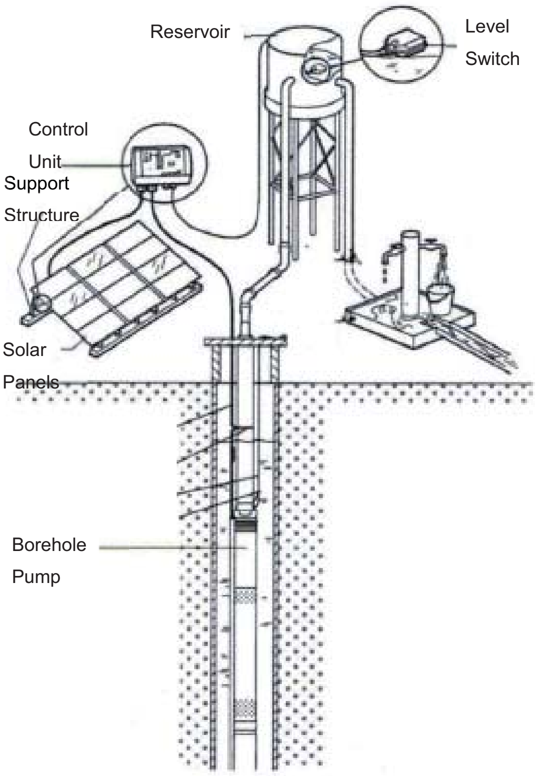


Figure E.5.5-1: Diagram of a solar borehole pump. (Source: Practical Action)

Figure E.5.5-2: Solar borehole pump. (Photo: S. Braid)

MAINTENANCE

Maintenance requirements:

- Solar panels should be kept clean. Be careful not to scratch the panel glass when cleaning. Use a damp soft cloth to clean.
- Check pipes & reservoir for leaks.

Potential drawbacks/disadvantages:

- Reduced water output in cloudy or rainy weather conditions.
- Limited water use applications due to the quality of the pumped water. Filters may be required to improve the quality.
- Solar panels may attract theft and vandalism.

REFERENCES

Definitions:

- **Aquifer** – An underground layer of rock, sand or gravel, or soil that holds water.
- **Reservoir** – A natural or man-made area used as a source of water supply.
- **Array** – A linked collection of two or more solar panels.
- **Submersible** – Capable of operating underwater.
- **Filters** – A device used for removing impurities from a liquid.

See also:

Guideline E.3.2. Borehole pump maintenance
Guideline E.5.6. Wind pump
Guideline C.2.1. Roof runoff and storage
Guideline C.1.3. Excess water re-use

Further references:

a. Green Empowerment, Solar Pumping Systems (SPS) Introductory and Feasibility Guide
b. www.greenempowerment.org
c. Journal of Innovative Research in Engineering and Sciences, Construction and Installation of Solar Powered Borehole for a Primary Health Centre, 2013
d. Practical Action, Solar Photovoltaic Waterpumping – http://practicalaction.org
e. Oxfam, Solar Powered Borehole Pumps – http://www.bvsde.paho.org/texcom/desastres/oxfaspbp.pdf
f. https://www.environment.gov.za/projectsprogrammes/greenfund

E.5.6. Wind pump

OVERVIEW

E.5.6. Wind pump

The force of the wind can mechanically drive a borehole pump, eliminating the need for electrical components, to provide a local source of water and reduce the need to fetch or manually pump water.

Objectives:

- Structure built adjacent to the home or within a village or community
- To provide a source of clean water for human consumption
- To replace more labour-intensive hand pumps

Criteria for application:

- It is essential to involve an engineer or an individual with experience in the planning and building of these structures
- Aquifer or water table of suitable water quality at an accessible depth
- Should be placed in open windy area

Catchment perspective:

- Reduces the need to carry water long distances
- Replaces dependence on labour intensive hand pumps to obtain water for consumption

Benefits:

- Local/community water supply
- Water for livestock
- Irrigation
- Low maintenance

Legislation:

National Water Act, Act 36 of 1998.

Funding opportunities:

- The 'Greenfund'[a] established by the Department of Environmental Affairs (DEA) and implemented by the Development Bank of Southern Africa (DBSA).
- Renewable Energy forms part of the Low Carbon Economy (LCE) window of the 'Greenfund'.
- This window is open to proposals from the private sector (including small and medium enterprises), research and non-governmental organisations.

MAINTENANCE

Maintenance requirements:

- Check pipes & reservoir for leaks
- Lubricate the main shaft and crankshaft as required

Potential drawbacks/disadvantages:

- Water output is reduced when the wind speed is low
- Fairly complicated process to construct relative to other methods and may require technical expertise

METHODOLOGY

Methodology:

1. Determine the local demand for water. This will be based on the size of the local community and their water needs.
2. Determine the available water supply including depth and well recovery rate. The borehole should be sited appropriately, e.g. 50-100 m away from pit latrines or waste sump sites.
3. Based on the above information, size the system and its subcomponents appropriately. This process must take into account:
   a. Storage requirements (reservoir size)
   b. The required water pressure (depth of borehole and height of reservoir)
   c. Pump type and size to meet the lifting requirements
4. Connect pump to the pump rod and pipes
5. Carefully dig/drill the well
6. Construct a suitably strong and stable support structure about 4-5 m high. This can be built from any suitable material available (wood, metal bars, etc.) This needs to be securely anchored to the ground and should **taper** towards the top so as not to interfere with the rotating wind wheel.
7. Construct a rotor frame for the wind wheel and attach blades or sails depending on locally available material.
8. Connect the centre of the rotor to a shaft and install on a rod/pipe structure at the top of the support structure allowing the rotor to rotate into the wind.
9. Construct a tail vane to steer the rotor to face the wind direction and connect to the back of the rotor
10. Connect the main shaft to the connecting rod using a crank-shaft type arrangement to convert the rotational motion from the motor to a **reciprocating** motion to drive the pump
    Install the pump and required water pipes, as for a conventional borehole pump

Illustrations/ Diagrams:

E.5.6. Wind pump

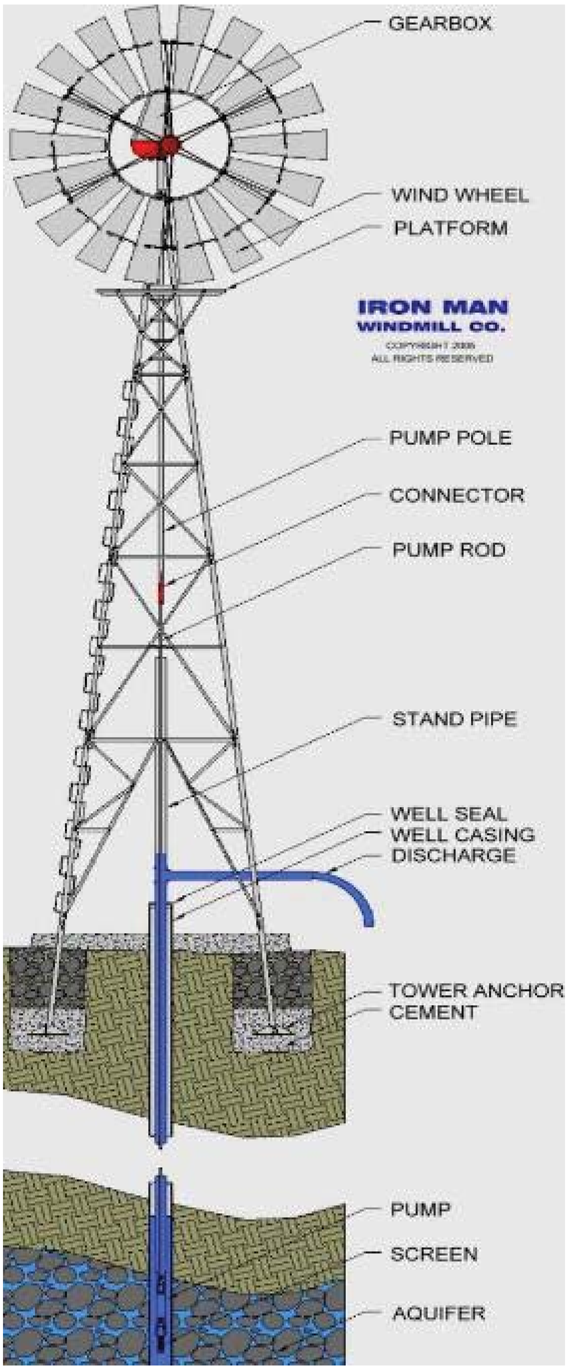


Figure E.5.6-1: Diagram of a Wind Pump [b]

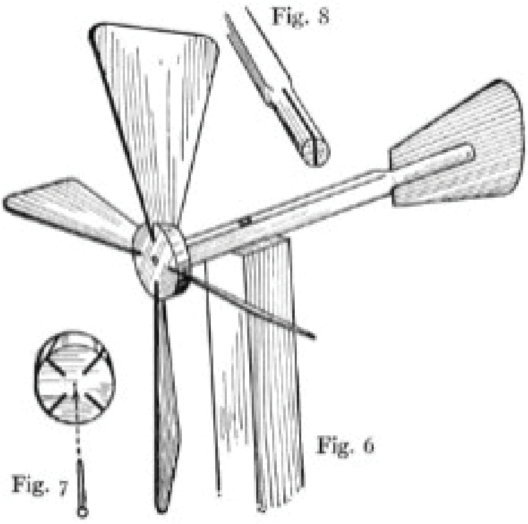


Figure E.5.6-2: Diagram of the blades of a wind pump [b]

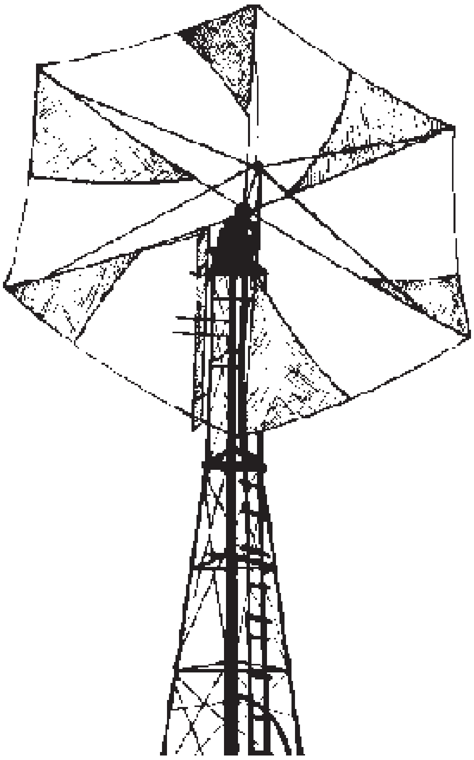


Figure E.5.6-3: Drawing of a wind pump [b]

Variations/Adaptations:

- Pump size and type will depend on the system size
- Blade/sail design can be varied according to locally available material
- Solar energy can also be used as a power source for water pumps
- Can be adapted to mill corn

Equipment requirements:

- Material for a support structure (wood or metal)
- For best results use bearings for the rotor and head
- Blades or sails (can be wood, sheet metal, or fabric type sails – adjust design according to locally available materials)
- Connecting rod
- Pump (typically a reciprocating or submersible low-volume, high-lift types)
- Reservoir or storage tank
- Water pipes

E.5.6. Wind pump

Photos:

Figure E.5.6-4: Wind Pump [b]

Seasonal variations:

- Output dependent on wind
- Dependent on the level of the water table

REFERENCES

Definitions:

- **Taper** – The narrowing of the wind pump structure towards the top.
- **Reciprocating** – Backwards and forwards motion in a straight line.

See also:

Guideline C.1.3. Excess water re-use
Guideline C.2.1. Roof runoff and storage
Guideline E.3.2. Borehole pump maintenance

Further references:

a. https://www.environment.gov.za/projectsprogrammes/greenfund

b. Dick Stanley, The Arusha Windmill: A Construction Manual, http://pdf.usaid.gov/pdf_docs/pnaak967.pdf

c. UNESCO, Consolidation of Information: Windpump Handbook, http://unesdoc.unesco.org/images/0005/000526/052605eb.pdf

E.5.7. Micro hydropower

OVERVIEW

Electric power can be generated on a community or village scale by installing small turbines in the flow path of a river if suitable conditions exist.

Objectives:

Structure built in area where there is a significant difference in water levels, e.g. waterfall or rapid, and a high enough associated flow rate to be used to generate electric power for use in a community or village.

Catchment perspective:

- Reduced dependence on charcoal as a fuel supply, thereby reduce deforestation in the catchment.
- Dependant on catchment management to ensure a constant flow of sediment-free water.

Legislation:

- National Environmental Management Act 107 of 1998.
- National Water Act 36 of 1998.

Criteria for application:

- It is essential to involve an engineer or an individual with experience in the planning and building of these structures
- A constant source of water supply with sufficient constant flow rate and geographical height difference (head) to allow for generation of power
- There should be a suitable geographical location where a pipe/**penstock** with intake structure can be constructed at a higher elevation than the lower outlet structure
- This solution can supply loads of anything up to 10kW or possibly more depending on the water resource
- Dependant on legislation, approval from the local authority may be required for the installation of this equipment in rivers

Benefits:

- Reduced dependence on charcoal
- Readily available low-cost fuel source near established water courses
- Provides environmentally friendly and reliable source of electric energy

Funding opportunities:

- The 'Greenfund'[a] established by the Department of Environmental Affairs (DEA) and implemented by the Development Bank of Southern Africa (DBSA).
- Renewable Energy forms part of the Low Carbon Economy (LCE) window of the 'Greenfund'.
- This window is open to proposals from the private sector (including small and medium enterprises), research and non-governmental organisations.

METHODOLOGY

Methodology:

1. Find suitable location on river/stream flow
2. Determine maximum usable difference in elevation (head) between proposed intake and outlet
3. Determine the daily flow rate and determine the approximate potential power as follows:

   $P = 9.8*0.8*H * Q$ where:

   P = Power in kW

   H = head in m

   Q = flow rate in cubic meters per second

   (80% efficiency assumed)
4. Determine the optimum type of hydro turbine required from the various types available.
5. Procure suitable turbine set
6. Design and construct suitable intake and outlet structures as well as intake/outlet pipes/penstocks
7. Energy can be used to charge battery sets for distribution

Photos:

Figure E.5.7-1: Turbine in a river [b]

Figure E.5.7-2: Cross-flow turbine [b]

E.5.7. Micro hydropower

Figure E.5.7-3: **Cross flow turbine** [b]

Equipment requirements:

- Civil works for intake and outlet structures as well as mounting of micro hydro unit
- PVC/Steel pipes for inlet and outlet penstocks
- Depending on the way in which the hydro power is integrated into the community this solution may require batteries for storage or connection into an existing local grid.

Illustrations/ Diagrams:

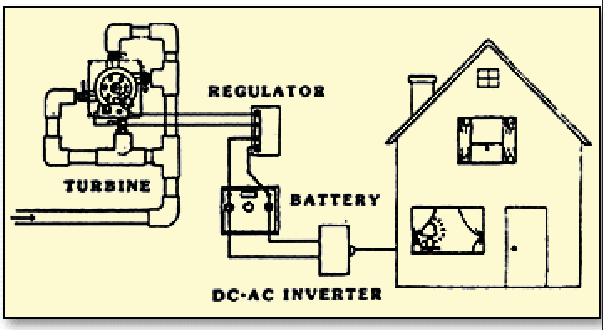


Figure E.5.7-4: Diagram of a turbine system [b]

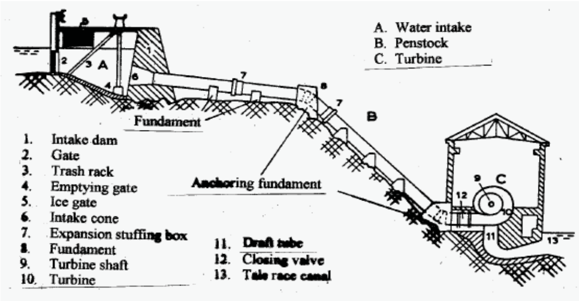


Figure E.5.7-5: Diagram of a Pelton turbine [b]

Variations/Adaptations:

There exist several types of hydro power turbines based on the amount of water available as well as the available Head including:

- Pelton (high head)
- Francis (medium head)
- Cross Flow, propeller type (low head/high flow rates)

Seasonal variations:

- The power output will depend on water flow, if this reduces during a dry season, the power output will reduce as well. Caution should be taken operating the pump if the water flow reduces below the system requirements as this could cause damage to the turbine.

MAINTENANCE

Maintenance requirements:

- Cleaning of waterways and lubrication of rotating parts as may be required
- Maintenance of electrical systems by qualified electrician

Safety requirements:

- For high head installations care should be taken for high pressure water
- Normal safety requirements regarding electricity should be adhered to

Potential drawbacks/disadvantages:

- Reduced power output during dry seasons.
- Fairly complex and costly to construct.
- Construction will require supervision from a suitably qualified person/engineer.

REFERENCES

Definitions:

Penstock – A channel or pipe used for directing the flow of water to a waterwheel or hydroelectric power plant.

See also:

Guideline C.5.1. Diversion weirs

Further references:

a. https://www.environment.gov.za/projectsprogrammes/greenfund
b. Best practices for sustainable development of micro hydro power in developing countries, Khennas et al. 2000. (http://www.microhydropower.net/download/bestpractsynthe.pdf)
c. Ashden Sustainable solutions: http://www.ashden.org/micro-hydro
d. hydroCoil Power
e. http://www.hydrocoilpower.com/

E.5.8. Biogas digester

OVERVIEW

Biogas digesters collect the methane gas released by organic waste – especially manure and urine. This can then be collected or piped and used for cooking, heating or lighting reducing the need for wood or charcoal burning stoves.

Objectives:

- Structure built adjacent to the home or within a village or community:
- To utilise organic waste to generate methane as an alternative source of fuel primarily for cooking or heating

Catchment perspective:

Reduced dependence on charcoal as a fuel supply, thereby reduce deforestation in the catchment, and reduce respiratory health problems.

Criteria for application:

- It is important to involve an engineer or an individual with experience in the planning and building of these structures
- There should be an available source of organic waste material such as:
  - manure (includes dung, urine, etc.) from cattle, goats, sheep or other livestock
  - Crop residues (maize, sugar cane, sorghum, tobacco, etc.)
  - by-products/waste from any agricultural industry
- A pressure relief valve must be installed
- Sufficient open space to allow installation below ground level.

Benefits:

- Reduced dependence on charcoal
- Readily available low-cost fuel source
- Provides a sanitary way to dispose of organic waste
- **Effluent** bi-product is a good fertilizer
- Smell of the gas is unpleasant which allows leaks to easily be identified

Funding opportunities:

- The 'Greenfund'[a] established by the Department of Environmental Affairs (DEA) and implemented by the Development Bank of Southern Africa (DBSA).
- Renewable Energy forms part of the Low Carbon Economy (LCE) window of the 'Greenfund'.
- This window is open to proposals from the private sector (including small and medium enterprises), research and non-governmental organisations.

Legislation:

Gas Act No. 48 of 2001

Stipulates that NERSA registers all small biogas projects not connected to the grid. Depends on size, small household digesters don't trigger but the larger ones do.

METHODOLOGY

Methodology:

1. Determine the size of bio-digester to be constructed. Dependent on amount of manure available and gas/energy requirements. Gas produced from 5 l of manure and 15 l of water is approximately equivalent to a 9 kg gas cylinder.
2. Select a suitable location for the digester – areas susceptible to flooding should be avoided. The area should also be well **ventilated**
3. Dig a pit of the appropriate size
4. Depending on the design the pit can be lined with brick, concrete, clay or plastic
5. The pit should be covered with an extraction point located at the top and centre. Cover design should take into account local materials available
6. A **pressure release valve** must be installed for safety reasons if the pressure gets too high
7. Install piping and an outlet valve to direct and control the flow of gas as required
8. A pipe must be also installed to drain the effluent which can be collected in a bucket and makes excellent organic manure
9. The digester should be fed daily with manure and water in a ratio of approximately 1:3, i.e. for every 1 measure of manure add 3 measures of water
10. It will take 6-8 weeks to start producing a steady gas supply
11. The gas is then piped from the digester to the stove, and the gas feeds the flame of the stove

Equipment requirements:

- Gas supply outlet valve
- Pressure release valve
- PVC piping
- Construction materials determined by design and the availability of local material

Variations/Adaptations:

- The bio-digester can also accommodate human waste and some are joined to toilets
- Biogas digesters can also be procured as a pre-constructed unit and installed

Seasonal variations:

No seasonal variation however continual supply of organic matter is required to maintain gas production

Illustrations/ Diagrams:

E.5.8. Biogas digester

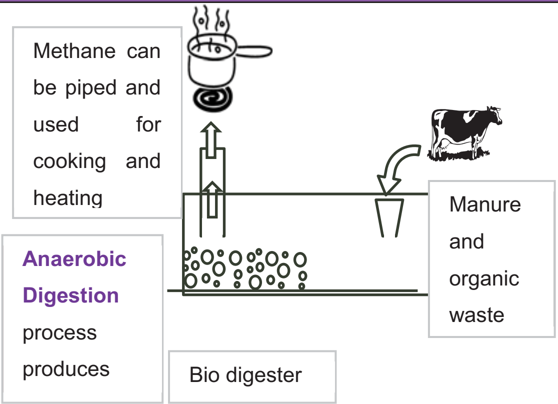


Figure E.5.8-1: Diagram of a biogas digester [b]

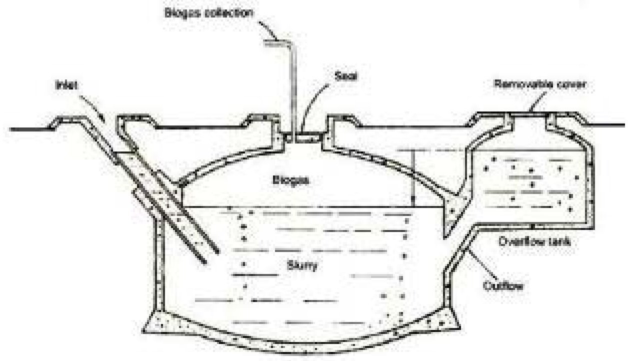


Figure E.5.8-2: Diagram of a biogas digester [b]

Photos:

Figure E.5.8-3: Biogas digester [c]

Figure E.5.8-4: Biogas digester [c]

MAINTENANCE

Maintenance requirements:

- Daily top up with organic waste material
- Check pipe regularly for cracks or leakage
- Periodic maintenance and cleaning of
- Valves

Safety requirements:

- Keep open flames away from the digester
- If the gas is piped into buildings, buildings should be well ventilated

Potential drawbacks/disadvantages:

- Requires a water supply.
- Needs to be fed daily with organic waste material.
- Methane is a Greenhouse Gas that contributes to Global Warming when ventilated to the atmosphere.

REFERENCES

Definitions:

- Biogas – A type of gas obtained from decaying organic matter that can be used as a source of fuel.
- Effluent – Liquid waste that flows into an environment that can be used as a source of fertiliser.
- Ventilated – Allowing air to enter and move around freely.
- Pressure release valve – A safety device used to control or limit the pressure in a system.
- Anaerobic digestion – Digestion that takes place in the absence of free oxygen.

Further references:

a. https://www.environment.gov.za/projectsprogrammes/greenfund
b. Bio Digester Information and Construction Manual. Guyana Energy Agency
c. Biogas Digesters. Engineering For Change. www.engineeringforchange.org
d. Biogas Stoves and Ovens. Wisions of sustainability. www.wisions.net

See also:

Guideline E.4.1. Constructing a composting toilet
Guideline E.4.4. Operating and maintaining a Ventilated Improved Pit (VIP) Latrine

E.5.9. Solar Turtle

OVERVIEW

The Solar Turtle is a container based solar **kiosk** that provides communities with easy access to electricity. It serves as a central battery charging station whereby community members can purchase plastic bottles of different sizes containing batteries, to supply electricity to their homes. The plastic bottles (batteries) can then be returned to the solar charging station for recharging at a small price. The Solar Turtle is an initiative undertaken by *Ugesi Gold* which is a renewable

E.5.9. Solar Turtle

energy social business that focusses on rural electrification. The Solar Turtle requires a significant amount of capital, however it is possible for rural communities to construct a similar system based on the Solar Turtle concept, although this may require supervision by a suitably qualified person/engineer.

Objectives:
To provide rural communities with easy and clean access to energy for lighting, heating & charging of electrical devices such as cell phones.

Catchment perspective:
Reduced dependence on charcoal or paraffin as a fuel supply, thereby reducing deforestation in the catchment, as well as reducing potential fires in the household.

Criteria for application:
- The container requires a small area of land that provides convenient access to the Solar Turtle for community members.
- Requires an area of land where there is minimal shading from the environment.
- Requires security and responsible person for locking and unlocking the solar panels.
- Requires funding for purchasing the Solar Turtle due to the high initial cost.

Benefits:
- Reduce indoor smoke and fumes from burning fuels resulting in a potential health benefit.
- Reduced deforestation as the use of wood and charcoal can be reduced.
- Operates on a similar concept as that of a gas cylinder, i.e. purchase energy, use and refill.
- The Solar Turtle is easy to transport and install anywhere.
- Consists of a secure panel mounting design that folds away to prevent theft.
- It is scalable and portable.
- The container can also be used to vend merchandise, e.g. airtime, colddrinks, etc.

Funding opportunities:
- World Bank and International Finance Corporation (IFC) initiatives such as Lighting Africa and Lighting global.
- The 'Greenfund'[a] established by the Department of Environmental Affairs (DEA) and implemented by the Development Bank of Southern Africa (DBSA).
- Renewable Energy forms part of the Low Carbon Economy (LCE) window of the 'Greenfund'.
- This window is open to proposals from the private sector (including small and medium enterprises), research and non-governmental organisations.
- The Industrial Development Corporation's (IDC) Green Energy Efficiency Fund (GEEF).
- Solar Electric Light Fund[b].

Legislation:
Not applicable.

METHODOLOGY

Methodology:
1. Obtain the necessary funding for purchasing the Solar Turtle.
2. Clear any vegetation and obstacles from a suitable piece of land where the Solar Turtle is to be placed.
3. Place Solar Turtle container at the chosen location, panels should face north.
4. Appoint a responsible person(s) to take responsibility for locking and unlocking the panels at the relevant times as well as charging the batteries and all other operational features of the Solar Turtle.

Illustrations/ Diagrams:

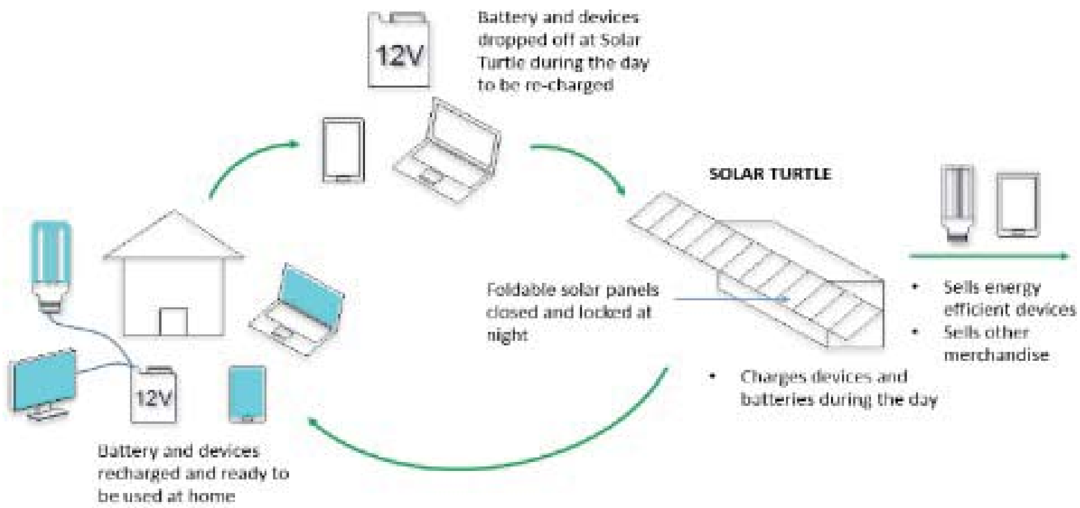


Figure E.5.9-1: Solar Turtle Operating Concept

E.5.9. Solar Turtle

Photos:

Figure E.5.9-2: Transporting the Solar Turtle[c]

Figure E.5.9-3: Unlocking the Solar Panels[c]

Figure E.5.9-4: Unfolding the Solar Panels[c]

Figure E.5.9-5: Solar Turtle in Operation[c]

Equipment requirements:

Tools to clear land of any obstacles and vegetation.

Variations/Adaptations:

- Manufactured variations with different power outputs are available.
- DC micro-grids[d] can be used at a smaller scale.

Portable or mobile solar systems can also be used at a smaller scale.

Seasonal variations:

Power output may be reduced during cloudy or rainy conditions.

Maintenance requirements:	**Potential drawbacks/disadvantages:**
• Use a clean soft damp cloth to clean solar panels before sunrise / after sunset. • Check for any wear on folding/hinge joints and replace if necessary.	• May not be able to provide enough energy to charge all batteries during cloudy or rainy weather conditions. • Batteries need to be carried/transported from houses to the Solar Turtle.

REFERENCES

Definitions:	**See also:**
Kiosk – A small structure used to vend merchandise or services.	Guideline E.5.4. Solar Electrification

Further references:

a. https://www.environment.gov.za/projectsprogrammes/greenfund
b. http://self.org/request-information/
c. http://www.ugesigold.co.za/micro-utilities
d. http://www.specializedsolarsystems.co.za/index.php/front-page-vm/dc-microgrid

E.6. Waste management (solid)

Waste management involves the generation, collection, transportation, and disposal of garbage, sewage and other waste products. Responsible waste management is the process of treating solid wastes and offers a variety of solutions for waste with the ultimate aim of changing mind-sets to regard waste as a valuable resource rather than something that must be thrown away.

The government is constitutionally bound to provide sanitation services to all of its citizens, this includes the removal and proper treatment of solid waste. In reality this is not being done in many parts of the country as Municipalities don't have the skills or funds, particularly in remote rural areas; this doesn't mean that as individuals we can't practice responsible waste management.

This guideline section therefore provides a variety of basic solutions for solid waste management that can be implemented at a household and rural village level to ensure a clean and safe environment.

E.6.1. Household waste management

OVERVIEW

E.6.1. Household waste management

In rural areas, in contrast to urban ones, land availability is not often a constraint and waste ends up being dumped or burnt with no control, which results in various undesirable health and environmental impacts. Waste, if managed properly, can lead to health benefits and to a clean environment and can be a resource to generate income and livelihood. This guideline provides instructions on how to implement responsible waste management in the house.

Objectives:

- To improve the overall cleanliness in homes and the surrounding areas
- To promote the reduction of waste generated in the home
- To promote the reuse of products in the home before throwing them away
- To promote recycling of domestic solid waste in the home
- To promote recycling of organic waste for composting or biogas digester
- To eliminate the environmental and health risks of illegal dump sites

Criteria for application:

- Social, educational status, etc.
- Local skills in building
- Sufficient space for waste separation bins
- Sufficient organic waste for composting or for a biogas digester
- Garden tools for composting
- Access to a biogas digester

Benefits:

- Cleanliness
- Reduce incidence/spread of disease
- Prevent spread of malaria

Funding opportunities:
Not applicable

Catchment perspective:
Reduces the potential for underground contamination of water by preventing the infiltration of pollutants into the surrounding soil of the illegal dump sites.

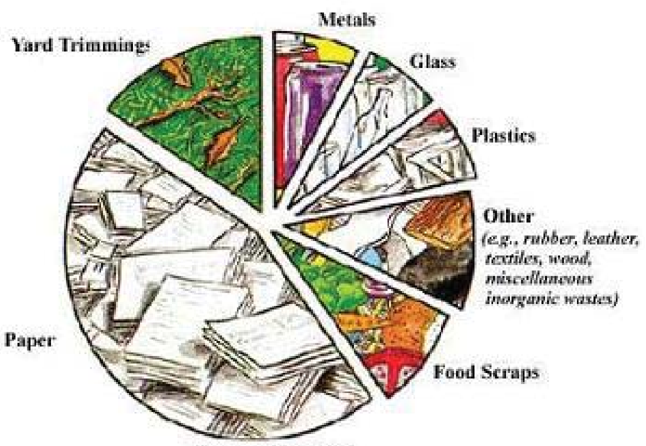
Legislation:
Not applicable at the household level

METHODOLOGY

Methodology:

1. Reduce the production of unnecessary waste by:
    a. Avoid buying packaged products
    b. Purchase durable and long-lasting goods
    c. Purchase products with minimal packaging, or purchase items in bulk or in concentrated form
    d. Seek products and packaging that are as free from toxins as possible
    e. Refuse to accept waste when buying groceries (remove the additional and unnecessary packaging and leave at the shop)
    f. Avoid use of plastic bags/substitute with alternate materials possibly bio-degradable
    g. Use products that can be used again and again, e.g. glass, metal, fabric
    h. Keep separation of waste as a priority activity at household level and recover what is possible, e.g. dry waste such as paper, plastic, glass, metal and wet organic waste
    i. Recycle what it is possible, after reusing it as much as possible, e.g. cans, glass bottles, plastic products, metal, paper, cardboard. The recycled waste can be taken to recycling depot or given/sold to a recycler
    j. Compost all the organic materials, such as food scraps, small/chopped yard trimmings
    k. Do not burn waste, as the toxic fumes reduce air quality and are bad for you
2. Dispose of what cannot be reused, recycled or composted, in a responsible way at a proper disposal site.

Illustrations/ Diagrams:



Source: U.S. EPA

E.6.1. Household waste management

Figure E.6.1-1: Non-hazardous waste management hierarchy (US-EPA)

Figure E.6.1-2: Typical composition of waste generated in the home

CAN COMPOST				DON'T COMPOST
Feathers	Old leather	bones	Cow manure	Plastic bottles
Burnt sticks	Paper and cardboard	Dead flowers and plants (avoid weeds)	Bird, chicken, dove, poultry manure	Pieces of china/ porcelain plates
Egg shells	Food scraps	Fruits and vegetables	Rabbit manure	Batteries, light bulbs
Wood ash and soot	Leaves and sticks	Organic rags, organic cloth e.g. cotton	Horse, donkey manure	Aluminium e.g. foil, wrappers, baking trays
Grass and weeds before they seed	Saw dust	Wheat, rice, nut husks	Goat, sheep, etc. manure	Any kind of plastic, including ear buds, straws, washing powder packets, plastic shoes

Table E.6.1-1: Materials that can be used as organic waste for composting (food for the soil), and materials that should NOT be added to compost. (Source: Growing Green)

Photos:

Figure E.6.1-3: Herbs growing in used cans

Figure E.6.1-4: Glass bottle garden

Figure E.6.1-5: Garden bed with tires

Figure E.6.1-6: Glass bottle wall

Figure E.6.1-7: Solar bottle bulb (clean plastic bottle, water and bleach)

Figure E.6.1-8: Carpet made from fabric scraps

Equipment requirements:

- Waste
- Individual bins for waste separation, e.g. paper and cardboard, plastics, glass and tins.
- Compost equipment
- Spade and bucket to help collecting the waste

Variations/Adaptations: See **Figures E.6.1-3 to E.6.1-8**

- Reuse of waste in construction
- Trench disposal
- Informal drop-off community facilities for recycling materials
- Community mobilisation – once a month promote community/village/ market clean-up

Seasonal variations:
Not applicable

E.6.1. Household waste management

MAINTENANCE

Maintenance requirements:

- Separation bins must be kept clean
- Hygienic waste management practices must be followed

REFERENCES

Definitions:

- **Recycling:** Convert something into a reusable material
- **Compost:** Decayed organic material used as a fertiliser

See also:

Guideline B.2.1. Compost making
Guideline C.2.5. Hillside runoff (Swales)
Guideline E.5.8. Biogas digester
Guideline E.6.2. Ecobricks
Guideline E.6.3. Village waste management

Further references:

a. http://refurbished-ideas.com/10-recycled-ideas-garden/
b. http://www.lovelytrash.com/projects-category/garden-and-outdoors/
c. http://www.pinterest.com/rosewitchrose/glass-bottle-walls/
d. http://aliteroflight.org/wp/wp-content/uploads/2012/09/Liter_Of_Light-How_to_build_a_Solar_Bottle_Bulb-English.pdf
e. http://www.knack.org/press/new-uses-old-textiles
f. Growing Green – Food and trees for Africa

E.6.2. Ecobricks

OVERVIEW

In the household, many things are wrapped or packaged in plastic, carried in plastic bags, or labelled with plastic. Not all plastics can be recycled, and therefore end up littering the environment or taking up space in landfill sites and contaminating water resources. This guideline demonstrates how to make a building brick by reusing the plastic packaging, wrappers, labels, etc. The bricks can then be used for building construction, furniture, vegetable plants, fencing, etc.

Objectives:

- To improve the overall cleanliness in the house and village
- To eliminate the environmental and health risks of litter.
- To reduce the volume of plastic washing into rivers, water resources and the ocean.

Criteria for application:

- Clean, non-recyclable plastic and wrappers, e.g. sweet, chips, clingwrap, packaging, shopping bags. Harder plastics such as bottle rings, or large pieces of plastic can be cut.
- Ecobricks can then be used for a variety of applications, e.g. building vegetable box, building furniture, or even fences and buildings.

Catchment perspective:

Reduces the potential for underground contamination of water by preventing the infiltration of pollutants into the surrounding soil of the dump sites.

Benefits:

- Cleanliness
- Reduce waste to landfill
- Provide alternative building materials
- Reduces incidence/spread of disease

Funding opportunities:

Not applicable

Legislation:

Not applicable

METHODOLOGY

Methodology:

1. Collect clean and dry household waste. We recommend only waste that you cannot recycle, but you can EcoBrick anything non-biodegradable and dry.
2. Twist or cut the waste and insert it into a plastic bottle. Compress it as tightly as you can with a stick.
3. Keep doing this – the strength of the brick is that all the gaps are filled and the bottle can't be squashed.
4. When your EcoBrick is done – check if you can squeeze the bottle by more than 10% with one hand, if you can then you should add more waste. If not, then you are done.
5. Put the lid on, and start your Ecobrick project.

Illustrations/ Diagrams:

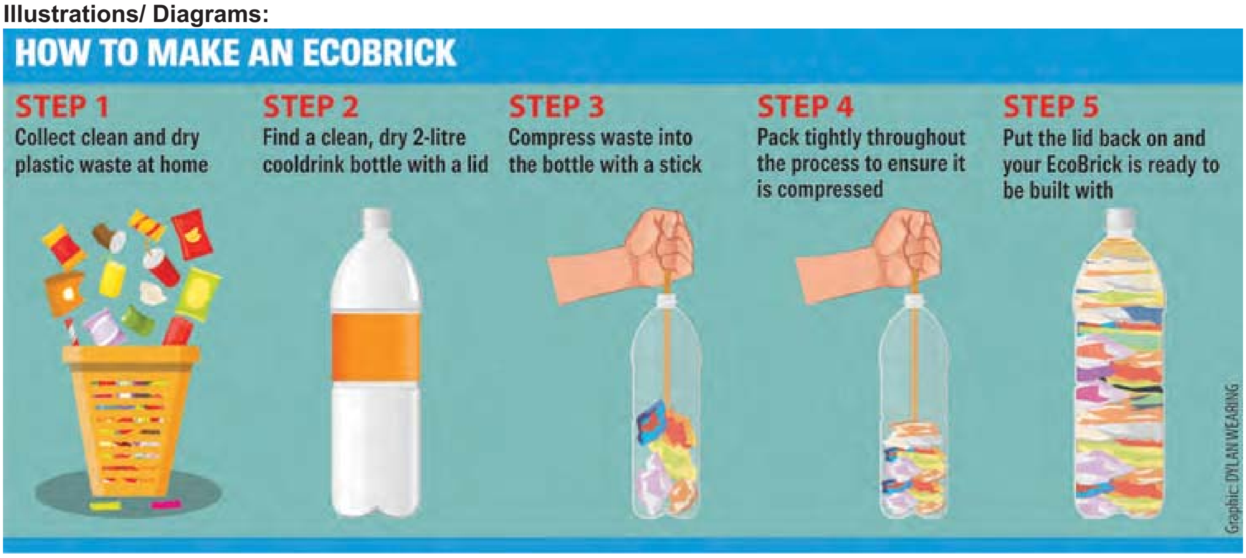


Figure E.6.2-1: Process to make an Ecobrick.

E.6.2. Ecobricks

Photos:

Figure E.6.2-2: Ecobrick tree basket

Figure E.6.2-3: Laying Ecobricks as walls of a house.

Equipment requirements:

- Collected and cleaned plastic wrappers, labels, packaging; cut into smaller pieces if necessary.
- Plastic bottle, e.g. 500 ml, 1 litre, or 2 litre bottles, with the lid.
- Stick to compact.

Variations/Adaptations:

- Use different size bottles for different designs or structures.
- Put colour plastics at the bottom of the bottle to make patterns when using the bricks.

Seasonal variations:
Not applicable

Figure E.6.2-4: Ecobrick vegetable box. (Source: Two Oceans Aquarium)

Figure E.6.2-5: Ecobrick Furniture

Figure E.6.2-6: Ecobrick Fences and walls

MAINTENANCE

Maintenance requirements:	**Potential drawbacks/disadvantages:**
• Be careful not to puncture the bottle with the stick, else water will get into the bottle.	• Material to fill the bottles must be clean, else food waste will rot and cause gas build up in the bottle.

REFERENCES

Definitions: Not applicable

See also:
Guideline E.6.1. Household waste management
Guideline E.6.3. Village waste management
Guideline E.6.4. Buy back centres

Further references:

a. Two Oceans Aquarium: https://www.aquarium.co.za/blog/entry/how-to-make-ecobricks-reducing-waste-at-home
b. http://www.ecobricks.org

E.6.3. Village waste management

OVERVIEW

In communal rural areas, solid waste is left on open land or dumped on the roadside. Food scraps and plastic bags present in dumped waste creates unpleasant odours and can contribute to the spread of diseases. Waste often spreads from these sites into drains causing blockages leading to local flooding and results in various undesirable health and environmental impacts. This guideline provides instructions on how to implement a waste management program for village scale.

Objectives:

- To improve the overall cleanliness in the village
- To eliminate the environmental and health risks of illegal dump sites

Catchment perspective:
Reduces the potential for underground contamination of water by preventing the infiltration of pollutants into the surrounding soil of the dump sites.

Criteria for application:

- Social and educational status
- Sufficient space for communal waste separation bins
- Sufficient space for making compost
- Regular waste collection by the Municipality
- A properly operated and licensed waste disposal site

Benefits:

- Cleanliness
- Provides a large quantity of organic waste needed for the community's biogas digester or compost heap
- Reduces incidence/spread of disease

Funding opportunities:

- Municipality

Legislation:
National Environmental Management: Waste Act 59 of 2008.

METHODOLOGY

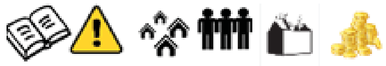
Methodology:

6. All waste management practices are to comply with national legislation. Waste management is the responsibility of the municipal district that the village is located in.
7. Allocate a few hours on one day a month to clean up the village. All members of the village must be involved.
8. Pool the resources between the surrounding communities to collectively manage the waste
9. Individuals of the village must be encouraged to minimize producing waste
10. Avoid use of plastic bags; substitute with alternate materials possibly bio-degradable
11. Sell products with minimal packaging, or sell items in bulk or in concentrated form
12. Have separation of waste as a priority activity, e.g. dry waste such as paper, plastic, glass, metal and wet organic waste. Locate collection points in prominent easy to reach places in the village area, especially for recycling
13. Compost all the organic materials, such as food scraps, or alternatively organise to collect the organic waste and send to the surrounding communities that already have compost making equipment
14. Dispose what cannot be reused, recycled or composted, in a responsible way at the legally designated waste disposal sites

Should a proper (licensed) waste disposal site not be located in or within a reasonable distance to the village and the municipality does not offer any other legally compliant alternative, an environmentally acceptable solution (albeit illegal) is to create a small dumpsite for the village. To do this:

1. Identify a waste disposal site away from water sources; must be in non-sandy soils. Surround the site with swales to direct stormwater and runoff away from the disposal site. Dig a trench around the disposal site, line with clay and partially re-fill with soil, then vegetation. This will help prevent leachate seeping out of the site. Keep a firebreak around the disposal site as decomposition produces highly flammable gases. Plant windbreaks between the swales and the trenches to protect from wind.
2. Dig a disposal pit
3. Line the disposal pit with clay.
4. When digging a hole to dump the waste store the topsoil for future waste coverage
5. Make sure that the waste is covered with a layer of soil or clay to avoid odours, vermin and windblown litter
6. **Do not burn waste**, as the toxic fumes reduce air quality

E.6.3. Village waste management



Illustrations/ Diagrams:

Figure E.6.3-1: Non-hazardous waste management hierarchy (Source: US-EPA).

Figure E.6.3-2: Illegal dumpsite

Variations/Adaptations:

- Reuse of waste
- Create products from recycled waste, e.g. tins and plastic bottles for nursery planting; plastic bags can be woven for basket weaving and string/ rope weaving

Equipment requirements:

- Different covered waste bins/containers for temporary storage allowing waste separation
- Compost making equipment in the surrounding communities
- Spades and buckets to help collecting the waste

Seasonal variations:

Divert clean stormwater from waste disposal site during the rainy season

MAINTENANCE

Maintenance requirements:

- Regular upkeep and general maintenance of the waste disposal site
- Regular litter collection and removal in the village

Potential drawbacks/disadvantages:

- No Municipal waste collection services
- No licensed waste disposal site
- No buy-in from the community

REFERENCES

Definitions:

- License: A valid waste management license for a site issued by the Department of Environmental Affairs
- Leachate: Water contaminated with waste. It is brown in colour and smells, it is also toxic.

See also:

Guideline A.3.2. Contour vegetation rows
Guideline B.2.1. Compost making
Guideline E.5.8. Biogas digester
Guideline E.6.1. Household waste management
Guideline E.6.2. Ecobricks
Guideline C.2.5. Hillside runoff (Swales)
Guideline E.3.1. Living fences and wind breaks
Guideline F.1.3. Fire breaks

Further references:

c. http://www.sanitation.kerala.gov.in/docs/pdf/malinya_muk_kera.pdf Accessed online at
d. http://www.recyclenewmexico.com/recycling_scraps_May20_2009.htm
e. http://www.unesco.org/csi/pub/papers/mega10.htm
f. https://www.kfw-entwicklungsbank.de/International-financing/KfW-Entwicklungsbank/Sectors/Transport/Projektbeispiele/Bangladesch-M%C3%A4rkte/ (Accessed October 2014)
g. Growing Green – Food and trees for Africa

E.6.4. Buy back centres

OVERVIEW

E.6.4. Buy back centres

Many unemployed people earn some income collecting and selling recyclable goods on an informal basis. Waste picking is therefore an important alternative for those who cannot find employment in the formal labour market due to a lack of skills. Buy back centres (BBCs) play a crucial role in facilitating the recycling potential of these informal sector participants. BBCs are depots where waste collectors can sell their recyclable waste. The BBCs, in turn, sell these waste products to other larger BBCs or directly to recycling companies. Formal recycling companies process the recyclable waste into a form that is readily usable by a manufacturer or end-use market, where the recyclable waste is converted into materials or other consumption products. BBCs are the link between formal and informal sector activities.

Objectives:

- To improve the overall cleanliness in the village
- To eliminate the environmental and health risks of illegal dump sites
- Informal job creation

Catchment perspective:

Reduces the potential for waste build up and contamination of water resources.

Criteria for application:

- Social and educational status
- Sufficient space for facility
- Regular waste collection by the Municipality or by informal waste pickers
- Sufficient densities of recyclable waste
- A valid waste management license

Benefits:

- Cleanliness
- Provides a place for waste pickers to bring their products to sell
- Reduces incidence/spread of disease

Funding opportunities:

- Municipal funding

Legislation:

National Environmental Management: Waste Act 59 of 2008.

METHODOLOGY

Methodology:

1. The location and operation of BBCs needs to be aligned with the municipalities Integrated Waste Management Plan (IWMP) and therefore should be controlled by the municipality but not necessarily operated by them.
2. A Waste Management License is required to establish and run a BBC; therefore, it is recommended that the municipality choose the location of the sites and be the permit holders but rent out the actual operation and running of the facility to private contractors.
3. This will be a job creator in the area.
4. The main activities of BBCs are the basic tasks of receiving, weighing, sorting and packing the recyclable waste. They rely heavily on waste collected by individual waste collectors. For this reason, they should be close enough and accessible to the informal waste collectors.
5. To be viable it should be close to an area where sufficient quantities of recyclables, i.e. shops, taxi rank
6. The BBCs should be careful not to inconvenience the people, residents or businesses in the immediate vicinity of the BBCs

Illustrations/ Diagrams:

Figure E.6.4-1: Buy back centre in Johannesburg

E.6.4. Buy back centres

Figure E.6.4-2: Informal waste pickers

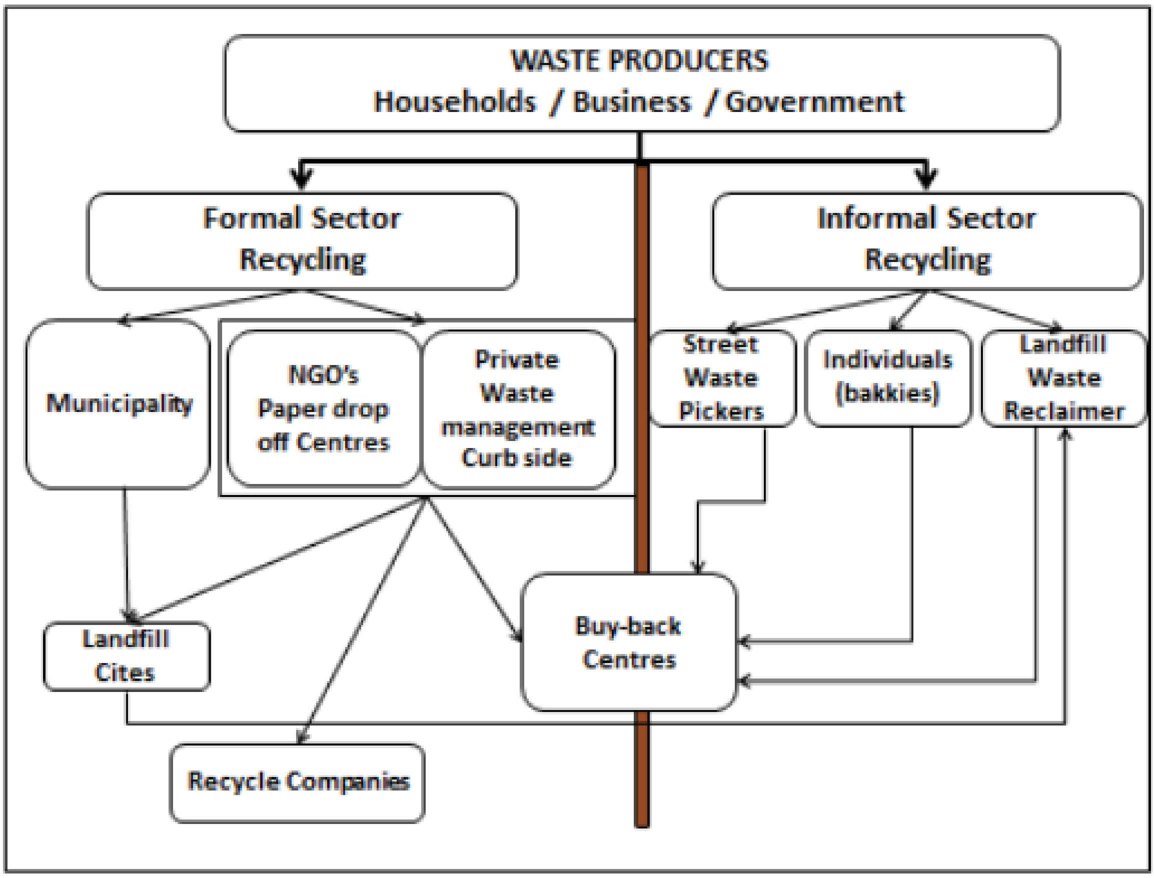


Figure E.6.4-3: General overview of the waste recycling industry. (Source: DEA)

E.6.4. Buy back centres

Variations/Adaptations:

- The BBC can be owned by the Municipality but operated by an independent contractor
- The BBC can be owned and operated by an independent contractor
- Separation of waste at source makes this task easier

Equipment requirements:

- Fenced land
- Covered and paved area
- Scales
- Loading equipment

Seasonal variations:
The area must be covered to prevent waste being contaminated by rain

MAINTENANCE

Maintenance requirements:

- Regular cleaning of the facility
- Servicing of the scales
- Security of the premises

Potential drawbacks/disadvantages:

- Health risk to the waste collectors, proper PPE must be worn
- Capital cost to buy the land and construct the facility
- Cost and effort to apply for waste management license

REFERENCES

Definitions:
Not applicable

See also:
Guideline B.2.1. Compost making
Guideline E.6.1. Household waste management
Guideline E.6.2. Ecobricks
Guideline E.6.3. Village waste management

Further references:

a. Viljoen, Schenck, Blaauw: The role and linkages of buy-back centres in the recycling Industry: Pretoria and Bloemfontein

F DISASTER PREPAREDNESS

CATCHMENT MANAGEMENT GUIDELINES	ISSUES										CAPACITY					
F. Disaster Preparedness	Soil Erosion	Loss of soil fertility	Sedimentation	Water degradation and depletion	Floods	Overgrazing / Deforestation	Threat to biodiversity	Loss of crop yields / Livestock fodder	Risk to infrastructure	Reduced standard of living	Prevention/Rehabilitation	Legislation	Scale	Labour requirement	Complexity	Cost
F.1. Fire management																
F.1.1. Firefighting wildfires (practical)	■						■	■	■		Prevention	Other	Village	Few people	Complex	Medium cost
F.1.2. Firefighting tools (construction and usage)	■						■	■	■		Prevention	Other	Household	Single person	Simple	Free to little
F.1.3. Firebreaks	■						■	■	■		Prevention	Other	Village	Few people	Simple	Medium cost
F.2. Landslide and land collapse																
F.2.1. Preventing, identifying and recovering from landslides	■	■	■						■		Prevention	Other	Catchment	Few people	Complex	Expensive
F.3. Health																
F.3.1. Bilharzia prevention and response				■						■	Prevention	Other	Household	Single person	Simple	Free to little
F.3.2. Cholera response - Oral rehydration				■						■	Prevention	Other	Household	Single person	Simple	Free to little
F.3.3. Cholera response - Food hygiene				■						■	Prevention	Other	Household	Single person	Simple	Free to little
F.3.4. Waterborne illness				■						■	Prevention	Other	Village	Single person	Simple	Free to little
F.4. Emergency Response Procedures																
F.4.1. Community emergency response										■	Prevention	Other	Catchment	Few people	Simple	Free to little
F.4.2. Community emergency response - Flood					■			■	■	■	Prevention	Other	Catchment	Few people	Advanced	Medium cost
F.4.3. Community emergency response - Drought								■		■	Prevention	NWA/NEMA	Catchment	Few people	Advanced	Medium cost

KEY: Capacity Icons					
Action	**Legislation**	**Scale**	**Labour**	**Complexity**	**Cost**
Prevention	Other	Household	Single person	Simple	Free to little
Rehabilitation	NWA/NEMA	Village	Few people	Advanced	Medium cost
		Catchment	Many people	Complex	Expensive

Disasters and emergencies can happen anywhere and anytime. However, in areas where natural resources are degraded or where no disaster planning has taken place, the communities are more vulnerable to the effects of the disasters. Fires can damage and destroy houses, forests, crops and grazing land. Floods can cause personal danger to communities, and can also wash away good farming soil if there is no village-level emergency planning in place. Floods can cut off access to clean water supply, and contribute to the spread of illnesses such as cholera. These guidelines provide techniques for practical firefighting. The guidelines also provide information about waterborne diseases such as bilharzia and cholera – and how to provide basic treatment for these. Guidelines provide techniques for emergency planning to ensure preparedness for future disasters and emergencies.

F.1 Fire management

The guidelines on fire management present best-practice firefighting methods. The specific topics of each guideline range from surveying the area and forecasting fire behaviour, to planning and implementing firefighting. Guidance is given on how to make and use the tools needed to fight fires safely, as well as how to make firebreaks to defend forests from runaway fires.

F.2 Landslide and land collapse

These guidelines focus on the impacts of landslides and land collapse and the mitigation strategy

F.3 Health

The health guidelines focus on waterborne diseases and present simple ways to keep yourself and your family healthy. General best-practice for keeping yourself safe from a variety of waterborne illnesses is described. Specific guidance is given on how to prevent and treat three of the most common waterborne diseases: malaria, bilharzia and cholera (note: these do not replace instructions from the Ministry of Health or a doctor). Lastly, best-practices for funerals are highlighted, describing how to limit the spread of communicable diseases.

F.4 Emergency Response Procedures

These procedures provide guidance for communities on how to respond to a variety of emergency situations. Guidelines are given for dealing with both fast occurring, life-threating emergencies (for example floods), as well as for longer lasting events (for example droughts). Procedures to introduce an early warning system for flooding are presented. The guidelines focus on describing practical ‘on the ground’ activities that will help limit the impact of these emergencies on the community and their livelihoods.

F.5 Risk Management

It is difficult to ask communities to protect their environments if their households are not safe. These guidelines provide guidance on risk assessments around the household and how to mitigate the risks for example – don’t leave live flames unattended. The resultant disaster from poor household risk management can have much larger detrimental impacts to the village and catchment.

F.1.Fire management

F.1.1. Firefighting wildfires (practical)

OVERVIEW

This guide seeks to introduce the simple practical methods of fighting wildfires through an emphasis on understanding the fire life cycle, personal safety and being able to predict fire behaviour based on terrain, vegetation and weather.

Objectives:
To introduce and educate communities regarding safe and effective wildfire fighting practices.

Catchment perspective:
Try to limit damage through fire-related activities to natural vegetation and agricultural land as well as to community assets. Capacitate the community to help combat wildfires where safe to do so.

Criteria for application:
Fires are prevalent in all communities. The risks associated with firefighting are enhanced by factors such as vegetation density/age, weather, topography, building materials, community assets, and slash and burn practices.

Benefits:

- Educate community members about effective fire practice to limit the incidence of death/injury to those involved in firefighting activities
- Reduce the extent of damage to assets/property caused by fires and limit the extent of burnt vegetation

Funding:
Not applicable

Legislation:
National Veld and Forest Fire Act 101 of 1998.

METHODOLOGY

Methodology:

1. **Fire basics:** Fires occur when the combination of heat, fuel (solid/liquid/gas) and oxygen, i.e. a fire triangle, are present and they are ignited. Removal of any one of these factors will stop the fire
2. **Fire behaviour:** Fire will move and burn relative to the vegetation, the present/recent weather and topography
   a. Vegetation determines fire movement and speed. Drier vegetation will burn faster than wet vegetation, heavier fuel loads (trees and thick stemmed, dense bushes) will take longer to ignite and be harder to extinguish, but will generally burn longer and hotter than lighter fuels (grasses, small bushes/shrubs)
   b. Present and recent rainfall will moisten and slow burning. Wind in the vicinity of a fire will direct the fire (Figure F.1.1-1). Additionally, wind will blow ash downwind which can lead to spot fires. Weather is also subject to change and this should be monitored
   c. Fires have the effect of heating and drying vegetation upslope and move four times faster uphill than downhill, and twice as fast as they travel to the sides (Figure F.1.1-2)
3. **Effective fighting:** Firefighting is dangerous, but strategies can be done to make fighting/containing fires safer and more effective. Fires should be assessed first; i.e. try to predict where the fire will go – based on hills, weather and the vegetation
4. Sequence of attacks (Figure F.1.1-3)
   a. Anchoring: In order to start fighting a fire you need to have a point from which to attack. This is the “anchor point” and is normally close to the origin of the fire – and should be upwind and downhill of the active fire. The edge of this burning area should be extinguished completely before moving up either side (flank) of the fire
   b. Flanks: Contain the fire by attacking the flanks of the fire. The centre of the fire is likely to burn itself out. Flanking a fire requires the team to move along the burning line from the anchor point, either side toward the head of the fire, knocking down flames and separating burnt material from unburnt material
   c. Head attack: As the flanks are extinguished, teams will approach the head of the fire. This part of the fire is moving the fastest, will tend to be the hottest and most dangerous to attack. If flanking is done correctly, the head will diminish in size and should be easier to extinguish. A direct frontal attack on the head is not advised
5. Type of attacks
   a. Direct attack: This focuses on killing the flames along the flanks of a fire and lets the middle burn itself out. Firefighters need to be near the fire to add water to the burning vegetation or very close to the burning material to use hand tools. The danger zone is where a firefighter may suffer serious harm from the heat: it is three times the flame height. That is a flame of 1 m has a horizontal danger zone of 3 m (Figure F.1.1-4). If safe to fight a fire, firefighters should smother/beat the flames with beaters (Figure F.1.1-6). Firefighters with the rake hoes (Figure F.1.1-7) will follow them along the line, separating the burnt and unburnt materials (Figure F.1.1-5). If there is water available, firefighters can spray water onto the burning vegetation, which will cool it down and bring the flame height down, allowing beater teams some relief to smother the flames
   b. Indirect attack: If the flame height is greater than 1 m and cannot be brought down with water, direct attack is unlikely to succeed and indirect attack is preferred. Indirect attack is the process of modifying

an area of unburnt vegetation in the fire's path, so that fire's progress is slowed or stopped. Knowledge of fire behaviour and local conditions is essential

6. **Clearing a scratch line** (Figure F.1.1-8) will make a gap between the oncoming fire and vegetation to be saved. The width of gap should be three times the flame height and should be cleared of all organic material. Using the existing breaks (roads/paths/rocky outcrops/thin vegetation) in the landscape can greatly help when making the scratch line
7. **Creating a wet line** is only possible if you have extensive water resources available. Ideally a firefighter would wet everything along a wide line of the approaching fire, limiting burning potential and allowing for direct attack
8. **Back burning** should only be considered as the last resort as 'back burning' means firefighters are required to start a small controlled fire line in the path of the existing fire. This fire burns the organic material in the path of the fire to slow/stop the main fire. This is risky, and needs intensive local knowledge of conditions and burn behaviour
9. **Mop up:** This is done when the fire has been controlled at the flanks/head and is the process of cooling down any hotspots (both buried and surface) to make sure any reigniting is improbable. Surface and buried burning material need to be dug up and moved to the centre of the burnt area, and separating burnt or smouldering from unburnt organic material with a rake hoe. The fire should be monitored of potential flair ups
10. **Additional hazards**: Other things to take note of:
    L = Look-outs – look what the fire is doing and act accordingly
    A = Awareness – know where other firefighters/buildings are
    C = Communication – talk to people helping and make it a team effort
    E = Escape routes – if needed know how to get out of the path of the fire
    S = Safety First – your safety is the most important thing

Illustrations/ Diagrams:

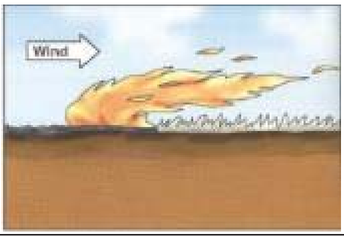


Figure F.1.1-1: Effect of wind[a]

Figure F.1.1-2: Fire movement[a]

Figure F.1.1-3: Sequence of attacks[a]

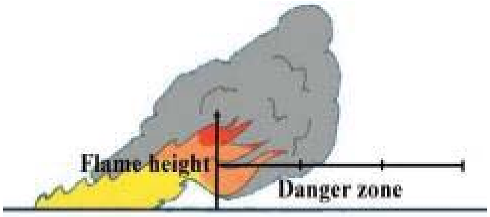


Figure F.1.1-4: Flame height vs Danger zone[a]

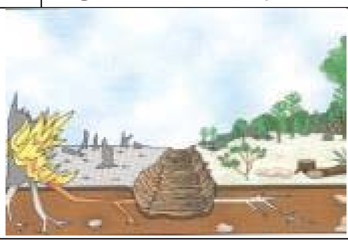


Figure F.1.1-5: Separating burnt materials[a]

Figure F.1.1-6: Fire beaters[c]

Figure F.1.1-7: Firefighter with rake[c]

Figure F.1.1-8: Scratch line[c]

Equipment requirements:

- Clothing: In the absence of proper firefighting clothing, long cotton shirt and pants should be used. No synthetic materials. Closed shoes, preferably boots. Head and eye protection, and gloves are strongly advised.
- Hand tools: Beaters are used to smother the flames while rake hoes are used to separate burnt and non-burnt materials and create scratch lines.

Seasonal variations:

Fires can happen at any time, but extra vigilance should be taken during the dry months of May to November. During the warm months of December to April, extra vigilance should be taken during short dry spells in the rainy season.

Variations/Adaptations:

Not applicable

F.1.1. Firefighting wildfires (practical)

MAINTENANCE

Maintenance requirements:

- **Clothing:** Care should be taken to ensure all clothing is maintained with no holes or buttons missing, and zips working. Clothing used for firefighting is however likely to get quickly worn out and damaged
- **Tools:** These will also get worn and damaged. They should be free of debris when stored, and maintained in working order and replaced when maintenance is no longer possible

REFERENCES

Definitions:	**See also:**
Not applicable	**Guideline F.1.2 Firefighting tools (construction and usage)** **Guideline F.1.3 Firebreaks**

Further references:

a. City of Cape Town Fire And Rescue Service, Wildland Firefighting guidelines for Urban firefighters, Fire Training Centre, Epping, Cape Town, South Africa.

b. Bretnall C. 2012. Lookouts, awareness, Communications, Escape Routes, Safety Zones (LACES). Australasian Fire and Emergency Service Authorities Council. Accessed online at http://nuweb.afac.com.au/docs/position/lookouts-awareness-escape-safety-zones-laces-dp.pdf?sfvrsn=18. 14 August 2015.

c. Department of Natural Resources (Canada). Basic forest fire suppression course. Accessed online at http://www.novascotia.ca/natr/forestprotection/wildfire/bffsc/ 14 August 2015.

d. EarthData. Active Fire Data. https://earthdata.nasa.gov/data/near-real-time-data/firms/active-fire-data#tab-content-7

F.1.2. Firefighting tools (construction & usage)	

OVERVIEW

This guide explains how to make and use wildfire fighting equipment to extinguish wildfires and to protect lives and property.

Objectives: To equip the local community with the knowledge to make, maintain and use practical wildfire fighting tools.	**Criteria for application:** Wildfires are prevalent in all communities, and members should be given every opportunity to extinguish the fires with tools that can be locally constructed.
Funding: Not applicable	**Legislation:** National Veld and Forest Fire Act 101 of 1998.

Catchment perspective:
Having tools to combat wildfires will provide the communities with the ability to limit damage, through fire-related activities, to natural vegetation and agricultural land as well as to community assets.

Benefits:
Educates the local community about firefighting tools and allows them to be self-sufficient in providing and utilisation of the tools needed to fight wildfires.

METHODOLOGY

Methodology:

1. **Fire beater:** The head of the beaters are lifted to about waist height and pressed down and then forward and backward on top of burning vegetation thereby smothering the flame (Figure E.1.2-2). This should be repeated until there is no flame – after which the firefighter can continue working the fire line
   a. Construction: Attach (hammering nails and wrapping with wire) a flat metal or wood cross bar (0.5 m) to a long wooden staff (1.6-1.8 m) about 10 cm from the end of the staff. Angled bars attached to the cross beam and staff will offer stability. Attach a flat rubber mat (0.5 x 0.5 m and thicker than 2-3 mm (tyres)) with fingers cut long ways to the cross bar. Attach a bracing bar parallel to the cross bar on the other side of the rubber mat to add extra support (Figure E.1.2-1). If construction is not possible, green large leafed branches will also work well as a fire beater
2. **Rake:** sturdy steel rakes can be used to separate burnt and unburnt material
3. **Slasher:** can be used to cut roots and smaller vegetation to help in making a firebreak

Illustrations/ Diagrams:	Photos:

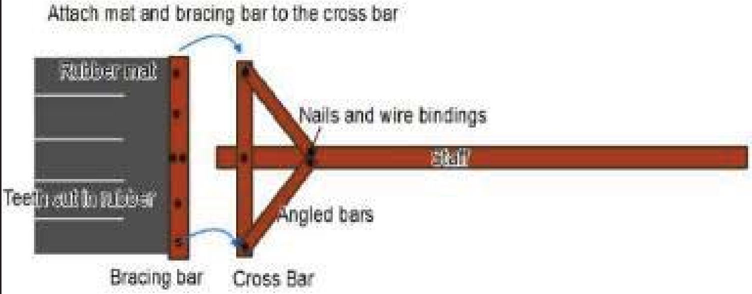



Figure F.1.2-1: Constructing a fire beater	**Figure F.1.2-2:** Fire beater

Equipment requirements:	**Variations/Adaptations:** Not applicable
• Fire beater – material to make and maintain the beaters: • Rubber strips such as car tyres • Strong wooden boards to make the frame • Hammer nails and wire to bind parts together	**Seasonal variations:** Not applicable **See also:** **Guideline F.1.1 Firefighting – wildfires (practical)** **Guideline F.1.3 Firebreaks**

MAINTENANCE

Maintenance requirements:

- Debris should be removed and tools should be checked for damage, loosening of attachments or perishing and melting
- Rakes – sturdy steel rakes will need replacements as rakes are likely to be damaged though continued use
- Slashers – sturdy slashers may also break and will need to be replaced

REFERENCES

Further references:

a. Enviro Wildfire Services. Weapons Of War – The Firefighters Handtools. Accessed online at http://envirowildfire.co.za/weapons-of-war-the-firefighters-handtools/. 14 August 2015.

b. City of Cape Town Fire And Rescue Service, Wildland Firefighting guidelines for Urban firefighters, Fire Training Centre, Epping, Cape Town, South Africa

F.1.3. Firebreaks

OVERVIEW

This guide will give the practical specifications needed to create and maintain an effective firebreak to stop the movement of a wildfire, saving lives and protecting property.

Objectives:
To give the community the knowledge to construct and maintain effective firebreaks based on vegetation present.

Catchment perspective:
Try to limit damage through fire-related activities to natural vegetation and agricultural land as well as to community assets.

Benefits:
Effective firebreaks will defend the community and important vegetation against wildfire damage. Breaks also serve to limit/slow the progress of a fire and help in firefighting operations.

Criteria for application:

- Wildfires are prevalent in all communities, and members should be given every opportunity to limit their movement and defend important areas. The firebreak needed in each area will vary with the vegetation present.
- Where slash and burn are practiced to open land for farming or to trap mice, the area to be opened/ burnt should be marked with a firebreak to reduce runaway fires and excessive damage and loss of ground cover on adjacent areas.

Funding:
Not applicable

Legislation:
National Veld and Forest Fire Act 101 of 1998.

METHODOLOGY

Methodology:

1. Types of firebreaks:
   a. **Clear area**: organic material is removed so that there is nothing to burn (Figure F.1.3-2)
   b. **Shaded fuel-breaks**: thinning vegetation to slow fire progression (Figure F.1.3-1)
2. Width of firebreak: is based on the vegetation and the likely flame height of a wildfire. However, under varying fuel, hill and wind conditions flames can still breach these distances and widths needed should assessed on a local scale, using local knowledge and experience.

Vegetation	Width of firebreak
Grasslands	**1-3 m**
Medium shrubs	**2-4 m**
Heavy shrubs	**5-10 m**
Plantations	**15 m**

3. Location of firebreaks: should defend important areas and be oriented across the dominant wind direction, especially uphill of the prevailing wind direction. There should be no gaps in the break, and where possible completely encompass the asset. Areas of higher vulnerability can also be ringed with firebreaks.
4. Constructing firebreaks:
   a. Clear area breaks require burnable organic material to be removed in a long strip. This can be done by carrying out a controlled burn (igniting vegetation in a controlled manner) along the strip with teams of firefighters ensuring that the fire doesn't spread to other areas. Large shrubs/trees should be cut down and removed from within the firebreak strip before burning starts. Alternatively, teams can manually remove the organic material along the strip with spades, rakes and axes. This is a more labour-intensive operation but is safer.
   b. Shaded fuel-breaks can be made by thinning vegetation on either side along a clear area break, by removing trees/shrubs and clearing ground materials to reduce the vegetation density. This will act to slow the progression of a fire and make it easier to control at the clear area break.

Photos:

Figure F.1.3-1: Shaded fuelbreak[a]

Figure F.1.3-2: Cleared area[b]

Seasonal variations:
Creating firebreaks should happen outside the heightened fire season of May to November, and should be done when there is minimal wind and recent rain.

Equipment requirements:
For making a firebreak are spades, rakes, axes, slashes and drip touches.

Variations/Adaptations:
See methodology Step 1.

MAINTENANCE

Maintenance requirements:

F.1.3. Firebreaks

Firebreaks should be checked to ensure no vegetation encroachment in the strip before the fire season (and during). Any organic material should be removed manually.

REFERENCES

Definitions:	See also:
Not applicable	**Guideline D.1.1 Sustainable plantation forestry** **Guideline E.3.4 Sustainable woodlot management** **Guideline E.6.3 Village waste management** **Guideline E.5.8 Biogas digester** **Guideline F.1.2 Firefighting tools (construction and usage)** **Guideline F.1.1 Firefighting – wildfires (practical)**

Further references:

a. Dennis F. Fuelbreak Guidelines for Forested Subdivisions & Communities. Colorado State Forest Service. Accessed online at http://static.colostate.edu/client-files/csfs/pdfs/fuelbreak_guidellines.pdf. 14 August 2015

b. Smith R. Firebreak Location, Construction and Maintenance Guidelines. Bush Fire and Environmental Protection Branch – Government of Western Australia. Accessed online at http://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/BushfireProtection Planning Publications/FESA%20Firebreak%20Guidelines_std.pdf. 14 August 2015

F.2. Landslides and land collapse

F.2.1. Preventing, identifying and recovering from landslides

OVERVIEW

Landslides occur when slopes become unstable and soil, rocks and vegetation slide down the slope to the valley bottom or to where the hill is less steep. Houses, communities and farming area in the path are can be destroyed and people and livestock may lose their lives.

The slope can become unstable for a few reasons.

1) When there is a lot of rain in the area. The water seeps into the ground, reduces friction and soil and rocks slip downward.
2) If the vegetation and roots are removed from the slope; either through clearing or slash and burn by the community.
3) If earth is removed to build a house or other structure.
4) If an earthquake occurs.
5) If terracing is done incorrectly.
6) General wear and decomposition of rocks stabilising the slope.

Landslides can move very fast. Seek safety as soon as you are aware of a landslide.

Objectives:

- Allow community members to use slope stabilizing practices to reduce the likelihood of landslides.
- To see when and where landslides may occur.
- Help communities recover after a landslide.

Catchment perspective:

- Improve safety of the communities
- Keep vegetated areas stable and reduces the scarring of the landscape
- Reduces land slippage and erosion.

Criteria for application:

- Areas to investigate land sliding activity are areas where it is known to have occurred in the past.
- Communities located at the base of a steep slope, particularly when that slop has diminished vegetation.
- Areas where critical supply rivers are close to steep vegetation poor slopes.

Benefits:

- Will improve community safety
- Will prevent the loss of nutrient soils through erosion.

Funding:

Not applicable

Legislation:

Conservation of Agricultural Resources Act 43 of 1983.

METHODOLOGY

Methodology:

Preventing landslides

1. Try not to disturb the natural vegetation on steep slopes. Limit grazing and tree harvesting where possible. If harvesting must occur, rather implement tree coppicing (see guideline XXXX) and also prohibit tree root removal from the soil.
2. Stop communities from removing material like rocks and soil from the slope.
3. If possible, revegetate the slope to increase slope stability.
4. Do not build any dams on a slope or stop the flow of water.
5. Identifying possible landslide areas and occurrence
6. Speak to the community elders about the history of landslides in the area. Ask questions like, “Have there been more landslides in the last few years?”, “How has the vegetation changed?”, “Is there any change in the rainfall or developments on the slopes?”
7. Look out for previous landslide scars on the slopes (see photo 1) and for signs of erosion or small gullies forming on slopes.
8. Look for new cracks in roads close to slopes.
9. Look for new springs or water seepage.
10. Newly tilted poles trees.
11. Recently burnt vegetation or cleared slopes have a higher chance of a landslide.
12. Landslides are more likely to occur when heavy rains or an earth tremor occurs.

Procedure during landslide

1. If there are heavy rains occurring and you are near a slope that has little vegetation, listen carefully for strange sounds of moving rocks or breaking of trees.
2. During the day you may be able to see dust rising into the air or even trees falling forward down the hill. At night though it’s unlikely you’ll be able to see anything.
3. If you suspect a landslide is happening, don’t hesitate or collect belongings. Move quickly to a safe place. While avoiding the landslide path.

4. If rocks are falling, seek shelter behind trees or other solid objects.
5. A safe place can be
6. A large flat area or a peak of a small hill/outcrop away from the bottom of the slope.
7. Along the ridge of a slope so that the landslide movement goes down to the valleys.
8. Up an opposite hill to the landslide hill.

Recovery after landslides

1. Do not enter damaged buildings until declared safe.
2. Be careful when clearing the debris and do not allow children in the area.
3. Be aware that a secondary landslide can occur and keep observing.
4. Recover the slope with vegetation and trees if possible.
5. Limit access to sensitive slopes that have slipped before.
6. Avoid rebuilding close to where the land slid occurred.

Photos:

Figure F.2.1-1: Montane landslide, Division of Forests and Lands. (Source: Ben Kimball)

Equipment requirements:

- Stakes
- Vegetation cover, creeper plants

Variations/Adaptations:

Not applicable

Seasonal variations:

Landslides are likely during the rainy season.

MAINTENANCE

Maintenance requirements:

- Check for erosion along the slopes.
- Check that there is a good vegetation covering on the slope.
- Inform the community about safe areas to go to when a landslide occurs.

REFERENCES

Definitions:

Not applicable

See also:

Guideline A.3.1. Contour ridging
Guideline A.4.3 Stone check dams
Guideline F.4.1. Community emergency response
Guideline F.3.4 Waterborne illness

Further references:

a. Learning to live with Landslides; Natural hazards and disasters, http://www.preventionweb.net/
b. Landslides Causes and Prevention, http://www.biotecharticles.com/

F.3. Health

F.3.1. Bilharzia prevention and response

OVERVIEW

This guide seeks to give information to local communities about the benefits of actively reducing the potential to contract bilharzia. It does this through simple practical preventative and treatment steps.

Objectives:
Adapt traditional/local practices
- to minimise risk of transmission
- to prevent or limit the spread of infection

Benefits:
- Less opportunity for spread of disease
- Prevention of new cases
- Residual protection against infection

Criteria for application:
Apply guidelines in areas where bilharzia is known to occur and/or when infection is suspected.

Catchment perspective:
- Exposure to pathogens generally may be related to resilience of human and natural systems – e.g. deforestation lessens the capacity of the watershed to absorb storm events and prevent excessive runoff laden with pathogens related to disease emergence
- Catchment management activities may influence pathogen exposure.
- Certain species of the parasite can infect animals such as cows or water buffalo. Runoff from pastures (if the cows are infected) can contaminate freshwater sources

Legislation:
Not applicable

Funding:
Not applicable

METHODOLOGY

Methodology:
Prevention
1. Avoid swimming or wading in freshwater in an area where bilharzia occurs, especially where reeds occur, and lots of snail shells.
2. Boil water for consumption for at least 1 minute, in areas where bilharzia is known to occur (chlorine treatment may not guarantee that water is free from parasites)
3. Water used for bathing should be brought to the boil for at least 1 minute and then cooled before bathing. (water that has been stored in a tank for at least 2 days should be safe for bathing)
4. When having to cross a river in contaminated areas, look for paths of clear water with no vegetation and dry yourself immediately afterwards
5. Vigorous towel drying after accidental contact with contaminated water may help prevent the parasite from penetrating the skin. However, this alone will not be able to prevent bilharzia

Treatment
1. Symptoms include:
   a. Rash – few days after infection
   b. Fatigue, fever, chills, muscle aches, stomach pain, diarrhoea, blood in urine – within 1-2 months after infection
2. If the abovementioned symptoms are present seek medical attention at nearest clinic
3. Treatment is aimed at reducing the risk of damage to body organs and usually has to be repeated. Three medicines have been used successfully:
   a. Praziquantel – used to treat all forms of bilharzia. A single dose has been proven to be effective to contain the disease. Primary health care workers can safely administer it.
   b. Oxamniquine – for treating intestinal bilharzia in Africa and South America
   c. Metrifonate – for treating urinary bilharzia
4. Because of the risk of reinfection, it is important to do follow-up tests for three months until a patient is declared cured

MAINTENANCE

Maintenance requirements:
- Awareness/Public education
- Improved sanitation

Eliminating snails required to maintain the lifecycle of parasites

Variations/Adaptations:
- Use of different disinfectants based on availability or familiarity to community
- Level of intervention to be determined by risk factors influencing infection rates; such as level of sanitation, proximity to water, livelihoods activities, etc.

Equipment requirements:
See treatment

Seasonal variations:
Infection rates are usually seasonal and highest just after the rainy season, but local circumstances should be taken into consideration.

REFERENCES

Further references:
WHO. 2015. Schistosomiasis Fact Sheet. World Health Organisation.

See also:
Guideline F.3.4 Waterborne illness

F.3.2. Cholera response – Oral rehydration

OVERVIEW

This guide suggests practical steps for the rehydration of a patient suffering from dehydration resulting from diarrhoea and/or vomiting induced through cholera exposure. Key to success is the initial replacement of fluids as well as the ongoing rehydration.

Objectives:

- Rehydration of patients is the first priority of cholera treatment
- Rehydration is accomplished in two phases: 1) replacement of fluids to replace the volume already lost and 2) maintenance of hydration to replace on-going fluid losses

Benefits:

- Prevention of severe dehydration
- Ability to rehydrate and maintain hydration at home, based on availability of rehydration solution
- Potential to decrease burden on treatment facilities

Criteria for application:

- During suspected or confirmed outbreak of cholera
- When individuals are presenting with suspected dehydration related to diarrhoea and/or vomiting
- Oral Rehydration Solution (ORS) alone can be used to treat patients with some dehydration. Patients with severe dehydration need intravenous fluid (IV) fluids

Table F.3.2-1: Assessment for Dehydration (UNICEF, 2013)

Assess	Condition *	
Eyes	Normal	Sunken
Tongue	Normal	Dry
Thirst	Normal	Thirsty (drinks eagerly)
Skin pinch	Normal	Goes back slowly*
Radial pulse	Normal	Reduced*
Diagnosis	No sign of dehydration	If at least 2 signs including one (*) sign is present, diagnose dehydration

Catchment perspective:

- Exposure to pathogens generally may be related to the resilience of human and natural systems – e.g. deforestation lessens the capacity of a watershed to absorb storm events and prevent excessive runoff laden with pathogens related to disease emergence
- Catchment management activities may influence pathogen exposure
- Cholera risk factors are related to poor access to water and poor water quality, poor access to sanitation
- Eliminate the practice of defecating outdoors
- Locate pit latrines at least 100 m away from water sources, especially boreholes

Funding: Not applicable

Legislation: Not applicable

METHODOLOGY

Methodology:

Making Oral Rehydration Solution

1. Wash hands with soap and treated (boiled) water
2. Wash container and stirring utensil with soap and treated water
3. Pour one litre of treated water into the clean container
4. Put ORS powder into water
5. Store ORS solution in clean container and do not keep for more than 24 hours

Application

1. Give half a litre of ORS to babies and toddlers who have diarrhoea
2. Give 1 litre of ORS each day to children who are vomiting or have diarrhoea
3. Give 3 litres of ORS to adults who have vomiting or diarrhoea
4. If the person vomits, wait 10 minutes before giving the ORS solution
5. Go to the nearest clinic as soon as possible. Give your child more ORS or breast milk on the way

Maintenance of Hydration

1. After adequate hydration has been established, treatment must be continued until diarrhoea stops

Rehydration Solutions

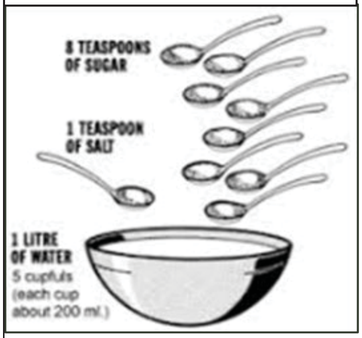
1. For most patients use of this fluid/electrolyte mixture in the recommended amounts is adequate to re-establish and maintain a normal state of hydration
2. Alternative rehydration solutions
3. Rice-based oral rehydration
4. Homemade rehydration solutions consisting of 6-8 table spoons of sugar, half a teaspoon of salt and 1 litre of clean water

Illustrations/ Diagrams:

F.3.2. Cholera response – Oral rehydration

Figure F.3.2-1: Using treated water to wash hands and utensils

ORS Mixture: (5x200 ml cups)
8 level teaspoons sugar
½ level teaspoon salt
1 litre clean (boiled and



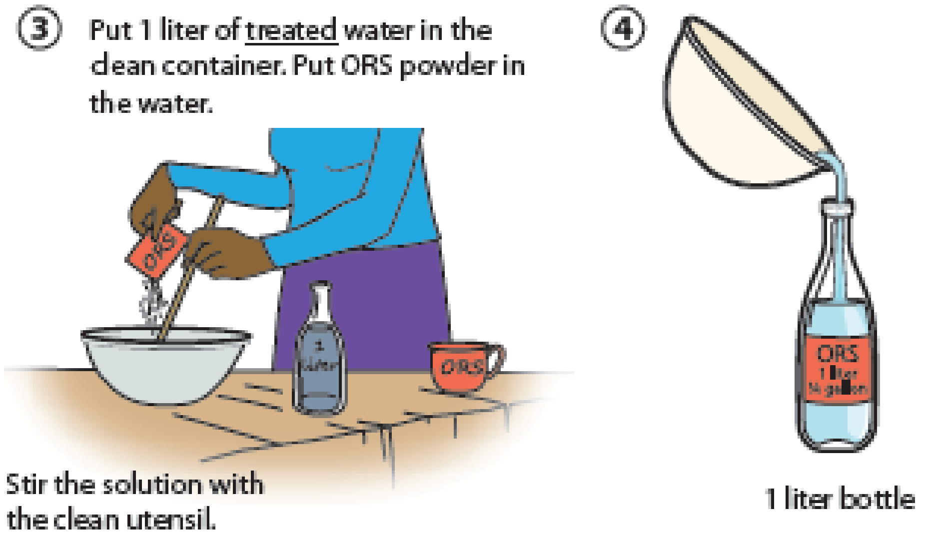


Figure F.3.2-2: Keeping treated water in clean containers. (Source: Mercy Corps. 2008)

Seasonal variations: Seasonal upsurges: increased spread during dry season with water shortages or during rainy season with flooding and contamination of water sources.	**Equipment requirements:** Cleaning equipment, containers, ORS sachets (or make ORS solution: 8 level teaspoons sugar, ½ level teaspoon salt). **Variations/Adaptations:** Use of different rehydration solutions based on availability or familiarity to community.

MAINTENANCE

Maintenance requirements: Teas, sugary drinks and carbonated beverages are not suitable as a rehydration solution during severe diarrhoea and can even increase purging.	**Potential drawbacks/disadvantages:** • Public education required • Reliant on the availability of Oral Rehydration Solution (ORS) or alternative rehydration solutions

REFERENCES

Definitions: Not applicable	**See also:** **Guideline F.3.4. Waterborne illness** **Guideline E.2.1. Nutrition in the home**

Further references:

a. Mercy Corps. 2008. Water, Sanitation and Hygiene Guidelines.
b. UNCEF. 2013. Cholera Toolkit. New York: UNICEF
c. IFRC. 2008. Household water treatment and safe storage in emergencies. International Federation of Red Cross and Red Crescent Societies

F.3.3. Cholera response – Food hygiene

OVERVIEW

This guide acknowledges the potential for cholera exposure from everyday practices and suggests simple practical adaptations through cooking and storing food properly and general hygiene to reduce this risk potential.

Objectives:

- Prevention, preparedness and response to cholera and other communicable disease outbreaks;
- Adapt traditional/local practices to minimise risk of transmission;
- Limit opportunity for contamination and transmission through food.

Criteria for application:

- Applicable to persons preparing or handling food at outlets, street vendors, markets and households
- Food safety is a critical element in the response to a cholera outbreak and should form part of public communications
- Applied to ensure food safety at home and social gatherings to limit risk of contamination and infection)

Catchment perspective:

- Exposure to pathogens may be related to resilience of human and natural systems – e.g. deforestation lessens the capacity of a watershed to absorb storm events and prevent excessive runoff that is laden with pathogens related to disease emergence
- Catchment management activities may influence pathogen exposure
- Food can be a major source of transmission due to contamination by water or soiled hands

Benefits:

- Improving food safety and hygiene standards in household, institutional and social settings
- Break chain of transmission
- Control disease outbreak

Funding: Not applicable

Legislation: Not applicable

See also:
Guideline F.3.4. Waterborne illness
Guideline E.2.1. Nutrition in the home

METHODOLOGY

Methodology:

Keep Clean

1. Exclude any infected persons from handling food
2. Wash hands before any food preparation with soap and boiled water
3. Clean all surfaces and utensils used during preparation
4. Ensure dishes and cooking utensils are washed in boiled water

Cook Thoroughly

1. Ensure food is sufficiently cooked and properly re-heated
2. Avoid raw or partially cooked fish or shellfish
3. Fruit and vegetables should be peeled or shelled
4. Boil or pasteurise all milk

Storage

1. Ensure proper storage and/or disposal of leftover food
2. Separate raw and cooked foods
3. Do not store food at room temperature for more than two hours

Behaviours

1. Wash hands with soap and clean water after using the toilet
2. Wash hands with soap and clean water before eating
3. Discourage eating from a communal food container
4. Train food handlers working in outlets and markets on basic food safety and hygiene standards

Equipment requirements:

- Soap/disinfectant, clean/boiled water
- A clean water container to store boiled water for hand washing during the day.

Variations/Adaptations:
Use of different techniques based on availability of equipment or familiarity to community.

Seasonal variations:
Seasonal upsurges: increased spread during dry season with water shortages or during rainy season with flooding and contamination of water sources

MAINTENANCE

Maintenance requirements: Public awareness campaigns on food safety and basic hygiene practices.

REFERENCES

Further references:

a. Mercy Corps. 2008. Water, Sanitation and Hygiene Guidelines.
b. UNCEF. 2013. Cholera Toolkit. New York: UNICEF
c. Global Task Force on Cholera Control. 2010. Cholera outbreak: assessing the outbreak response and improving preparedness. World Health Organisation

F.3.4. Waterborne illness

OVERVIEW

This guide shows simple and low-cost methods of treating and disinfecting water to reduce the potential for exposure to waterborne diseases. The methods include boiling, chlorination and solar disinfection.

Objectives:

Benefits:

F.3.4. Waterborne illness

- Access to safe and adequate water supply;
- Removal of germs and parasites that cause disease.

Catchment perspective:

- Pathogen exposure may be related to resilience of human and natural systems – e.g. deforestation lessens the capacity of a watershed to absorb storm events and prevent excessive runoff that is laden with pathogens related to disease emergence;
- Catchment management activities may influence pathogen exposure;
- Waterborne illnesses risk factors are related to poor access to water and poor water quality, and poor access to sanitation.

- Reduction of most bacteria and viruses in water
- Residual protection against contamination;
- Acceptability due to ease of use
- Documented health impact
- Scalability
- Low cost

Limitations

- Boiling and solar disinfection has no residual effect, so improper storage can lead to re-contamination
- Potential user taste and odour objections
- Lower disinfection effectiveness in turbid waters contaminated with organic and some organic compounds, therefore filter it first

Legislation: Not applicable

Funding: Not applicable

Criteria for application:

- **Chlorination** – Most appropriate in areas with a consistent water supply chain, with relatively lower turbidity water, and situations where educational messages can reach a target population to encourage correct and consistent use
- **Boiling** – Most appropriate in areas with an affordable and accessible supply of cooking fuel (takes one kilogram of firewood to boil one litre of water for one minute), a cultural tradition of boiling, and where water is stored safely after boiling
- **Solar Disinfection** – Most appropriate in areas where there is availability of bottles and repeated community motivation and training for users on how to correctly and consistently use solar disinfection for treating household drinking water. Effectiveness is reduced in very turbid water.

METHODOLOGY

Methodology:

Strain water through clean cotton cloth to filter

Boiling

1. At low altitude, boil water for 1 minute
2. At high altitude boil water for 3 minutes
3. For boiling to work, water must be brought to a rolling, bubbling boil. Allow water to cool before using for hand washing or drinking
4. Boiled water should be stored safely and used within a few days

Chlorination

1. Wash your hands with water and soap or ash
2. Put chlorine tablet in container
3. If the water looks cloudy use a double dose
4. Wait 30 minutes
5. Water is ready for consumption and/or storage

Solar Disinfection

1. Use clear plastic or glass bottles to increase water temperatures by placing it in direct sunlight for five hours, or for two days in cloudy conditions
2. For greater effectiveness place the bottle on a corrugated-iron roof, or on a painted black surface
3. Cool water and shake before use

Illustrations/ Diagrams:

F.3.4. Waterborne illness

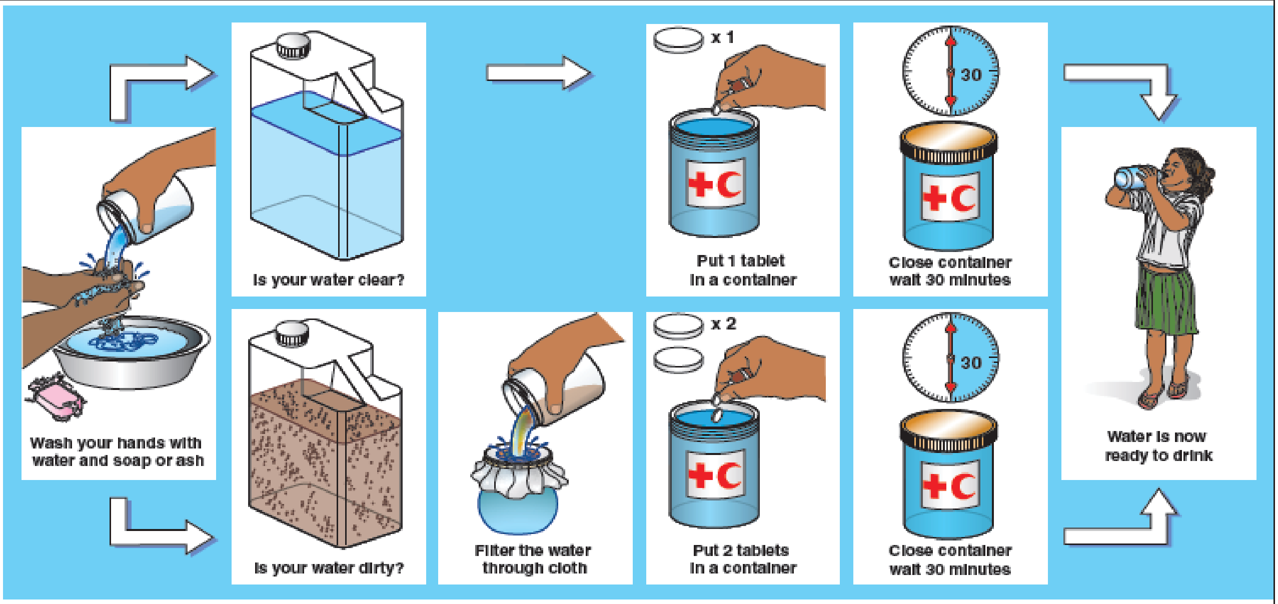


Figure F.3.4-1: Treating water with chlorine tablets

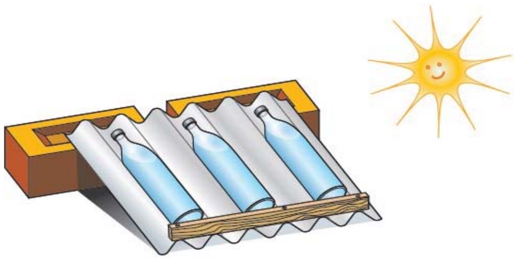


Figure F.3.4-2: Solar Disinfection

Figure F.3.4-3: Straining Water

Variations/Adaptations:
Different methods as described.

Seasonal variations:
Seasonal upsurges: increased spread during dry season with water shortages or during rainy season with flooding and contamination of water sources.

Equipment requirements:
Storage: Container to store clean water
Boiling: Fuel, vessel to boil water in
Chlorination: Container, Chlorine tablets
Solar Disinfection: Clear plastic or glass bottles

MAINTENANCE

Maintenance requirements:

- Boiled water should be stored safely and used within a few days
- Chlorine tablets have instructions on the packaging. However, the instructions might not be in the language the people speak or they may not be able to read. Make sure all people who receive chemicals are trained how to use them. These products must be brought from outside the community; it is not something they can do with local resources. **DO NOT EAT CHLORINE TABLETS**
- Encourage people to keep containers clean, covered, and out of reach from children. It is best if people use a different container for collecting water, and for storing treated water

REFERENCES

See also:

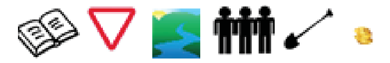
Guideline F.3.2. Cholera response – Oral Rehydration
Guideline F.3.3. Cholera response – Food Hygiene
Guideline E.2.1. Nutrition in the home

Further references:

a. Mercy Corps. 2008. Water, Sanitation and Hygiene Guidelines
b. UNICEF. 2013. Cholera Toolkit. New York: UNICEF
c. IFRC. 2008. Household water treatment and safe storage in emergencies. International Federation of Red Cross and Red Crescent Societies

F.4. Emergency Response Procedures

F.4.1. Community emergency response



OVERVIEW

This guide makes recommendations for people in an emergency situation to act calmly, assist where possible and communicate to relevant response points in the event of an emergency. It also highlights that all people should learn from these events to ensure they don't occur again in the future.

Objectives:
To provide rapid and effective response to natural or human-induced emergency situations involving physical threat to life / property / environment / socio-economic activity.

Criteria for application:
Implement during emergencies physically threatening life, property, the environment or socio-economic activity in a community.

Catchment perspective:
Natural and human-induced emergencies that may arise in the catchment are linked to water resource management within the catchment. Proper catchment management will reduce the risk of water-resource linked emergencies occurring.

Benefits:
- Protection of life, property, environment and socio-economic resources and activities
- Improved response to emergencies
- Mitigation of hazard impacts

Funding: Not applicable

Legislation: Not applicable

METHODOLOGY

Methodology:

1. The community should identify what emergency response organisations operate in their area, and how to contact them if there is an emergency. The information should be shared with everyone in the village or community.
2. Any member of a community should, after witnessing or receiving information of an existing or developing emergency, without delay:
   - **Help.** Provide immediate assistance if necessary and safely possible to protect life, property, and the environment.
   - **Call.** Communicate what was witnessed or the information received to the controlling staff of emergency response bodies that can assist as well as the leadership and members of the affected and/or threatened community.
     - Request the emergency response bodies to activate their resources in support of the community;
     - Request the community to avoid the hazard and protect themselves and to assist others who need help if it is safe to do so.
   - **Share.** Support the collection and sharing of information on the emergency and its impact as well as the response by the community and/or emergency response bodies inclusive of: type of impact; area and severity of impact; damage experienced (property, infrastructure, environment); number of affected people (deceased, missing, injured, displaced), assistance required, assistance provided).

Illustrations/ Diagrams:

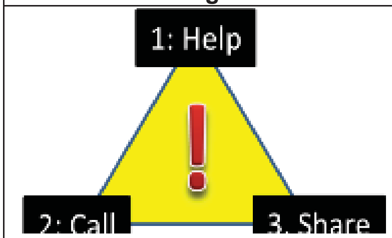


Figure E.3.1-1: Process of development. (Source: Aurecon, 2015)

Figure F.4.1-2: Call Process

Seasonal variations:
The types or emergencies that may be expected will vary seasonally with climate and weather patterns.

Variations/Adaptations:
Not applicable

Equipment requirements:
- Emergency response checklist
- Emergency report form

MAINTENANCE

Maintenance requirements:
- Maintenance of emergency response equipment Maintenance of communication channels
- Maintenance of early warning systems

See also:

Guideline F.4.2. Community emergency response – Flood
Guideline F.4.3. Community emergency response – Drought
Guideline F.1.1. Firefighting – wildfires (practical)
Guideline F.3.4. Waterborne illness

REFERENCES

Further references:

a. USAID, 2014, Disaster Risk Reduction Knowledge Product 38: All Hazard Preparedness & Response Planning (in development at African Centre for Disaster Studies, North-West University, South Africa)

b. Aurecon, Community-based disaster risk management plan, 2015

c. Aurecon, Community-based disaster risk assessments and resultant Risk Profiles, 2015

d. World Conference of Disaster Reduction, 2005, Hyogo Framework for Action (HFA) 2005-2015. http://www.preventionweb.net/drr-framework/hyogo/

e. Third UN World Conference on Disaster Risk Reduction, 2015, Sendai Framework for Disaster Risk Reduction 2015-2030. http://www.preventionweb.net/drr-framework/sendai-framework/

F.4.2. Community emergency response – Flood

OVERVIEW

This guide presents steps a community can take to reduce the impact a flood has on property, environment and livelihoods. These steps focus on pre-emptive actions, information sharing with the community and learning from past events.

Objectives:
To ensure rapid and effective response to flooding.

Criteria for application:
When flooding is experienced or anticipated.

Catchment perspective:
Flooding can harm populations and the resources they depend on within a catchment. Proper planning to deal with flood early warning and response can save lives and protect property against damage.

Benefits:
- Protection of life, property, environment and socio-economic resources and activities.
- Improved response to flood emergencies.

Funding: Not applicable

Legislation: Not applicable

METHODOLOGY

Methodology:

1. Monitor early warning indicators:
   - Identify and mark a point and level in nearby rivers, where once the water passes that point will flood the village.
   - Communicate the marker and level to the village, e.g. paint the marker and level on a close by building wall for the community to see.
   - Identify people in the community to regularly check the marker in the wet season or expecting rains
2. Share information about possible flooding with community leadership and motivate people for a joint community response:
   - Identify a safe meeting/ collection point above flood level where people should move to, should a flood occur;
   - Have a store of dry fuel wood, clean water and non-perishable food, blanket and first aid kit (regularly replenished) there.
   - Identify the communication type to be used to warn of evacuation, e.g. drum, bell, siren, etc.
   - Identify who will give this signal (and deputy in case that person is away on the day)
   - Notify the village or community where this higher ground is and what signal will be used to communicate and who will give the signal.
   - Identify if neighbouring community or village should be notified, how and by whom.
3. Remove valuable movable assets including equipment and livestock out of flood-risk area;
4. Evacuate areas at risk (move to the identified higher ground); notify neighbouring village.
5. Do an attendance check to identify if missing persons.
6. Prepare and mobilise search and rescue teams for missing or trapped persons.
7. Record the extent of flooding experienced and losses suffered.

Illustrations/ Diagrams: Not applicable

Photos:

Figure F.4.2-1: Basic flood warning marker: green is fine, yellow needs to get ready, red will flood. (Source: M. Kleynhans)

Figure F.4.2-2: Flood response and communication plan painted on side of a bridge, Malawi (Source: S. Braid)

Equipment requirements:
- Emergency response checklist
- Early warning system
- Emergency water and dry fuel wood

Variations/Adaptations:
The speed of onset expected for flooding will differ depending on topography.

Seasonal variations:
The types or emergencies that may be expected will vary seasonally with climate and weather patterns

MAINTENANCE

F.4.2. Community emergency response – Flood

Maintenance requirements:

- Maintenance of emergency response equipment
- Maintenance of communication channels
- Maintenance of early warning systems

REFERENCES

See also:

Guideline F.4.1 Community emergency response
Guideline F.3.4 Waterborne illness

Further references:

a. World Conference of Disaster Reduction, 2005, Hyogo Framework for Action (HFA) 2005-2015. http://www.preventionweb.net/drr-framework/hyogo/

b. Third UN World Conference on Disaster Risk Reduction, 2015, Sendai Framework for Disaster Risk Reduction 2015-2030. http://www.preventionweb.net/drr-framework/sendai-framework/

c. USAID, 2014, Disaster Risk Reduction Knowledge Product 38: All Hazard Preparedness & Response Planning (in development at African Centre for Disaster Studies, North-West University, South Africa)

d. Aurecon, Community-based disaster risk management plan, 2015

e. Aurecon, Community-based disaster risk assessments and resultant Risk Profiles, 2015

F.4.3. Community emergency response – Drought

OVERVIEW

This guide presents recommendations for community members and subsistence farmers to follow during times of drought. Adaptation to limited water can be achieved through usage reduction, finding potential new water sources, improving efficiencies and limiting losses. Furthermore, communities need to monitor and communicate with each other and with specialists to prepare for the months ahead.

Objectives:

- To provide effective response to drought.
- To increase community resilience.

Catchment perspective:

- A lack of sufficient water supply.
- All people in a catchment reliant on water to some degree. Reduced water availability will impact commercial and substance farmers as well as domestic water use.
- Acceptability of drought management strategies.

Criteria for application:

- Implement during emergencies physically threatening life, property, the environment or socio-economic activity.
- Dependent on good information or at least discussion of available water sources, past drought impact, past climate, factors that affect severity of drought impacts.
- Agreement on drought indicators to monitor.
- Drought mitigation methods should be practiced to reduce the risk of drought.

Benefits:

- Protection of life, property, environment and socio-economic resources and activities against drought.
- Improve community awareness about water, climate and drought.
- Reduce losses during drought.

Funding: Not applicable

Legislation: Not applicable

METHODOLOGY

Methodology:

1. Monitor and communicate drought conditions, request and consider long-range forecasts and crop selection advice from specialists.
2. Share information about drought indicators with community leadership and motivate for joint drought monitoring and planning of drought response as well as general education and communication on the topic.
3. Reduce possibilities for conflict through ongoing dialogue on challenges and solutions.
   a. Reduce water use and secure water supply:
   b. Reduce water use to essentials only;
   c. Measure water use and comply with restrictions and rationing;
   d. Stop any leakage / wastage;
   e. Ensure existing supplies are not contaminated.
4. Supplementing / augmenting water supply by:
   a. Considering emergency allocation of water sources outside normal practices;
   b. Sharing information on potential sources of water;
   c. Use grey water (washing water, cooking water) to water crops;
   d. Making water system improvements such as new wells; and
   e. Sourcing water from outside the area and transporting water to distribution points.
5. Improve efficiency and appropriateness of agricultural and commercial water use:
   a. Practice planned grazing to reduce impact of livestock on grazing availability;
   b. Adapt number and type of livestock to carrying capacity of available land;
   c. Source emergency supplies of fodder for livestock;
   d. Recycle used water;
   e. Reforestation;
   f. Repair and maintain irrigation systems and use water-wise irrigation and agricultural methods;
   g. Adapt crop selection and planting to expected climate and ground conditions.
6. Reduce wildfire impact during dry periods through controlled burns, firebreaks, and safer housekeeping and building practices.
7. Monitor health and nutrition of households and prioritise the most vulnerable households for assistance in identifying alternative sources of water and nutrition.

Photos:

See also:
Guideline A.3.1. Contour ridging
Guideline A.4.3. Stone check dams
Guideline C.1.1. Water use efficiency (WUE)
Guideline C.2.1. Roof runoff and storage
Guideline C.2.2. Water storage – Below ground

F.4.3. Community emergency response – Drought

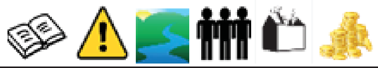


Figure F.4.3-1: Steenbras Upper during a drought year, 2018. (Source: S. Braid)

Guideline C.2.3. Road runoff
Guideline C.2.5. Hillside runoff (Swales)
Guideline C.3.3. Infiltration trenches (Water Absorption Trenches)
Guideline C.3.1. Contour bunds
Guideline C.3.2. Zaï planting pits
Guideline C.4.2. Sand dams
Guideline C.4.3. Farm dam
Guideline F.4.1. Community emergency response
Guideline F.3.4. Waterborne illness
Guideline F.1.1. Firefighting wildfires (practical)

Equipment requirements:
- Emergency response checklist
- Water storage tanks
- Pumps and pipes
- Water tanker trucks

Variations/Adaptations:
- Hydrological drought.
- Interruption in access to water supply due to social issues.
- Over utilisation of existing water resources exceeds supply.

Seasonal variations:
The types or emergencies that may be expected will vary seasonally with climate and weather patterns

MAINTENANCE

Maintenance requirements:
- Maintenance of emergency response equipment
- Maintenance of communication channels
- Maintenance of early warning systems

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Further references:

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c. USAID, 2014, Disaster Risk Reduction Knowledge Product 38: All Hazard Preparedness & Response Planning (in development at African Centre for Disaster Studies, North-West University, South Africa)
d. Aurecon, Community-based disaster risk management plan, 2015
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ANNEXURES

ANNEXURE I : PARTICIPATORY APPROACHES

LIST OF ABBREVIATIONS

PRA : Participatory Rural Appraisal
RAAKS : Rapid Appraisal of Agriculture Knowledge Systems
RRA : Rapid Rural Appraisal

PARTICIPATION

I.1 Introduction

The right to an environment that is not harmful, and access to basic services such as water and sanitation is a right of all South African residents (sections 24 and 27 respectively in Constitution of South Africa). Due to the democratic nature of South African governance, local municipalities not only have to effectively provide basic services, they have to do so in a manner that will "encourage, and create conditions for, the local communities to participate in the affairs of the local municipality including in the strategic decisions relating to the provision of municipal services: (DLG, 2000:15). Furthermore, Dyer et al (2014) argues that the manner in which a community is engaged in projects, is one of the key determining factors of whether or not the anticipated outcomes of a project will be achieved. It is therefore important for communities to be involved in service delivery projects, whether these are formal service infrastructure or ecological infrastructure to protect and rehabilitate natural resources.

The levels of engagement vary from consultation to partnership as shown in Figure I-1. It is important in the catchment management planning process that an engaging process is undertaken.

Figure I-1: Levels of community engagement (Source: Sunderland Partnership Community Development Plan, 2008:7)

The right to an environment that is not harmful, and the right to services places a responsibility on the government to ensure legislation supports the provision of these rights, as well as in investment plans to ensure implementation to achieve these rights. On the public's side, the public are responsible for appropriately and responsibly using the services provided, including preventing pollution or preventing activities that may cause a harmful environment. While we all have the right to an environment that is not harmful, we all have the responsibility to not make the environment harmful.

I.1.1 Role-players and Stakeholders

Throughout the planning and implementation processes there are different people involved in different roles. There are Role-players who are involved in the formal decision-making process such as Government Departments, funding agencies, Local Government; and there are stakeholders who are directly affected by the decisions being made (also called Interested and Affected Parties, 'IAPs'). Both types of participants play an active and crucial role in the design, development and implementation of any project whether ecological infrastructure, rehabilitation or service delivery. It is important that the role-players don't impose decisions on the stakeholders, and it is important that the stakeholders communicate with the role-players, this is done through various mechanisms of public participation and stakeholder engagement.

What is the difference between a role player and a stakeholder?

A **role player** is involved in decision-making but isn't affected by the decision, whilst a **stakeholder** is directly affected by the decisions being made.

I.1.2 Public Participation

Public participation is a legislative requirement in South Africa (DLG, 2000) and has become a priority both locally and internationally. Public participation is expected to enhance development and service delivery (Eales, 2004). It is defined as:

> *"An open, accountable process or channel through which individuals and groups within selected communities can exchange views and influence decision-making. It is further defined as a democratic process of engaging people, deciding, planning and playing an active part in the development and operation of services that affect their lives" (DPLG, 2005:1).*

The tools used for public participation include public meetings, community meetings, ward committees, surveys, newsletters, posters, loudhailers, email notifications, and media advertisements (DPLG, 2007). The promotion of community action in encouraging community members to be responsible for the services provided to them, the implementation of development plans and services that are context-relevant, and the legislative requirement for public participation; are among the reasons why public participation should be promoted (DPLG, 2007). Public participation also enables community members to understand the resource constraints within which services are provided.

For example: In Wardha, India, a rural sanitation project to provide communal pit-latrines to rural villages was scrapped due to lack of community support. When asked why the community preferred open defecation to the communal pit latrines, the women responded by asking who would be responsible for fetching the water and cleaning the pit latrines. Ultimately it would add additional chores to the women's already heavy work day.

In informal townships in South Africa, many communal toilets are viewed as a rape-safety risk for women.

In many service delivery projects, community members are merely informed about the project details (Theron et al., 2007:4-5). The supply-driven service delivery approach, which is focused on delivering and servicing infrastructure, is commonly adopted by municipalities as a result of pressure to deliver basic services, can result in the long-term unsustainability of infrastructure, for example sanitation infrastructure.

I.1.3 Stakeholder Engagement

Similarly, to Public Participation, Stakeholder or Community Engagement speaks to the involvement of communities in projects. Community engagement methods and mechanisms are arguably more inclusive and facilitate continuous dialogue between stakeholders. Community engagement moves beyond the mere information and consultation of community members that is implied by the term public participation.

Community Engagement is not simply consultation or notification

Community engagement speaks to knowledge-transfer, education and appreciation and acknowledgement of the local context within which projects will be implemented. Community engagement has proven to result in community development, overall health and hygiene improvement, and an increased sense of ownership, which has resulted in the sustainability of sanitation systems as users are empowered to ensure the long-term sustainability of the infrastructure (Eales, 2004). Community engagement are therefore a necessity not only for successful sanitation projects but other service delivery projects as well, such as land and water rehabilitation and conservation projects. Community engagement also enhances service delivery and development, therefore contributing to effective governance and the deepening of democracy (Buccus et al., 2007). Community engagement facilitates close coordination between stakeholders in a project and the efficient transfer of knowledge.

The leadership and cultural dynamics within the communities wherein projects are conducted are therefore important to the community engagement and knowledge transfer process. Additionally, the consideration of indigenous knowledge in design and delivery projects is vital for the protection of the environment and ensuring proper use and management of infrastructure. The transfer of knowledge in projects where new technologies are being introduced in communities therefore must be a two-way exchange of information (Murphy et al., 2009) especially where infrastructure and services are being installed. For example, a project providing electrification: training in how to use and maintain electrical appliances is important. For someone who has never had an electric light they don't know that the light bulb must be replaced, how to replace the light bulb, that they need to budget to purchase a new light bulb (and transport to/from the shop), where to get new bulbs from, and that operating the light bulb will increase the household expenses to pay for the electricity.

The knowledge transfer process needs to not only allow for project facilitators and role-players to share knowledge, but for local stakeholders to provide feedback and share their indigenous knowledge (Murphy et al., 2009). Both project facilitators and project recipients are thus knowledge holders and knowledge recipients.

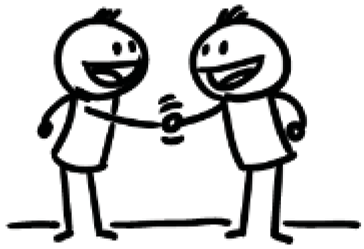
Community engagement methods and mechanisms include:

- **Early engagement** of communities in the project/process not only be engaged once key project-related decisions have already been made.
- Clear setting out of, and agreeing to/of **objectives** at the beginning of the project/process.
- Continuous **conversation** between all stakeholders throughout the project.
- Acknowledging and using **indigenous knowledge**.
- The selected methods of engagements must be **relevant** to the context within which the project is implemented, and the stakeholders.
- The community engagement process must create opportunities for **accountability**.
- Create community **ownership.**
- Incorporate the **capacity building** of the community to ensure that they can participate in the process (and project) in a meaningful manner.
- The decision-making process must be **structured, open** and **inclusive** of key stakeholders representing the community, ideally without political or self-bias.
- **Early identification** and **representation** of key stakeholders.

Methods or techniques used in participatory approaches are listed in Table I-1. These techniques are used in conjunctions with each other.

Table I-1: Participatory Methods or Techniques

Participatory Methods and Techniques	
1	Village Meetings
2	Visual Mapping
3	Semi-structured Interviews
4	One-to-one interview
5	Transect walks
6	Time lines
7	Historical (and other) matrices
8	Ranking, rating and sorting (e.g. three pile sort)
9	Problem trees
10	Venn diagrams
11	Group work (focus groups)
12	Action research



I.2 Principles in participatory practice

All participatory practice entails the following:

- Reverse the conventional direction learning: Gain social, physical and technical knowledge from and with people face-to-face. Facilitate analysis by letting people use maps, diagrams, explanation, planning, monitoring and evaluation. Figure I-2 demonstrates mapping in action, the seeds, leaves and sticks represent various village assets (natural and infrastructure). The community has contributed to drawing out the map on the ground, this is captured by the planning team as photos and drawn on paper for project records.

Figure I-2: Resource mapping (Source: S. Braid)

- Understand the power of the practitioner's role: Denying your power as a practitioner simply confuses people – it works better to discuss with stakeholders how you can use your power effectively.

- Work as a team: A balanced team represents environmental, socio-economic and cultural perspectives. The team should include local stakeholders who know the area, as well as people with the required skills and knowledge.
- Share knowledge: Share knowledge and experience willingly and openly, allowing for self-critical appraisal and learning from others. Local people should share knowledge amongst themselves and with outsiders. Practitioners should share their findings with each other and with the local people. Figure I-3 demonstrates a semi-structured interview taking place, where the community can contribute openly on issues they feel should be addressed.
- Use non-authoritarian approaches: Listen rather than lecture, be relaxed and unhurried, probe and explore instead of rushing to the next topic, don't dominate or control, learn about the community's concerns and priorities. Enable the people to do their own research and analysis and state their own priorities.
- Make trade-offs: Balance the costs of different ways of learning against usefulness of the information. Make trade-offs between quantity, relevance, accuracy and timeliness of different approaches to learning.
- Triangulate: Use a range of methods, investigators and disciplines to crosscheck information.
- Seek diversity: Deliberately look for contradictions and differences rather than simply working with averages.

Figure I-3: Semi-structured interviews being undertaken (Source: S. Braid)

I.2.1 Rules to remember

There are a number of important basic rules to adhere to in all the approaches:

- Respect stakeholders, learn with them and learn from them;
- Be patient and courteous – don't undermine, intimidate, exclude or label people;
- Try not to interrupt speakers; control domineering participants; and let everyone feel comfortable to contribute;
- Find ways to help people to express and analyse their knowledge;
- Resist the temptation to impose your ideas and values;
- Be aware of your body language during the meeting, be respectful;
- Be approachable;
- Be interested;
- Turn your mobile phone off, don't text or take calls during the participatory approach, unless it is a dire emergency;
- Follow protocol, where applicable, both cultural and political; and

- If you record, photograph or film any of the participation sessions, be sure to ask permission from the participants first, especially if using drones.

I.2.2 Facilitation

Facilitation is a skill and participatory methodologies require the inclusion of experienced facilitation. A team undertaking a participatory exercise should ideally comprise of a lead facilitator, an observer, and a recorder. The observer watches the process and the reactions of the participants, guiding the facilitator as required. Typically, the observer notes when people are showing signs of feeling alienated, or seeks ways of distracting dominant voices or powerful figures in order to give others the space needed to contribute freely.

The key to facilitation is empathy. People must feel that they are being heard. It is also vital that people are heard and that opinions are accommodated or sensitively dealt with, whilst not everyone can facilitate, these are skills that can be learned, and training is recommended for all planning team participants so that they can fully understand and support the process.

I.3 Identifying Stakeholders

Key stakeholders in rural communities include residents, civic and tribal authorities, government officials and policy makers, natural leaders (i.e. people identified by residents as leaders in the community generally due to their level of influence in the community not just political leaders but people who the community will listen to and follow), community-based organisations and any other organizations with vested interest in the community. Figure I-4 illustrates an example of a stakeholder analysis identifying various stakeholders that may have interest in the development of a Village Level Catchment Plan.

There are various ways of identifying key stakeholders including:

- Taking into consideration the project objectives and the context within which the project will be implemented, compile a draft list of potential stakeholders which will be used as an initial guideline for key stakeholders.
- Consult with organizations that have conducted work within the community, which required the engagement of the community.
- Obtaining a list of key stakeholders from civic and tribal authorities, government officials, church groups, and community-based organizations, and community members themselves.
- Use various forms of media to invite potential stakeholders.
- People who are part of typically marginalized groups such as women, children and the disabled must be represented.
- Coordinate community meetings prior to or at the commencement of the project, during which community members are given an opportunity to select stakeholders to represent them and/or recommend key stakeholders which may have not been identified.
- Agree on the best means of communication with stakeholders, e.g. newsletters, SMS text updates, a messenger system, etc.
- Within the identified stakeholders identify who will benefit/impacted directly by the project, ensure they are actively engaged during the stakeholder engagement process.

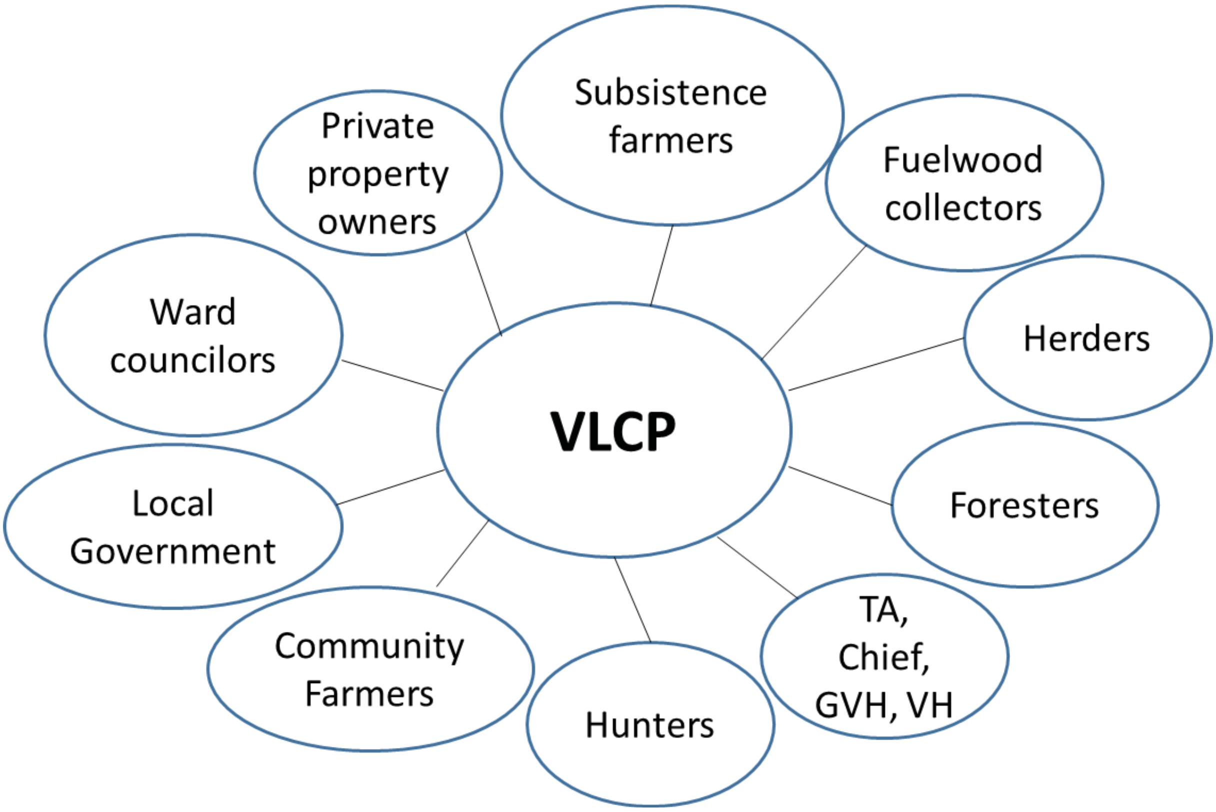


Figure I-4: Stakeholder analysis to identify stakeholders.

- Introduction

The key to facilitation is empathy. People must feel that they are being heard. It is also vital that people are heard and that opinions are accommodated or sensitively dealt with, whilst not everyone can facilitate, these are skills that can be learned, and training is recommended for all team participants so that they can fully understand and support the process. Types and techniques of participatory approaches are discussed further.

- Rapid Rural Appraisal (RRA)

This input on Rapid Rural Appraisal (RRA) has been adapted from the website for '*Community Adaptation and Sustainable Livelihoods*' (CASL)[17].

RRA consists of a series of techniques that can generate results of less apparent precision, but greater evidential value, than classic quantitative survey techniques. The method does not need to be exclusively rural nor rapid, but it is economical of the researcher's time. It is essentially extractive as a process: the agenda is still that of the outside researcher.

RRA emerged in the 1970s as a more efficient and cost-effective way of learning by outsiders, particularly about agricultural systems, than was possible by large-scale social surveys or brief rural visits by urban professionals. It emphasises the importance and relevance of situational local knowledge, and the importance of getting the big things broadly right rather than achieving unauthentic statistical accuracy. It developed a style of listening research, and a creative combination of iterative methods and verification, including "triangulation" of data from different sources – using

[17] Participatory research for sustainable livelihoods: A guide for field projects on adaptive strategies. https://www.iisd.org/casl/CASLGuide/guidebook-home.htm

two different methods to view the same information. Both primary[18] and secondary[19] data pertaining to the community is collected. RRA is usually conducted by a multi-disciplinary team, and the chief techniques are set out in Table I-2 below.

Table I-2: Chief techniques used in RRA

	RRA Techniques
1	Review of secondary sources, including aerial photos, even brief aerial observation
2	Direct observation, foot transects, familiarisation, participation in activities
3	Interviews with key informants, group interviews, workshops
4	Mapping, diagramming
5	Biographies, local histories, case studies
6	Ranking and scoring
7	Time lines
8	Short simple questionnaires, towards end of process
9	Rapid report writing in the field

RRA remains fundamentally an extractive, externally-driven process. A note on this point is that materials developed by the community, whatever the methodology employed, should always be left behind with the community, enhancing ownership of both process and outcome.

- Participatory Rural Appraisal (PRA)

This section has been adapted from the website for '*Community Adaptation and Sustainable Livelihoods'* (CASL) 17.

Emerging in the 1980s, Participatory Rural Appraisal (PRA) builds on RRA but goes much further. PRA involves local people carrying out their own appraisal, analysis and actions, with facilitation as outlined above. PRA is distinguished by the use of local graphic representations created by the community that legitimise local knowledge and promote empowerment, Figure I-5.

PRA uses group exercises and interactive visual tools to facilitate information sharing and analysis. PRA encourages shared learning and gives people the freedom to try and fail, or succeed. It views mistakes as learning opportunities and chances for constructive criticism. In this way the people own the decisions and are committed to the work.

PRA adds some more radical activist perspectives to RRA, including those of (i) Empowerment – where knowledge is power and shared knowledge is shared power (ii) Respect – where the researchers are the learners and the community are the teachers: (iii) Localisation – on-site engagement with on-site materials and representations (iv) Enjoyment – PRA as fun, with an emphasis on the process and not on time taken (v) Inclusiveness – where everyone is included.

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[18] Primary sources are namely 'raw data' or first-hand accounts of the subject that is being researched, and in this context, are collected specifically in relation to the study. For example, primary sources include observations, interviews and surveys that would be undertaken by the planning team.

[19] Secondary sources are generally sources of information that have been collected and documented by a third party that provide context and background to the subject that is being researched. These could include maps, documents, and biographies that were documented by another party.

Figure I-5: PRA (Source: C. Blanché)

Note that at the broader catchment scale, it is recommended to carry out several PRA workshops throughout the catchment, rather than attempt to cover the whole catchment in one PRA. (At the village catchment scale, one PRA workshop is suitable.)

A risk to be guarded against with all methodologies, and all development interaction, is the possible build-up of unrealistic expectations.

PRA is the fundamental methodology that should be adopted at all levels of catchment planning although it can be said that provided participatory approaches are adopted and community knowledge is respected, it matters little what label the technique is given and practitioners can mix and match methodologies as best appropriate.

- Rapid (Relaxed) Appraisal of Agriculture Knowledge Systems (RAAKS)

RAAKS is an action-orientated method for stakeholder analysis and problem solving, with a focus on the social organisation of innovation. The method enables stakeholders to gain an overview rather than see the situation from one perspective. RAAKS uses systems thinking, multiple perspectives, action orientation, and participatory and joint learning. It is a way of systematically monitoring and improving stakeholder performance in use of the land.

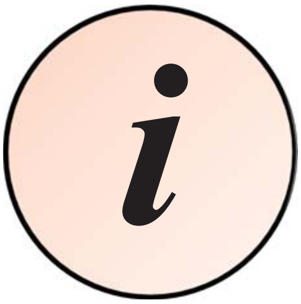
This technique can be useful in catchment scale and sub-catchment planning. At village level the method to use in information gathering and sharing remains PRA.

- Village meetings as participatory practice

Village meetings bring different groups of people together to discuss the project, gain information and get feedback. The way you conduct the first village meeting is critical as it sets the tone for your future relationship with the people in the area. At the first meeting give a full account of:

- Who you are;
- Where you are from;
- What organisation you are working for;

- Who is funding the project;
- Why you are there;
- What you plan to do;
- What you expect of the stakeholders;
- What they can expect from you;
- The expected time period of the project; and
- An outline of other projects.



Do not raise unrealistic expectations by agreeing to things that the project may not be able to achieve or deliver. Be positive; make it clear from the beginning the limits of what the project can achieve. Agree on a course of action only if you are quite certain that it can go forward. If you are not sure about a suggestion, keep the possibility open. Be attentive. Listen; listening in itself encourages people to come up with practical ideas that may have seemed impossible before.

At the end of a village meeting, express appreciation for the stakeholder's time. Highlight the important features of the meeting. Arrange times and venues for activities that were agreed upon in the meeting.

Be cautious not to create false expectations or bad attitudes. Catchment management is important for everyone. It is not for practitioners to "pay" stakeholders to carry out good catchment practices. Be cautious about creating this expectation.

- Visual mapping

Visual mapping is the collective act of drawing a map, Figure I-6. It builds rapport among the people making the drawing, and generates lively discussions about the environmental, economic and social aspects in the catchment. The map can later be used to plan, implement and evaluate IWRM activities. Two common maps used in IWRM are:

- Social maps, which show a village, including households, gardens, beehives, schools, roads, streams and rivers.
- Resource maps, which show land-use patterns, trees, rivers, ponds, and soil types, problem areas.

Mapping helps participating stakeholders describe locations, land tenure patterns and the condition of the land. It gives people a clearer spatial understanding of the upstream and downstream effects of IWRM.

First plan a rough layout of the map. Participants need to agree on the type of map (social map, resource map, or a combination), the categories of information to include, the physical area that will be mapped, the format (size and shape of the paper), and the orientation (where to position north and south). Where paper isn't available, drawing in the sand, or on the side of a building is also fine.

Figure I-6: Resource mapping (Source: S. Braid)

Stakeholders then use coloured pens (markers) to show different features and how they experience the catchment and river (not simply just a drawing of the river and its physical features). The practitioner and project team should not interfere in this part of the exercise in terms of correcting the drawing, but can guide the stakeholders about types of detail to include, e.g. areas of erosion or flooding. When the drawing is complete, the practitioner can hold a semi-structured interview. People may then decide to add new information, such as number of schoolchildren, beehives, crop yields and size of pastures.

Questions to stimulate a resource map:

- What crops are planted, where?
- How is the farm managed?
- What farming systems are applied?
- What is the yield of the farm?

- Where does the farm get its water from?
- Where are key linkages or access points, e.g. pathways, roads, market area?
- Where are areas of erosion?
- Which areas are affected by floods?

This technique can be carried at for all the various scales of catchment planning. At the broader scale, the participants can be grouped, and several visual maps for the different parts of the catchment created.

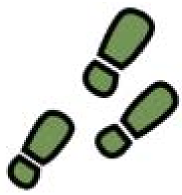
Information in the map can be verified with a transect walk as described below.

The visual map can also beused in developing a vision. First let the participants create a map of their “catchment” showing the present day. Then add/delete from the map what they would like for their future. These maps are key in both planning and in monitoring and evaluating progress – which should also be undertaken in participatory conjunction with the community.

- Transect walks

In a transect walk, stakeholders identify and discuss different aspects of the catchment as they walk through part of the catchment. They walk along a chosen route, talking among themselves and with the practitioner about things that they notice, and things that impact on water resources: such as soil conditions, erosion, land use patterns, location of- /state of water collection points, irrigation, landslides and gullies, ground cover, etc. Group discussions around overgrazing, deforestation, soil conditions, pasture conditions, farming systems applied, are useful topics for discussion and understanding the level of awareness of catchment issues.

Make sure not to walk too fast on a transect walk. Be observant and ask questions, “Why?”, “what do you think?” Encourage participants to ask their own questions and share their knowledge about the use of local resources.



- Wear suitable shoes (hat, water, etc. may also be appropriate)
- Plan the route with the stakeholders (identify what needs to be seen).
- Take notes, photos. Mark on the route map points of interest and discussion.
- If the walk focuses on a specific aspect, make sure the participants have the necessary background knowledge.

Transect walks are appropriate for village scale and micro-scale catchment planning. A transect walk may also be carried out where specific issues have been identified in the broader catchment planning process, as means to gather more information about the issue.

- Semi-structured interviews

A semi-structured (conversational) interview is one with a loose structure that responds to the person or group being interviewed, Figure I-7. The interview is highly adaptive to the situation. Many participatory techniques, such as mapping, transect walks, etc. use this tool to gain more insight into relevant issues or topics. For example, after a group of stakeholders has drawn a visual map, you can use a semi-structured interview to enable them to share their knowledge, experiences, perceptions and understanding of the map.

A semi-structured interview allows a free flow of conversation so that participating stakeholders can introduce whatever topics they feel are important. One-to-one interviews are better when the issues being discussed are specific or sensitive, but a semi-structured group interview also works when a topic is applicable to many people. Be aware of one or two strong participants hijacking the conversation. Be sure to enable everyone to participate and contribute their own views in the discussion.

Semi-structured interviews can be carried out at all scales of catchment planning. With larger groups of stakeholders, break into smaller groups to facilitate more discussion and inputs from the participants. A small group (±10 people or less) is more personalised than a large group (30 people and more). Consider the type of information you would to gain from the conservation, and arrange your groups accordingly. For example, if you want to raise women’s role in water management, then have a group of only women, don’t group the women with the men.

Figure I-7: Semi-structured interviews being undertaken (Source: S Braid)

Start with your own set of thoughts about what you want to discuss – but remember that this is not a questionnaire. Allow a free-flowing conversion and use this only to ensure that important issues are not forgotten.

- One-to-one interview

Gently guide and balance the interview to ensure that the person remains focused on the task. Don't be rude or forceful. Use a mental (or written) list of questions to make sure you achieve the aims of the interview, but always remain open to exploring new or unexpected issues that the interview raises. Start with open-ended questions, then look into specific issues. Use both visual and verbal methods to probe. A useful strategy is to apply the 'but-why?' method to get to the deeper causes. Accurately record and date the information from the interviews. You can synthesise your own notes, but keep an accurate reflection of the interview. Give copies of the interview reports to the stakeholders. If you record the interview, be sure to ask permission from the interviewee first.

Note how this differs from a semi-structured interview. It is an in-depth interview – but scripted in a way that is not obvious.

- Group work (focus groups)

Group work is a most useful way of injecting energy into meetings and especially in allowing the silent voices to be heard. There are a number of different ways of undertaking group work: Reflection, Buzz Groups, Rounds, Brainstorming, etc. The most common of these is "buzz groups" where participants are simply asked to discuss an issue with an immediate neighbour (or neighbours) in the group. It is remarkable how stimulating this can be.

Small group techniques are useful in workshops with a large number of participants. They give quiet, less dominant members a chance to express their views. There are many different small group methods, including problem census and brainstorming.

Practitioners need to clearly explain the purpose of a group exercise to all participants. Once in their small groups participants discuss the task and carry out the exercise. Then the whole (plenary) group comes back together to reflect on each small group's findings and explore the issue further.

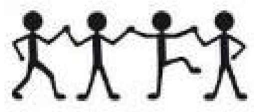
In the catchment context issues that may be discussed could include:

- Extent of land cultivated
- Extent of erosion, and causes of erosion
- Availability of water, or problems with access to water
- Farming practices used (rotation, mono-cropping), etc.
- Extent of pastures
- Extent of forests, or threats to forests
- Number of cattle, sheep, goats, pigs, chickens, or donkeys

Group work is appropriate for broad scale planning. Where detailed more specific information is required, then the small-scale approaches such as village meetings, visual mapping and PRA can be used in conjunction with group work.

- Action Research

Action Research is a method of getting diverse social groups to work together in ways that consciously build their relationship. By working towards a common purpose, the groups begin to understand the social, economic, historical and political forces that influence them and others, and that they have on each other (upstream-downstream).



The Action Research process is a series of structured interactions. First, the problem is defined. Then the action is planned. Then the action is carried out. Finally, the action is observed and reflected upon. The problem is then redefined (or next problem identified), further action is planned, and another cycle of action research takes place. Action Research can be described as a spiral of events in which action and relationships evolve as the cycle goes forward. Refer to Figure I-8 below.

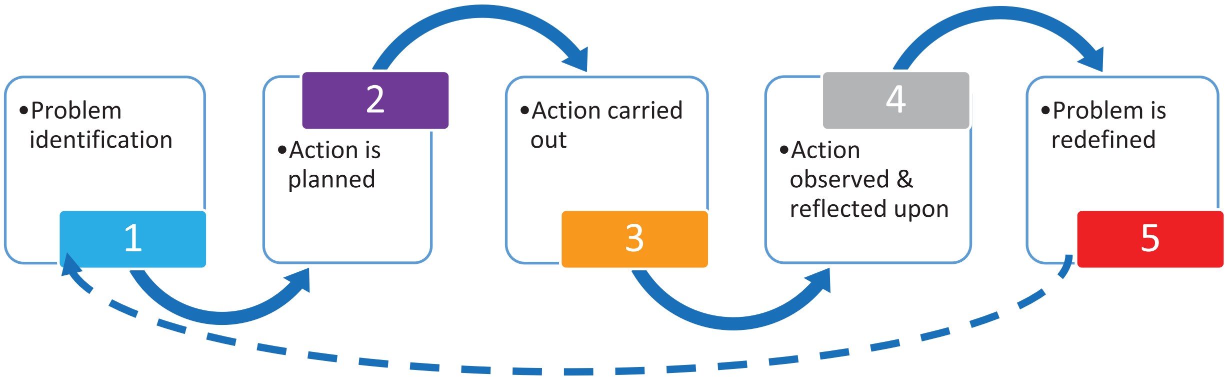


Figure I-8: The cycle of Action Research

Action Research is a process of learning by doing, and learning with others. It helps participants learn about their practices, languages, modes of work and power relationships. They examine how their skills and values shape their identity and the socio-political structures around them, and how social structures may be limiting their growth. All parties gain a broad perspective on new possibilities to make decisions about the structures and interventions they need. The method is a good way to challenge unjust and unproductive systems of working. It helps people look critically at how oppressive and destructive situations are created and maintained. It helps upstream and downstream participants understand each other's contexts.

This technique is appropriate for catchment-wide planning.

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ANNEXURE II : ESTABLISHING A GREEN VILLAGE COMMITTEE (GVC)

In a Green Village Committee (GVC), the members are elected by the village to form a grass roots committee. In terms of the Village Catchment Planning (VCP) process, the GVC is the most suitable vehicle to champion the development of a VCP because it is an existing structure at the village level and has objectives in Natural Resources Management (NRM). Catchment management planning is essentially underpinned by NRM principles.

The role of the GVC is to initiate and facilitate the VCP process. The GVC is also responsible for organising itself – this step may need to be facilitated by the extension officers and the traditional authority body, e.g. Chief or Village Headman. Often GVCs in reality only meet when a new initiative arises so this is a good opportunity for them to reconvene. When convening for the VCP the GVC must decide the following:

- Where and how often the GVC will meet;
- Who will act as the chairperson to keep order, call meetings and assign work
- Who will record minutes, so that everyone is clear about what has been decided at meetings; and
- How the GVC will schedule activities required to develop the plan.

The Project Implementation Committee (PIC) is a temporary body selected by the village which is established to implement a particular set of activities and projects as set out in the VCP. It should include representatives from the GVC and will report to the GVC. Specifically, the PIC should be set up as Step 6 of developing a VCP. A selection process that is fair, open and inclusive will ensure community support. With reference to the VCP, the PIC is tasked with the following:

- Compiling the implementation plan and schedule;
- Preparing a budget;
- Applying for funding from a donor;
- Setting up a village savings group;
- Implementation of projects:
- Procurement and storage of project materials;
- Procurement of services;
- Project fund management;
- Submission of progress reports; and
- Monitoring and evaluation of project progress.

The composition of a PIC is set out in Table II-1.

Table II-1: Composition of the Project Implementation Committee

PIC Composition
Member 1 (Chairperson)
Member 2 (Treasurer)
Member 3 (Secretary)
Member 4 (PIC member)
Member 5 (PIC member)
Member 6 (Chairperson Procurement Sub-Committee)
Member 7 (Secretary Procurement Sub-Committee)
Member 8 (Procurement Sub-Committee member)
Member 9 (Procurement Sub-Committee member)

Some suggested selection methods are:

- Election by representation (i.e. decide the number of members from each sector of the community and establish a democratic process to elect members);
- Election by geographical boundaries (i.e. if the village is large, break it down into manageable parts and host meetings to elect representatives from the smaller areas); and/or
- Interim appointments followed by a meeting to present PIC members and seek endorsement from the village for the PIC (this could be an election).

Guidelines for the villagers when selecting a PIC:

- Consider the skills the PIC needs;
- Invite people who are prepared to give their time and talents to participate in this process, it is a voluntary committee;
- Membership should reflect the diversity of the village;
- There will be many village representatives throughout the overall process, however keep the core decision making team (the PIC) to a few people;
- Consider the size of the team, as too large a group will not be effective;
- Two of the members should be from the village leadership (male and female);

- Remember it is essential that the team is representative of the village.

Some lessons learnt from project experiences when establishing either the GVC or PIC:

- Make sure you have the Chief's permission and support when establishing the committee.
- Include representatives from neighbouring villages to the particular catchment site to facilitate transfer of knowledge and capacity.
- Make clear that it is a volunteer basis, as the management of natural resources is everyone's responsibility.
- Ensure the committee has committed members. It will be up to the committee to drive process.

ANNEXURE III : COMPILING A BUDGET

List of Acronyms
CBSL : Community-Based Savings and Loan club
GVC : Green Village Committee
NGO : Non-Governmental Organisation
VCP : Village Catchment Plan

How to compile a budget

What is a budget?

A budget describes the amount of money that an organisation, for example the Green Village Committee (GVC), requires to spend for set purposes over a given period of time, in this case a Village Catchment Plan (VCP).

A budget has several different functions and is important at various stages of a project (Figure III-1 and Table III-1), including:

Planning: project managers, e.g. the GVC can use it to establish an accurate idea of the VCP cost. This allows them to work out if they have enough money to complete the project and if they are making the best use of the money they have available. The budget indicates when certain amounts of money will be needed to carry out specific activities.

Fundraising: the budget is an important tool for convincing donors the VCP and its constituent sub-projects are viable. It sets out in detail what the money will be spent on, and what results will be achieved. Donors use the budget as a basis for deciding whether the funds being requested are reasonable and well-planned.

Project implementation: an accurate budget is needed to control the VCP, once it has been started. It is an important tool to compare the actual costs against the budgeted costs for on-going monitoring. It will be necessary to review the budget after a project has started because plans sometimes change.

Monitoring and evaluation: the budget is used to monitor the income and expenditure as the projects progress to identify any problems and determine if adjustments need to be made to any specific activities or goals. It is also used as a tool for evaluating the success of the VCP when it is finished. It helps to determine if the VCP succeeded in achieving what it set out to achieve. The budget promotes financial accountability and transparency which results in good project governance.

Budgets are based on objectives, action plans, and resources.

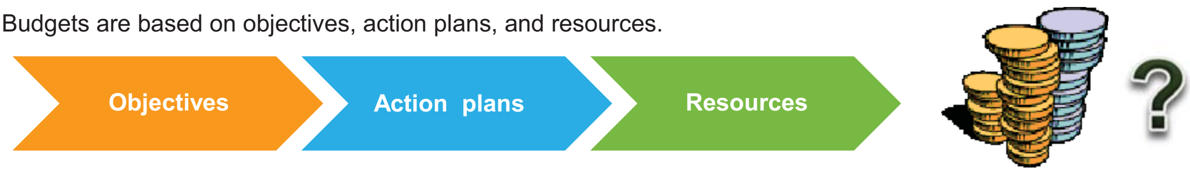

Figure III-1: Elements to considerer when compiling a budget

While the GVC is responsible for preparing the preliminary budget, the PIC may later review and suggest refinements. This input gives the PIC an opportunity to modify the budget and helps identify if any budget items or expenses have been omitted, based on experience gained from other similar projects – and during implementation. This collaboration helps to develop a budget that reflects realities.

When preparing a budget consideration is given to what the VCP expects to cost (i.e. expenses) against the funds available (i.e. income) during a specific time period. Usually, there are two major types of costs to consider: direct costs and indirect costs Figure III-2.

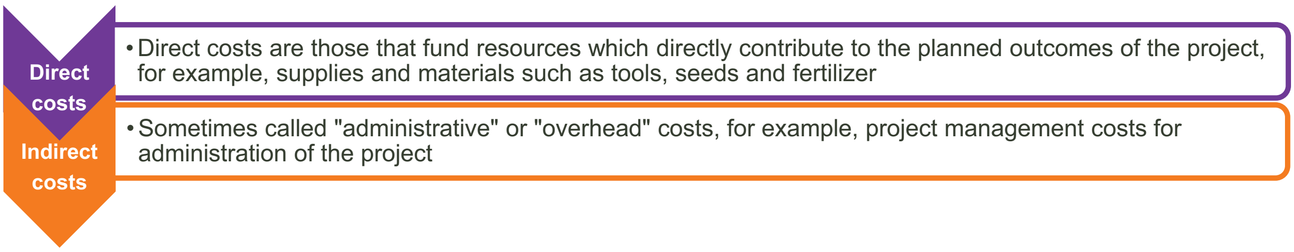

Figure III-2: Types of costs to be considered

The administrative costs should not exceed more than half the budget. In addition, funders always require reporting on monies spent on overheads and directly on the project (Figure III-3).

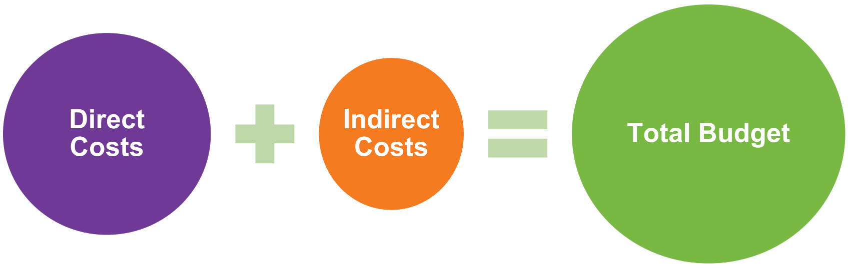

Figure III-3: Components of costs to be considered in budget

Budgeting technique

- The easiest technique for budgeting is known as **incremental budgeting,** in which the figures are based on those of the actual expenditure for the previous year, with a percentage added for inflation for a new year. This is an easy method that saves time but it is the "lazy" way and is often inaccurate and can only be used on projects with similar activities that run for a number of years. This may not be the case with the VCP.
- Other techniques, such as **zero based budgeting**, may provide a more detailed and accurate budget, but take more time and energy to prepare. In this approach each activity that is required to be undertaken to reach the projects aim must be broken down to establish its component costs. This comes closer to the VCP characteristics.

Budgeting process

Preparing a meaningful and useful budget is best undertaken as an organised and structured group exercise by the GVC with input from the PIC (and others as required). The budgeting process can be assisted by asking a number of key questions such as:

What are the objectives of the project? *Refer to the VCP*

What activities will need to be undertaken to meet these objectives? *Refer to the VCP*

What resources will you need to successfully complete these activities? *Refer to the VCP*

What will the identified resources cost?

What additional resources will be required to manage the project?

Where will the funds come from?

Is the VCP realistic?

A stepwise approach to budgeting will include the following steps:

1. **Identify** exactly what is planned and how it will be implemented. List each of the activities and then plan how much each will cost and whether the result will generate income.
2. **Determine what each of the expenses will be**. Assume an increase for inflation when comparing expenses from a previous year, e.g. 10%. Aspects to consider in budgeting include those listed in **Table III-1**.
3. **Analyse the difference between the available funds, additional income required and expected expenses.** Make adjustments to balance your budget. Determine if and what expenses need to be reduced and how these may affect the implementation of the project.
4. **Develop a plan for the unexpected**, such as a crisis (e.g. flooding), or if there are price fluctuations.
5. **Make any changes and finalise income and expenses budgets**, as well as the timing of expenditures and income. Review this with the implementation plan, the timing of some project activities may be limited by available funds, or basic interventions can be implemented and when funds are available these can be upgraded.
6. **Monitor the budget** as the VCP progresses, i.e. monitor what is actually being spent compared to what was planned and budgeted for.

Table III-1: Framework for estimating costs

Operational costs: Each activity will have a number of resources that will cost money.			
Resources	Unit cost	Quantity	Total cost of item

Materials Equipment Services Transport 	*The unit cost is the cost of a single item, or one unit, e.g. Cost per day, per kilometre, per person.*	*This is the number of units (how many) are needed for the activity, e.g. 1 TLB Grader for 20 days.*	*Multiply the total number of units by the unit cost.*
Organisational costs: The management of all the required activities will need to include money for some or all of the following aspects, depending on the size and complexity of the project.			
Management (time):	Administration:	Governance & Organisational development:	Overheads:
Expenses (travel; out of pocket expenses, etc.) Public relations Fundraising	Secretarial help Equipment Software Stationery Permits and Licences	Organisational processes (committee meetings) Resource materials (books, pamphlets)	Rental of space for meetings Electricity, water (if required) Refreshments for meetings Maintenance Telephone costs

FOR EXAMPLE:

This is an example of compiling a budget for constructing earth contour bunds on one hectare during a 3-year plan, Table III-2 to Table III-5.

Step 1	• **Identify what resources are needed, e.g. for a 3 year plan**

Table III-2 Resources needed for a 3 year plan

Resource items	Year 1 (quantity)	Year 2	Year 3
Pegs	20	0	0
Hammer / stone	1	0	0
Spade	3	1	1
Line level / A-frame or Phiri-Lino-frame	1	0	1
Supervision (person-days) voluntary/unpaid	9 (3 people x 3 days)	(1 person x 1 day)	(1 person x 1 day)
Labour (person-days) voluntary/ unpaid	150 (family of 5 x 30 days)	10	10

In the first year of constructing the contour ridges there is a requirement for equipment and labour to dig the ridges. However, in year 2 and year 3, there is little equipment required but there is still some labour to maintain the ridges.

Step 2	• **Price each of the resources**

The general cost price is obtained for each of the items of equipment / resources that are required to construct the contour ridges. This needs to be fairly accurate as this will form the foundation of your budget.

Table III-3: Price of each resource

Resources	Unit price
Pegs	R 50
Hammer / stone	R 150
Spade	R 200
Line level / A-frame or Phiri-Lino-frame	R 100
Supervision	R100 per person per day
Labour	R0 (voluntary)

Don't forget to consider inflation if prices go up each year as well as taxes such as VAT. (Budget = resource unit price x quantity)

Step 3 • **Calculate each budget**

Calculate how many of each resource / equipment item is needed for the initial construction in year 1, as well as for the maintenance in year 2 and year 3.

Table III-4: Budget calculation

Resources	Year 1 Budget	Year 2 Budget	Year 3 Budget
Pegs	R1,000 (20 x R50)	R0 (0 x R50)	R0 (0 x R50)
Hammer / stone	R150 (1 x R150)	R0 (0 x R150)	R0 (0 x R150)
Spade	R600 (3 x R200)	R200 (1 x R200)	R200 (1 x R200)
Line level / A-frame or Phiri-Lino-frame	R100 (1 x R100)	R0 (0 x R100)	R100 (1 x R100)
Labour (people / days)	3 people 3 days R0 (3x3xR0)	1 person 1 day R0 (1x1xR0)	2 person 1 day R0 (2x1XR0)
TOTAL	**R1,850**	**R200,00**	**R300.00**

Step 4 • **Review budget each year and adjust accordingly**

Table III-5: Budget review and adjustment

Year 1	Budget			Actual Cost		
	Unit price	Quantity	Budget R	Unit price	Quantity	Spent R
Pegs	R50	20	1000	R30	50↑	R1,500↑
Hammer / stone	R150	1	150	R200	2	R400↑
Spade	R200	3	600	R180	2↓	R360↓
Line level / A-frame or Phiri-Lino-frame	R100	1	100	R100	1	R100=
Supervision: person-days (R100 per day)	R100	3 x 3	900	R100	2 x 3↓	R600↓
TOTAL			**R2,750**			**R2,960**↑
Difference (=Actual cost – Budget)				**+R210 (over budget)**		

Keep records of how much you actually spent each year.

Timeframes

Organisational budgets (for example for a GVC) are usually calculated for a year at a time to establish an annual budget, but it is best to break it down into months for management purposes. A monthly breakdown facilitates monitoring (refer to **Annexure IV** for more information on monitoring and evaluation). Budgets for specific, timebound projects[1] may be calculated for the whole life of the project. For monitoring purposes, it is probably best to break this overall VCP budget into months (where the project runs over several months). For smaller seasonal projects it may be decided to break it up into weeks to accurately manage cash flow.

> [1]**What is a time-bound project?**
> Timebound projects run for a specific length of time and have a set start and end date.

Once the budget has been agreed by the GVC and the activity implemented, the process is completed by comparing the plan (budget) with the eventual outcome ('actual'), to see if there is anything that can be learnt or could be done differently next time.

The following important points should also be considered when preparing a budget:

- **Income**: Funders like to see a diverse source of revenue which shows that project sustainability does not rely on one sole source of funding. Projects that can start to generate their own income over time are preferred: in the case of a VCP, tree nurseries may be income generating for example
- **Expenses**: Expenses should be itemized and include unit costs, for example, daily fees or travel for number of participants.
- **Budget Headings**: Make sure that budget headings or categories are consistent throughout the period the GVC and PIC are actively engaged, for both income and expense items. This will simplify the book-keeping and help with reporting.
- **Notes**: Keep notes to record the budgeting process. Notes explain how and why budget calculations are made, and can be used later to clarify how and why certain decisions were taken. This makes it easier to make later changes to the budget should circumstances change. It also helps when the activity is audited.
- **Contingency funds**: Include a line item that will incorporate fluctuation of costs or unexpected expenses.
- **Non-monetary contributions**: It is helpful to show the funds or resources contributed by donations from other organisations or by voluntary work (much of the work under a VCP will be voluntary labour: 'in-kind' contributions). Funders see in-kind contributions as evidence of the community's commitment to the sustainability of the project.
- **Maintenance**: where materials, e.g. tools, can be used for multiple activities, include budget for maintenance if applicable, e.g. new wheel for a wheelbarrow, new shovel handle, etc.
- **Streamlining expenditure**: where several of the same tools are required for different activities, try and streamline the activities if possible, rather than relying on purchasing new equipment for each activity. Where additional tools are required, then these additional items should be budgeted for.

How to finance the plan

Finance is most often the main constraint to community initiatives being implemented or to those that are started and not being successfully completed. Projects can be financed through a community's own resources facilitated through Village Savings and Loans clubs (discussed in the next section) or through donations, of both time (volunteering) and money, or through financial institutions or funders (e.g. Government, Donor agencies, NGOs) who have an interest in seeing communities attain specific goals such as social well-being, food security or sustainability. Implementation of VCPs and sustainable catchment management activities should not be limited by lack of funding as an excuse.

Funders consider a budget as an essential tool that provides an understanding of the work that is planned and demonstrates the level of thought and planning that has gone into the VCP. When analysing budget proposals, potential funders consider the following points, Table III-6 closely:

Table III-6: Funder considerations

Considerations of funders:
How you are planning to use the grant funds?
What other sources of funds have been investigated to support the project?
Does the budget reflect realistic local costs?
Do the expenditures correspond to the magnitude and complexity of the activities?
Does the budget fall within funder's specific guidelines for the projects they support?
What percentage of overhead expenses (such as salaries, expenses and utilities) versus operational costs (such as materials, tools) is included in the budget?

Fundraising exercises must be carefully planned and implemented to be successful. Consider which funders are most suited to the type of projects and activities that are being planned; different funders will tend to fund different types of projects and some will only fund specific aspects of projects, such as operational costs only for example. Funders will also want to be sure that the plans comply with local laws and regulations.

In order to approach a suitable funder, it will be necessary to draw up a proposal that clearly sets out what is intended and what budget will be required to achieve those aims. Some funders require the use of their own specific application forms but the type of information they require regarding each aspect of the project remains similar. Remember that there are many projects out there looking for funding so the challenge is to make sure that the particular VCP proposal includes all the key points that make it stand out for the identified donor.

As a first step the GVC should list the top five reasons why this particular funder should finance the VCP (or sub-project within the VCP). Keep this list in mind and come back to review it once your proposal is complete, to check how strongly these points stand out in your final version. A proposal should address the main aspects outlined in **Table III-7**).

Table III-7: Main components of proposal for funding for VCP

Summary
Even short proposals should have a paragraph summarizing what the project (in this case the VCP) is about, to catch the reader's attention and makes them take an interest in the project. Longer proposals may have a summary up to a page long (no longer) comprising a short paragraph covering each of the main sections.
Background
The background section will provide some information on the GVC and the context within which it operates. It should persuade the funder that the GVC is a credible organization that will manage funds and resources responsibly. The background will explain who you are, what you do, how and where you work, and how your experience and/or qualifications will allow you to succeed in the project you are proposing. Relevant information that establishes the trustworthiness and professionalism of the GVC should be included, such as the previous donors worked with or other projects that have been successfully completed. Sometimes additional supporting information can be provided in appendices, such as organizational history and CVs. However, keep the background to the point and brief.
Project need
This section explains the social issues that the VCP is designed to tackle. You should aim to provide detailed information about the specific region and area you will be working in, and the socio-economic status of the people that will benefit from the project to demonstrate that the need is genuine & substantial, and that you have a thorough understanding of what the need is. Explain how the VCP came into being – highlighting the participatory processes employed. Some insight into the funder's specific interests should influence how you describe the problem to match their interests, without changing the nature of your project. For example if they support food security initiatives you should describe the challenges your communities face in accessing food rather than employment issues.
The project
Describe what you are planning to do in such a way that even a donor who is not familiar with your area will understand. Describe your aims, the methods you will you use, how long the project will run and how activities will be managed. Explain the level of support you have from the community – again stressing the participatory nature of the VCP – and local government structures and whether the GVC will collaborate with any other organizations. Describe the features of the VCP and explain what will take place, and why. If, for example, the plan includes a plant nursery you must also explain its purpose in terms of the benefits it will bring, i.e. if it is for nutrition, income generation, agroforestry, afforestation, education, or all of these.

Outcomes
It is vital for funders to understand what the VCP involves and what the outcomes of it will be: that is, what results do you expect to achieve? The outcomes should ideally reflect a decrease in the need which the community previously identified as being important. These outcomes must be specific and not just general statements such as 'the community will learn many useful skills'. Good outcomes can be described as being 'SMART' if they are Specific, Measurable, Achievable, Realistic, & Time bound. It is important to give timeframes to how budgets will be used, and results achieved, in order to be able to measure the success of the VCP. This section should also contain details of how you intend to monitor progress & evaluate success to provide evidence that the outcomes of your project are being achieved.
Resources and financing
In order to successfully implement the VCP, the PIC will need sufficient financial and non-financial resources. Every proposal must include a clear budget covering the project's projected income and expenditure. The level of detail will depend on who the proposal is intended for and the funder's specific requirements. Short proposals might just contain a summary budget broken down into main headings while longer proposals will need to specify more precisely what is included under each of the headings. If the VCP – or components of it – has income projections these must be made clear and be justified in terms of identifying the potential markets for any products that may be produced. If you have approached other funders who have committed to funding certain aspects of the project, you must make sure this is clear in this section. Mention also any in-kind support from the local community or donations from other sources and specify what form this support will take and its estimated value. This will give funders a clear picture of where your resources are coming from and demonstrate that your project has local commitment.
Motivate the funder's interest
Throughout the proposal you should include information on any areas you know will be of interest to the funder in question. Add a few paragraphs to the end of your proposal that clearly state how your project matches their priorities. Most funders have a real interest in sustainability – it ensures their money continues to have an effect even after the initial funding period is over. You need to demonstrate how the project will continue to operate after they are no longer funding it, or how it will bring benefit to the community even after completion of the project.
Appendices
The amount of information needed in the appendices will normally be specified by the funder. This will normally include evidence of previous successful projects such as audited accounts and an annual report of the GVC. Organizational and program budgets for previous and current years, and more detailed income & expenditure breakdowns for the project can also be included

Financial management

When savings and loans are an important part of the VCP, financial control can be exercised through Community Based Savings and Loans Clubs (CBSL or "Bank Mkhonde"), which can manage a pooled investment in which everyone in the community has an interest.

In many respects, CBSL Groups resemble any other businesses but have distinctive features. They have similar physical facilities, perform similar functions, and must follow sound business practices. They are usually incorporated under Microfinance Policy and may require bylaws and other necessary documentation. Even though CBSL Groups are similar to many other businesses, they have distinct differences. Some differences are found in the CBSL's purpose, ownership, control, and distribution of benefits. CBSL Groups follow three principles that define or identify their distinctive characteristics Figure III-4.

User owned

- The people who own and finance the CBSL Group are those who use it. "Use" usually means buying credit products, or using services of the CBSL Group business. Members provide finances to the CBSL Group through different methods, e.g. direct contributions or withholding interest payments.

User controlled

- Those who use the CBSL Group also control it by electing committee members and voting on major organizational issues. This is generally done on a one-member, one-vote basis.

User-benefited

- The CBSL Group's sole purpose is to provide and distribute benefits to members on the basis of their use. Members unite in a CBSL Group to receive services otherwise not available, to purchase quality supplies, to increase market access, or for other mutually beneficial reasons. Members also benefit from distribution of net earnings or profit based on the individual's business volume with the CBSL Group.

Figure III-4: Principles of a CBSL

Steps in setting up a CBSL

The village or community can set up its own CBSL for the implementation of the VCP. The steps to set up a CBSL are discussed in Table III-8.

Table III-8: Steps to set up a CBSL (LUPP, undated)[20]:

Steps to set up a CBSL:
Identify the participants: there should already be a group that have a shared interest in wanting to invest in certain income generating activities under the VCP, but there may be other community members that may wish to be involved. Between 5 and 25 members is ideal. Form a committee: members of the committee are democratically elected by the general meeting. The committee should comprise a chair, treasurer and secretary and two money counters. They should be people of good credit history and of good standing in the community. It must be ensured that there is representation of women and youth. The committee can be rotated every few years. Write a set of rules: These rules can form a 'constitution' and should set out how the savings will be regulated and how disputes will be settled. It can also be decided how often the group must meet and where the money can be kept for safety if there is no access to a bank account. Decide on the operational cycle: Before any savings begins, the following must be decided: The amount of savings to be contributed on a monthly basis. How long the group will operate for before a loan can be taken out. How long before members receive shares from the saved money. When deciding on this cycle, the group should consider when there will be a need for it the majority of members to have access to large sums of money (for example: Christmas or at the commencement of the rainy season). In such cases, members have a right to withdraw from the group without penalty, taking their share with them and thereby ending the cycle. At times like this, new members can be admitted to the group. The maximum loan (this could be based on how much the individual has contributed, e.g. three times their savings) The repayment period and interest rates – interest rates vary but the average is 10%. Start saving! When the operational cycle comes to an end the group may receive back its share or conduct a collective investment such as implementation of the VCP

Accountability issues

Capacity Building: To operate under these distinctive principles, an important practice, particularly for new CBSL Groups, is to conduct continuing member education. This is especially important for attracting and recruiting new members. It is also necessary because the CBSL Group's membership continually changes. Older members retire and new ones join or other may just resign.

Communication: Keeping owners (members) informed is an important practice for any business, but vital in a CBSL Group for at least:

- The democratic control principle, exercised through majority rule, requires that the entire ownership (members) be informed and involved to assure that enlightened decisions are made; and
- Members must indicate their needs and accept the accompanying financial responsibilities before the CBSL Group can fulfil those needs.

Therefore, there needs to be accurate records kept of monies paid into the CBSL and monies paid out of the CBSL.

ANNEXURE IV : MONITORING AND EVALUATION (M&E)

List of Acronyms

GVC : Green Village Committee
M&E : Monitoring and Evaluation
VCP : Village Catchment Plan

Introduction

[20] LUPP (Editor) (undated): Community-based Microfinance: Community Savings and Loan Groups. Good practice in the musseques of Luanda. Luanda Urban Poverty Programme (LUPP). URL http://www.sswm.info/sites/default/files/reference_attachments/LUPP%20ny%20Community%20Based%20Microfinance.pdf [Accessed: 06.04.015].

It is the responsibility of the GVC to monitor and evaluate the process during and after implementation, known as monitoring and evaluation (M&E). The purpose of M&E is illustrated in Figure IV-1. Village stakeholders, government, donors and other communities can all benefit from the information that is obtained from monitoring and evaluation.

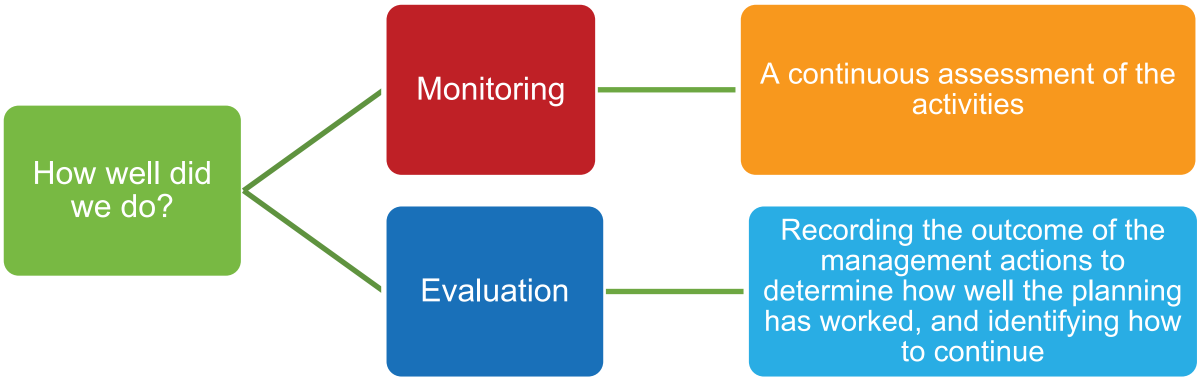

Figure IV-1: Purpose of monitoring and evaluation

Key components of the monitoring and evaluation (M&E) system should be the selection of the indicators and ensuring feedback of the results into the decision-making and implementation processes. In simple terms, M&E is necessary to ensure that implementation takes place with the intended results and impacts. A proper M&E system, whose results are shared among stakeholders, also fosters accountability and transparency, and is likely to generate broad-based support for the plan implementation. It is essential that there is consistency between the goals, objectives, strategies, activities and the chosen indicators.

M&E systems can be costly and demanding of resources – human, data and financial. It is therefore necessary to develop an efficient, effective and sustainable system, which can be implemented within resource limits and line functions. The data and its interpretation should be rigorous and robust; it is important to measure what is valued, not value what is being measured, e.g. availability of water at boreholes, rather than number of boreholes drilled.

Strategies and plans must be monitored and evaluated on a regular basis. How often, and when, monitoring is carried out will be dictated by what is being measured – environmental improvements will have different timescales to budget expenditure. Stakeholders need to know whether progress is being made and what the achievements have been at any given time. A good M&E process will also provide indications of where delays or diversions are being experienced, so these can be addressed. Monitoring also provides an evidence base to:

(i) Show funders that their money is being used effectively;

(ii) Identify where more funding is required to tackle new issues; and

(iii) Suggest new actions where stubborn problems remain.

Indicators

The next step is therefore to identify targets and indicators in order to measure progress, Good targets and indicators, stakeholder participation in monitoring process, as well as good feedback mechanisms are essential for effective M&E.

Terminology

An indicator is a “pointer” that helps to measure progress towards achieving results. There are two types of indicators: quantitative indicators (measurable) and qualitative indicators (statement/visual).

An indicator, quantitative or qualitative, provides a simple and reliable means to measure or reflect the changes connected to catchment management interventions. An indicator helps to isolate a result or change. Indicators are not important on their own but they are important at pointing or signalling the change that is a result of planned interventions derived from the implementation plan. The indicator is not the change but signals the change. Indicators should be used for establishing a baseline for an intervention within the catchment area. The baseline values are used to track progress of a catchment intervention or lack thereof and to monitor whether it achieves the objectives set out.

When selecting an indicator, it is important to look at the following:

- Validity: Does the indicator allow you to be precise in measuring the results (quantity, quality, time-bound) that conforms to the needs and priorities set out in the VCP.
- Reliability: Do the indicators measure trends over time (for example: the volume / rate of runoff on rehabilitated land may vary according to the time of the year, in relation with the wet season)? To be reliable, the information must normally be collected at the same time period.
- Representation: Do the indicators provide disaggregated information (by different sites, different type of vegetation, etc.
- Simplicity: Is the information available and will it be feasible to collect and analyse it?

- Affordability: Can one afford to collect and analyse this information?

Monitoring techniques

The following description of monitoring techniques is reproduced with permission from Everson, TM, Everson, CS, (2014) Upper uThukela Natural Resource Management (NRM) implementation: monitoring for payment of ecosystem services. Unpublished report to the Department of Environmental Affairs.

Runoff plots

Runoff from eroded and rehabilitated areas can be measured using runoff plots. Square metre run-off plots are installed in the ground and connected via a plastic pipe to a water collection receptacle. In the pilot project a two-litre coke bottle was used, refer Figure IV-2 and Figure IV-3. However, due to the intensity of rainfall events it has been necessary to replace the coke bottles with 20 litre containers. All water runoff from the plot is collected in the container and is transferred to a measuring cylinder where the water is quantified (measured). The depth of silt from the plot is also measured as an indicator of water quality.

Figure IV-2: Adapted runoff plots with 20 litre collection container

Figure IV-3: Runoff water from rehabilitated (left) and eroded (right) plots.

Splash Board

The detachment and transport of soil particles resulting from the impact of raindrops or rain splash is usually considered an important first step in the chain of processes leading to loss of soil and subsequent sediment transport (Mouzai & Bouhadef 2003). Once detached, sediment is easily movable by overland flow which may often lead to the development of rills and later gullies or dongas. An assessment of rain splash detachment is therefore important in recognizing areas potentially vulnerable to accelerated soil loss so that corrective action can be initiated.

A splash board (Figure IV-4) is a simple method of measuring the extent of soil detachment. The apparatus is constructed by attaching a central shaft to a rectangular board (225 x 300 mm) 15 mm on which is drawn parallel lines 15 mm equidistant apart. Each band within the board is numbered from 1-14. The apparatus is placed within the area to be monitored such that the bottom edge of the board is 50 mm above the soil surface. Sediment that is detached from the soil during a rainfall event is displaced upwards some of which is trapped on the surface of the board. By noting the height of staining on the board it is possible to determine the extent of soil loss by rain splash. The higher the intensity of rainfall the greater will be the rain splash and equally the more erodible the soil the greater will be the extent of sediment detachment. In this way it is possible to develop an understanding of the factors that regulate rain splash. The data collected by the community have shown how effective their rehabilitation efforts have been. It has also been useful in communicating the importance of good vegetative cover as a means of combating soil detachment to prevent soil erosion.

Erosion Standards

An effective method for evaluating soil loss or gain particularly in areas behind stone walls located within gully systems has been the use of erosion standards. A standard fencing dropper is hammered a fixed distance into the soil. As a reference condition the distance from the top of the dropper to the soil surface is measured accurately. As sediment builds up behind the stone-wall the distance of the dropper that is exposed decreases. Conversely if erosion is active then this distance will increase. Thus, a temporal measure of sediment built up or erosion is obtained.

Figure IV-4: Splash board

Donga profiles (Ukujulakodonga)

The previous technique was aimed specifically at evaluating the extent of soil displacement following rainfall. Gullies, which are much larger scale erosion features are extensive within the region and as before cost-effective simple techniques for monitoring gully development were needed. A common approach to assess gully development has been to measure its cross profile (Figure IV-5).

Figure IV-5: Profiling a donga

A fixed frame of reference is constructed perpendicularly to the long axis of the gully. For this fencing standards were hammered and secured on either side of the gully to which was attached a stiff strand of wire that served as a reference. Markings spaced at equidistant apart were attached to the wire. Beginning from the left-hand side and always facing upslope the perpendicular distance from the wire (reference) to the gully floor is measured. These results are then plotted either electronically or on graph paper to derive the gully cross-profile. The first measurement is taken as the reference state for the system. This procedure is repeated at regular intervals of time. It follows that if the gully is expanding then the distance from the reference to the gully floor will increase and conversely filling in will shorten the distance. Thus, over time changes in gully morphology can be determined and an assessment of gully stabilisation efforts carried out by the community can be assessed.

Plant Basal cover quadrats

Plant basal cover is determined using a square metre quadrat subdivided into 100 squares (Figure IV-6). The presence of plant cover is recorded for each square and expressed as a percentage. Initially squares where rooted cover was found were marked with the initials of the species found (e.g. k = kikuyu) while bare soil squares were marked with a 0. However, identification of species proved to be too difficult, especially when there was no flowering material due to heavy grazing. The technique was simplified so that any squares with rooted vegetation present were marked with an X. This minor modification enabled illiterate people to participate in the recording of basal cover.


Figure IV-6: Quadrat used to measure basal cover of vegetation

To ensure accuracy of the data, the quadrat should be placed in exactly the same position for each record so that changes in basal cover can be monitored over time. This can be achieved by marking the top-right and lower-left corners of the quadrat. In the light of the susceptibility of the materials at this site to theft, the following suggestions were made:

- Use of steel droppers, hammered in to just above the soil level and painted green so as not to attract the attention of passers-by,
- Use of pieces of wire attached to steel droppers hammered in to below the soil level with just the wire protruding, or
- Use of railway sleeper bolts.

It was suggested that quadrats be placed at various locations within the rehabilitated area (e.g. behind stone lines, in areas of patchy cover as well as on the cattle paths). It was recommended that basal cover should be monitored every six months to enable changes in plant establishment to be detected when growth was slow.

Clarity meter

A clarity meter (Figure IV-7) measures how clean the water is (Zulu word is Ukuhlanzena kwamanzi). The meter comprises a clear tube that is graduated with numbers from 1 to 100. A black magnetic disc can be moved inside the tube. The operator looks through the tube with the disc at the end closest to the operator's eye. The operator then moves the disc along the tube until he/she can't see it. The operator then takes a reading. The dirtier the water the lower the reading. This is a simple technique that is easy to use and gives an accurate measure of low to medium turbidity. The meter cannot measure within the range of high turbidity.

Figure IV-7: Themba Khumalo using a clarity meter to assess water quality

Rain Gauge

Rainfall should be measured with rain gauges placed throughout the study site, Figure IV-8. These should be erected according to the specifications for the specific rain gauge. For example:

- It should be placed 1.2 m above the ground
- It must be level
- It must be far from obstacles.
- The gauge should be read every day at approximately the same time. The gauge should be emptied after reading.

Following experiences in this project it is recommended that some rain gauges be installed at community members' homesteads to create interest in the records. Although it may not always be possible to fit the specifications above these estimates of rainfall create awareness and a focal point for discussions among the homesteads.

Figure IV-8: Homestead rain gauge

Monitoring and evaluation sheet

Once indicators have been identified an M&E sheet should be developed to structure the way in which information is collected. The format of an M&E sheet will be fairly similar to the Implementation Plan table, i.e. the columns of targets, activities, indicators, but with a scoring column, notes/progress column, date column, and a column for responsibility. This is then used as a scorecard, and can be kept as a record to follow progress. It would be useful to arrange the activities into order of timeframes as well: i.e. short, medium and long, so it is easy to follow what should be done immediately.

A scoring matrix will be needed, so that the same rating can be used in the future and not be subjective. Possible scoring types could include:

- Measurement against set targets, for example, expressed as % or numbers achieved versus the target number;
- Fixed measurement, for example, hectares or number of schemes; and
- Qualitative / subjective evaluation, which could for example be on a scale from 1 to 5.

An M&E example from the Implementation Plan is shown in Table IV-1 and an associated M&E evaluation sheet is shown in Table IV-2

Table IV-1: Example of an M&E plan from an implementation plan

Strategic Option 4: Improved Livelihoods and Socio-economic development					
Strategic Objective: To develop and manage water resources to serve social and economic development in the catchment.					
Strategy 4.1: Water demand of intensified, agricultural and aquaculture developments					
Target	Indicators (M&E)	Timeframe	Responsibility		
			Catchment Scale	Micro-catchment Scale	Village Scale
c) Increase area of irrigation and drainage	Irrigation development plan (Catchment master plan) in place Area under irrigation in ha	Quarterly data and annual evaluation	CMC – evaluation, assessment and feedback	Data management and evaluation	Provide information

Strategic Option 4: Improved Livelihoods and Socio-economic development					
Strategic Objective: To develop and manage water resources to serve social and economic development in the catchment.					
Strategy 4.1: Water demand of intensified, agricultural and aquaculture developments					
	Efficiency of water use New irrigation projects implemented				

Table IV-2 Example of M&E evaluation sheet

Strategic Option 4: Improved Livelihoods and Socio-economic development						
Strategic Objective: To develop and manage water resources to serve social and economic development in the catchment.						
Strategy 4.1: Water demand of intensified, agricultural and aquaculture developments						
Target	Activities	Indicators (M&E)	Scoring	Notes/ progress	Date	Assessed by
c) Increase area of irrigation and drainage	Develop the catchment's irrigation master plan in which lands best suited to irrigation are defined and a long-term irrigation development plan put forward for discussion with stakeholders. Opportunity to be linked to needs.	Irrigation development plan (Catchment master plan) in place	Yes/no	Note progress on development of irrigation master plan.	Capture date	Institution responsible for monitoring assessment
c) Increase area of irrigation and drainage	Existing irrigation schemes evaluated and indicated improvements implemented. (or alt. number of improvements)	Current area under type of irrigation in ha	Measure in ha		Date of measure	Institution responsible for monitoring assessment
c) Increase area of irrigation and drainage	Plan for the expansion of irrigation within the limitations of catchment water access.	Studies completed	No of studies	Notes on irrigation expansion	Capture date	Institution responsible for monitoring assessment
c) Increase area of irrigation and drainage	Seek optimal use of irrigation water through crop selection, improved irrigation methods and WC/WDM	Efficiency of water use	Scale from 1 to 5. 1 = none 5 = full WC/WDM	Notes on efficiency improvements achieved	Capture date	Institution responsible for monitoring assessment

Evaluation and feedback

The monitoring results need to be evaluated annually. Data analysis or interpretation means making sense of the data that you have collected – it is a collection of methods used to derive useful information from collections of data. The findings should be discussed by the GVC and the implementing stakeholders need to ensure that implementation remains on schedule and yield good results. The findings of the evaluation need to be incorporated into the Village's development planning cycle and in the plans of major stakeholders, e.g. Local Government. Evaluation will normally lead to modification of the VCP or its implementation.

Managing data

As reporting on indicators will be carried out by different stakeholders, it is important to ensure the data collected are managed and stored in an accessible format and place, for example a Monitoring Notebook where records of all monitoring are kept together.

Reporting

Reporting takes two forms. The first relates to reporting on progress on the Implementation Plan as a whole. This should be undertaken by the implementing committee (PIC) that meets every 6 months. The second relates to the reporting on the achievement of the specific actions and targets of the plan's vision. It is important to report on progress of the activities and targets using the indicators. The timeframe for carrying out assessments must be realistic, i.e. it must provide time for projects to be implemented and take effect. A standard reporting timeframe is 2-3 years, depending on the targets and the longevity of the Implementation Plan. It is important to note that the stakeholders that were tasked specific activities are responsible for reporting on the activity-specific indicators. This may result in several stakeholders reporting on the same target. The GVC or implementing committee must identify a person to collate all the reporting into the M&E report.

Communicating

It is essential to ensure that the effective communication of progress against the targets, to all stakeholders involved, as well as to the general public, is carried out in order to build trust in the Catchment Management process. Communication can take the form of village meeting, updated progress chart at a central location in the village. Some Funders are interested to know what has been done with what results before granting funds.

When reporting, the message should be clear and unambiguous for specific audiences, e.g. Chief, village members, or Local Government. The results should be clear and make sense to the target audience. There should be an agreed frequency for reporting. The information should be timely, and any delays should be explained for credibility. Keep it simple and focused.

Presentation and format determine how well the information is actually received by the targeted audience. The results should be presented in such a way that the target audience will relate to them and understand the results. Within the format the information or results should be presented in a compelling manner, for example by using pictures graphs, tables and summaries, for example before and after photos taken with a cellphone.

Update, adapt and revise plan

Based on the monitoring and evaluation of the implementation of the VCP, the plan may need to be adapted or updated to reflect changes in the environment, priorities, etc. To undertake an evaluation, the GVC should decide on the methods for gathering feedback/ results (i.e. interviews, surveys, photographs, etc.), then ask the following:

- Did we achieve what we wanted?
- What lessons did we learn from this experience that we could apply in future?
- Did the village / community appreciate the process?
- Would you recommend the process to another village?
- Communicate the progress to all of the village stakeholders – the Chief, village members, Local Government, the community at large, the other interested parties and any funding partners.
- Use the outcomes of the evaluation when updating the plan or compiling the next management plan.

It is advised that VCP be reviewed and revised every five years in order to ensure the plan is still relevant, and to revise the plan, as activities are implemented, new activities may be required.