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DWAF Water Resource Study in Support of the ASGISA EC Mzimvubu Development Project

Assessment of the Potential of Rainwater Harvesting as a Water Resource in the Mzimvubu Development Zone

OCTOBER 2010

PREPARED BY:

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DWA WATER RESOURCE STUDY IN SUPPORT OF THE ASGISA-EC MZIMVUBU DEVELOPMENT PROJECT

LIST OF STUDY REPORTS

REPORT	DWA report number
Summary Report	P WMA 12/000/00/3609
Existing water supply infrastructure assessment	P WMA 12/000/00/3609 Volume 1 of 5
Agricultural assessment and irrigation water use	P WMA 12/000/00/3609 Volume 2 of 5
Groundwater assessment	P WMA 12/000/00/3609 Volume 3 of 5
Water resources assessment	P WMA 12/000/00/3609 Volume 4 of 5
Assessment of potential for pumped storage and hydropower schemes	P WMA 12/000/00/3609 Volume 5 of 5
Rainwater Harvesting	**P WMA 12/000/00/3609**
An assessment of rain-fed crop production potential in South Africa's neighboring countries	P RSA 000/00/12510

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DWAF WATER RESOURCE STUDY IN SUPPORT OF THE ASGISA-EC MZIMVUBU DEVELOPMENT PROJECT

ASSESSMENT OF THE POTENTIAL OF RAINWATER HARVESTING AS A WATER RESOURCE IN THE MZIMVUBU DEVELOPMENT ZONE

EXECUTIVE SUMMARY

Introduction

The Mzimvubu River is the catchment which simultaneously has both the most water and the greatest poverty in South Africa. Through the ages, its abundant water has cut deep, steep valleys into the landscape, creating inaccessibility and remoteness, with major challenges for travel, service provision and most land-based economic activities. Even water, as abundant as it is, is mostly inaccessible. In such a landscape, rainwater harvesting techniques are valuable for users to capture water before it slips beyond economic reach into the deeply incised valleys.

Rooftop rainwater harvesting in different socio-economic contexts

Rainwater harvesting presents an attractive option for households in remote villages or areas with limited access to water supply infrastructure. The cost of operation and maintenance of a household rainwater tank is very minimal indeed, therefore a once-off capital investment by the state to install a tank can provide a poor family with a high degree of water security and independent responsibility. In this context, rainwater harvesting also enables year round production of fruit and vegetable crops high in micro-nutrients and therefore key in poor households' fight against child malnutrition which is rife in the study area.

Counter-intuitively, the report also shows that rainwater harvesting becomes even more affordable and beneficial – for both poor and non-poor households and urban buildings – in situations where a reliable municipal supply is available and can be used in conjunction with rainwater harvesting. Smaller, cheaper tanks are needed for conjunctive use and enable households to save on municipal water bills. This results in reduced demand on mains supply, which can reduce pressure on over-stretched municipal systems.

Economics of rainwater harvesting

The high and evenly distributed rainfall in the Mzimvubu River produces good rainwater yields, but the area has some of the lowest water tariffs in the country. The net present value (NPV) of cost savings on conjunctive rooftop rainwater harvesting for an urban household in Lusikisiki turns positive at a water tariff of R3.20/kℓ, while the current tariff is R2.49/kℓ and experiencing strong upward pressure.

The report shows that in virtually all climatic zones in the Mzimvubu Development Zone, a household with an RDP-size house roof (60 m^2) and a 5 kℓ rainwater tank, can harvest more than half of its annual Free Basic Water (FBW) requirement from rainwater. These results apply even when rainwater is the sole supply.

In a conjunctive use scenario for a medium-sized urban house on mains supply, up to 90 kℓ/a (125% of FBW) can be harvested from a 100 m^2 roof in Port St Johns, and 57.2 kℓ/a (79% of FBW) in Cedarville.

Rainwater harvesting for domestic use is a longstanding practice of many generations on commercial farms in the Mzimvubu Development Zone, and holds potential for expansion.

Applicability of rainwater harvesting techniques in Mzimvubu Development Zone

The potential for rainwater harvesting as a water resource in the Mzimvubu Development Zone was assessed through a desktop study to provide a preliminary indication of the rainwater techniques that can be used to augment conventional supplies. The study covers possibilities for different areas of application, namely in:

The built environment, including homesteads, villages, towns and urban areas

Cultivated areas, including irrigated and dryland production in crop fields and homesteads

Uncultivated areas, including improved grazing, nature conservation areas, etc.

An assessment tool, the Rainfall Harvesting Calculator, has been developed and used to assess the yield potential for rainwater use for drinking and household food production at rural and urban homes. Rainfall quantity and seasonal distribution in the study area is highly favourable for household use of rainwater.

In contrast with rapid progress in other parts of the world, South Africa is lagging behind with the application of rainwater harvesting in urban contexts, both for public access buildings and for landscaping and drainage associated with roads, parking areas and urban beautification. As national implementation experience grows, improved assessments will become possible. In this report, some possibilities are discussed for urban contexts like those of Kokstad and Lusikisiki.

The potential for improved rainfed agriculture through increased infiltration of rainwater into the soil profile is currently central to many agricultural initiatives across the continent. Many of these techniques apply to the topographical, climate and social characteristics found in the Mzimvubu area.

Natural resources for rainwater harvesting

Rainfall, topography and collection surfaces are important in the assessment of rainwater harvesting potential. The Mzimvubu Development Zone is a summer rainfall area, and average annual rainfall varies from 600 mm to 1 500 mm across the study area. To its advantage, rainfall in the winter months is more frequent than in many other parts of the country, meaning that rainwater tanks are replenished more often, and dry periods are shorter.

The hilly terrain in large parts of the Mzimvubu Development Zone increases runoff potential compared to very flat areas. While on flatter slopes it is easier to achieve in situ infiltration to increase dryland crop yields, the steeper slopes produce more water, e.g. to channel to underground storage tanks. Through thoughtful layout, success has been achieved with both applications in the mountains inland of Port St Johns. Steep drops in topography create opportunities for bio-filtering above the intakes of rainwater storage tanks, thus improving the quality of stored water and reducing the required frequency of tank cleaning.

The characteristics of collection surfaces greatly impact rainwater harvesting potential. Good quality roofing is beneficial for collection of drinking quality water, while thatch and uneven and rusted roof sheeting presents a limitation. In the landscape, grass cover is often maintained year round in parts of the Mzimvubu Development Zone, thanks to the relatively even distribution of rainfall across seasons, which reduces the surface runoff potential but is an important erosion barrier.

Through judicious application of rainwater harvesting, the landscape can be improved to help fight erosion and achieve other gains in the context of potential Payments for Ecosystem Services (PES), which may include water and carbon credits, e.g. for avoided pumping. Climate change benefits of rangeland improvement are considered highly significant across the continent (FAO, 2010).

Recommendations

It is recommended that rainwater harvesting for the built environment, cultivated areas and uncultivated areas in Mzimvubu Development Zone should be analysed as a standard component of water supply options for all economic development options and municipal water supply requirements.

DWAF WATER RESOURCE STUDY IN SUPPORT OF THE ASGISA-EC MZIMVUBU DEVELOPMENT PROJECT

WATER RESOURCES ASSESSMENT

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1 INTRODUCTION

WORKING DEFINITION FOR THIS REPORT

Rainwater harvesting is the collection and control of runoff to increase its beneficial use.

The Mzimvubu River is the catchment which simultaneously has both the most water and the greatest poverty in South Africa. In a water scarce country, with a deep appreciation of the links between water poverty and material poverty, this sounds like a great anomaly. How is it possible?

Figure 1 On the mountains inland of Port St Johns, in the great river valleys, there is great despondency about the lack of water at this school. So near and yet so far! (De Lange, 2009).

Through the ages, the Mzimvubu River's abundant water has cut deep, steep valleys into the landscape, creating inaccessibility and remoteness, with major challenges for travel, service provision and most land-based economic activities. Even water, as abundant as it is, is inaccessible through the sheer distance between habitable areas on the valley ridges and water bodies deep down in the steep valleys.

In such a landscape, rainwater harvesting techniques are valuable for users to capture water before it slips beyond economic reach into the deeply incised valleys.

Still, as remoteness is an inherent characteristic of the landscape, economic opportunities and technologies for the residents of the small and scattered villages need to be responsive to these realities. The principles of local economic development will need to be applied from the most local of economic units: the household; then the immediate neighbourhood; and only then even the neighbouring village. Without the establishment of such deliberate bottom-up growth strategies, the area can be expected to continue on its steady path of decline and marginalisation. Indeed, this area faces some of the greatest challenges in South Africa with regard to levels of multiple deprivation of children, malnutrition, low service provision and decline of natural resources.

Can rainwater harvesting help the citizens of the Mzimvubu Development Zone to benefit from its water wealth?

Part 1 of this report focuses on specific opportunities for the implementation of rainwater harvesting to strengthen current and potential economic development and job creation initiatives in the Mzimvubu Development Zone.

Various techniques can be used to collect, store and use rainwater for a variety of purposes. In the Mzimvubu Development Zone rainwater can be harvested from roofs and ground surfaces at people's homes, in fields and veld, at business premises and in towns:

- for household, industrial and commercial water uses;
- for home food gardening and for non-potable urban uses like landscaping, cleaning, fire fighting;
- to improve dryland crop yields and reliability, and to reduce irrigation demand;
- to improve and/or restore grazing areas in both commercial farming and communal contexts; and
- to help combat erosion and produce other ecosystem services that help to mitigate climate change.

Literature on rainwater harvesting tends to have either an agricultural focus (e.g. Critchley et al, 1991; FAO, 2009; Mati, 2007) or an urban bias (especially municipal manuals, e.g. City of Tucson, 2005; Texas, 2005; etc). In both these types of literature, a variety of rainwater harvesting techniques applies to a varying degree in different areas and contexts of the Mzimvubu Development Zone

Part 2 of this report provides a description of some techniques which may be appropriate for the Mzimvubu River catchment, with comments on their suitability for use in the Mzimvubu River catchment based on factors such as topography, land use, rainfall characteristics and social conditions.

Part 2 aims to show the full spectrum of rainwater harvesting applications from cities to villages to cropping fields to conservation zones. A major objective of Part 2 is to show that rainwater harvesting is not limited merely to a small tank next to a house capturing roof runoff, although this is also an important application.

Part 3 examines some of the features of the Mzimvubu Development Zone which influence the potential and feasibility of rainwater harvesting for the range of uses, including natural resource characteristics, social conditions in commercial farming (Sector 1) and former homeland (Sector 2) areas.

Part 3 also shows the study findings on potential for roof rainwater harvesting for sole supply and conjunctive use scenarios, in rural and urban households. Further work is required to perform similar quantification for rainwater harvesting on cultivated and uncultivated areas (grazing, nature conservation areas, etc).

> The results in Table 9 are very significant indeed. It shows that in virtually all climatic zones in the Mzimvubu Development zone, a household with an RDP-size house roof (60 m^2) and a 5 kℓ rainwater tank can harvest more than half of its annual Free Basic Water requirement from rainwater. These results apply even when rainwater is the sole supply.
>
> In a conjunctive use scenario for a medium-sized urban house on mains supply, up to 90 kℓ/a (125% of FBW) can be harvested from a 100 m^2 roof in Port St Johns, and 57.2 klℓ/a (79% of FBW) in Cedarville.

The potential for rooftop rainwater harvesting for domestic water use is thus very significant in Mzimvubu Development Zone:

- from the municipal perspective, in the reduction in requirements on bulk infrastructure and on operation and maintenance costs; and
- from the household perspective, in the improved water security and potential reduction in municipal water bills (where applicable).

2 PART 1: SPECIFIC OPPORTUNITIES WHERE RAINWATER HARVESTING CAN CONTRIBUTE TO DEVELOPMENT IN THE MZIMVUBU AREA

The issue for this report is essentially the development of the Mzimvubu area to maximise benefits to its people, recognising that the Mzimvubu Development Zone ironically has both the most water available and the greatest poverty in South Africa. Its plentiful water quickly runs beyond the reach of its residents; so they suffer scarcity amid the bounty. In the Mzimvubu area, more than any other catchment in SA, water needs to be stored and used where it falls; not by trying to fetch it back at great cost once it has escaped into the deep river ravines.

Currently, resource interaction processes in the Mzimvubu area are in a downward spiral, resulting in an acceleration of degradation of resources. Already, some parts of the Mzimvubu area are viewed as 'beyond restorability'. Not only is urgent restoration necessary, but a fundamental change in the nature of the ongoing processes. The trend needs to be turned around from downward spiralling to spiralling upward.

The majority of people in the Mzimvubu area are poor with no prospects. Children get damaged early, underlined by the fact that some of the highest levels of multiple child deprivation in the country occur here. Without reversing this vicious cycle, the Mzimvubu area cannot turn around its own degradation (people, nature, resources, and capacities).

The truth is that the majority of residents just need and want jobs. Therefore interventions should best maximise opportunities for both formal and self-employment.

Some possible opportunities are tabled below.

The ranges of rainwater harvesting techniques which are suitable in the Mzimvubu River catchment are shown in Part 2.

Part 3 shows how much water a typical household can harvest from their roof and yard.

Challenges	Possibilities	Role of water (including rainwater harvesting)
1. How can the natural resources (including water) be used to give the people of the Mzimvubu area the jobs they need?	*1.1 'Nature-based economy', e.g.:* • Improving grassland, reducing soil erosion, etc. to produce carbon earnings which can help pay (not enough in itself) for 'restoration jobs'. • This needs to be implemented at very large scale to make it worthwhile.	Rainwater harvesting (landscape-level techniques) for watershed restoration Rainwater harvesting techniques for trees to recover biodiversity Spin-off home industries, e.g. home production of tree seedlings for sale to restoration programmes. (e.g. 2-year old tree seedlings can fetch up to R1000 a piece)
	1.2 Economic development opportunities: 1.2.1a Homestead irrigation A secure water source enables vegetable and fruit production, sold from the homestead to neighbours. 1.2.1b Irrigation schemes (limited opportunity, poor track record, benefits tend to reach relatively few people).	Irrigation water, three workable possibilities: 1. implement on-site rainwater storage to enable homestead irrigated production for sale; 2. develop small schemes with technology that is appropriate for remote areas, and which are manageable by the users; and 3. implement commercial irrigation projects with employment and community shareholding. Not workable: Large schemes with small individual holdings which are inherently impossible to become commercial. Rainwater harvesting techniques for cropping, to reduce irrigation requirement of crops, thereby reducing pumping and thus the cost of production.
	1.2.2 Dryland production • Biofuel crops; • Commercialisation of dryland production; • Reduce cropping risk on households' cropping on people's own croplands; • Diversification to fruit and vegetables on crop fields and homestead plots	Rainwater harvesting techniques for cropping, to: • stabilise dryland crops (reduce risk of crop failure); • improve yields; and • expand cultivable areas. Rainwater harvesting techniques for trees
	1.2.3 Industrial development	Water for production The moment stored water is available to a household or business, a range of business opportunities become possible.

Challenges	Possibilities	Role of water (including rainwater harvesting)
2. How can the constant outflow of money out of the area be turned around? (Pensions come in, but go out again immediately to purchase food and products made elsewhere, thereby forfeiting cash which could stimulate and sustain local economic development).	***2.1 Maximise local production and services among residents, e.g.:*** • Local production and processing of staple food (largest current expenditure of pension money), • Fruit and vegetables (currently 80% imported from other areas), • Clothing manufacture, • etc.	**Water for production:** • for commercial initiatives; • for production by households' on their crop fields and homestead plots (both increased production, and increased value of production=higher value crops for which there is local demand) **Maximise water availability for production at homesteads**, through a range of 'green water' and 'blue water' rainwater harvesting techniques for trees, cropping and on-site rainwater storage.
3. How can people achieve greater energy-water-food security in their present circumstances? (Given that most families are likely to still be living where they are in the foreseeable future; and given the challenge to curb further ongoing damage of preschool children)	***3.1 Use all opportunities to help improve households' water-energy-food security (of both the employed and unemployed).*** Recognising that improved security of water-energy-food supplies free people up to better engage in economic activities and opportunities.	**Rooftop rainwater harvesting** for domestic water use; to be retained for conjunctive use with municipal supplies as their reach expands over time. **Rainwater harvesting techniques for cropping and trees**, for use in homestead plots and crop fields, as discussed above. Many households are already producing; this can help them produce more, with fewer failures. Note that other crop production aspects would need simultaneous attention. **Homestead renewable energy sources, such as biogas from household waste**. • Water for biogas production. • Co-construction with rainwater harvesting to reduce cost of implementation.

3 SOME PRESENT, PREVIOUS AND POTENTIAL INITIATIVES RELATED TO RAINWATER HARVESTING

It was not within the scope of this study to do an inventory of rainwater harvesting currently practiced in the Mzimvubu Development Zone. In the next few pages, some information is provided on a variety of current rainwater harvesting applications and initiatives in this area. These are indicative rather than exhaustive.

What is already happening in the Mzimvubu River catchment?

Rooftop rainwater harvesting is not new to the people of the Mzimvubu Development Zone. **Figure 2** below shows that the study area has a greater incidence of rainwater tanks than most of the country. In addition, it is very common to see makeshift guttering catching roof runoff into all sorts of drums and containers next to people's homes, even in remote villages. Over the years, different organisations have also promoted the harvesting of rainwater – not only off roof surfaces, but also the collection of surface runoff, particularly for agricultural production.

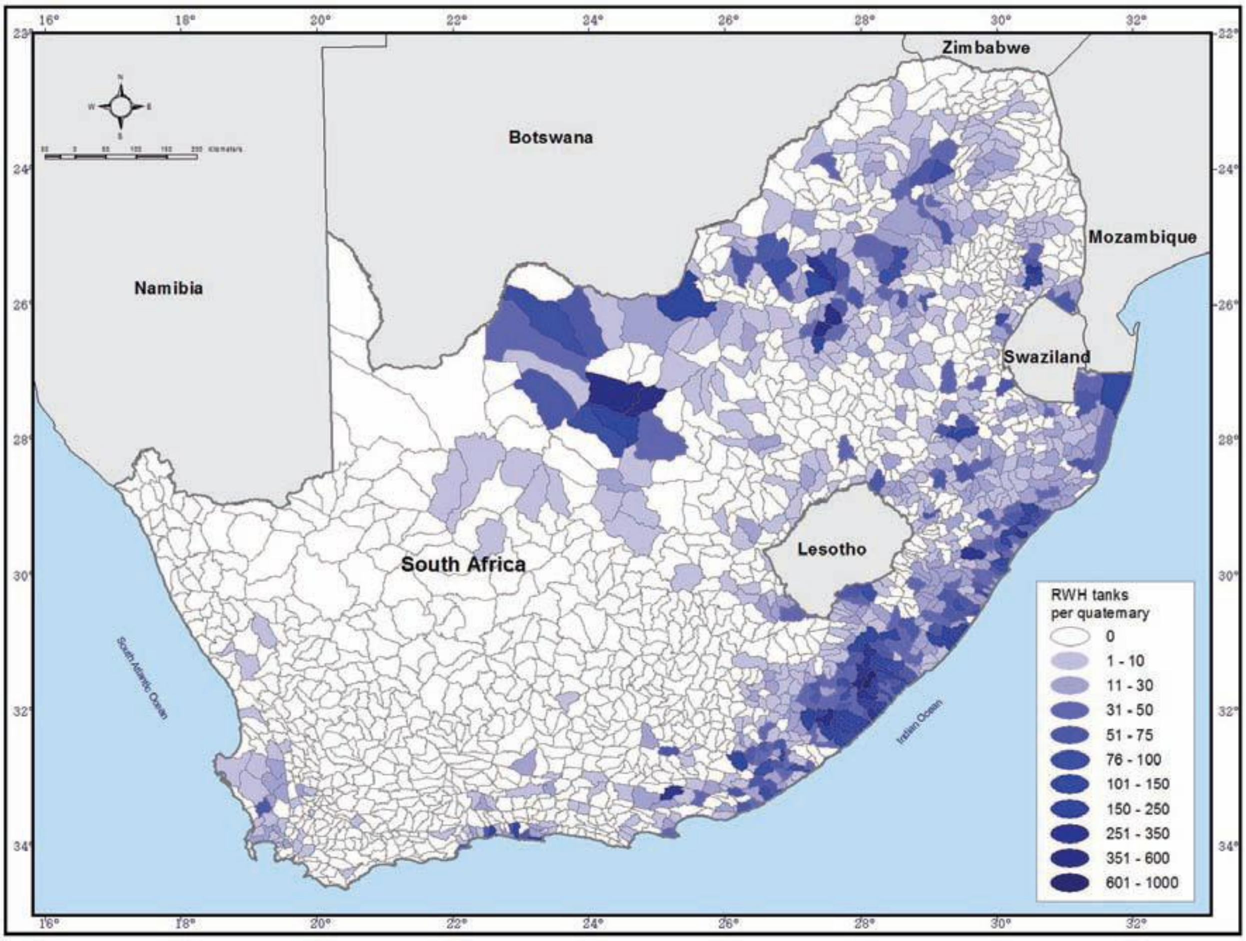


Figure 2: Incidence of rainwater harvesting tanks per quaternary in March 2007 (DWA Water Services, quoted in Mwenge Kahinda et al, 2008)

3.1 DWA RAINWATER HARVESTING SUBSIDY FOR HOME FOOD SECURITY

Most recently, the Department of Water Affairs (DWA) initiated a national programme to subsidise the implementation of rainwater tanks in support of home food security. To date, 500 households across the country have participated in the programme, of which many live in or around the Mzimvubu Development Zone, including Qumbu, Lubala, Port St Johns and Gogela.

From April 2010, responsibility for the planning and expenditure of the Department's rainwater harvesting funds has shifted from the national office to being managed directly by the DWA regional offices.

3.2 RAINWATER HARVESTING PROJECTS FOR DOMESTIC WATER

Several organisations have implemented rooftop rainwater harvesting projects over the years: government, municipality, NGO and private organisations.

As a response to the expressed need by poor households in rural areas for water, a Water Harvesting Programme (WHP) was initiated in 1996. The WHP was funded by the Eastern Cape Provincial Government and the Interchurch Organisation for Development Co-operation. The focus of the WHP was on three main activities:

- Activity 1: Ferrocement Tanks Project
- Activity 2: Small-scale irrigation project / Spring protection and harnessing Project
- Activity 3: Catchment dam Project

418 ferrocement tanks were built in two years, benefiting about 34 000 people. 328 of the 418 tanks were built for households, 86 tanks for schools/clinics and 4 tanks for irrigation purposes, at a cost of R4 300 per 5 kℓ tank. Sand was not readily available and many trips were made to various rivers to look for the right type of sand. The required community contributions of R1 720 per tank were rather excessive, therefore the project failed to reach the poorest members of the targeted rural communities.

The catchment dam project was based on channelling water from springs, rainwater etc, into catchment dams constructed by households, to irrigate their gardens, thus increasing food security. It was implemented in Alice, Butterworth, Cala, Cofimvaba, Idutywa, Lady Frere, Middledrift, Mqannduli, Mount Fletcher, Mount Frere, Ngqamakwe, Ntabankulu, Tsomo, Umtata and Willowvale. A total of 339 dams were constructed in two years, benefiting over 2 000 people from rural households, who now use the harvested water for vegetable gardening and watering livestock.

Food production from homestead plots is presently the most sustainable and effective agricultural activity and contributes significantly to livelihoods (DWA, 2009a irrigation report), therefore this can be viewed as an initiative with very high relevance to people's livelihoods in the Mzimvubu area.

3.3 PAYMENTS FOR WATERSHED SERVICES PROJECT (UNEP/WORKING FOR WATER)

Figure 3 presents the value per hectare of environmental restoration compared to current land use.

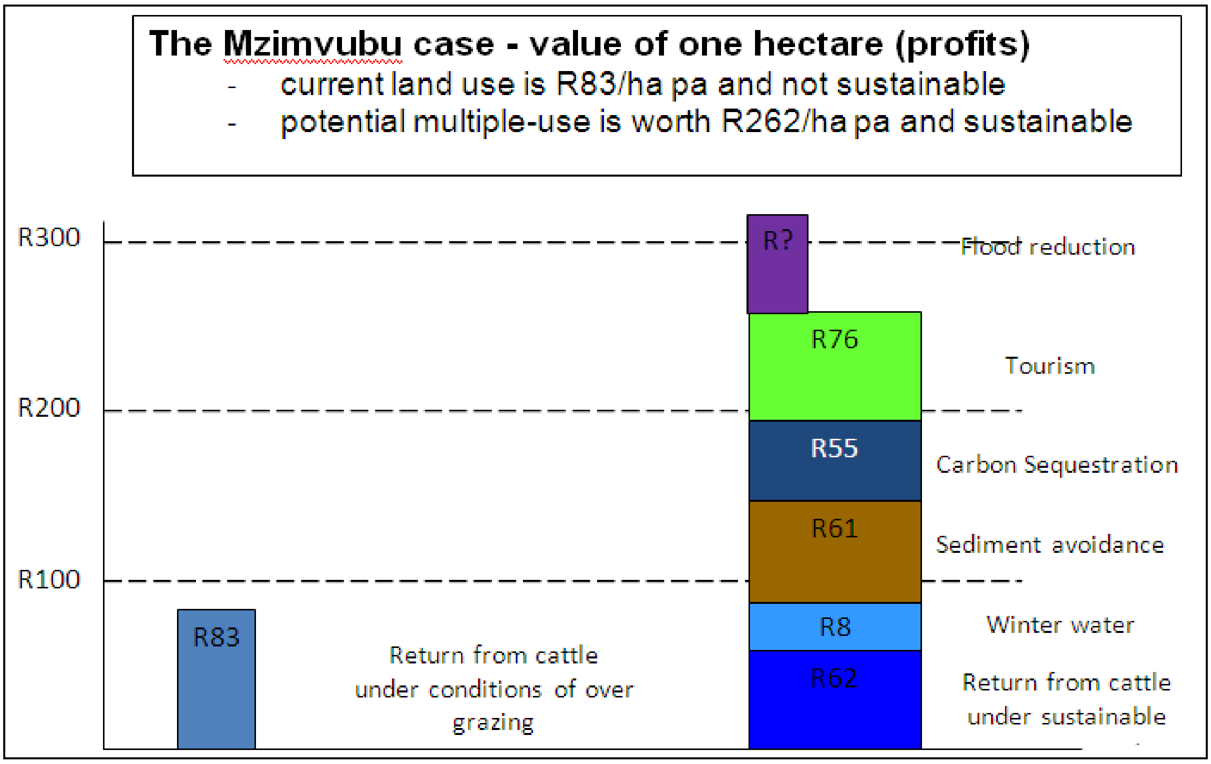


Figure 3 Value per hectare of environmental restoration compared to current land use (Manders in UNEP Mzimvubu project document, 2009)

This UNEP Mzimvubu project on 'Payments for Watershed Services' commenced in March 2010. The purpose of the project is to implement a pilot 'Payments for Watershed Services' project in the Mzimvubu River catchment, to

(i) assess the institutional options available for the implementation of Payments for Watershed Services projects;

(ii) optimise the livelihood options for rural communities; and

(iii) do action research on the impacts of land management practices on water quality and quantity.

This is a highly significant project for all interventions that yield ecosystem services in watersheds (including rainwater harvesting), and a world-first, although similar in principle to many Payments for Ecosystem Services projects the world over, particularly in South America (UNEP Mzimvubu project document, 2009). This project is relevant to rainwater harvesting, and *vice versa*, in two ways:

- From the results of this project, a mechanism should emerge through which polluters elsewhere can pay the people of the Mzimvubu River to improve their own natural resource base, and thereby offsetting the polluters' carbon and water footprint; and
- The current UNEP proposal is to achieve the carbon and water credits through the establishment and maintenance of improved vegetative cover, by reducing stock numbers on veld; and changes in burning practices (biennial spring burn instead of annual winter burn).

Rainwater harvesting practices for improved grazing and environmental restoration can play a key role in achieving this objective:

- Improved runoff control would reduce erosion; and
- increased infiltration is essential to provide a foothold for the recovery of vegetation.

3.4 MAJOR JOB CREATION PROGRAMME POTENTIAL FOR LONGTERM ECONOMIC AND ENVIRONMENTAL GAINS

It is interesting to note that China had by 2009 been reported as having already implemented rainwater harvesting on a third of its total land surface (FAO, 2010). Similar focus and achievement is possible in South Africa:

- Implementation of rainwater harvesting holds job creation potential similar to the Working for Water family of programmes, especially the land-based techniques (micro- and macro-catchment RWH).
- Its labour absorption potential reaches right into the most remote areas.
- Financing for implementation can be boosted from Payments for Ecosystem Services and climate change mitigation mechanisms such as carbon and water credits (Neely *et al*, 2009; UNEP Mzimvubu, 2009).
- Prioritisation for implementation should be based on an analysis of the expected short and long-term impact on poverty and economic growth, environmental restoration and climate change adaptation and mitigation.

4 PART 2: RAINWATER HARVESTING TECHNIQUES FOR THE MZIMVUBU DEVELOPMENT ZONE

Various techniques can be used to collect, store and use rainwater for a variety of purposes. In the Mzimvubu Development Zone rainwater can be harvested from roofs and ground surfaces at people's homes, in fields and veld, at business premises and in towns:

- for household, industrial and commercial water uses;
- for home food gardening and for non-potable urban uses like landscaping, cleaning, firefighting;
- to improve dryland crop yields and reliability, and to reduce irrigation demand;
- to improve and/or restore grazing areas in both commercial farming and communal contexts; and
- to help combat erosion and produce other ecosystem services that help to mitigate climate change.

Literature on rainwater harvesting tends to have either an agricultural focus (e.g. Critchley *et al*, 1991; FAO, 2009; Mati, 2007) or an urban bias (especially municipal manuals, e.g. City of Tucson, 2005; Texas, 2005; etc). In both these types of literature, a variety of rainwater harvesting techniques applies to a varying degree in different areas and contexts of the Mzimvubu River catchment.

The rainwater harvesting techniques described here is a collation drawn from both agricultural and urban-biased literature. This was done to cover a broad spectrum of rainwater harvesting possibilities in accordance with the variety of contexts found across the Mzimvubu Development Zone.

5 CATEGORISATION OF RAINWATER HARVESTING TECHNIQUES

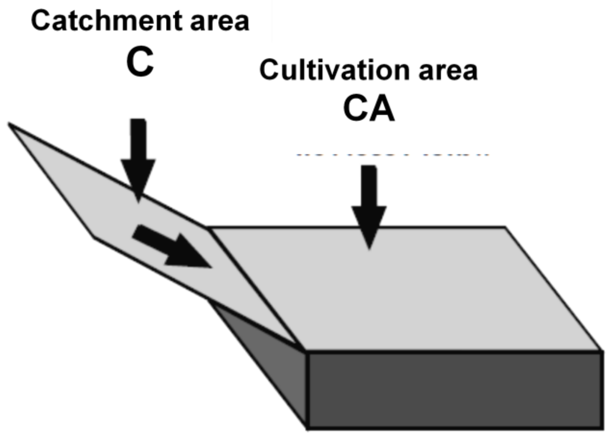
A number of approaches to categorisation of rainwater harvesting are discussed below. This information was then used to develop **Table 1: Land uses and potential rainwater harvesting applications in Mzimvubu Development Zone.**

Rainwater harvesting techniques which apply to each of the categories in Table 1 are then described in the rest of this Part 2, to more easily see the possible practical application in the Mzimvubu Development Zone, namely techniques for the following:

- the built environment,
- cultivated areas (dryland and irrigated); and
- uncultivated areas (grazing, natural veld, mountainous areas, conservation areas).

5.1 FIRST EXAMPLE OF CATEGORISATION OF RAINWATER HARVESTING TECHNIQUES

In the agricultural context, an authoritative guideline was published by the Food and Agriculture Organisation (FAO) of the United Nations (Critchley *et al*, 1991). It deals with **'water harvesting for production'** and focuses on techniques that **increase the infiltration of rainwater runoff** from a 'catchment area' (C) into the soil profile in a 'cultivation area' (CA).



Source: Adapted from FAO, 2006.

Critchley *et al*, 1991 classifies rainwater harvesting techniques in accordance with the relationship between C and CA, as described below, and not on the use of above- and below-ground storage tanks. It only focuses on runoff stored in the soil profile for agriculture, but does not consider urban and residential applications of rainwater harvesting.

Category	Description	Examples of techniques
Micro-catchment: (sometimes referred to as "within-field catchment system")	• overland flow harvested from short catchment length, usually between **1 and 30 m** • **runoff stored in soil profile** • ratio **C:CA** usually **1:1 to 3:1** • normally no provision for overflow • plant growth is even	• Negarim micro catchments (for trees) • contour bunds (for trees) • contour ridges (for crops) • semi-circular bunds (for range and fodder)
External catchment systems: (long slope catchment technique or macro-catchment RWH)	• overland flow or rill flow harvested • **runoff stored in soil profile** • catchment usually **30 - 200 m** in length • ratio **C:CA** usually **2:1 to 10:1** • provision for overflow of excess water • uneven plant growth unless land leveled	• trapezoidal bunds (for crops) • contour stone bunds (for crops)
Floodwater farming (floodwater harvesting, often referred to as "water spreading" and sometimes "spate irrigation")	• turbulent channel flow harvested either (a) by diversion or (b) by spreading within channel bed/valley floor • **runoff stored in soil profile** • catchment long (may be several **kilometers**) • ratio C:CA **above 10:1** • provision for overflow of excess water	• Permeable rock dams (for crops) • water spreading bunds (for crops)

5.2 SECOND EXAMPLE OF CATEGORISATION OF RAINWATER HARVESTING TECHNIQUES

During the development of a rainwater harvesting decision support system (RHADESS) for South Africa, the authors (Mwenge Kahinda *et al*, 2008) used a categorisation according to the catchment area, which suited the hydrological analysis for modelling purposes, but failed to capture some applications, as shown below.

Category	Description	Comment
DRWH 'domestic rainwater harvesting'	Storage of rainwater collected from rooftops and other **compacted surfaces** in above-ground **tanks** (AGT) and underground tanks (UGT) for domestic uses and garden irrigation.	Both the definition and the analysis excluded the use of micro-catchment RWH techniques on the homestead yard, which stores runoff in the soil profile for food and ornamental gardening.
IRWH 'infield rainwater harvesting' (similar to micro-catchment RWH)	Techniques used in croplands to increase the infiltration of **runoff generated in the same field** to stabilise and improve crop production.	Hydrological analysis concentrated on rainfed cropping fields. Yet, micro-catchment techniques are also important for domestic and urban landscaping (including Xeriscaping); for reduction of irrigation demand; and for environmental restoration (including stabilisation and improvement of pastures, rangeland and nature areas).
XRWH 'ex-field rainwater harvesting' (the authors also refer to this as 'runoff farming')	Runoff is channelled from a collection area which is external to the production area or storage structure (pond, dam)	Combines the 'external catchment systems' and 'floodwater farming' categories defined in FAO 1991; and adds storage in ponds or dams.

5.3 THIRD EXAMPLE OF CATEGORISATION OF RAINWATER HARVESTING TECHNIQUES

In developing GIS-based maps of the potential for rainwater harvesting in ten African countries south of the Sahara, RELMA-in-ICRAF (Mati et al, 2006) took a pragmatic approach and produced composite maps that show attributes or "development domains" that serve as indicators of suitability for targeted RWH interventions, grouped as:

- rooftop RWH;
- surface runoff from open surfaces with storage in pans/ponds;
- flood-flow harvesting from watercourses with storage in sand/subsurface dams; and
- *in-situ* soil water storage systems.

5.4 FOURTH EXAMPLE OF CATEGORISATION OF RAINWATER HARVESTING TECHNIQUES

Similarly, the Water for Food Movement took a pragmatic view in developing the following simplified approach in training sessions to help food-insecure households explore all possibilities for water harvesting, storage and use at their homes:

How can a household make best use of rainwater? Simply by laying out the yard in such a way that water is... ➔ **intercepted** (captured), then… ➔ **slowed down** so that it doesn't flush away everything in its path, then… ➔ **channeled** to where it is needed, and then… ➔ **stored** for use, in two ways: o directly in the soil of the planting beds, and o in tanks or containers.
Water collection (where can I get extra water from?): o Grey water collection (collecting used water from the house) o *In-situ* rainwater collection (catching the rain where it falls and preventing it from flowing away/running off) o External stormwater run-off collection (from adjacent fields, roads or roofs)
Water storage (where can I keep the water?): o In the soil profile o In structures, like above and below-ground water tanks o In groundwater, through recharge of groundwater
Water use or application (how can I use the water?): o Directly from the soil profile o Through irrigation, i.e. by applying water to the plants from storage

5.5 FIFTH EXAMPLE OF CATEGORISATION OF RAINWATER HARVESTING TECHNIQUES

Municipal guidelines and manuals tend to pay attention to rainwater harvesting techniques in relation to the area of use, as follows:

Category	Description and comments
Residential applications	Often narrowly focused on rooftop rainwater harvesting tanks; but sometimes with a more integrated view of indoor and outdoor uses, and using tanks as well as the soil for storage in 'landscape holding areas'
Public buildings	For landscaping: drainage of parking areas, paving, roofs into garden beds and lawn, with provision for safe overflow of excess water into municipal stormwater systems
Public rights-of-way	Integrating road drainage and landscaping, by laying out planted areas at a lower elevation than roads, streets, pavements and parking areas (depressed areas).
Urban landscaping (including 'Xeriscaping')	Following a Xeriscaping or Sustainable Urban Drainage (SUD) approach to capture and/or infiltrate runoff in a cascading manner to reduce flood peaks lower down in the system. Increased infiltration serves to recharge groundwater closer to predevelopment levels, while storage in ponds and wetlands provide urban beautification as well as distributed water sources for irrigation, fire fighting, etc.
Industrial and commercial applications	A range of non-potable applications for cleaning, cooling, industrial processes, etc. Also, on large commercial buildings, the harvesting and storage of air conditioning condensate (@40 ℓ/d per unit) for use on gardens.

Municipal manuals also often include sections on financial incentives and tax exemptions aimed at promoting the uptake of rainwater harvesting in the urban context (some examples are given throughout the report and in the section on 'Financial instruments and incentives for rainwater harvesting').

No publications could be found which classified rainwater harvesting techniques specifically for use for environmental restoration purposes. This was most closely approximated by the techniques for improvement of grazing areas (Critchley *et al*, 1991) and by the importance of water control to the restoration of natural grasslands for climate mitigation (Neely *et al*, 2009).

Following from the variety of approaches taken above, it was a challenge to define a useful categorisation of the range of rainwater harvesting applications suitable for use in the Mzimvubu Development Zone. To facilitate the use of spatial data and planning, it was decided to present rainwater techniques in this report according to the land uses and potential point-of-use and type of user.

Table 1 Land uses and potential rainwater harvesting applications in Mzimvubu Development Zone

Land uses and points-of-use	Rainwater harvesting applications
Built environment/ urban extents	
Residential	• Rooftop RWH, for indoor and outdoor domestic uses • Micro- and macro-catchment RWH for food and ornamental gardening
Industrial and commercial	• Rooftop RWH for industrial and commercial uses • Runoff collection and storage in large cisterns for cleaning and process uses
Roads and landscaping	• Micro- and macro-catchment RWH for drainage of roads and parking areas, ornamental gardening, landscaping; ‘xeriscaping’.
Cultivated land	
Rainfed	• Micro- and macro-catchment RWH
Irrigated	• Micro- and macro-catchment RWH
Uncultivated areas	
Grazing, natural veld, mountainous areas, conservation areas	• Micro- and macro-catchment RWH • Floodwater dissipation (also called spate irrigation or flood water farming)

6 RAINWATER HARVESTING TECHNIQUES

Based on the rainwater harvesting applications identified for different land uses in the Mzimvubu River catchment captured in Table 1 above, a collection of techniques are presented below, and can be added onto as experience grows.

6.1 BUILT ENVIRONMENT: POTABLE, NON-POTABLE, LANDSCAPING AND PROCESS USES

6.1.1 Rooftop rainwater harvesting: determining potential

The rainfall characteristics that influence the performance of a rooftop rainwater system include the average annual rainfall, its variability from year to year, and its distribution within a single year. In South Africa, daily rainfall data for a 50 year period (1950-1999) is available for all quaternary catchments across the country (Schulze, 2008).

Figure 4 Rainbarrel in Lubala, near Lusikisiki (De Lange et al, 2009)

> The performance of a RWH system thus depends upon both supply and demand factors, in particular:
>
> - the local climate
> - the area of guttered roof
> - the capacity *V* (in liters) of the RWH storage tank
> - the strategy the household members use to draw water from their tank
> - the 'standard' daily household requirement.
>
> *(Source: Thomas et al, 2007.)*

For rooftop RWH in South Africa, the **Rainfall Harvesting Calculator** runs a daily water balance based on:

- the 50-year daily rainfall data for the chosen quaternary;
- roof drainage area (roof size, or that area of the roof that can be fitted with gutters to channel rainwater from into the storage tank);
- tank storage capacity;
- standard daily usage from the tank (drawdown); and
- provision for a chosen 'adaptive demand strategy' followed by the user in times of scarcity.

Type	Run-off coefficient	Notes
Galvanised Iron Sheets	>0.9	• Excellent quality water. Surface is smooth and high temperatures help to sterilise bacteria
Tile (glazed)	0.6 – 0.9	• Good quality water from glazed tiles. • Unglazed tile can harbour mould • Contamination can exist in tile joints
Asbestos Sheets	0.8 – 0.9	• New sheets give good quality water • No evidence of carcinogenic effects by ingestion • Slightly porous so reduced run-off coefficient and older roofs harbour moulds and even moss
Organic (Thatch, Palm)	0.2	• Poor quality water (>200 FC/100 ml) • Little first-flush effect • High turbidity due to dissolved organic material which cannot easily be filtered or settled out

On average 85% of a rainstorm enters the storage tank from a firm roof surface.

The following is then calculated:

- Annual RWH yield (volume harvested); and
- Empty tank days per year (total and consecutive).

The annual rainwater yield is used to calculate two efficiencies, namely:

- Demand satisfaction: The proportion of total annual water requirement of the household or business that can be supplied by RWH; and
- Annual capture efficiency: The proportion of total roof runoff stored, which is a measure of the correctness of match between roof size, storage capacity and drawdown.

The 'empty tank days' provides a measure of the reliability of rainwater as a water supply option, which is irrelevant where rainwater is used in conjunction with a reliable municipal or other supply.

Results for rooftop rainwater harvesting potential in the Mzimvubu River catchment are shown in Table 9.

Daily drawdown has a profound effect on annual rainwater yield, demand satisfaction and annual capture efficiency. This is quite logical because the more water is drawn from the tank the more space is available to capture subsequent rain.

This means that rooftop rainwater harvesting is most effective when used in conjunction with other water supply options. On the other hand, when rainwater harvesting is the sole supply option, the use from the tank needs to be restricted to avoid running dry, which severely limits the annual rainwater harvesting yield. Rooftop rainwater harvesting can also be used in conjunction with the re-use of waste water in the house, business or factory.

Finally, rooftop rainwater harvesting is best used in an integrated way with micro-catchment techniques. Overflow from rainwater tanks can be channelled and infiltrated into the garden beds, and provision must be made for safe overflow to the natural or municipal stormwater drainage routes.

a) Rainwater tanks for non-poor urban contexts

City dwellers are often discouraged from rooftop rainwater harvesting by the ugliness of rainwater tanks. There are a number of ways to overcome this problem, namely:

- Selection of acceptable tank construction materials (e.g. wood, stone), attractive cladding (e.g. stone finishing) or screening (e.g. live hedging);
- The use of modern aesthetically pleasing tanks;
- Construction of cisterns (underground tanks);
- (Retro)fitting of rainwater 'storage gutters'; and
- For garden uses, building of French drains on-contour to intercept water, or across contour to intercept and transmit water slowly downslope to planted areas, without erosion.

Figure 4

Modern rainwater tanks (DWA, 2009c)

Figure 5

Attractive stone rainwater tank (Texas, 2005)

Table 2 Advantages and disadvantages of above and below-ground rainwater tanks (Thomas *et al*, 2007)

	Pros	Cons
Above ground	• Allows for easy inspection for cracks or leakage • Water extraction can be by gravity and by tap • Can be raised above ground level to increase water pressure	• Require space • Generally more expensive • More easily damaged by accidents • Prone to attack from weather • Failure can be dangerous
Underground	• Surrounding ground gives support allowing lower wall thickness and thus lower costs • Difficult to empty accidentally by leaving tap on • Requires little or no space above ground • Unobtrusive • Water is cooler • Some users prefer it because "it's like a well"	• Water extraction is more problematic – often requiring a pump, a long pipe to a downhill location or steps • Leaks or failures are difficult to detect • Possible contamination of the tank from groundwater or floodwaters • The structure can be damaged by tree roots or rising groundwater • If tank is left uncovered, children (and careless adults) can fall in, possibly drowning • Heavy vehicles can drive over a cistern causing damage • Cannot be easily drained for cleaning • Unsuitable for areas where the water table rises above the bottom of the tank • Usually unsuitable when soils are loose

b) Rainwater tanks for appropriate rural water supply

Figure 9

Downpipe visible for 40 kℓ underhouse roofwater storage tank. Built in Namaqualand in 1975, this tank had never run dry in 25 years, with household size ranging from 4-6 persons over the years

Figure 8

Brazil technology in Limpopo: 22 kℓ ferrocement tank built at below R7 000 in Sep 2009. Note the yellow firstflush downpipe which fills with roofwash before clean water passes into the tank. The firstflush is drained by removing the end cap at the bottom of the downpipe. Alternatively a bleeding hole can be drilled 20 cm above the end cap (Photo Calvin Netshikovhela, Dams for Africa, 2009)

Figure 7

On the mountains inland from Port St Johns, Mzimvubu, the Department of Water Affairs implemented underground tanks to capture surface runoff for food production to help households fight malnutrition (De Lange et al, 2009)

Figure 6

Underground tank for home food gardening (Papenfus, Dams for Africa, 2008)

6.1.2 Rooftop rainwater harvesting for gardening

a) Simple rooftop rainwater harvesting systems for gardening (without tanks)

In the simplest system, rainwater running off roofs without gutters is captured into

(i) garden beds adjacent to the house; or

(ii) a channel along the drip line and routed into garden beds or tree basins.

Runoff must be led away from building foundations. Care needs to be taken with layout to avoid water logging and to create safe escape of excess water to natural or municipal stormwater drainage routes.

Where gutters are present, the water is routed from the downpipe to where it can infiltrate and water vegetation.

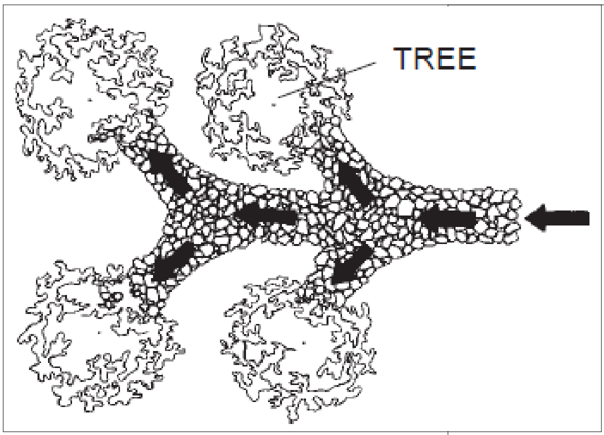


Figure 10
Branched french drain to water trees (City of Tucson, 2005)

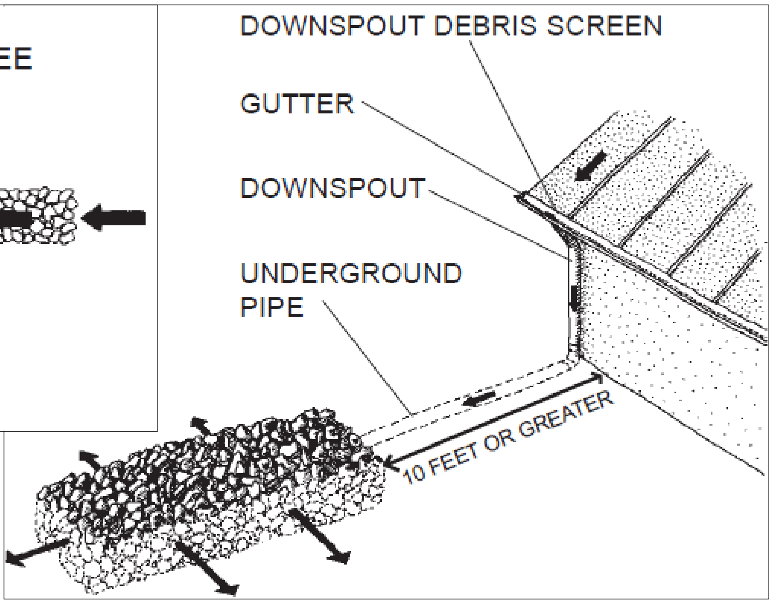


Figure 11
French drain minimum 3 m from building foundations (City of Tucson, 2005)

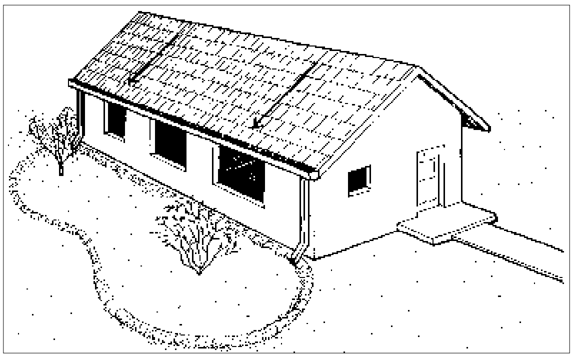


Figure 13
Rainwater from gutter downpipes routed to bermed planting area (Waterfall, undated)

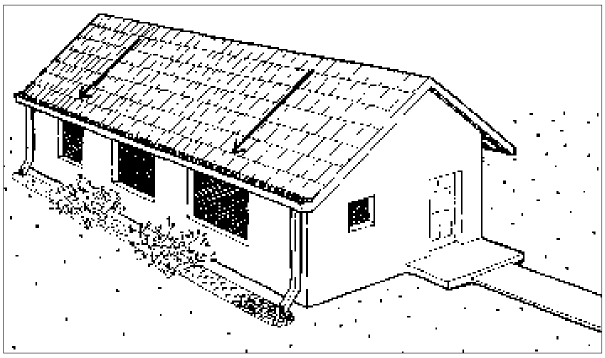


Figure 12
Rainwater from gutter downpipe routed along french drain to vegetation (Waterfall, also note Fig 12)

b) More complex rooftop rainwater system for gardening

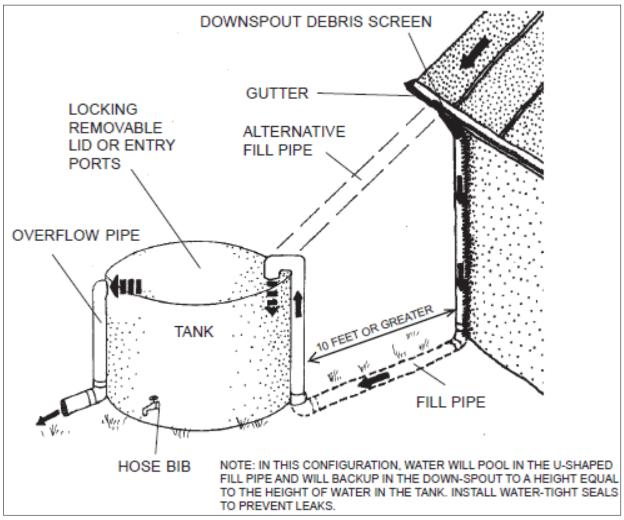


Figure 15
The connecting pipe from gutters to the tank can run underground (City of Tucson, 2005)

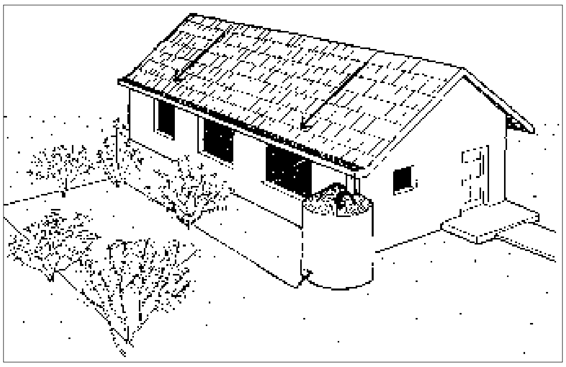


Figure 14
Rainwater from the downpipes fill a storage tank from where trees are drip irrigated (Waterfall, undated)

c) Reducing garden irrigation demand by routing and infiltrating rainwater

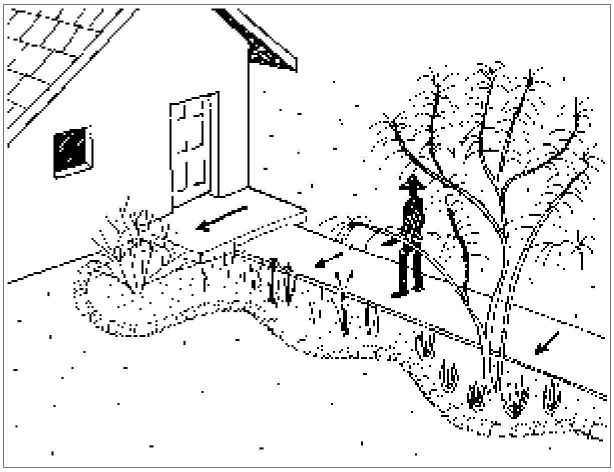


Figure 17
Rainwater from roof and driveway stored in cistern under driveway; for drip irrigation of trees (Waterfall, undated)

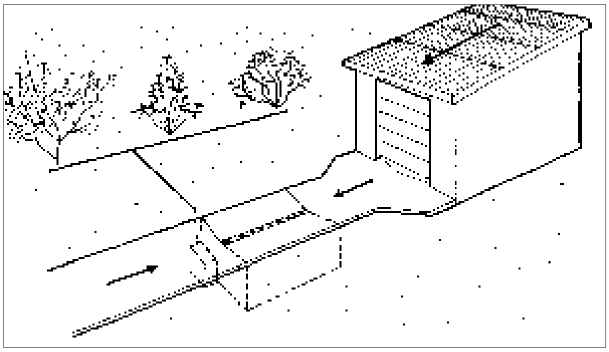


Figure 16
Rainwater routing from pathway into vegetated area (Waterfall, undated)

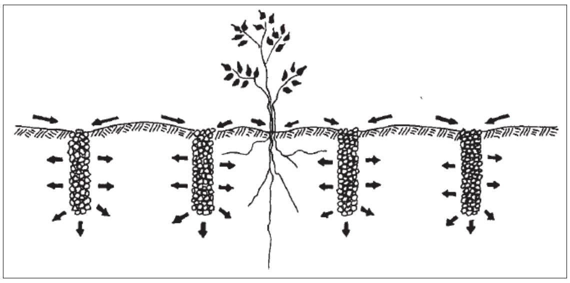


Figure 18
Vertical gravel columns around existing trees to increase infiltration (City of Tucson, 2005)

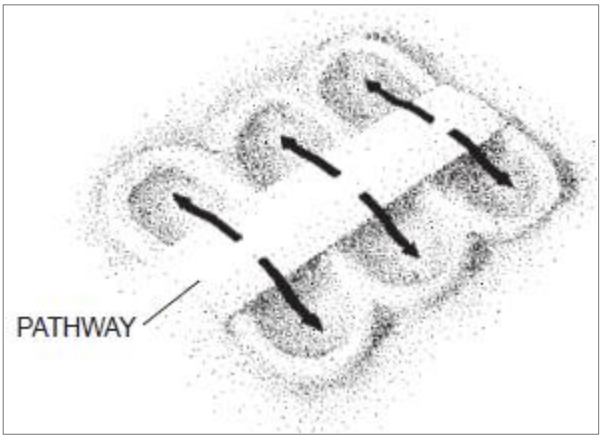


Figure 19
Micro-basins are created to retain runoff from pathways for plant growth (City of Tucson, 2005)

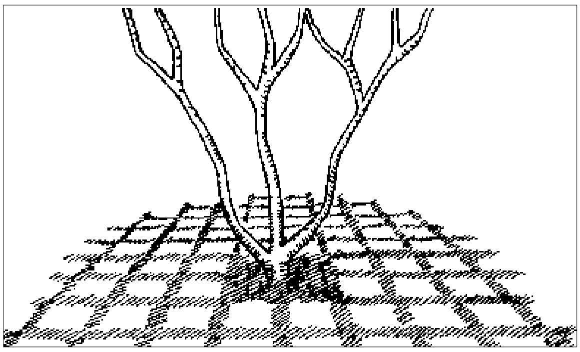


Figure 20
Pervious paving to support tree growth (Waterfall, undated)

6.1.3 Plumbing options for rooftop rainwater harvesting for domestic uses

The plumbing approach depends directly on the intended use of the rainwater.

Table 3 Plumbing requirements for different household rainwater uses

Intended rainwater use	Plumbing or retrofitting requirement
Garden and pool only	No re-plumbing indoors. Plumb rainwater system to garden system (see example from Australia, in Hardie, 2010)
All non-potable uses (washing machine, toilet flushing, bathing, garden and pool)	Retrofit/plumb rainwater supply to relevant applications. This can be a major and costly undertaking.
Full conjunctive use, with the following options for water treatment:	No retrofitting inside the house. Plumb rainwater system into mains supply (e.g. as shown below in Water Rhapsody, 2010); plus:
No treatment	None.
Point-of-use treatment of drinking water only (e.g. standard inline drinking water filter at a designated kitchen tap)	Install point-of-use treatment system.
Inline treatment between the tank and household plumbing system.	Install inline filtration system between tank and house connection.

Roofwater harvesting provides a safe and convenient source of water of limited quantity, which is best used as a source of good quality water (e.g. for drinking and cooking) in a context where less convenient and/or dirtier sources are available to meet some of a household's other water demands.

(Source: Thomas et al, 2007)

"Guidelines on Rainwater Catchment Systems in Hawaii," which has information for people using rainwater for potable consumption. (See References.)

These guidelines for potable systems recommend that storage tanks be constructed of non-toxic material such as steel, fiberglass, redwood, or concrete. Liners used in storage tanks should be smooth and of food-grade material approved by the U.S. Food and Drug Administration (Macomber, 2001).

a) Full conjunctive use system

b)

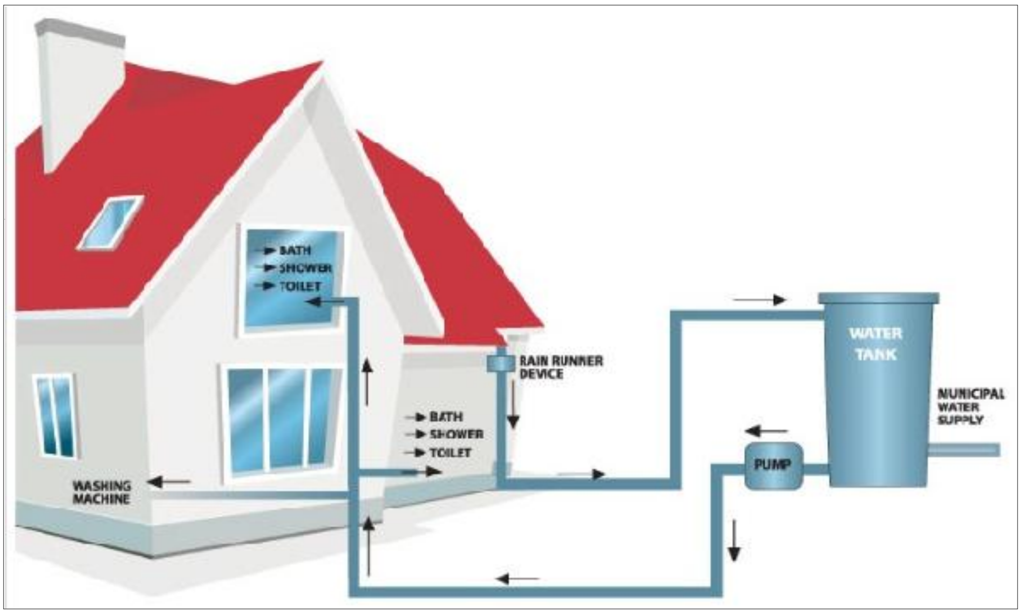
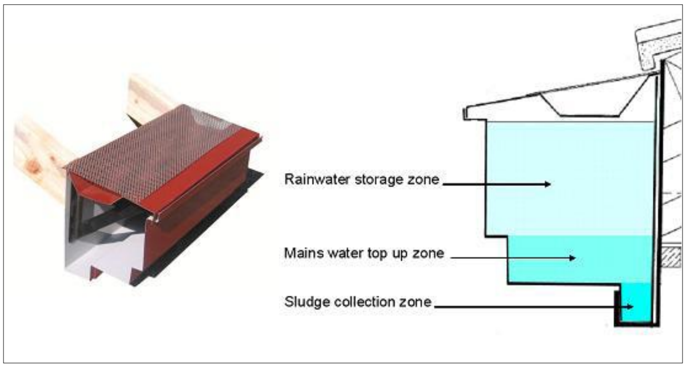


Figure 21 Schematic for full conjunctive use system (Water Rhapsody, 2010)



Rainwater storage gutters keep the water elevated at roof height, thereby obviating the need for pumping.

Note the piping installed from the bottom of the storage gutter to supply toilets, washing machines, gardens and other non-potable uses.

The sludge collection zone needs to be flushed occasionally.

In sizes of 15, 25 and 48 liter storage capacity per running meter of gutter, storage gutters can respectively provide 0.9, 1.5 and 2.9 kℓ storage on a 200 m^2 house of 20 m x 10 m.

The differences in annual rainwater harvesting yield with these configurations in Kokstad and Mthatha (see Table 4 below), is due to differences in rainfall amount and seasonal distribution.

Table 4 Rainwater harvesting potential of a 200 m^2 residence with 15 kℓ/month drawdown

Storage option	Storage capacity (kℓ)	Kokstad (T32D, 727 mm/a)		Mthatha (T20C, 656 mm/a)	
		Annual RWH yield (kℓ/a)	RWH proportion of annual requirement %	Annual RWH yield (kℓ/a)	RWH proportion of annual requirement %
15 ℓ/m storage gutter	0.9	60.0	33	55.4	31
25 ℓ/m storage gutter	1.5	69.6	39	63.9	36
48 ℓ/m storage gutter	2.9	83.2	46	76.4	42
5 kℓ roofwater tank	5.0	93.4	52	86.2	48
10 kℓ roofwater tank	10.0	103.1	57	95.8	53

For technical detail on storage gutters, please refer to Hardie, 2010.

c) **Gutter leaf screens**

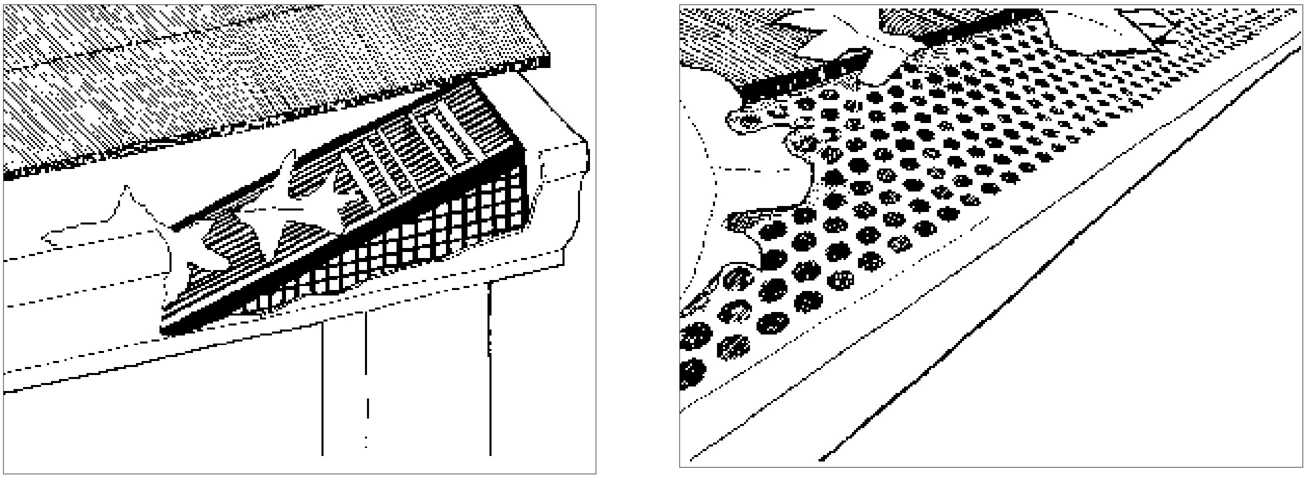


Figure 22 Gutter leaf screens

6.1.4 Urban buildings

a) Rainwater harvesting in public buildings

Note to example below (City of Tucson, 2005): Reorient north-south for southern hemisphere applications.

b) Rainwater harvesting on commercial and industrial sites

Note that in the Southern hemisphere, the orientation would be opposite to this drawing (from City of Tucson, 2005).

c) Ethekwini service station example

The following example illustrates the potential for surface runoff collection to reduce the use of potable supplies for non-potable commercial and industrial uses. Building regulations require a proposed new service station development in eThekwini Municipality to maintain peak stormflow generation from their site at pre-development levels. To hold and release flood flows off-peak, on-site water storage of 165 kℓ must be created. Paved surfaces and roofs total at 850 m^2. This creates an opportunity to use some 475 kℓ harvested rainwater for washing the forecourt, for landscaping and general cleaning purposes, representing an estimated reduction in overall potable water use of up to 50%.

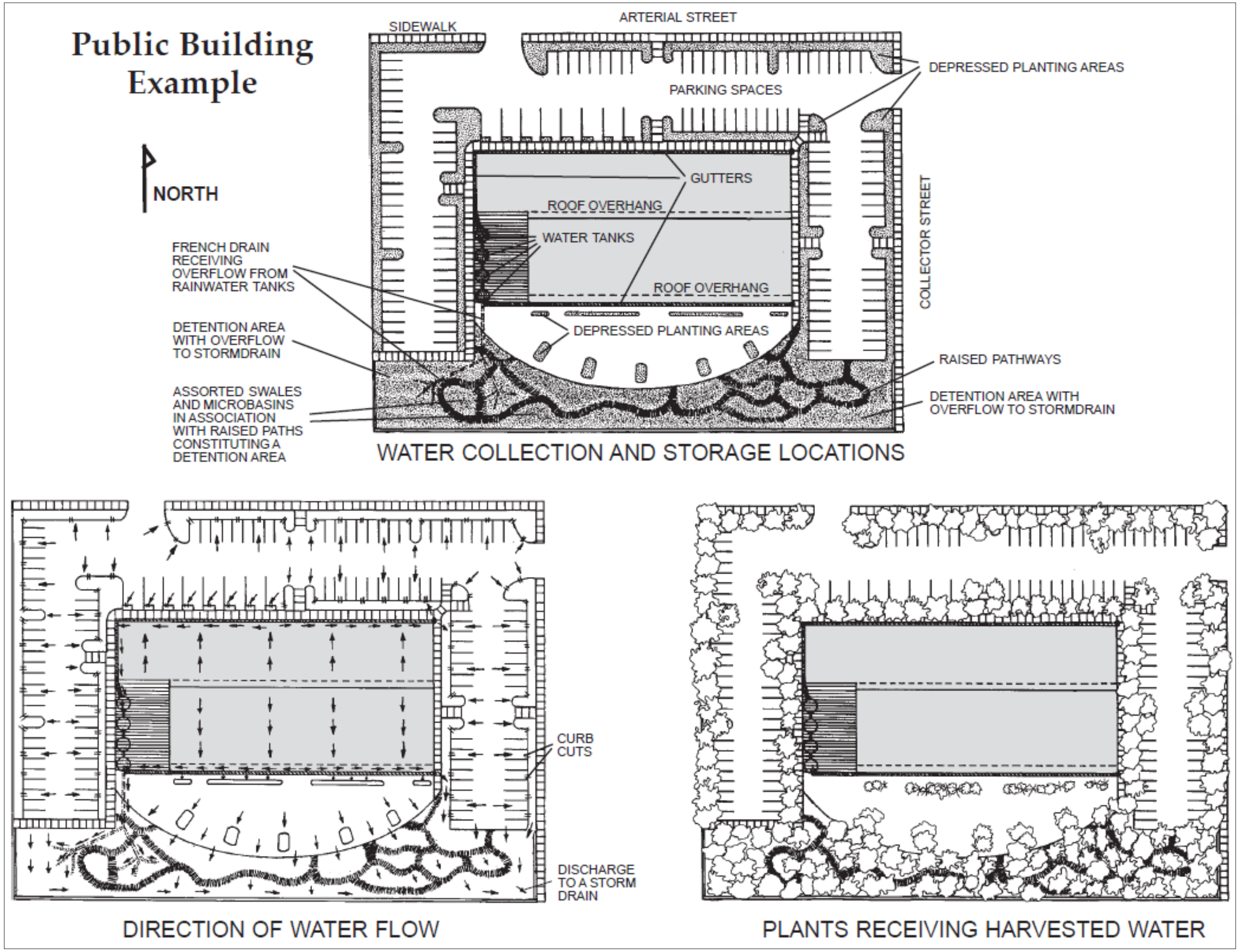


Figure 23 Public building example (City of Tucson, 2005)

Building Codes

In addition to voluntary effort, some states and municipalities are choosing to establish rules. Ohio, Kentucky, Hawaii, Arizona, New Mexico, Washington, West Virginia, Texas, and the U.S. Virgin Islands are considering or have developed rules related to rainwater harvesting.

for the state of Texas. Best management practices reached by a consensus of the Task Force address rainwater harvesting and air conditioner condensate in the Task Force Water Conservation Best Management Practices Guide (TWDB, 2004).

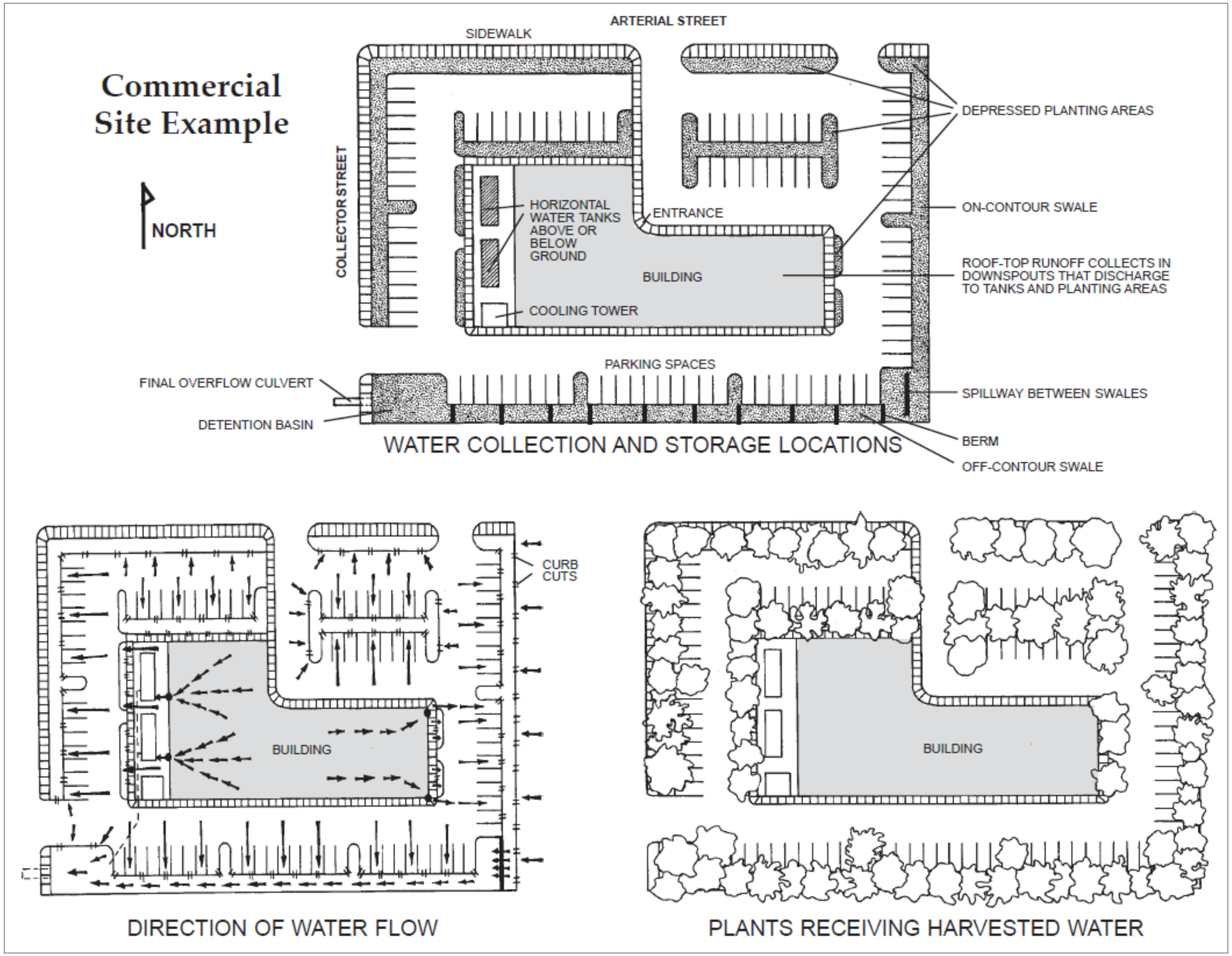


Figure 24 Commercial site example (City of Tucson, 2005)

Figure 26 eThekwini proposed service station with 475 kℓ potential for rainwater harvesting (WRP, 2010)

City of Austin Rainwater Harvesting Programs

The City of Austin Water Conservation Department promotes both residential and commercial/industrial rainwater harvesting. (See References.) The City of Austin sells 75-gallon polyethylene rain barrels to its customers below cost, at $60 each, up to four rain barrels per customer. City of Austin customers who purchase their own rain barrels are eligible for a $30 rebate.

Customers may also receive a rebate of up to $500 on the cost of installing a pre-approved rainwater harvesting system. The rebate application includes a formula to calculate optimum tank size and a list of area suppliers and installation contractors. (See References.)

Commercial entities may be eligible for as much as a $40,000 rebate against the cost of installing new equipment and processes to save water under the Commercial Incentive Program. (See References.)

6.1.5 Landscaping along roads, streets and parking areas

a) Roads and streets

Note how all vegetated areas are below the level of paved areas. Rainwater drains into vegetated areas, which in turn drain to natural or municipal stormwater drainage routes.

For technical detail of the public rights-of-way example below, please consult Tucson, 2006.

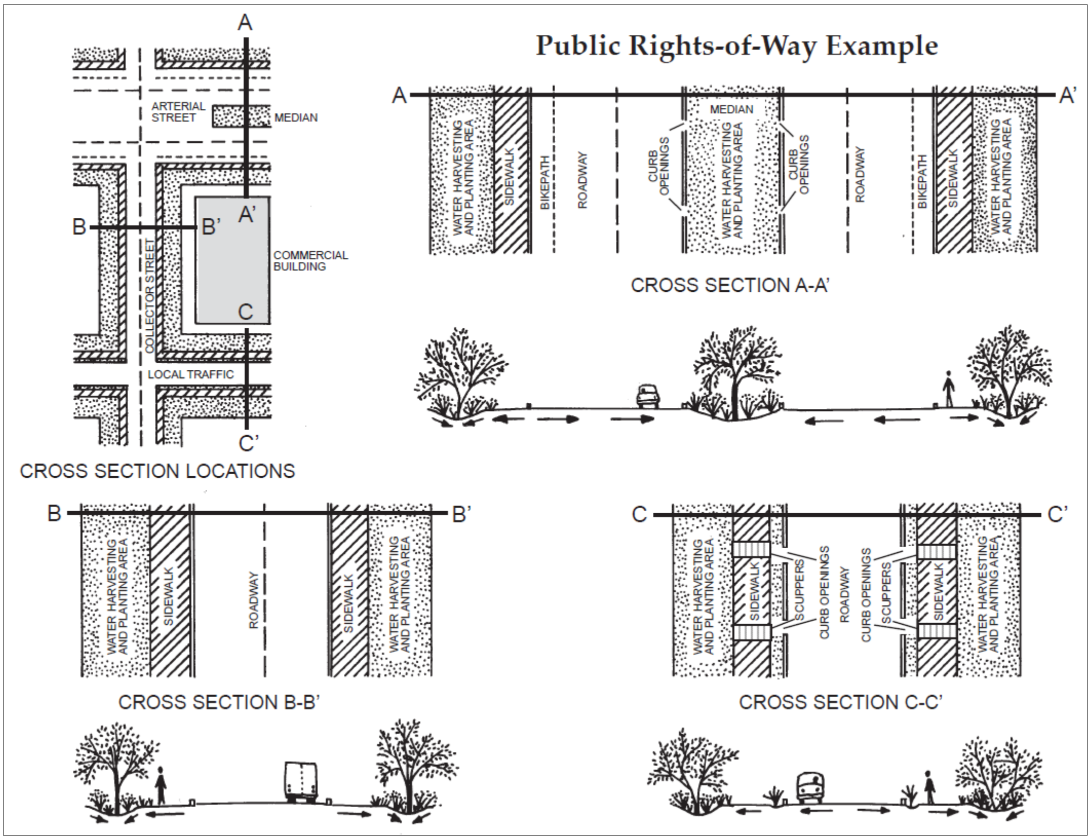


Figure 25 Public rights-of-way example (City of Tucson, 2005)

b) Parking, pathways and pavements

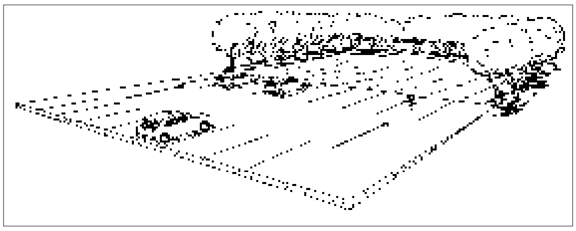


Figure 26 Parking area draining to landscaped area (Waterfall, undated)

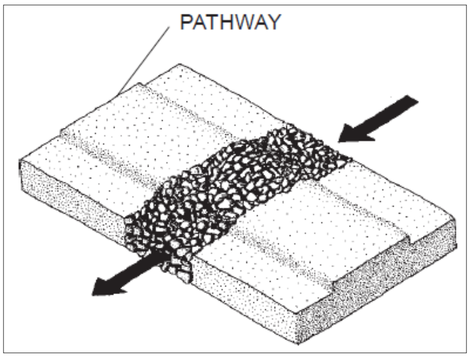


Figure 27 French drain (gravel insert) in pathway to allow throughflow of runoff (Tucson, 2006) (Waterfall, undated)

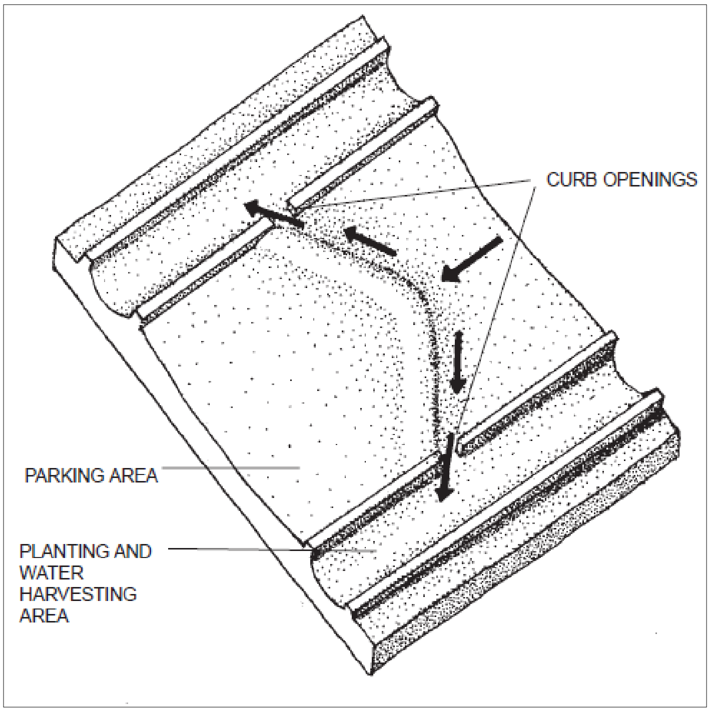
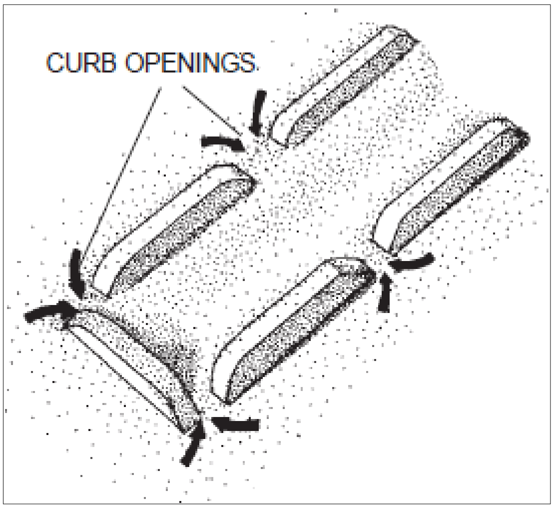


Figure 28 Instead of the planting soil being level with the top of the curb, as is the norm in South Africa, parking areas drain into depressed planting beds (Tucson, 2006)



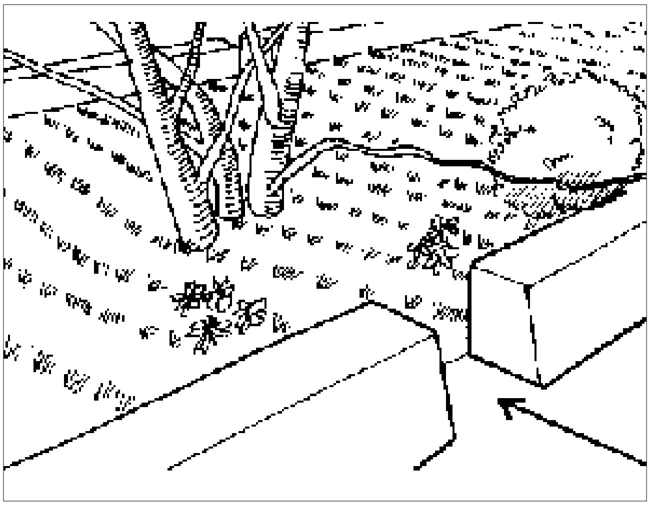


Figure 31a & b Parking areas that water their own shade trees? These curbs still stop car tyres, while runoff can flow through to depressed planting areas (Tucson, 2006)

6.1.6 Stormwater storage tanks, ponds and permeable dams

The principle of Sustainable Urban Drainage (SUDS) is to control and infiltrate stormwater progressively in a cascade effect down the drainage path, instead of the conventional approach, which is to collect and convey stormwater away. Following the new philosophy, stormwater drainage planning becomes an investigation into how stormwater can be utilized beneficially (UCT, 2010; WRC, 2009). A variety of rainwater harvesting techniques can be used to achieve this objective in the urban context.

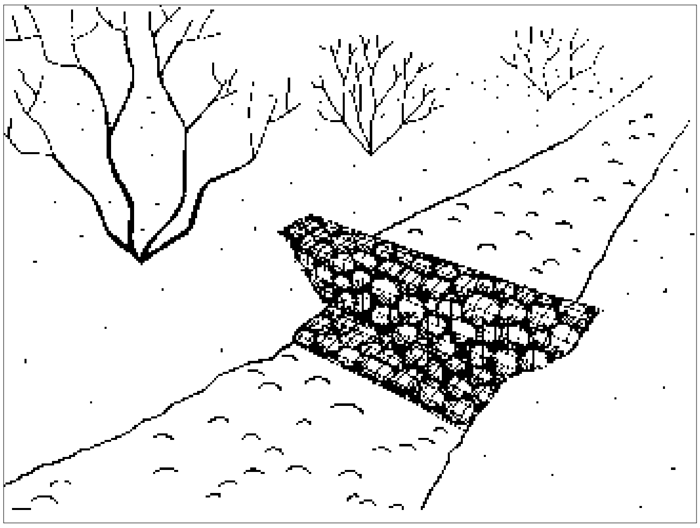


Figure 32 The use of 'permeable dams', e.g. with gabion baskets, is well known in South Africa (picture, Waterfall, undated)

6.2 CULTIVATED AREAS: IMPROVING RAINFED YIELDS AND REDUCING IRRIGATION DEMAND

Rainwater harvesting techniques form part of a larger family of Agricultural Water Management (AWM) methods (Mati, 2007) and are also closely associated with Conservation Agriculture methods.

In recent years, distinction has been made between so-called ‘blue water’ and ‘green water’ water control techniques, although there is some controversy because the definitions are not always clear. In essence, water stored in structures like dams and tanks and which can be pumped is ‘blue water’, while water stored in the soil profile is ‘green water’ which cannot be pumped.

Figure 33 Water harvested (a) into a storage dam in the form of 'blue water’ or free water; and (b) as ‘green water’ into the soil profile through appropriate soil preparation methods (photo Mati, 2008)

Many agriculture-biased publications on water harvesting concentrate more on techniques aimed at increasing the ‘green water’, in other words, techniques which aim to infiltrate and store more water in the soil profile. Both ‘blue’ and ‘green’ AWM techniques have a role to play in rainfed and irrigated cropping in the Mzimvubu River catchment.

Suitability in the Mzimvubu area

In the Mzimvubu River catchment, rain-fed maize and sorghum production occurs on some top slopes in allocated cropping areas. These scattered production areas are managed at a subsistence level with very few inputs of fertilizer and plant protection chemicals. Yields are therefore very low and there is seldom a cash surplus generated from this form of land use (DWAF, 2009a). The utilisation of cropping fields has declined in the past few decades due to reduced labour availability, increased security problems and a decline in communal land use management traditions which provided better control of livestock movements. The prevalent low yields in return for significant household investment in labour and cash input, act as a major disincentive to plant. The improvement in access to social support further reduces the pressure on households to invest in maize production.

By storing more runoff in the soil profile, 'green water' techniques can reduce crop losses due to dry spells during critical crop stages. However, good production remains impossible without adequate plant nutrition. On irrigated fields, the same applies. By using more runoff, less irrigation water needs to be supplied, implying a saving on pumping and system costs.

6.2.1 Croplands

a) Contour bunds (kontoerwalle) / 'off-contour' swales

Through the most extensive government soil erosion programme implemented in South Africa, the greater proportion of croplands across the country where 'contoured'. These contours are evident as undulating horizontal lines all over the countryside and were highly successful in curbing a severe soil erosion problem and embedding across-slope rather than downslope ploughing/cultivation of crop fields.

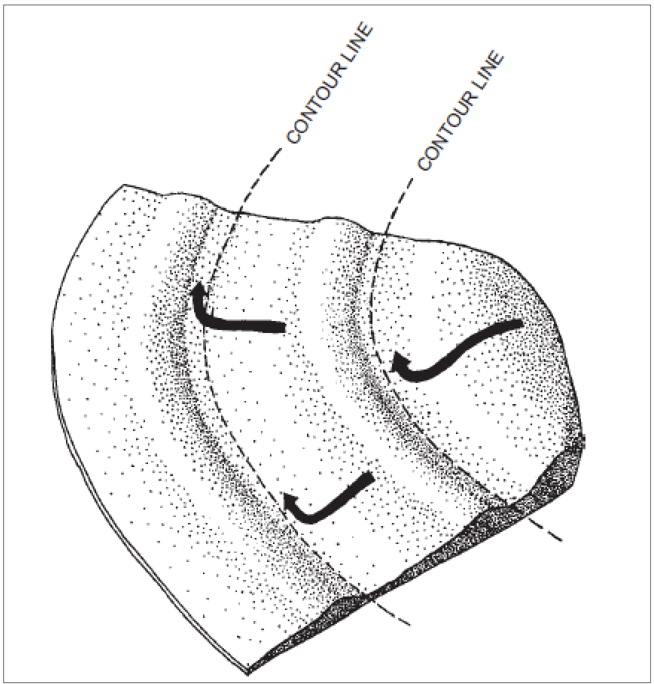


Figure 34 'Kontoerwalle' or off-contour swales direct excess runoff slowly to natural drainage channels, thereby preventing soil erosion (sketch: Tucson, 2006)

In reality these ‘contours’ are off-contour swales, constructed at a slight angle from the contour line. As shown in the illustration, the swales and berms are aligned slightly off parallel with the contour lines. Off-contour swales convey stormwater **slowly** downslope in a controlled manner to maximize infiltration, support vegetation, control erosion, reduce stormwater flow velocity, and eventually discharge any excess stormwater to a safe location (City of Tucson, 2005). Where contours breach and fail to be maintained, severe gully erosion can form.

Suitability in the Mzimvubu area

Contours were implemented in cropping fields across the Mzimvubu Development Zone, therefore there is already a base to work from. Several opportunities for labour-based job creation can improve the natural resource base, which would reduce erosion and consequent siltation of dams, and help earn soil-based and vegetation-based carbon credits. These earnings could in turn help finance the job creation programme, which could include:

- Repair and maintenance of existing contours;
- Adaptation of contours for increased runoff infiltration for improved dryland crop yields; and
- to enable tree planting (see contour bunds for trees below).

Figure 35 Contours are not just for conventional use on croplands (photo Mati, 2008)

b) Contour bunds adapted for trees

In a further development, these off-contour swales can be adapted for tree planting as shown in the drawing. The infiltration pits concentrate runoff in the root zone and excess water can escape safely around the point of the cross-tie, thereby ensuring controlled cascading of excess flow to the natural drainage routes.

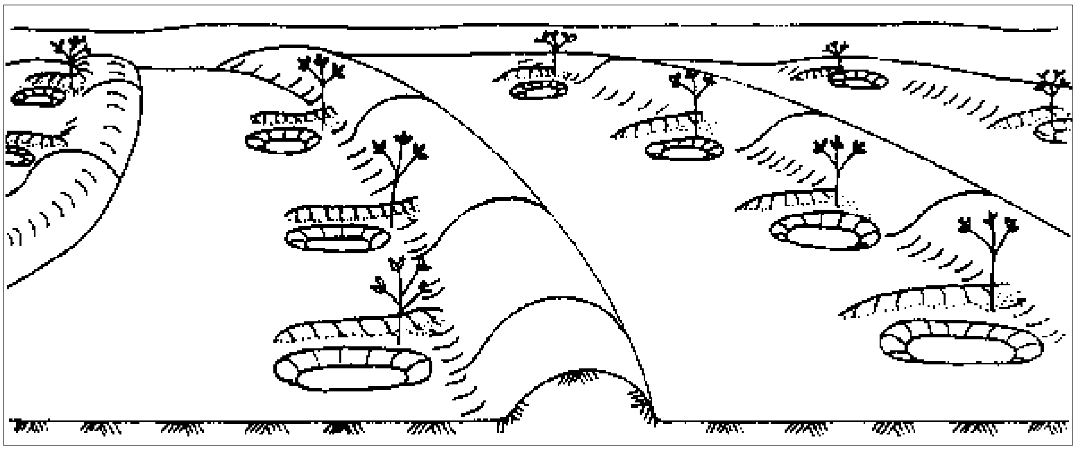


Figure 36 Contour bunds for tree planting (FAO, 1991)

c) Glen 'Infield Rainwater Harvesting' system

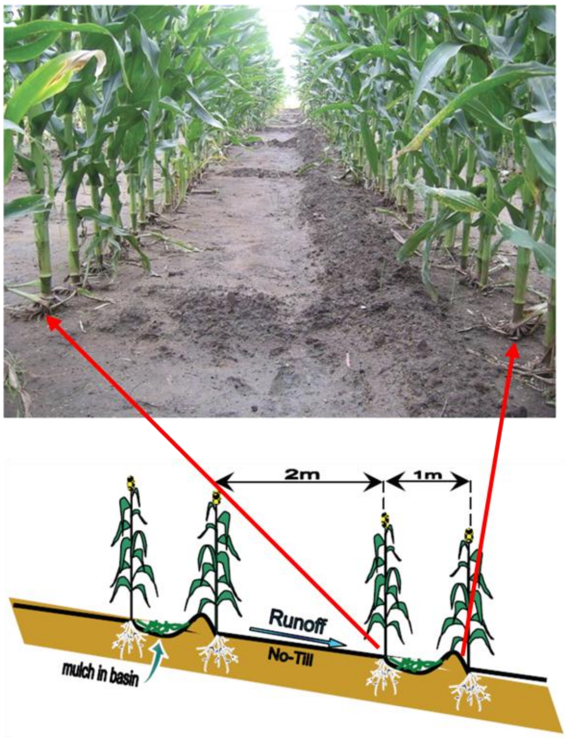


Figure 37 ARC Glen 'Infield Rainwater Harvesting' (IRWH) technique (Mwenge Kahinda, 2008)

This is a micro-catchment rainwater harvesting technique, which collects rainwater from a 2 m run-off strip and infiltrates it in 1 m strips with crops planted in rows along both sides of the infiltration strip. This is a zero-runoff system, carefully planned to capture and infiltrate all rain falling onto the field. It does not incorporate runoff generated outside the cropping field.

Developed to improve infiltration and thus crop yields in the ThabaNchu area, this technique is suitable on duplex and clay soils of at least 700 mm depth and slopes of less than 3% (Mwenge Kahinda *et al*, 2008).

It is currently being tested and adapted for implementation in the Mzimvubu River catchment and adjacent areas by a collaborative programme between the Agricultural Research Council and the Eastern Cape Department of Agriculture (ECDA)

d) Diversion ditches (sloped)

Uphill from sets of rainwater harvesting structures, it is often essential to construct diversion ditches to divert large stormflows away from the planted area to prevent erosion. Diversion ditches are typically sloped at 0.25% and may need to be up to 1.5 m wide and 0.5 m deep, depending on the runoff potential.

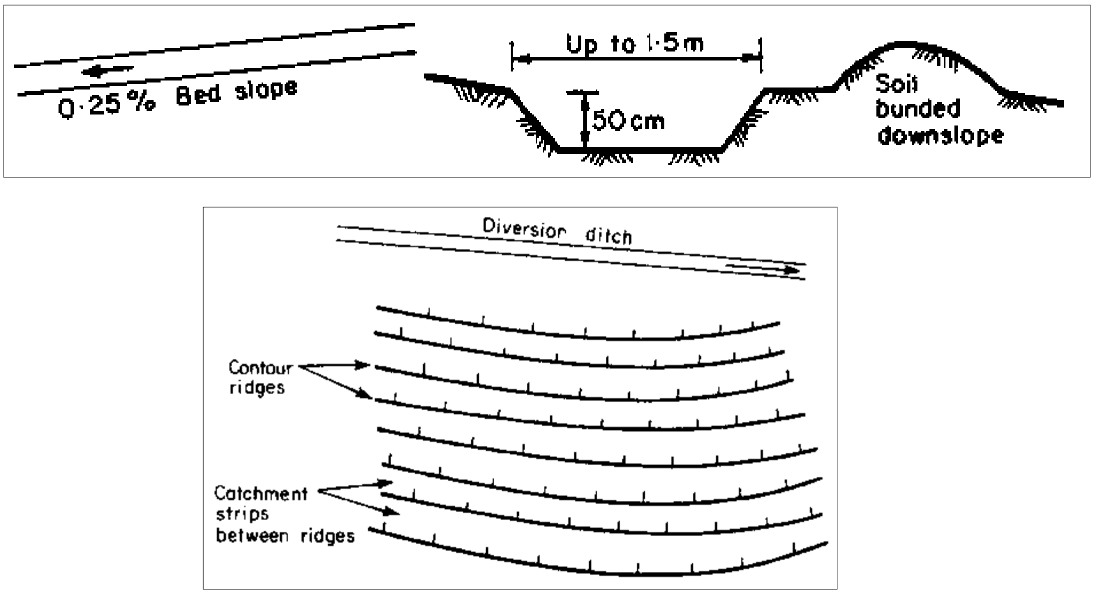


Figure 38 Diversion ditch above a set of contour ridges adapted for increased infiltration to support improved cropping (Critchley et al, 1991)

e) Cut-off ditches (level)

Cut-off ditches are level and deep, and may be constructed uphill of a set of level contours and/or micro basins. These cut-off ditches capture stormflows and spread the water on-contour along their full length. Controlled overflow occurs at defined spillways out of the cut-off ditch into sets of on-contour swales lower down, creating a cascading effect until any remaining excess overflows at the bottom end of the water harvesting area into natural drainage routes.

A level ditch can equally be applied at the bottom end of the water harvesting area, to maximise contact time and thus infiltration through the sides of the raised beds.

Figure 39 Water marks showing the level of ponding in the bottom ditch before overflowing downhill (towards the right on the photo) during a rainstorm. Infiltration into the ridge on the left produced a bumper crop of sweet potatoes, which had just been planted into the ridge at the time of this photo (WRC, 2010)

f) Level contours / 'on-contour' swales

Level contours can be used in a number of ways to slow down and infiltrate runoff. The design must provide an escape route for excess water, and this can be achieved in a number of ways.

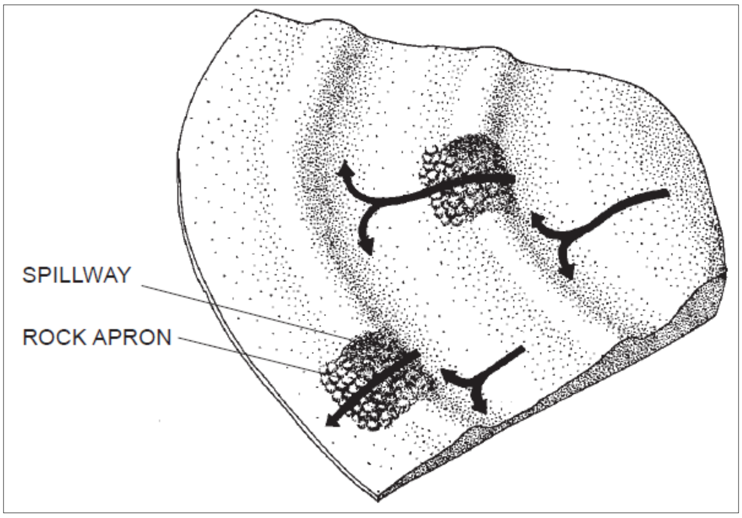


Figure 40 Level contour with rock cladded spillways

g) Terracing

Figure 41

'Radical terracing' in Rwanda, to convert steep slopes into cultivable area (Mati, 2007)

Figure 42

'Progressive terracing' (Mati, 2007)

6.2.2 Food gardening

Food production from homestead plots is presently the most sustainable and effective agricultural activity and contributes significantly to livelihoods in the Mzimvubu River catchment (DWA, 2009a; Fort Hare, 2006). Both maize and vegetables are cultivated in homestead plots, contributing some staple food, but more importantly, a range of micronutrients that helps counteract the high prevalence of malnutrition, especially among pre-school children when they are most vulnerable to permanent physical and mental damage through malnourishment.

Over the past few decades, home food production has steadily gained compared to field cropping as a strategy that:

- is less vulnerable to damage by roaming livestock and theft;
- produces higher value outputs (both cash and nutritional value) on smaller parcels of land; and which therefore
- requires less labour input, which is especially important to households affected by HIV/AIDS and the absence of working age adults through migration.

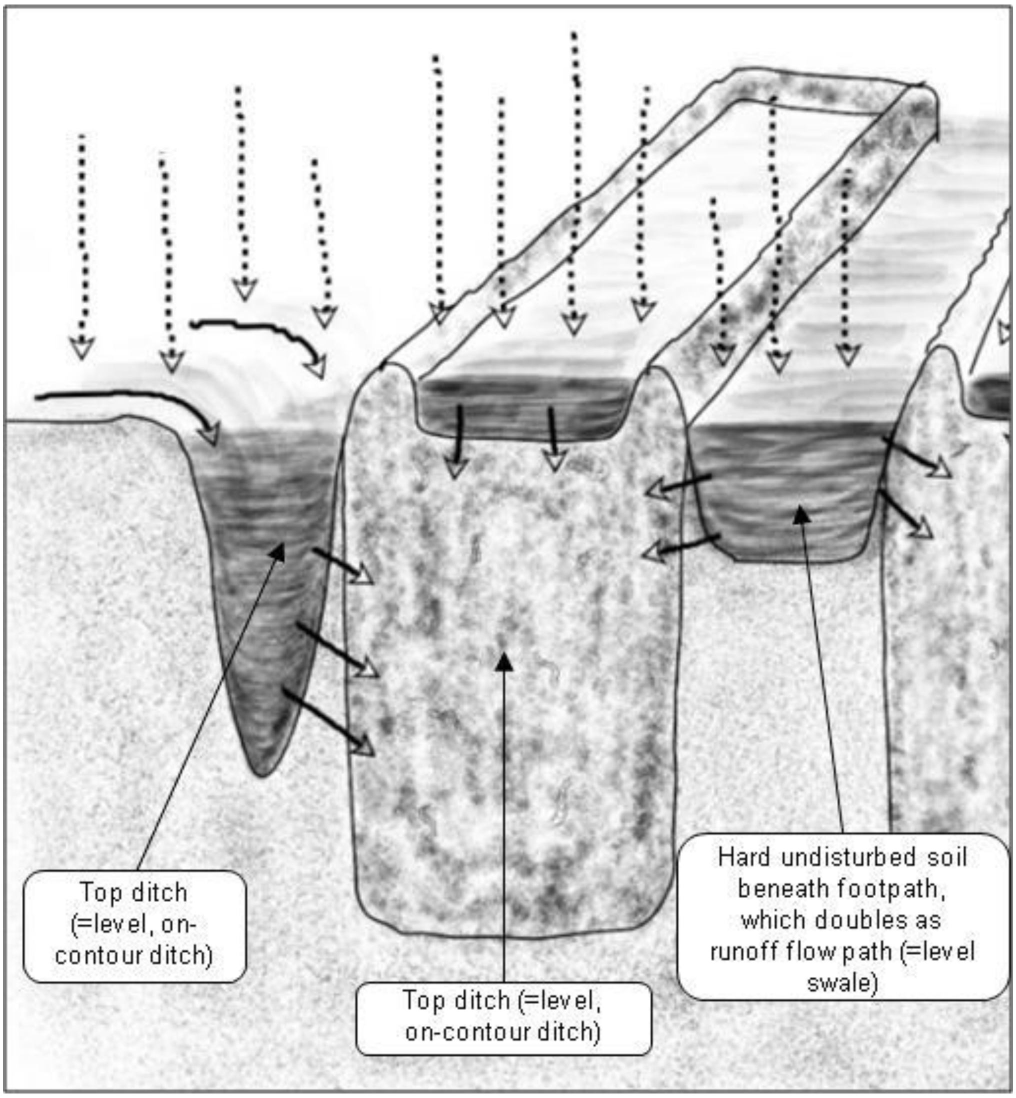
The use of rainwater harvesting techniques for both vegetable gardening and tree planting are of great relevance to household food security.

a) Raised trench beds harvesting rainwater from on-contour swales

Deep trenching is a well proven strategy to enable food gardeners to achieve early, and sustained, successes with gardening. Deep trenching creates ideal soil conditions for plant growth and helps the soil inside the planting beds to <u>absorb</u> and <u>hold</u> more water. Gardeners are shown how to lay out their gardens so that water can pool around their deep trenched beds to maximise <u>infiltration</u> (Kruger *et al*, 2010 in press).

[Note: See photo overleaf]. During a rainstorm, water pooling in the top ditch (left on this drawing) and in the rainwater flow paths (right on this drawing) infiltrates (soaks) sideways into the deep soft soil of the trench bed. This all happens underground, so you cannot see it unless you dig and look! Very little water soaks into the soil beneath the footpath/rainwater flow path, because this soil is very hard, while the ridges and deep soil in the trench beds are very soft and absorbent from all the organic matter that has been mixed into it.

All hand watering or irrigation is applied on top of the trench bed – <u>not</u> in the rainwater flow paths between the trench beds. Evaporation losses are tremendous if one tries to apply irrigation water via the rainwater runoff flow paths.



Note that each bed is trenched, raised, ridged and surrounded by footpaths which double as rainwater flow paths during rain:

- TRENCHED to create a deep fertile root zone;
- RAISED to elevate it above the flow path of the water and make the soil even deeper;
- RIDGED to keep the water on the bed when you irrigate. The ridges also absorb lots of extra warmth from sunlight for the roots, and creates an ideal space to grow sweet potatoes and other crops that need ridging ; and
- SURROUNDED by rainwater flow paths so that water can pool all around the trench bed during a rainstorm to give maximum time for water to infiltrate into subsoil of the trench beds through the soft porous ridges. The footpaths are on hard, undisturbed soil; therefore the pooled water absorbs mostly sideways into the ridges, and then soaks down into the deep trench.

b) Key-hole gardens

Suitability in the Mzimvubu area

Keyhole gardens can be constructed where sufficient stone is available. Rainwater enters into the open end of the ‘V’, which faces upslope. Grey water is also used on top of the bed.

These gardens are preferably made as closely as possible to the cooking area, to facilitate easy watering and harvest, and protection of crops from livestock and pilfering.

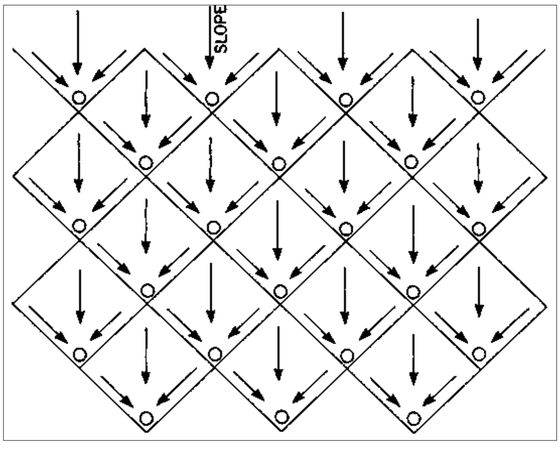
In high altitude areas, the stone helps to heat the rooting zone.

Figure 29 **Keyhole garden in Lesotho, laid out to channel runoff into the open 'V' (photo Mati, 2008)**

6.2.3 Rainwater harvesting for trees

a) Negarim

Negarim is the most well-known micro-catchment RWH technique worldwide and derives from the Hebrew word for runoff, ‘neger’. Negarim are laid out diagonally to the contour, with a tree planted in an infiltration pit in the bottom corner as shown.



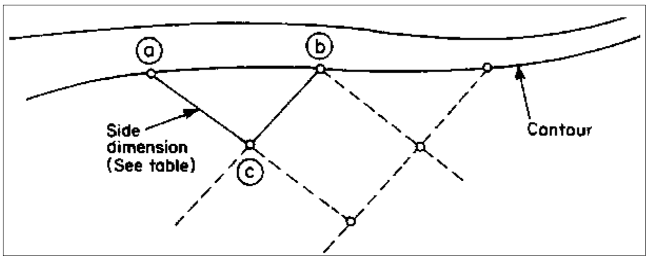
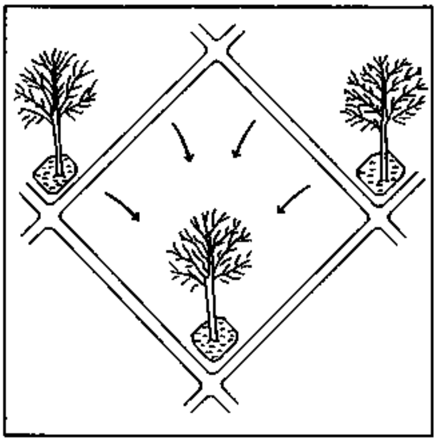


Figure 30 Keyhole Negarim for tree planting (photo from Smith, 2009)

Suitability in the Mzimvubu area



This technique is suitable on slopes from 0-5%, e.g. for fruit tree planting in yards and fields in and around the scattered villages throughout the Mzimvubu area. Uneven terrain is not a problem.

In higher rainfall areas like the Mzimvubu River catchment, the negarim can be small: the diamond-shaped catchment area must catch and hold enough rainwater to satisfy the crop water requirement.

'Take note' points

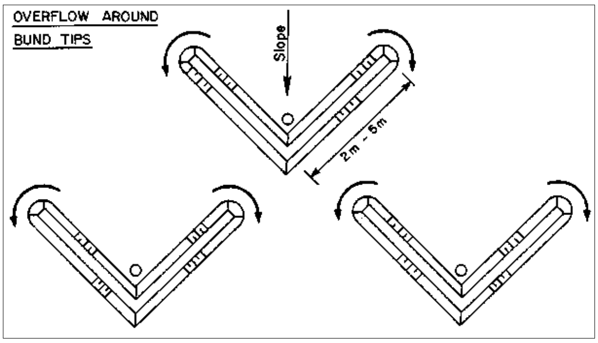
- Shallow soils as found in parts of the Mzimvubu River catchment need to be compensated for. Ensure sufficient water holding capacity by making larger infiltration pits and/or adding large quantities of organic matter before planting the trees.
- Negarim construction cannot easily be mechanised, but are well suited for hand construction, and thus attractive for labour-based job creation programmes.
- Also, it is not possible to operate and cultivate with machines between the tree lines, which makes this method well suited to remote areas. It may be less practical on large commercial farms and estates that are more dependent on mechanisation.

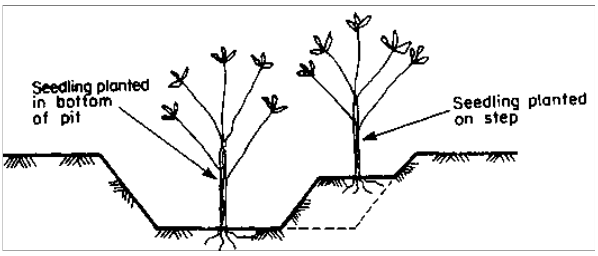
For technical detail for layout and construction, refer to Critchley *et al*, 1991.

b) V-shaped micro-catchments

An alternative to negarim, V-shaped catchments are better able to deal with runoff peaks, as excess water escapes around the points of the V. However, the Vs hold less water than the diamond shapes of the negarim.

In the infiltration pit in the bottom corner of either the negarim or the V, two tree seedlings are planted as shown in the sketch. This reduces the need for replanting when some trees fail to thrive. Only one is kept.

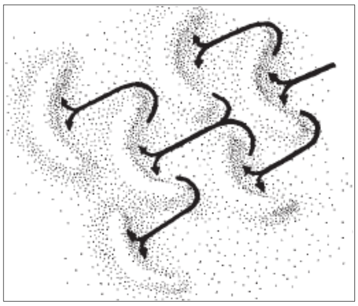




Photos and sketches from: FAO 1991; Tucson, 2006; Smith, 2009; Waterfall, undated.

c) Semi-circular bunds

Semi-circular earth ridges can be used to slow down and infiltrate runoff to support tree growth whether in nature, orchards, residential gardens or urban landscaped areas. A staggered configuration is important to allow excess to flow into the next half moon, thus safely cascading down through the landscape or orchard. The size and spacing must be calculated according to the rainfall, slope and water requirement of the trees.



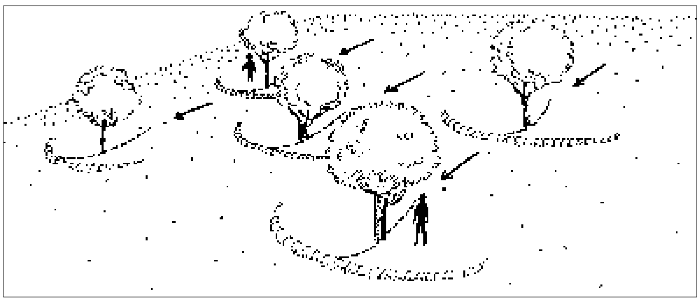


Figure 31

Semi-circular bund for tree planting (Smith, 2009)

Suitability in the Mzimvubu area

Earth bunds are very simple to implement to support the growth of fruit trees and even high value hardwood trees in homesteads and on cultivated lands in the Mzimvubu area. It is possible to use a portion or border of a maize field in this way, thereby increasing the diversity and the value of production on a much under-utilised resource (DWAF, 2009a).

Semi-circular bunds can also be used for rangeland improvement and fodder production, where rainfall is between 200 - 750 mm, soils are not too shallow or saline, and slopes are below 2% (but with modified bund designs up to 5%). Identification of suitable areas in the Mzimvubu River catchment would be a necessary first step for implementation planning.

d) Depressions and planting pits

Figure 33

Rainwater routed to a natural depression to improve crop yield (Smith, 2009)

Figure 32

Bananas in planting pits, Kenya (Mati, 2008)

Figure 35

In-line depressions to improve growth in urban landscaping (Waterfall, 2006)

Figure 34

Micro-catchment system with planting pits and control ridges in slightly stepped terraces (photo Mati, 2008)

Suitability in the Mzimvubu area

Planting pits and depressions are of value in soils that suffer from low infiltration, which is a common problem in the Mzimvubu area.

Figure 36

'Zai' planting pits are shallow depressions that hold runoff for improved crop production (photo Smith, 2009)

6.2.4 Road water harvesting

Large quantities of runoff are generated from road surfaces, creating stormwater management challenges. At the same time, this is a potential water resource if users can take control of stormflows by slowing it down, clearing it of sediment and debris and storing it in structures or soil profile of cultivated areas.

This is a macro-catchment technique, as the catchment lengths are often greater than 30 m.

Figure 37

A simple technique to channel water from road runoff, using a small stone 'check dam' to slow it down and filter sediments and debris, then leading it to infiltrate where it is needed (photo Mati, 2008)

6.3 UNCULTIVATED AREAS: ENVIRONMENTAL RESTORATION AND RANGELAND IMPROVEMENT

A variety of water harvesting methods can be used to increase runoff infiltration in grazing areas, natural veld and conservation zones. The specific choice of method would depend on the rainfall quantity and patterns, characteristics of the soil and vegetation, and local availability of materials in an area, e.g. stone for stone bunding. Application in the Mzimvubu area would thus vary to suit these differences.

In most cases it is not necessary to calculate the ratio C:CA for systems implementing fodder production and/or rangeland rehabilitation. As a general guideline, a ratio of 2:1 to 3:1 for micro-catchments (i.e. catchment slope length < 30 m) is appropriate (Critchley *et al*, 1991).

Often the most important factors for success are initial protection (including temporary fencing or hands-on herding), followed by long-term grazing management, including appropriate stocking and burning regimes. Natural revegetation often gives satisfactory results without reseeding. However, where reseeding is used, it is usually best to collect seeds from local species known to do well there.

These methods are well suited to use in major labour-based job creation programmes, earning carbon and water credits to help pay for implementation and sustainable maintenance programmes. Such methods can add to the suite of interventions to be implemented in the upcoming UNEP Mzimvubu '*Payments for Watershed Services*' programme. In turn, the UNEP programme is expected to produce a mechanism for payments for watershed services that could be used to structure further climate mitigating initiatives, including rainwater harvesting initiatives aimed at environmental restoration.

a) Contour stone bunds

Contour stone bunds are used to slow down and filter runoff, thereby increasing infiltration and capturing sediment. The water and sediment harvested lead directly to improved crop or grassland performance. This technique is well suited to small-scale application on farmer's fields and, given an adequate supply of stones, can be implemented quickly and cheaply (Critchley *et al*, 1991; Mati, 2008).

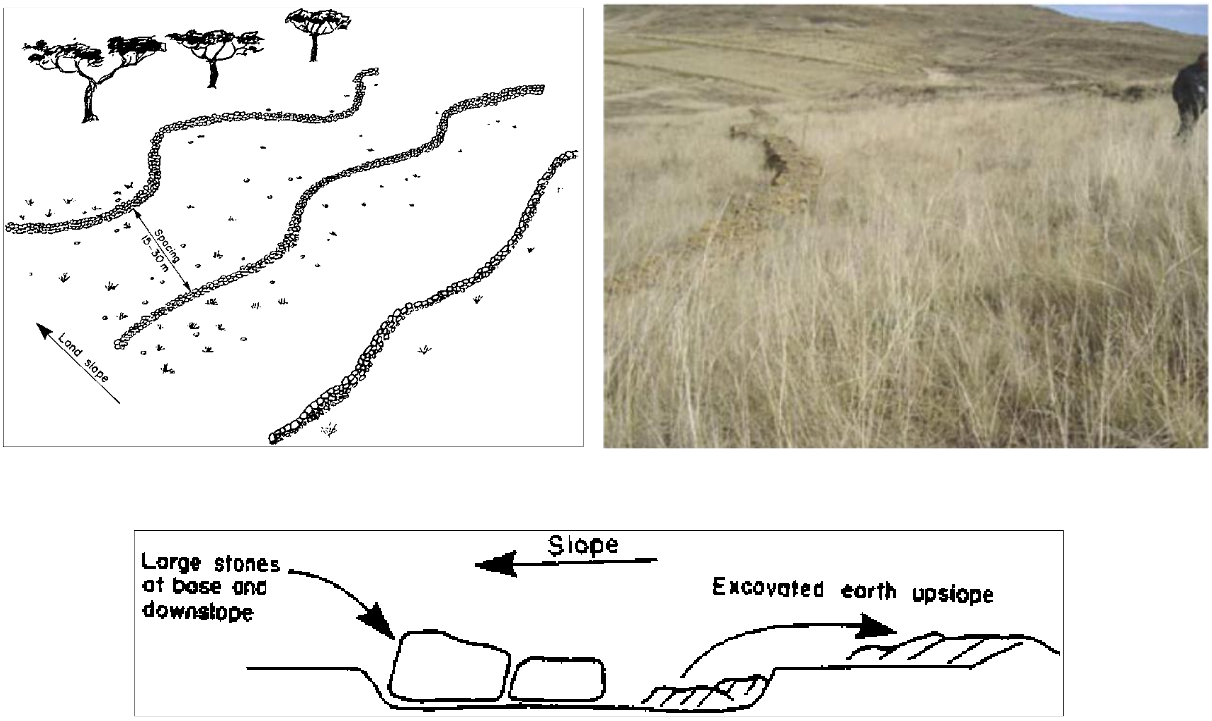


Figure 38 Contour stone bunds to control rangeland erosion, Mafeteng, Lesotho (Mati, 2008)

b) Conservation ditches

Strategic placement of conservation ditches help to capture runoff and force infiltration. Usage in the correct set of circumstances can increase soil moisture around the ditch, help reduce flash floods and flood peaks, and improve longer term baseflow in the rivers. In some cases, maintenance requirements can be reduced by adding filter material (e.g. broken rock) in the ditches, or by planting Vetiver grass on the uphill lip of the ditch.

Figure 53 Lock-and-spill ditch for catchment protection, Rwanda (Mati, 2008)

Figure 54 Vetiver grass stabilising the edge of a ditch, and used for fodder (photo Mati, 2008)

Suitability in the Mzimvubu area

In the Mzimvubu area, such strategies are important for a variety of reasons, including the importance of using runoff before it escapes beyond economic reach down the steep river valleys, and people's high dependence on baseflow in the tributaries for their daily water needs (whether through direct withdrawal or indirectly through communal water supply systems drawing directly from rivers).

Action research would be useful to refine parameters for placement and configuration in different contexts across the Mzimvubu Development Zone.

c) Semi-circular earth bunds

This method was discussed above for trees, but can also be used for rangeland improvement.

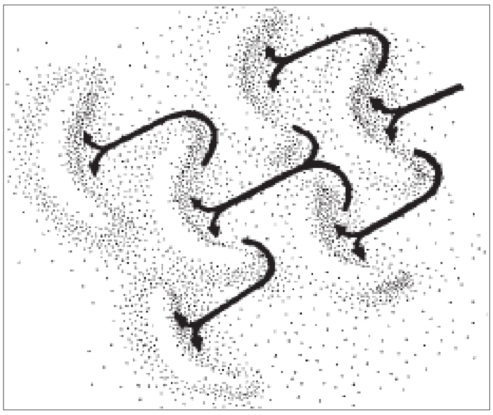


Figure 55 Diagram of semi-circular earth bunds (Waterfall, 2006)

d) Trees: rainwater harvesting methods and tree nurseries

The various rainwater harvesting techniques for trees mentioned earlier are of relevance for the establishment of indigenous tree species for environmental restoration.

The need for large quantities of tree seedlings and grasses, like Vetiver, creates an opportunity for the establishment of local nurseries with a guaranteed market. This contributes to the local economic development and job creation potential of restoration projects.

This activity lends itself ideally to 'cottage industry'-type development: even households in remote and scattered villages can propagate tree seedlings at home and sell to the restoration project. Logistics can be handled as a separate service (e.g. by mobile traders) or through a local nursery.

Figure 56 Tree nursery of local species for environmental restoration, Rwanda (Mati, 2008)

e) Water spreading techniques

<u>Suitability in the Mzimvubu area</u>

Water spreading techniques are suited to arid areas with flat slopes and even terrain. Trapezoidal bunds are large structures with limited application in the undulating and mountainous terrain of the Mzimvubu area. It requires flat slopes (0.5% is ideal) and is not suitable for uneven terrain. The same limitations apply to permeable rock dams, level bunds and graded bunds (see Critchley *et al,* 1991 for technical detail).

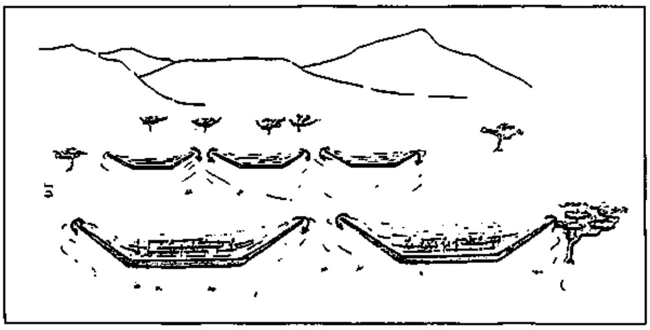
Table 5 Earth and stonework for various water harvesting systems

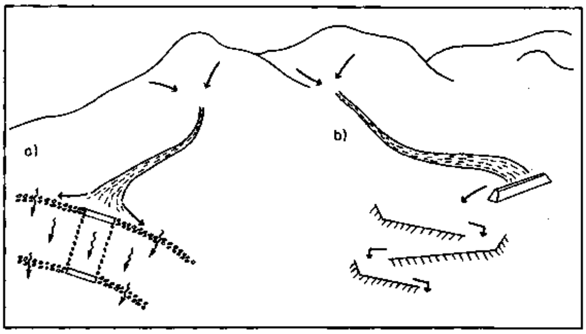
System Name and Number	Earthwork (m^3/ha treated)						Stonework (m^3/ha treated)	
	Negarim micro-catch-ments (trees)	Contour bunds (trees)	Semi circular bunds (grass)	Contour ridges (crops)	Trape-zoidal bunds (crops)	Water spreading bunds (crops)	Contour stone bunds (crops)	Permeable rock dams (crops)
Slope %	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
0.5	500	240	105	480	370	305	40	70
1.0	500	360	105	480	670	455	40	140
1.5	500	360	105	480	970	N/R*	40	208
2.0	500	360	210	480	N/R*	N/R*	55	280
5.0	835	360	210	480	N/R*	N/R*	55	N/R*

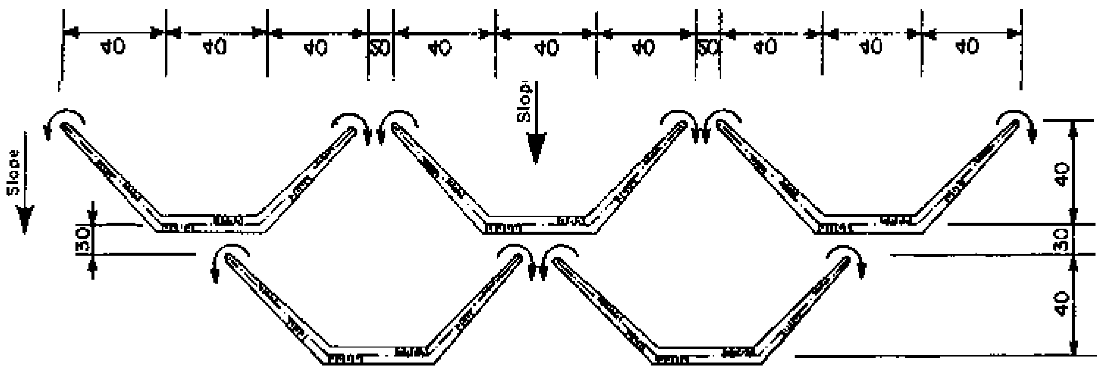
* Not recommended

Notes

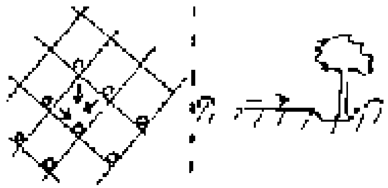
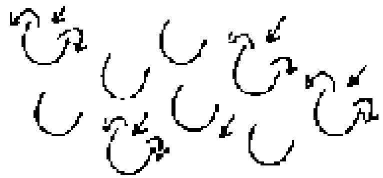
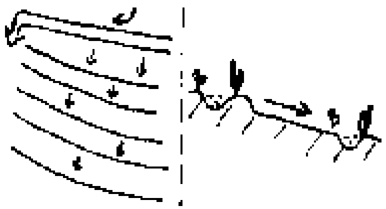
1. Typical dimensions are assumed for each system: for greater detail see Critchley *et al,* 1991.
2. For micro-catchment systems (1, 2, 3 and 4), the whole area covered (cultivated and within-field catchment) is taken as "treated".
3. Labour rates for earthworks: Typical rates per person/day range from 1.0 to 3.0 m^3.
4. Labour rates for stoneworks: Typical labour rates achieved are 0.5 m^3 per person/day for construction. Transport of stone increases this figure considerably.

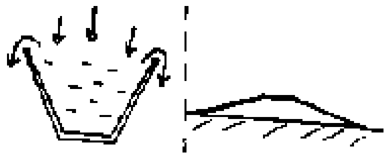
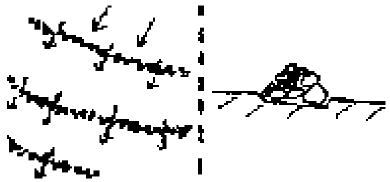






6.4 SUMMARY CHART OF THE MAIN 'GREEN WATER' HARVESTING TECHNIQUES

	Classification	Main uses	Description	Where appropriate	Limitations	
Negarim micro-catchments	Micro-catchment (short slope catchment) technique	Trees & grass	Closed grid of diamond shapes or open-ended "V" s formed by small earth ridges, with infiltration pits.	For tree planting in situations where land is uneven or only a few tree are planted.	Not easily mechanised therefore limited to small scale. Not easy to cultivate between tree lines.	
Contour bunds	Micro catchment (short slope catchment) technique	Trees & grass	Earth bunds on contour spaced at 5-10 m apart with furrow upslope and cross-ties.	For tree planting on a large scale especially when mechanised.	Not suitable for uneven terrain.	
Semi circular bunds	Micro catchment (short slope catchment) technique	Rangeland & fodder(also trees)	Semi-circular shaped earth bunds with tips on contour. In a series with bunds in staggered formation.	Useful for grass reseeding, fodder or tree planting in degraded rangeland.	Cannot be mechanised therefore limited to areas with available hand labour.	
Contour ridges	Micro-catchment (short slope catchment) technique	Crops	Small earth ridges on contour at 1.5m -5m apart with furrow upslope and cross-ties. Uncultivated catchment between ridges.	For crop production in semi-arid areas especially where soil fertile and easy to work.	Requires new technique of land preparation and planting, therefore may be problem with acceptance.	

	Classification	Main uses	Description	Where appropriate	Limitations	
Trapezoidal bunds	External catchment (long slope catchment) technique	Crops	Trapezoidal shaped earth bunds capturing runoff from external catchment and overflowing around wingtips.	Widely suitable (in a variety of designs) for crop production in arid and semi-arid areas.	Labour-intensive and uneven depth of runoff within plot.	
Contour stone bunds	External catchment (long slope catchment) technique	Crops	Small stone bunds constructed on the contour at spacing of 15-35 metres apart slowing and filtering runoff.	Versatile system for crop production in a wide variety of situations. Easily constructed by resource-poor farmers.	Only possible where abundant loose stone available.	
Permeable rock dams	Floodwater farming technique	Crops	Long low rock dams across valleys slowing and spreading floodwater as well as healing gullies.	Suitable for situation where gently sloping valleys are becoming gullies and better water spreading is required.	Very site-specific and needs considerable stone as well as provision of transport.	
Water spreading bunds	Floodwater farming technique	Crops & rangeland	Earth bunds set at a gradient, with a "dogleg" shape, spreading diverted floodwater.	For arid areas where water is diverted from watercourse onto crop or fodder block.	Does not impound much water and maintenance high in early stages after construction.	

7 FINANCIAL INSTRUMENTS AND INCENTIVES FOR RAINWATER HARVESTING (EXAMPLES)

Tax Exemption Application Form

01-339 (Back)
(Rev. 6-04/5)

TEXAS SALES AND USE TAX EXEMPTION CERTIFICATION

Name of purchaser, firm or agency	
Address (Street & number, P.O. Box or Route number)	Phone (Area code and number)
City, State, ZIP code	

I, the purchaser named above, claim an exemption from payment of sales and use taxes (for the purchase of taxable items described below or on the attached order or invoice) from:

County property tax exemptions

Homeowners planning to install rainwater harvesting systems should check with their respective county appraisal districts for guidance on exemption from county property taxes.

Property tax exemption for commercial installations (State-wide exemption)

A constitutional amendment passed as Proposition 2 by Texas voters in November 1993 exempted pollution control equipment, including water-conserving equipment at nonresidential buildings, from property taxes. Rainwater harvesting equipment at commercial installations is considered water-conserving equipment. The intent

San Antonio Water System Large-Scale Retrofit

Rainwater harvesting projects are eligible for up to a 50-percent rebate under San Antonio Water System's (SAWS) Large-Scale Retrofit Rebate Program. (See References.) SAWS will rebate up to 50 percent of the installed cost of new water-saving equipment, including rainwater harvesting systems, to its commercial, industrial, and institutional customers. Rebates are calculated by multiplying acre-feet of water conserved by a set value of $200/acre-foot. Equipment and projects must remain in service for 10 years. The water savings project is sub-metered, and water use data before and after the retrofit are submitted to SAWS to determine if conservation goals are met. To qualify for the rebate, an engineering proposal and the results of a professional water audit showing expected savings are submitted.

8 PART 3: RAINWATER HARVESTING POTENTIAL IN THE MZIMVUBU DEVELOPMENT ZONE

The potential for rainwater harvesting as a water resource needs to be viewed in two ways:

- Firstly, the '**upper limit of potential**', which depends on the natural resource potential for different rainwater harvesting techniques; and
- Secondly, the '**demand potential**', whereby the upper limit of potential is adjusted according to factors such as:
    - the priorities of individuals and organisations who stand to be affected by the introduction and/or up-scaling of rainwater harvesting,
    - the economic viability of a rainwater harvesting technique for a specific use in a specific context; and
    - availability of suitable financing mechanisms and implementation capacity.

Upper limit of potential

In this report, the upper limit of potential for rooftop rainwater harvesting for rural and urban domestic use has been determined for selected quaternary catchments in each of the main agro-ecological zones (see **Figure 57**).

Further work is needed to determine the upper limit of potential for rainwater harvesting in each of the agro-ecological zones for:

- wider urban uses (commercial, industrial and landscaping);
- cultivated areas (for improved dryland and irrigated crop production); and
- uncultivated areas (improved grazing and environmental restoration).

The area covered by the Montane, Upper Plateau and Minor escarpment zones has been the subject of a detailed study on the potential for water resource improvement through environmental restoration based on improved grazing management and reduced burning. A major UNEP funded environmental restoration programme started in the Mt Fletcher/Matatiele area in March 2010. Part 2 touched on some of the rainwater harvesting techniques which could further support and strengthen the envisaged activities and future similar environmental restoration initiatives in the Mzimvubu Development Zone.

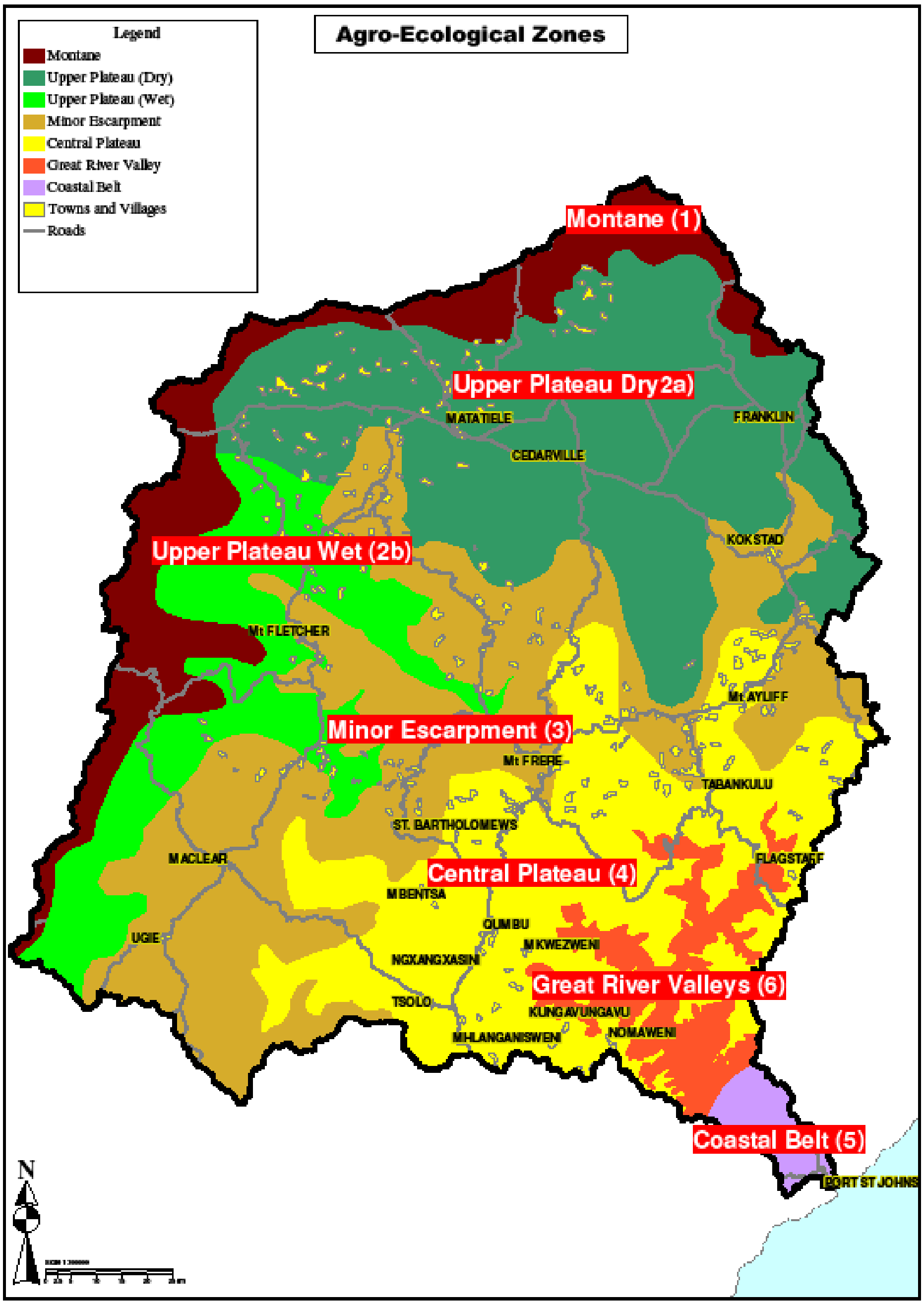


Figure 57 Defined agro-ecological zones in Mzimvubu River catchment

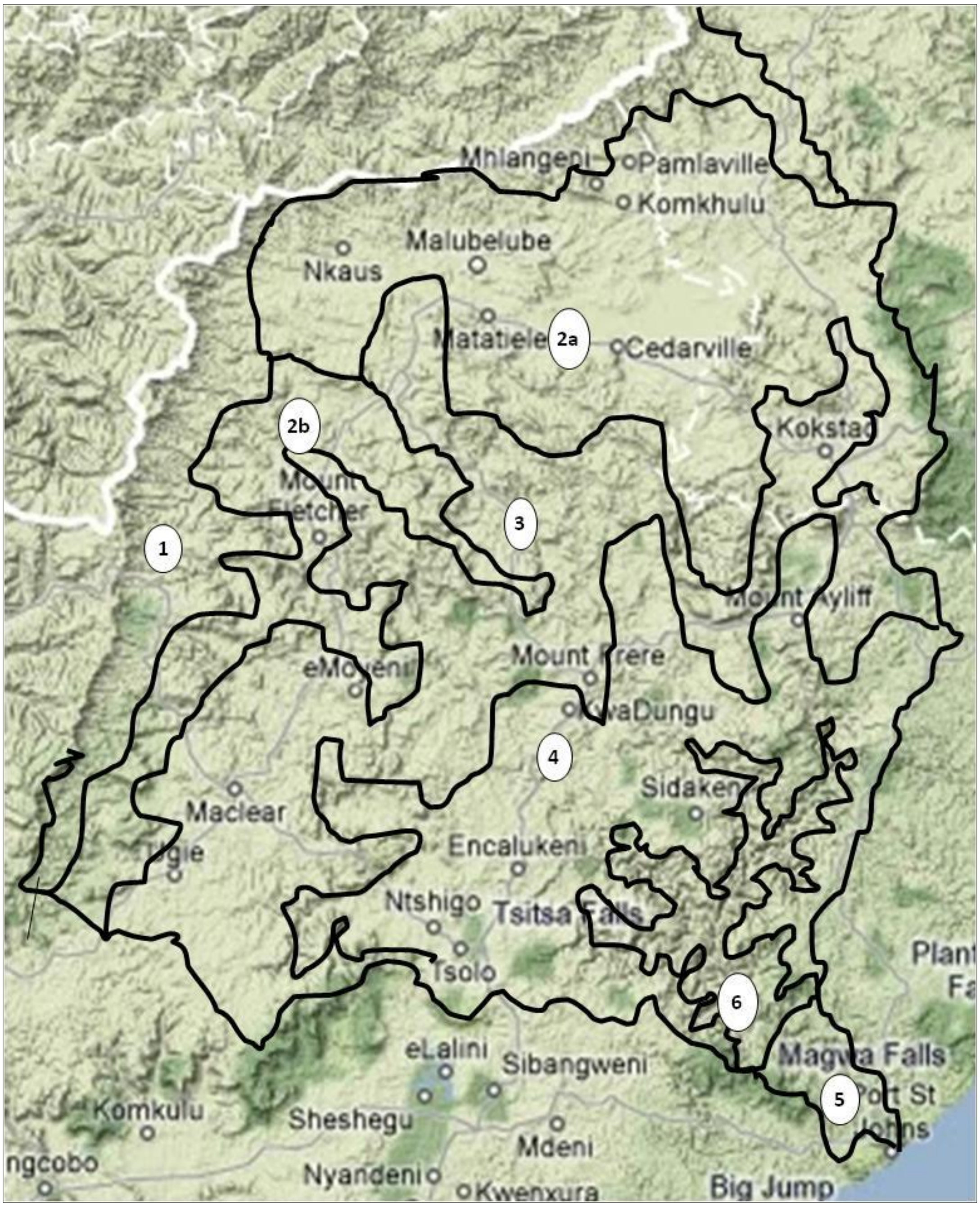
(Source: Report P WMA 12/000/00/3609 Volume 2 of 5)

Demand potential

Demand potential rests to a large degree on the 'appetite' for an intervention, which in turn depends on the extent to which people see it as responding to their livelihood priorities. For this reason, considerable attention needs to be paid to the socio-economic context in the Mzimvubu Development Zone when selecting interventions.

9 POTENTIAL FOR DEVELOPMENT BASED ON RAINWATER HARVESTING IN THE MZIMVUBU AREA

Rainwater harvesting potential in the various Agro-ecological Zones



Slopes: On the map below, the steepness of the slopes of the Montane zone (1) is clearly visible along the north-western border with Lesotho. It then flattens out towards the central plateau (4). The landscape drops down very steeply into the great river valleys (6) before it reaches the coastal area (5) around Port St Johns. Steeper slopes generate more runoff, while opportunities for increased infiltration are better on flatter slopes.

Table 6 Rainfall characteristics of the agro-ecological zones in the Mzimvubu River catchment (DWA, 2009a)

Agro-ecological zones		Altitude (masl)	Mean rainfall (mm)	Rainfall seasonality	Rainfall concentration (%)
1	Montane	> 1 800	1 000 - 1 500	Mid-summer (Jan)	50 - 60
2a (dry)	Upper Plateau (dry)	1 300 - 1 800	700 - 800	Mid-summer (Jan)	50 - 60
2b (wet)	Upper Plateau (wet)	1 300 - 1 800	800 - 1 000	Mid-summer (Jan)	50 - 60
3 and 4	Minor escarpment	1 200 - 1 800	700 - 900	Late summer (Feb)	45 - 50
	Central Plateau	700 - 1 200		Late summer (Feb)	
5	Coastal	0 - 700	1 000 - 1 200	Mid to late summer (Jan to Feb)	30 - 45
6	Great River Valleys	0 - 700	700 - 800	Mid to late summer (Jan to Feb)	40 - 50

The potential for rainwater harvesting for the range of applications identified in Part 2, need to be tested in a number of quaternaries as examples for each of the agro-ecological zones, as shown in **Table 7** below. The summary results for rooftop rainwater harvesting and the guesstimates for application in urban, cultivated and uncultivated areas are presented in **Table 8**. Full results supporting the summary for rooftop rainwater harvesting as shown in Table 8, are shown in **Table 9**.

Table 7 Rainwater harvesting potential in the various agro-ecological zones: Quaternaries tested

Application of RWH / Zone	Rooftop	Urban landscaping	Cultivated areas	Uncultivated areas
	Rural and urban households; businesses; factories	**Road and street drainage; parking areas; litter handling; erosion control**	**Food gardening; improved rainfed; reduced irrigation water demand**	**Improved grazing; environmental restoration**
Montane	T34C Northeast of Mt Fletcher			
Upper plateau (dry)	T34D Mt Fletcher			
Upper plateau (wet)	T33A Matatiele		T31F Cedarville	
Minor escarpment	T35D Maclear (West) T32C Kokstad (East)		T33G Mt Frere	
Central Plateau	T35K Qumbu		T32G Mt Ayliff	
Coastal	T36B Port St Johns			
Great river valleys	T32H Flagstaff			

Table 8 Rainwater harvesting potential in the various agro-ecological zones: Summary of findings

Zone \ Application of RWH	Rooftop	Urban landscaping	Cultivated areas	Uncultivated areas
	Rural and urban households; businesses; factories	**Road and street drainage; parking areas; litter handling; erosion control**	**Food gardening; improved rainfed; reduced irrigation water demand**	**Improved grazing; environmental restoration**
Montane	Medium	*Low*	*Medium*	*High*
Upper plateau (dry)	High	*High*	*High*	*High*
Upper plateau (wet)	High	*High*	*High*	*High*
Minor escarpment	High	*High*	*High*	*High*
Central Plateau	High	*High*	*High*	*High*
Coastal	High	*Medium*	*High*	*Medium*
Great river valleys	Medium	*Low*	*Medium*	*Medium*

Note: Values in *Italics* are guesstimates and need further analysis.

For **rooftop rainwater harvesting**, the potential is high throughout the Mzimvubu Development Zone, but was indicated as medium where population is lower, such as in the most inaccessible area remote Montane quaternaries (e.g. T34E and T35B) and the inaccessible portions of the Great River Valleys. The potential for roofwater harvesting is better where rainfall is higher and less concentrated across the seasons, with the best potential in the coastal area.

User sector	Per capita consumption (2005) (ℓ/c/d)
Rural	25
Urban	87

In the water resources assessment for the Mzimvubu River catchment (DWA, 2009b), the requirements for domestic water was based on the 2005 per capita consumption according to the National Water Resources Strategy.

In this report, the potential for rainwater harvesting for **domestic water use** was assessed based on Free Basic Water use (6 kℓ/month) in rural dwellings, and 15 kℓ/month in urban houses.

The potential for rainwater harvesting for **urban landscaping** has been assumed good throughout from a natural resource perspective, and highest where urban areas are prevalent (T32C, T35K, T35C, T33H).

For **cultivated areas** the rainwater harvesting potential is expected to be high where the slopes are manageable and the infiltration characteristics of the soils favourable.

For **uncultivated areas**, the impact of rainwater harvesting is expected to be high where grazing areas are degraded, and where rainwater harvesting can help counteract the effect of seasonal concentration of rainfall.

Table 9 Rooftop rainwater harvesting potential in the Mzimvubu Development Zone

				Rooftop rainwater harvesting				
				Sole supply e.g. remote rural house (Adapt demand to 25% when tank at quarter-full)			**Conjunctive use** e.g. medium urban house on mains supply	
				60 m^2, FBW	6 kℓ/m		100 m^2, 87 ℓpd	15 kℓ/m
Zone	**Nearest town**	**Quat**	**Rainfall (mm)**	**RWH potential (kℓ/a)**	**% of FBW**	**Tank dry days/a**	**RWH potential (kℓ/a)**	**% of urban household use**
1	Mt Fletcher	T34C	813.1	41.2	57	6	69.1	37
2a	Mt Fletcher	T34D	757.0	38.5	53	8	64.3	34
2b	Matatiele	T33A	718.9	36.5	51	7	61.1	33
2b	Cedarville	T31F	675.8	34.2	48	14	57.2	30
3	Maclear	T35D	800.5	40.7	57	8	68.0	36
3	Kokstad	T32C	708.8	36.1	50	6	60.2	32
3	Mt Frere	T33G	732.3	37.2	52	19	62.2	33
4	Qumbu	T35K	721.1	36.6	51	7	61.3	33
4	Mt Ayliff	T32G	801.2	40.8	57	3	68.1	36
5	Port St Johns	T36B	1 076.7	52.8	73	2	90.1	48
6	Flagstaff	T32H	915.4	46.0	64	3	76.9	41

The results in Table 9 are very significant indeed. It shows that in virtually all climatic zones in the Mzimvubu Development zone, a household with an RDP-size house roof (60 m^2) and a 5 kℓ rainwater tank, **can harvest more than half of its annual Free Basic Water requirement from rainwater**. These results apply even when rainwater is the sole supply.

In a conjunctive use scenario for a medium-sized urban house on mains supply, up to 90 kℓ/a (125% of FBW) can be harvested from a 100 m^2 roof in Port St Johns, and 57.2 kℓ/a (79% of FBW) in Cedarville.

The potential for rooftop rainwater harvesting for domestic water use is thus very significant in Mzimvubu Development Zone:

- from the municipal perspective, in the reduction in requirements on bulk infrastructure and on operation and maintenance costs; and
- from the household perspective, in the improved water security and potential reduction in municipal water bills (where applicable).

10 UPPER LIMIT OF POTENTIAL FOR RAINWATER HARVESTING

What determines RWH yield? What is the situation in the Mzimvubu area?

Natural resource potential

As was seen in Part 2, the natural resource characteristics determine which rainwater harvesting techniques can be used. Rainwater harvesting planning and management is a challenge which is due less to the limitations in rainfall quantity than to the inherent degree of variability associated with it.

- Runoff is generated by rainstorms and its occurrence and quantity are dependent on the characteristics of the rainfall event (intensity, duration and distribution) and other factors such as soil type, vegetation, slope (degree and length) and catchment size.
- Generally, runoff increases with more intensive rainstorms, steeper slopes, harder surfaces and with less vegetative cover. Rainwater also runs off more quickly when it falls on soils that are already saturated, e.g. from previous rain.
- For rainwater harvesting, low infiltration capacity is desirable for collection areas, while high infiltration capacity is needed for production areas or other infiltration zones. When a choice needs to be made, the quality of the production area always takes preference (Critchley *et al*, 1991).

In 'blue water' techniques, which collects runoff into storage structures for later use, design seeks to find an economic balance between storage capacity, drawdown, size and characteristics of the available collection area, and the quantity and frequency of rainfall.

With rainwater harvesting for

(i) the restoration of grazing areas

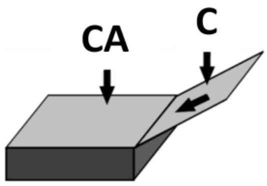
(ii) improved rainfed cropping, and

(iii) home food gardening

the emphasis is on techniques that improve the **infiltration capacity** and the **water holding capacity** of the soils, and on **shaping the runoff path** to channel and concentrate water where it is needed.

In such 'green water' techniques, which seek to infiltrate runoff into the root zone of plants, the design rainfall is the amount of seasonal rain at which, or above which, the system is designed to provide enough runoff to meet the crop water requirement. If the rainfall is below the "design rainfall," there is a risk of crop failure due to moisture stress. When rainfall is above the "design", then runoff will be in surplus and may overtop and damage the rainwater harvesting bunds, unless they have been designed with adequate provision for safe overflow.

Each 'green water' rainwater harvesting system consists of a catchment (collection) and a cultivated (concentration) area. The relationship between the two, in terms of size, determines by what factor the rainfall will be "multiplied". For an appropriate design of a system, it is recommended to determine the ratio between catchment (C) and cultivated (CA) area.



$$\frac{\text{CROP WATER REQUIREMENT DESIGN RAINFALL}}{\text{DESIGN RAINFALL * RUNOFF COEFF * EFF FACTOR}} = \frac{\text{CATCHMENT AREA}}{\text{CULTIVATED AREA}}$$

Runoff coefficient

This is the proportion of rainfall which flows along the catchment area (e.g. rooftop or soil surface) as runoff.

Type	Run-off coefficient	Notes
Galvanised Iron Sheets	>0.9	• Excellent quality water. Surface is smooth and high temperatures help to sterilise bacteria
Tile (glazed)	0.6 – 0.9	• Good quality water from glazed tiles. • Unglazed tile can harbour mould • Contamination can exist in tile joints
Asbestos Sheets	0.8 – 0.9	• New sheets give good quality water • No evidence of carcinogenic effects by ingestion • Slightly porous so reduced run-off coefficient and older roofs harbour moulds and even moss
Organic (Thatch, Palm)	0.2	• Poor quality water (>200 FC/100 ml) • Little first-flush effect • High turbidity due to dissolved organic material which cannot easily be filtered or settled out

For rooftops the runoff coefficient depends on the roofing material and effectiveness of guttering, and varies between 0.6-0.95, with 0.85 normally an acceptable value (Thomas *et al*, 2007).

For surface runoff the runoff coefficient depends amongst other factors on the degree of slope, soil type, vegetation cover, antecedent soil moisture, rainfall intensity and duration, and usually ranges between 0.1 and 0.5. When measured data are not available, the coefficient may be estimated from experience. However, this method should be avoided whenever possible (Critchley *et al*, 1991).

Efficiency Factor

This factor relates to 'green water' techniques and takes into account the inefficiency of uneven distribution of the water within the field as well as losses due to evaporation and deep percolation. Where the cultivated area is levelled and smooth, the efficiency is higher. Micro-catchment systems have higher efficiencies as water is usually less deeply ponded. Selection of the factor is left to the discretion of the designer based on experience and of the actual technique selected. Normally the factor ranges between 0.5 and 0.75 (Critchley *et al*, 1991).

Soil texture

This soil texture triangle shows soil suitability for runoff (catchment) areas and run-on (cropping) areas (FAO 2003, quoted in Mwenge Kahinda et al, 2008).

Constructional characteristics of soils

The ability of a soil to form resilient earth bunds is very important, and often overlooked. Soils which should particularly be avoided for bunding are those which crack on drying, namely those which contain a high proportion of montmorillonite clay (especially vertisols or "black cotton soils"), and those which form erodible bunds, namely very sandy soils, or soils with very poor structure (Critchley *et al*, 1991).

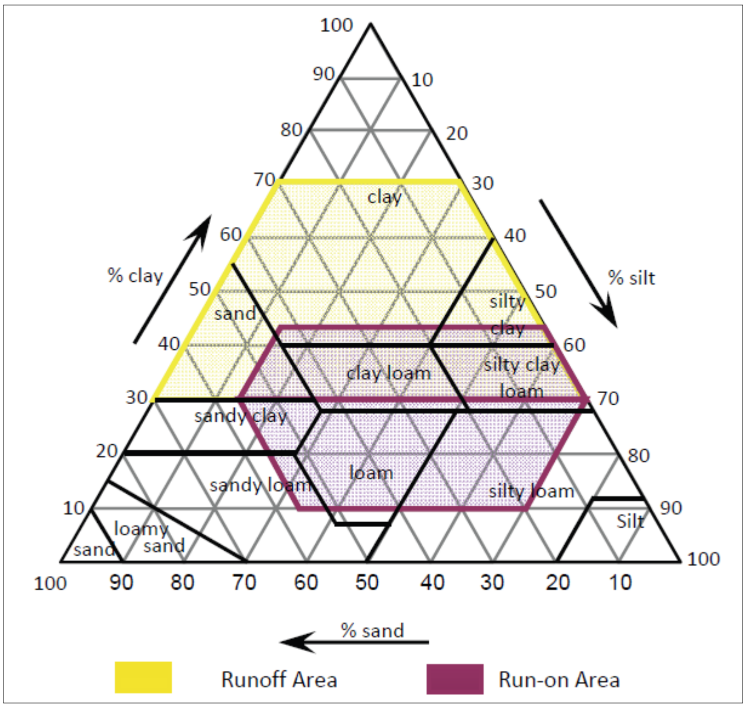


Figure 39 Soil texture triangle for runoff and run-on areas for rainwater harvesting (FAO, 2003)

11 DEMAND POTENTIAL FOR RAINWATER HARVESTING

What is likely to be doable?

The demand potential for rainwater harvesting is likely to be influenced by at least the following factors, which will be discussed in more detail in this section:

- Social factors
- Economics
- Political factors

11.1 SOCIO-ECONOMIC CONDITIONS AFFECTING RAINWATER HARVESTING

What do people need and want?

An early publication by the United Nation's Food and Agriculture Organisation (Critchley *et al*, 1991) identifies the following as socio-economic factors affecting the uptake of rainwater harvesting:

- People's priorities
- Participation
- Adoption of systems
- Area differences
- Gender and equity
- Land tenure
- Land use management

Principle: In any development, people's priorities determine not only whether they participate, but also whether and how they remain active after the initial implementation phase.

Recognition of this principle lies behind the insistence of DFID and other international funders on the 'Sustainable Livelihoods Approach' (SLA) to project development. In his book 'Catalysing cooperation: The design of sustainable user organisations', Professor Tushaar Shah (Shah, 1996) uses the same principle of people's priorities to explain why some cooperatives thrive and other fail to survive in periods of stress. He shows that an organisation can continue to do well amid difficult periods (economic hardship, market fluctuations, social disturbance, etc.) provided it can adjust its core function in accordance with shifts in its members' core needs. If it fails in this, it inevitably disappears. The same phenomenon is described in 'Good to Great' (Collins, 2001), in an in-depth assessment of Fortune 500 companies that have improved their performance substantively and sustainably above the norm.

The scope for uptake of any development initiative is thus determined directly by the degree to which the initiative responds to the priorities of the people of the area.

Extract: Mzimvubu Report on '*Agricultural Assessment and Irrigation Water Use*' (DWA, 2009a)

SECTOR 1

Sector 1 consists of the area within the boundaries of KwaZulu-Natal (KZN) prior to 1994 and the Ugie/Maclear region which fell into the pre-1994 Eastern Cape boundary where mainly freehold land tenure and associated commercial farming occurs. This area is characterized by:

- large-scale commercial farming that is mostly livestock based,
- commercial forestry
- a few country towns that support the farming communities
- well-developed infrastructure in terms of roads, power supply, services and communications
- a relatively low human population except in the town of Kokstad which is a busy regional centre
- a satisfactory conservation status with good farming practices ensuring very few signs of overgrazing and soil erosion.

SECTOR 2

Sector 2 consists of the remainder of the Eastern Cape component of the catchment which fell into the pre-1994 Transkei and is characterised by:

- state-owned land that is mostly administered through the Tribal land tenure system
- widespread rural villages in which most homesteads have a piece of land allocated to subsistence agriculture (750 - 1 200 m^2)
- consolidated rain-fed farming areas made up of many plots (1-3 ha in extent) "owned" by individuals or families under the "permission to occupy", quitrent or leasehold tenure systems administered by the local Tribal Authority. These lands are usually situated adjacent to the villages whose residents cultivate the plots, although in many cases the distances to walk are considerable and arduous, large areas of communal grazing land which has manifested itself into severe overgrazing and related soil erosion. The conservation status of this sector is generally very low.

A thorough understanding of people's priorities in the Mzimvubu Development Zone should therefore be at the heart of development planning activities. However, development planning is most often driven primarily by market demands matched to natural resource potential, and stops short of specific innovation to match these opportunities to the priorities of the local population. Policy development and programme/project design needs to consider how it can best respond to the diversity of priorities, catering for both immediate and longer-term needs of the people it aims to involve.

For rainwater harvesting planning, one needs to ask:

- How important is water to the prevalent livelihoods in Sector 1 (commercial farming areas) and Sector 2 (former Transkei areas)?
- How could rainwater harvesting for household, urban, agricultural and environmental restoration purposes contribute to these livelihoods?

Extract: Mzimvubu Report on '*Agricultural Assessment and Irrigation Water Use*' (DWA, 2009a) Extended area (Wild Coast and areas west of Port St Johns)

Food production from homestead plots is presently the most sustainable and effective agricultural activity and contributes significantly to livelihoods. Limited areas of semi-commercial vegetable production, under irrigation, occur on the alluvial soils adjacent to the larger perennial rivers that run through the study area to the coast. Rain-fed maize and sorghum production occurs on some top slopes in allocated cropping areas. These scattered production areas are managed at a subsistence level with very few inputs of fertilizer and plant protection chemicals. Yields are therefore very low and there is seldom a cash surplus generated from this form of land use. Present livestock production in the study area is mainly restricted to the use of communal grazing land to maintain family-owned herds. Livestock provides traditional benefits in terms of many cultural requirements such as lobola and ceremonial and festive occasions. Commercial off-take from this livestock is minimal and overgrazing on poor quality veld prevails throughout the study area. This in turn is causing significant degradation of landscapes in many areas. In the few areas where a more secure form of land tenure applies, the standard of livestock production and the degree of commercialisation is dramatically improved.

Socio-economic factors

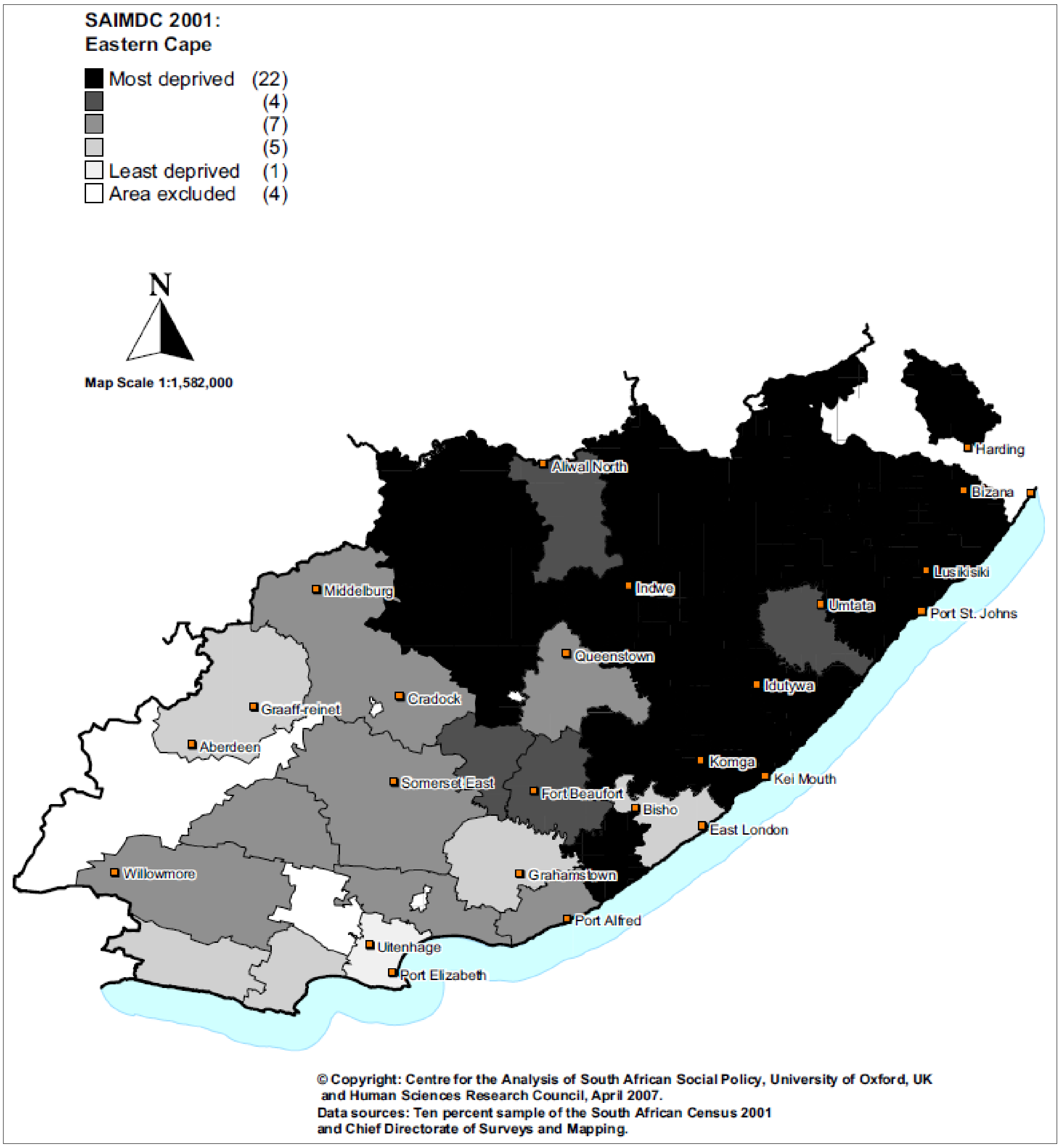
A number of factors affect the way people live in the Mzimvubu Development Zone.

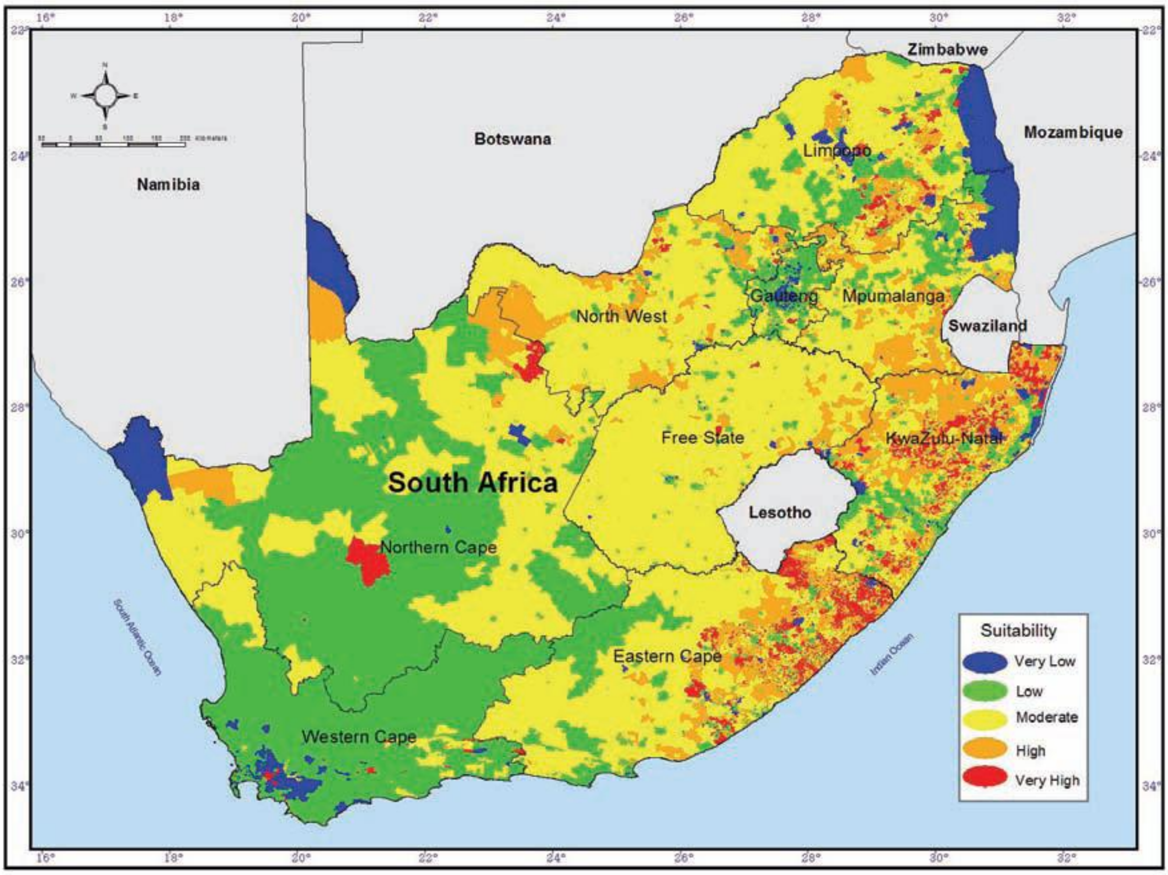
The South African Index of Multiple Deprivation for Children (SAIMDC) (Barnes et al, 2007) measures child poverty in terms of the following:

- Income and Material Deprivation
- Employment Deprivation
- Education Deprivation
- Living environment Deprivation
- Adequate care Deprivation

Multiple deprivation of children in the Mzimvubu Development Zone is among the worst in the Eastern Cape province, which in turn is one of the worst affected areas in the country (from Barnes et al, 2008).

> **Extract: Mzimvubu (Blignaut, 2010 in press)**
>
> The majority of the Mzimvubu population depend on direct abstraction from rivers for their daily water needs. This becomes particularly critical during low flow periods in winter.





These factors are interpreted broadly for various situations in Sector 1 and Sector 2 areas, focusing on the energy-water-food nexus for development.

In Sector 1 (commercial farms and rural towns) typical livelihoods most directly dependent on water for production of crops and livestock are farming families, farm worker families and food gardeners.

a) Sector 1: Household water use

Rainwater harvesting for domestic use is not attractive where a strong, quality source of groundwater and a reliable energy source are available, but it becomes more attractive where its implementation can obviate the need to develop costly water distribution networks and where a low maintenance requirement is important (e.g. due to remoteness). For townspeople (poor and non-poor) the main attraction of rooftop rainwater harvesting is:

- as a reliable backup during disruptions in municipal supply;
- its reliable quality where roofs are suitable; and
- where the reduction in the household's municipal water bills exceeds the cost of implementing the rainwater harvesting system.

b) Sector 1: Agriculture

On commercial farms, rainwater has been harvested for generations through ploughing and other cultivation practices, and water runoff control is exercised through systems of contours and grassed water runoff strips along the natural drainage channels. Yet, there is scope for the use of a greater range of rainwater harvesting techniques for increased rainwater infiltration to improve grazing and crop production levels (e.g. Mati, 2007 and 2008a; FAO 1991 and 2009), but these have not been actively promoted, nor specifically adapted for local circumstances and production techniques (e.g. for beef rearing on veld, pastures and fodder crop production, rainfed crop production, and irrigated fruit and vegetable production).

Lack of awareness of the possibilities and potential benefits, as well as the labour requirement for construction can act as disincentives to greater uptake, as has been the case elsewhere. There is currently no service available to farmers to plan their farm layout and operations to maximise rainwater utilisation, assess the cost and benefits, and utilise PES and other climate mitigation mechanisms to help finance implementation of such measures.

c) Sector 1 and 2: Home food gardening

Home food gardening is a widespread and long-standing practice in Sector 1, by farming households, farm worker families and townspeople; and by rural and even some urban households in Sector 2. It is possible to reduce irrigation requirement by using rainwater techniques to concentrate surface runoff (stormwater) into gardening beds while protecting them from getting flooded out and/or eroded. A large percentage of households across Sector 1 and 2 are not practicing any vegetable gardening, while malnutrition remains rife among poor households in both sectors, especially among preschoolers, causing permanent damage to the child's lifelong capacity for learning and income potential.

d) Sector 2: General

Across Sector 2 (former Transkei areas), there are distinct differences between areas which affect people's priorities.

In remote villages, many of which are underserviced and hard-to-service, there is a low level of economic activity and a low capacity to pay for services, thus the revenue base for operation and maintenance is very low. At the same time, many households are in need of additional water to cope with caring for the sick (HIV/AIDS), especially for daily washing of bed linen, towels, etc. The outsider's perspective is that access to water should not be a problem, as this is a high rainfall area crisscrossed with rivers and tributaries. The reality is, however, that many households walk long distances down steep valleys to fetch water (e.g. slopes of 25% are not uncommon). This places a significant demand on their time and energy, which, together with the additional demands of caring for the sick and a proliferation of funerals, eats into the time available for food production activities. Pensions and grants are the main source of income. This brings relief by reducing the pressure to grow food, but further inhibits the economic growth potential of the area as a whole: money entering the area leaves it again almost immediately through the purchase of food produced and processed elsewhere. This applies to staple maize meal, but even to vegetables: 80% of the vegetables consumed in the Mzimvubu Development Zone are imported from elsewhere. This leaves little opportunity for money to circulate or change hands among members of the community, which is the essence of and basic mechanism for local economic growth (Douthwaite, 2004).

In areas like Qumbu, especially those portions close along the N2 highway, where many households face similar challenges in living with HIV/AIDS, their reliance on and interest in agriculture is less evident than in more remote areas. As always there are exceptions, but as a whole these areas are more representative of an almost purely cash-based economy, where young people aspire to office jobs and similar opportunities to earn cash income. In some instances, labour availability have been found low due to a reluctance to engage in hard physical labour (Makhetha, 2007), but some people may be found willing to do so for a defined period of time to earn some cash.

Even in places like Qumbu and other places with good accessibility, households experience problems with the reliability of water supply. Household supplies are also not sufficient to cater for home food production. People's reliance turn back to natural streams, meaning that they too have to contend with steep slopes and long walking distances. Water vendors cart water to households at R10 per 20 liter of 'clean' (i.e. clear, not treated) water; or R20 per 200 liter 'dirty' (i.e. murky) water (study field visit, September 2008).

11.2 ECONOMICS OF RAINWATER HARVESTING

<u>What influences viability?</u>

Rainwater harvesting is most attractive where:

- rainfall is high and reliable, resulting in high rainwater harvesting yield; and
- where water use demand is high, resulting in high use efficiency of rainwater infrastructure.

Further, the rainwater option becomes increasingly competitive:

- the more expensive the alternative water supply options, and
- the lower the cost of rainwater harvesting technology used.

Looking at the potential for rooftop rainwater harvesting in the Mzimvubu River catchment, rainwater harvesting yield is very good compared to other parts of South Africa, and water use demand is high, especially if water for productive uses can be made available on a reliable basis. In terms of the cost of rainwater technology, there has been gradual improvement. However, the water tariffs in the Mzimvubu River catchment have been some of the lowest. The following example shows the major influence of water tariff on the economic viability of rainwater harvesting in the Mzimvubu River catchment.

An analysis was done for a 200 m^2 house in Lusikisiki (Qaukeni Local Municipality, T60F quaternary), with a monthly water demand of 30 kℓ and a 5 kℓ rainwater tank installed at R3 500. The average annual rainfall is 1 057 mm and the household can harvest 126.8 kℓ/a (i.e. 176% of Free Basic Water) with this configuration.

Unit cost (R)	Water tariff (R/kℓ)	Unit reference value (URV), 20 years (%)	Payback period (years)	Net present value (NPV) of cost savings (R)
R3 500	2.49	3.23	11.0	-919
R3 500	5.00	3.23	5.1	2 206
R3 500	10.00	3.23	2.4	8 431

With no subsidy, the net present value of cost savings is negative at the present tariff of R2.49 per kiloliter. This is one of the lowest tariffs countrywide, and is unlikely to escape current upward pressures on tariffs. Should the tariff increase to R5/kℓ, the payback period reduces to 5.1 years and the NPV on cost savings is positive. At R10/kℓ the payback period would be less than 2½ years and the NPV jumps to R8 431. NPV turns positive at a tariff of approximately R3.20/kℓ.

Below, the effect of reduced installation cost on URV, payback period and NPV is demonstrated.

Unit cost (R)	Water tariff (R/kℓ)	Unit reference value (URV), 20 years (%)	Payback period (years)	Net present value (NPV) of cost savings (R)
R3 500	5.00	3.23	5.1	2 206
R3 000	5.00	2.77	4.2	2 780

11.3 POLITICAL FACTORS AFFECTING RAINWATER HARVESTING

What political support is needed, and is it present?

Often, politicians enter politics because they care for people. In South Africa one of the most pressing challenges facing politicians is to make it possible for people to have a decent living, which includes maximizing opportunities for decent employment. However, they also have a duty to ease the burden on those that remain unemployed despite the best efforts within a politician's term of office.

'Confront the brutal facts, yet never lose faith' is a duality that has lead to greatness among Fortune 500 companies, according to Collins' authoritative work on the subject (Collins, 2001). The same applies to politicians who aspire to the type of leadership which can carry their achievements to being 'great', rather than merely 'good'.

It is a brutal fact that unemployment will not be solved in the short term, therefore it is of paramount importance to enable unemployed people to maximise their economic activity within their current circumstances, i.e. mostly at home.

Initiatives to support home-based productivity must therefore never be viewed as a way of 'keeping people poor', but rather as a very important stepping stone to a better future, to help free the Mzimvubu area from ranking among the worst in terms of multiple child deprivation and unemployment.

Its abundant but 'un-accessed' water resources must be harnessed – especially at the household level – to help the Mzimvubu River catchment break out of the vicious intergenerational cycle of child deprivation → adult poverty → child deprivation → and so on and on.

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