

# **INDIGENOUS WATER HARVESTING AND CONSERVATION PRACTICES: HISTORICAL CONTEXT, CASES AND IMPLICATIONS**

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## **BACK COVER - Video on Rainwater Harvesting**

# Acronyms

ARC	Agricultural Research Council
DWAF	Department of Water Affairs and Forestry
IMWI	International Water Management Institute
NGO	Non-Governmental Organisation
RWH	Rainwater harvesting
WH&C	Water harvesting and conservation
WRC	Water Research Commission

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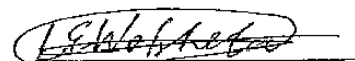
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Jonathan Denison



Luvuyo Wotshela

# Abstract

Indigenous rainwater harvesting and conservation practices are the product of accumulated knowledge, practices and traditions which have evolved over many generations of experimentation and adaptation. These practices thus have inherent sustainability and present a sound platform on which to develop new practices aimed at maximising the benefits of 'runoff farming', as rainwater harvesting might best be summarised. The scoping study concluded that while there is substantial anecdotal evidence of agricultural water-use in South Africa since the stone-age, indigenous rainwater harvesting and conservation technologies have not evolved to the same extent as in the more arid areas of North Africa. This is explained by historical settlement in the wetter eastern half of South Africa and a cattle-based culture. The scoping study did identify 13 practices across the breadth of South Africa and reported in detail on ten of these: one distinctly indigenous (Gelesha practice), five indigenised (in that they are the product of local and external influences) and four more which are essentially contemporary-scientific methods. The techniques that were documented in detail covered scales varying from tens of thousands of hectares (saaidamme) to micro-catchments of a few square metres in size. The classification of rainwater harvesting methods in South Africa has not been consistent and a categorisation, based on international convention and South African parameters, is presented. The practices documented in this study have demonstrated the value of rainwater harvesting and conservation across the socio-economic and cultural spectrum of South Africa, inclusive of resource-poor farmers and fully-fledged commercial farmers. They also present an opportunistic platform on which to inform the technical aspects of new interventions and can place them in a valuable historical light.





# 1 INTRODUCTION

## 1.1 Research Objectives

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The general objective of the assignment was to document indigenous water harvesting and conservation practices in South Africa through literature review and primary fieldwork. Documentation was to be in the form of a written report and a 20 minute video of illustrative cases.

More specifically, the objectives as set out in the terms of reference and the proposal were:

- To undertake a detailed literature review of indigenous rain water harvesting and moisture conservation practices in South Africa over the past 300 or more years.
- To identify indigenous water harvesting and moisture conservation techniques that are still being practised in South Africa today and record a range of these by documentation of oral history, video and photography.
- To recommend technical interventions to indigenous methods based on current research initiatives, current best practice so as to improve the usefulness and efficiency of indigenous rainwater harvesting and moisture conservation practices.
- To document, using participatory video, the indigenous practices and the recommended improvements for use by scientists, researchers, community development agencies and government to support new and existing initiatives targeting RWH, poverty and food production.

## 1.2 This Report

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This report is the final deliverable on the assignment.

Section 1 presents a set of working definitions and outlines the methodology and approach.

Section 2 sets out the historiography of African WH&C from available literature. It also explores categorisation of WH&C practices, both South African and international and proposes a categorisation system for application in South Africa.

Section 3 presents six cases considered as indigenous or indigenised documented from primary fieldwork and supplemented by available literature.

Section 4 presents four contemporary WH&C practices that are being used in South Africa and comments on how the indigenous practices might complement existing implementation approaches.

Section 5 comments on the prevalence (or lack of) indigenous techniques in South Africa, and outlines potential for cross-learning between indigenous / indigenised practices. Opportunities for current implementation initiatives and for future research are noted.

## 1.3 Working Definitions

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The research topic requires clarity on two terms that set the parameters of the research work and the likely cases for documentation, i.e. 'Indigenous' and 'rainwater harvesting and conservation'. The definitions provided a rationale for inclusion into the study of practices that were encountered in literature and the field.

### 1.3.1 Indigenous Knowledge

Indigenous knowledge is characterised by the concept of local knowledge that is unique to a given culture or society and is the basis for decision-making in numerous social realms including agriculture, health care, food preparation, education, natural-resource management, and a host of other activities in rural communities (Warren, 1991). Not is this only a basis for decision-making but indigenous knowledge is a key element of the social capital of the poor, and constitutes their main asset in their effort to gain control of their own lives (Gorjestani, 2001).

One of the strengths of indigenous knowledge, as pointed to by Oweiss et al. (2004), is the cumulative body of knowledge, practices and traditions that is built up over extended generations. Indigenous information systems are dynamic and are continually influenced by internal creativity and experimentation as well as by contact with external systems (Flavier et al., 1997). As a result, where rainwater harvesting practices in this case, have been built on indigenous knowledge, these have the inherent characteristic of

sustainability, evidenced by the practices' continued existence and the continual improvement and adaptation over time.

It is widely argued that indigenous knowledge is a rich platform on which to develop new practices and can be particularly effective in helping development practitioners in reaching the poor. This view is supported by the World Bank (2008) who argue that indigenous knowledge is not yet fully utilized in the development process. "Conventional approaches imply that development processes always require technology transfers from locations that are perceived as more advanced. This has led often to overlooking the potential in local experiences and practices". Oweiss (ibid) motivates that there is a strong economic case for building on indigenous knowledge as it will have evolved with increasing efficiency and sustainability over time. Gorjestani (2001) points to improved outcomes of development initiatives where these incorporate or build on indigenous knowledge, which provides both contextual relevance and technical content.

The dynamic and evolutionary nature of indigenous knowledge is important in this study because it suggests a more inclusive definition and therefore what will be valid for documentation, and what should be excluded due to its recent or non-indigenous nature.

While the latter may be more easy to identify (e.g. a recognised recent and foreign approach), it is not so easy to be exact about what is indigenous. This is because, during 1500 years of African migration, Arab conquest, European colonisation and more recently, 20<sup>th</sup> century scientific farming practices, there has been an ongoing process of knowledge diffusion and adaptation of 'indigenous' and historical practices resulting from ex-Southern African influences. Flavier et al. (1997) argues that adaptations resulting from these outside influences are an essential part of the evolution of indigenous knowledge. Yet it would seem logical and unavoidable that there is a point where the essential content of the knowledge shifts from being identified as primarily indigenous in nature, to primarily contemporary in nature as a result of these outside influences.

Indigenous practices then, when viewed in the light of Flavier's argument of ongoing acquisition of new influences and local adaptation, can be seen as a continuum. The continuum starts with practices evolved from early local civilisations and ends with externally or scientifically originated practices, which are modified in the light of existing indigenous knowledge, to become current indigenous knowledge, or perhaps indigenised knowledge. The epistemological minefield that ensues from appreciation of this continuum of indigenous knowledge-origins, makes categorical classification of techniques as indigenous or non-indigenous within the spectrum, somewhat oblique and arguably of little use.

The general discussion on indigenous knowledge above provides a strong motivation to recognise the value of indigenous knowledge in relation to rainwater harvesting and conservation and maximise application of indigenous knowledge to new development initiatives. The research team has not found it necessary or useful to ascribe a hard-lined definition of 'indigenous' or 'non-indigenous' to practices described in this report, by aligning these to simplistic notions of original and new, or personified in the particular South African settlement history of 'Africans' vs. 'settlers'. The potential challenge of

defining boundaries was eased by the literature review and the studied cases which showed few documented historical South African practices that can be considered as indigenous from pre-settler times. Thus the pragmatic reality of modernisation and external knowledge acquisition over the last millennium and particularly the settler-dominated 19<sup>th</sup> and 20<sup>th</sup> century were absorbed into the concept of indigenous, and aligned to some extent with the ever-modernising notions of indigenous knowledge acquisition put forward by Flavier (ibid), summarised into the term indigenised knowledge. The literature survey in Section 2 and the discussion of cases in Section 3 are presented in the context of this discourse on an appropriate understanding of indigenous knowledge, emphasising a pragmatic inclusiveness rather than a clean-cut categorisation.

### 1.3.2 Rainwater Harvesting

There is little difference in published definitions of rainwater harvesting and its function and purpose in relation to domestic and agricultural use. Numerous authors, both South African and international present definitions which set out a range of collection surfaces and uses, both agricultural and domestic (Auerbach, 2003; FAO, 2003; Hai, 1998; Hensley et al., 2000; Houston et al., 2001; Lancaster, 2008; Oweis et al., 1999; Texas, 2005).

The selected definitions below illustrate:

*“Rainwater harvesting is the process of capturing rain and making the most of it as close as possible to where it falls. Examples include enhancing local food security, passively cooling cities in summer, reducing costs of living and energy consumption, controlling erosion, averting flooding, reviving dead waterways, minimizing water pollution, building community, creating celebration and more.”* (Lancaster, 2008)

*“Rainwater harvesting, in its essence, is the collection, conveyance, and storage of rainwater. The scope, method, technologies, system complexity, purpose, and end uses vary from rain barrels for garden irrigation in urban areas, to large-scale collection of rainwater for all domestic uses”* (Texas, 2005)

The International Water Management Institution defines rainwater harvesting as *“ the collection and/or concentration of runoff water for productive purposes. It includes all methods of concentrating, diverting, collecting, storing, utilizing and managing runoff for productive uses. Water can be collected from natural drainage lines, ground surfaces, roofs for domestic uses, stock and crop watering”* (IWMI, 2003)

*“Rainwater harvesting refers to the concentration and entrapment of rainwater runoff from a catchment. A catchment is any discrete area draining into a common system and thus can be a roof, a threshing floor or a mountain watershed. Similarly, the means of rainwater storage can range from a bucket to a large dam.”* (Houston and Still, 2001).

*“Water harvesting can be defined as the process of concentrating rainfall as runoff from a larger catchment area to be used in a smaller target area. This process may occur naturally or artificially. The collected runoff water is either directly applied to an adjacent agricultural field (i.e. stored in the soil-rootzone) or stored in some type of on-farm storage facility for domestic use and as supplemental irrigation of crops.”* (Oweis et al., 1999)

The reviewed definitions of rainwater harvesting are inclusive in that they combine both agricultural and domestic uses, which reflects reality of use more accurately. Practice in the rural development context in South Africa shows that rainwater harvesting is an essential water source not only for agriculture but also for domestic and small-commercial uses. In South Africa (and elsewhere) people use harvested water for multiple uses – domestic and supplementary irrigation (Houston and Still, 2001; IMWI, 2005) and indigenous systems would be expected to have the same characteristics.

The definition provided by Oweis (1999) best reflects the consensus, provides additional detail of scale and seems most appropriate to the thrust of this study.

However, the reviewed definitions do not separate rainwater harvesting from two other agricultural techniques that have similar soil-water implications, namely supplementary-irrigation and soil-conservation. This spectrum is arguably bounded by the distinct disciplines of irrigation on one side and soil-conservation on the other. No definitions that were reviewed explicitly separated water-harvesting from irrigation or from soil conservation, and some (e.g. Lancaster, 2008) specifically include both irrigation and soil-conservation within the definition. However, rainwater harvesting does have a distinctive character that is separate from irrigation and soil-conservation, although there is significant overlap in how these practices are effected in reality.

The Oweis definition, proposed for use in this scoping study does also not exclude a wider spectrum of practices than rainwater harvesting per-se. An irrigation dam for example is an ' on-farm storage facility ... for supplemental irrigation of crops' and soil-conservation contour ridges facilitate a direct increase in water ' ... stored in the soil-rootzone.' Somewhere within this spectrum of irrigation and soil-conservation is the grouping of techniques that classify as rainwater harvesting and in their indigenous form are the subject of this scoping study.

To allow appropriate delimitation in this scoping study, the Oweis definition is accepted, with an addendum which sets out the primary objective as follows:

The primary objective of the rainwater-harvesting systems is to facilitate 'runoff farming' (Van Rensburg, 2008) and that these works are (for the purpose of this study) not primarily for soil-conservation or primarily for domestic use, although these important secondary benefits are recognised as an integral part of the water-harvesting system as a whole.

### **1.3.3 Water Conservation in the Context of Rainwater Harvesting**

The term 'conservation' is used in different ways and requires definition in the context of this study. Woyessa et al. (2006) provide a useful description that has application:

*"A reduction in runoff will result from practices that successfully increase the infiltration capacity of the soil, increase the contact time, and/or reduce surface sealing. It is commonly accepted that covering the soil with a mulch, for example, with a crop residue, will achieve these goals (Unger, 1990) and will also reduce evaporation from the soil surface."* Woyessa et al. (2006).

Thus conservation as applied to this study means 'water conservation' of water within the soil profile. Practices of interest may include covering the soil with dry organic material (mulch), stone cover or cover crops as well as any other practice that reduces evaporation during the fallow period, or reduces crop evapo-transpiration or deep percolation (water passage below the plant root zone).

The efficient use of water, through irrigation management approaches or irrigation technology is specifically excluded as this is outside of the bounds of water-harvesting as discussed earlier. Similarly, the inclusive range of natural resource conservation measures linked to soil, grazing, water, forests and bio-diversity in general are excluded from the scoping study. The understanding which has informed this work follows from the title of the research, 'Water Harvesting and Conservation Practices', which implies 'water-related' conservation and not resource conservation in general. Resource conservation, while fundamentally important to rural development objectives broadly, are considered to fall outside of the ambit of this scoping study aimed at indigenous water harvesting and conservation.

## **1.4 Research Methodology**

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### **1.4.1 Case Identification and Scoping**

The process of searching for possible WH&C sites with an indigenous or indigenised element to them was undertaken in two ways. First a detailed literature survey was carried out on the Fort Hare academic search engine.

Secondly extensive phone interviews were carried out with all WH&C organisations and researchers that are known to be involved in the field of rainwater harvesting. Contact lists were collected from workshop attendance registers connected to:

- existing and past WRC projects related to WH&C
- forums coordinated on WH&C and NGOs working in the field of study.

E-mails were sent to all possible e-mail contacts and phone calls were made subsequently as a followup. Secondary leads and contact persons that emerged from these discussions were also followed up.

The document and publications search yielded numerous general references to indigenous practices but few with specific locations or technical details on the practices themselves. Almost all documented cases with any detail on method and location related to contemporary WH&C practices and not older indigenous practices.

The phone discussions and subsequent discussions with all possible leads yielded 12 potential cases, although the extent of the 'indigenous' character of these sites was not known. After further research and in some instances, initial field visits, six cases were documented and presented as 'indigenous or indigenised' and four cases are presented in the section on contemporary cases.

It is a fact that additional rainwater harvesting and conservation practices to those documented in this report do exist, as related by reliable sources, but for which detailed information could not be obtained as the sites of practice could not be located. These were;

- grass-strips which had been seen by a fieldworker in the western part of KwaZulu-Natal, but details of the location (or the fieldworker) could not be traced (pers comms, Kruger, 2007), and
- rock-packs around individual maize plants which were photographed somewhere in Eastern Mpumalanga or Limpopo (pers comms, Laker, 2007) by a student in the early 1990s, but neither the student nor any literature relating to these semi-circular rock-bunds could be traced.
- A method observed in Limpopo of packing rocks into large cracks and crevices in granite and basalt domes, packed with soil and planted with maize and other crops. The cracks and crevices are the natural flow path of water running off the domes and this water is concentrated into the soil at the rock-pack (pers comms, Van Averbek, 2007). The site was observed some years back, but despite a number of efforts to relocate it during the course of the study, it could not be found.

#### **1.4.2 Field Visits and Data Collection**

The field visits were conducted in two phases. First a master's student made a field visit to verify the location, the technology and to conduct initial interviews. This preparatory visit was also used to identify key informants and set up dates for the video team and the senior researchers. In the second visit, oral history narratives of the technology were recorded on video using semi-structured interviews. These recordings formed the basis for the documentation of the technique.

The review of water-harvesting systems from the Middle-East and North Africa, when compared with the cases identified in South Africa, showed that almost all of the systems in South Africa, except perhaps Gelesha, are replications of these ancient systems. It is not known whether the replication was informed by these older systems, or was developed independently of them, but where close similarity (or in many cases identical approaches) exists, these have been noted in the text for interest.

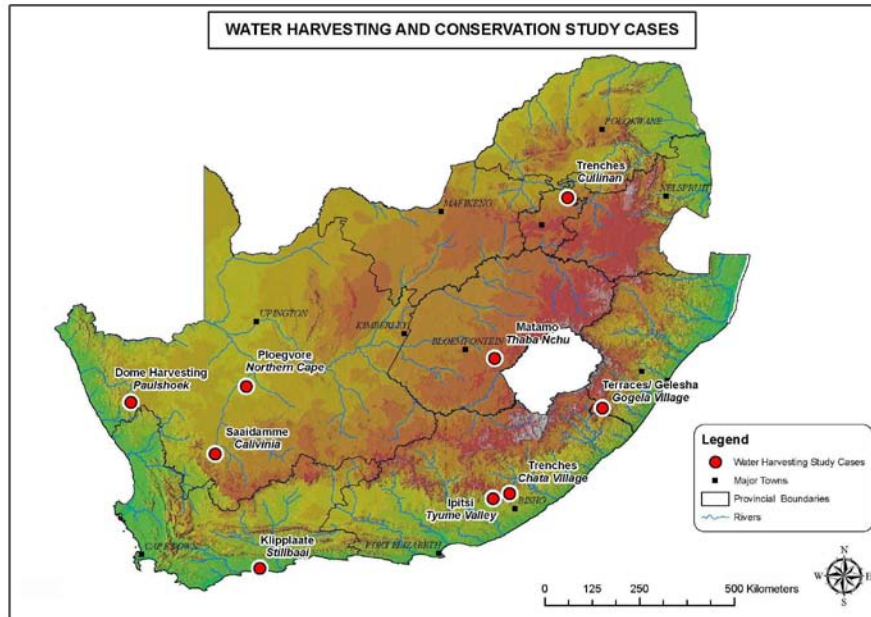


Figure 1.1: Location of Water Harvesting and Conservation Sites in the Study

### 1.4.3 Inclusion of Indigenous and Indigenised approaches

The definition of indigenous was extended to the more inclusive ‘indigenous and indigenised’ WH&C following the findings of the literature survey and the networking exercise which showed that the number of possible research sites were relatively few. It was decided to follow up all of the cases identified. Six of the cases have a history of about 100 years or more and appear to be a mix of African, Arab and European settler techniques. The one exception, and perhaps the only truly indigenous case identified is the practice of Gelesha, discussed in the first case description.

The remaining four cases documented in this report are essentially contemporary techniques and arose from interventions in the last few decades.

This division between indigenous-indigenised and contemporary has ended up being linked more to the historical timeline than the anthropological root of the innovation. Nonetheless, it provides a basis for grouping into what are essentially ‘older historical’ practices and ‘newer contemporary’ technologies in South Africa.



## 2 LITERATURE REVIEW OF INDIGENOUS WH&C

### 2.1 African Practice and Indigenous Systems

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Literature on indigenous rainwater harvesting locates the historical prevalence of this technique in parts of Asia and Africa. It also reveals the transference of knowledge about this technique as well as mobility of its practice as various groups gravitated to various terrains and geographical areas (Oweis et al., 2004, 3-25). In this report we provide an overview of literature and African historiography regarding farming and settlement. We focus on rainwater harvesting and water management generally, as well as adaptations to natural environment.

We have few cases of literature and geographical area references, from the early civilization period to the late Iron Age (500 BC-1400 A.D) where emphasis on newer adaptations to ecological cycles and innovations in Southern Africa were evidenced.

While early civilisation is mentioned to provide historical context, the literature survey is focussed on Southern African literature covering three broad historical phases during which use and adaptation to natural environment has been well documented. Here we have noted literature relating to various communities' strategies to water resource, utilization accessing and management. We occasionally refer to literature that details mobility of settlements, their adaptations to various terrains as well as variable climate and more specifically their use and manipulation of terrain with varied rainfall.

The literature cuts across these three broad historical phases:

- firstly, the period of contact with and conquest by European groups, from late 17th century to the second half of the 19th century. This was accompanied by aggressive seizure and enclosure of land, by infiltrations of various denominational church mission(s) stations as well as intensification of agricultural economy.
- Secondly, there is also another set of literature that emphasizes responses and adaptations of African and Settler communities to environmental challenges at the turn of 19th and the early decades of the 20th century.
- Thirdly, there is rapidly emerging literature on the legacy of betterment planning, particularly the contemporary uses of zinc and plastic gutters and storage tanks within centralized villages. This literature focuses on new innovations and on how individual communities have adapted to changing natural resources in the face of aggressive developmental regimes.

## **2.2 Early History (500 to 1400 AD)**

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### **2.2.1 Africa North of the Equator**

General literature and African historiography emphasizes that rainwater harvesting practice arose out of ancient civilizations, which proliferated around the Mediterranean World, North Africa and had over the years cross-pollinated with skills and techniques from parts of the Middle and the Near East as well as Asia (Falkenmark et al., 2001, Oweis et al., 2001). The arch of dry-land Northern African countries - in Egypt, Morocco, in Tunisia, in Sudan and in Ethiopia is documented to have had a longer history of water harvesting and irrigation practice in the African continent. Water harvesting in parts of Egypt and Morocco has been noted to precede even the Roman empire of 500 B.C.

In discussion of rainwater harvesting and irrigation in the history of Africa, this practice is almost inseparable from the discourse on the origins of various types of farming, especially crop cultivation and stock farming. Crop cultivation that proliferated and spread along the Mediterranean fringes of North Africa consisted of largely wheat cereals and barely which were imported originally from Egypt and Western Asia. In and around these areas, rainwater harvesting during various seasons was already evident and was one of the few practices of the ancient civilization. At times cereal crops were irrigated with stored water. Writing on this particular subject reveals the evolution of plants' domestication as well as innovations on their growth and upkeep (Oweis et al., 2001).

Significantly, literature on domestication and cultivation of African crops is associated with tropical Africa, particularly the Savanna grasslands, which stretches along the southern margins of what is presently known as the Sahara desert. Discussed as stone-age farming (between 3000-1000 B.C) because of recent archaeological findings that reveal African agriculture practice by stone-using people, this area offers one of the earliest documented evidence of use of portable stone-bowls for rainwater collection and food storage. Literature on increased dependence on crop farming in this region is associated with the gradual drying up of the Sahara. As fishing alone was no longer adequate to meet food demands of large settled communities, they gathered grains of wild cereals and grasses. They exploited these intensively and domesticated a number of important tropical African cereals. Growth and processing of these for consumption actually prompted water harvesting and as a result collection of rainwater became quite significant (Shillington 2005, 30-31).

### **2.2.2 Africa South of the Equator**

Historical literature offers another dimension regarding utilization of natural resources and rainfall variables south of the equator. It emphasizes that people in this area remained primarily hunter-gatherers until the introduction of iron about two thousand years ago. Iron stage itself is defined as a long historical process of 12 or even more centuries (i.e. the First to the 15th Century AD in other parts of Southern Africa). Its early origins are associated with central Africa but there was gradual spread of Iron Age elements and activities southwardly with Bantu-speaking people who in the early centuries had settled

on parts of Southern Africa (Curtin et al., 1987, 5-30; Martin and Omeara, 1992, 9-45; Shillington, 52-54, 138-140).

Critically, from its earliest stages, Iron Age gave birth to and consolidated the farming economy. Farming became mixed, emphasizing variety of crops (sorghum, millets, pumpkin, melon and beans) as well as livestock keeping, particularly cattle, sheep or goats. During the first few centuries of their expansions, Bantu Iron Age farmers moved onto regions only thinly populated by small roving bands of Stone Age hunter gatherers in the present South Africa.

In the process of doing so, they were able to select the most suitable sites for their farming settlements – and thus looked and settled in smaller communal units at areas where soil was most fertile as well as where grazing and rainfall were just right for their crops. This probably explains their relatively rapid spread across the south-eastern areas, where stable settlements had developed by the fourth century A.D. New generations could move onto new areas and there was not much need to clear thick forest or adopt new techniques to suit other more difficult environments (Shillington, 138-141).

Even so, literature also highlights how this evolving settlement pattern, particularly in areas of Natal, offered new innovations on animal keeping, food storage, rainwater collection and containment. Small round houses were usually arranged in a circular pattern enclosing a fenced livestock pen where cattle or goats were confined at night. Each village also contained members of storage bins for grain. Occasionally, clay lined pits below hut roof edges collected and contained rainfall water for domestic use.

Literature also mentions rainwater harvesting or even water collection and utilization during this Iron Age in the most eccentric circumstances. It emphasizes the significance to locate sources of iron-ore together with sufficient hardwood to fire smelting furnaces during this age. It also highlights the featuring of rainwater harvesting and/or diversion and use of water in this process. Water was harvested or diverted in the construction of clay furnaces with draught pipes attached for rapid ventilation purposes. Water was also reticulated during smelting process and used when hammering iron, during forging.

Significantly, pre-colonial Southern African literature notes again the increased utilization of natural resources as the rapid dispersal of Iron Age farmers to new areas slowed down by the seventh century. Even so, a most-westerly South African Early Iron Age settlement, just west of the Kei had developed by this period. This area was the westernmost limit of summer seasonal rainfall and not suitable for growing tropical cereal crops. This group of farmers began the fuller use of climate, by developing new types of crops and adapted new techniques of diverting rainfall water to valley land crops. Innovations and adaptations were adopted even on the areas they had earlier occupied. In the Natal region of the south east, for instance, settlements were confined to coastal lowlands and valley bottoms where rainfall water flows could be conserved for longer use. Gradually more use was also made of sour summer grazing veld of the Drakensberg foothills which also relied heavily on summer rainfalls.

A watershed period in the shift to later Iron Age period especially in economic, social and political development has been noted by Shillington. He and other group of African

historical writers note the increasing use of natural environment especially the drier grasslands. Southeast of the Drakensberg, which had more varied environment and adequate rainfall attracted Iron Age families who accessed wide range of hills and valley grazing, woodland and land for grazing. Like the Khoisan speaking hunter-gatherers who occupied the south west, this group managed an ecological cycle, whereby they allowed rainfall to soak a particular valley grazing grass and cultivation land for a while before they reverted to its use (Elphick and Giliomee, 1979, 8-10). While this is not rainfall harvesting (collection and/or concentration) it is early evidence of management.

Insights of natural resource utilization and its management between these groups cross fertilized as late Iron Age Bantu-speaking chiefdoms gradually absorbed the Khoisan speaking hunter-gathers and specialists pastoralists. By the mid-fifteenth century, these small sized family groups had become self-sufficient in their own ways in adapting to and use of their natural resource for multiple livelihoods. By this time their segments also came into contact with white European groups, some of whom had become traders, voyagers or even travellers following their shipwrecks or landfalls on the southern coastline. This particular contact has patterned the literature on South African Africans' use of and adaptation to their natural resources and environment into three general and broad historical phases mentioned below.

### **2.3 Contact with and conquest by Europeans, from late 17th to late 19th Century**

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The historiography and literature of the period from when early European contacts with Southern African shores happened to when colonial rule reached its zenith at the turn of the 19th century, especially in South Africa, has been constructed from various sources. Importantly these sources are predominantly primary in nature. They revolve around experiences and recordings of local people, European travellers some of whom at various stages became traders or even missionaries from particular denominational church affiliations. Later they also revolved on experiences, memories and recordings of colonial officials.

Writing on this period therefore relied on chain of knowledge linking the transforming settlement, livelihood pattern of indigenous systems under European groups they contacted, particularly under colonial transformation. European groups, especially the Portuguese' contacts with coastal areas of African is long, varied and it precedes the colonial era. South Africa's contact with Europeans and its colonial history with the Dutch and the British in the Southern region of the continent is probably one of the longest. This effectively meant that much of the farming methods, utilization of and adaptation to natural environment, which the Iron Age Bantu speaking groups as well as Khoisan hunters and gatherers relied on for a long period became subjects of outside scrutiny and writing, albeit at times in an uncomplimentary fashion.

The most influential set of literature, which focused on the transition of pre-colonial Iron Age African agricultural economy of mixed pastoralism and agriculture under colonial

era was provided by the peasantry historiography authors Beinart and Bundy (Beinart & Bundy 1987; Bundy 1988).

Coming out against the backdrop of earlier texts that decried the 'primitive' nature of African agriculture, this peasantry historiography went all out to prove the capability of Iron Age Africans in coping with and adapting to their natural environment. It demonstrated the robust innovative techniques some African groups had embarked on in transforming their agriculture under the face of colonial pressure, especially during the early decades of the 19th century.

Multiple cases of use of plough for cultivation, furrow irrigation and diversion of rainwater from down-slope streams to cultivated lands were noted in a number of Ciskei settlements, around Peddie, Tyume and Keiskamma rivers and Fort Cox. Such farming methods also spread to other mission stations and other mission settlements, Clarkebury and Buntingville in the Transkeian area. Most of these incidents were already evident during the first half of the 19th century (Bundy, 23-118).

It should be noted that the Eastern Cape featured intensively in this peasantry literature not only because of the alacrity of colonial government and missionary operations in this region at that time, but also because of the availability of documentation of these activities from a number of sources. There were however other areas of focus where agricultural innovations were equally impressive in the north, particular within the Southern Highveld and in the far-north areas, where the Pedi-speaking (current Limpopo) also interacted with missionaries.

In sum, in both parts of the Eastern Cape and in these northern areas the 1980s peasantry (rural) historiography emphasized the farming techniques, innovations as well as adaptations that colonial transformation coerced local Africans to embark on. Hand in hand with clearance of bush vegetation was ploughing and crop cultivation on valley low-lying land as well as rain and down stream water diversion for irrigation use. These farming innovations became subject of discussion even in the later periods.

## **2.4 Adaptations of African and Settler Communities to Environmental Challenges – re. turn of 19th and early 20th Century**

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Authors such as Beinart, Bundy, Delius and Trapido have also focussed on key subjects of state conservation policies, rural planning and mechanization of agriculture that took place in the early to mid 20<sup>th</sup> Century. The literature they generated offers insight on expanding African farming adaptations, whilst conversely it also illustrated the changing fortunes of the African peasantry class towards the turn of the 19th century.

Bundy's book, 'The Rise and Fall of South African Peasantry' illustrated the grim picture faced by rural peasants in the early decades of the twentieth century as their land accessing options diminished in the wake of reserve legislation, particularly after the implementation of the 1913 Land Act.

As implied throughout this report, water and rainfall strongly influenced patterns of rural settlement. Most settlements since the Iron Age proliferated at the proximity of streams, rivers and springs where pasture and cultivation water could be accessible. By the late nineteenth century progressive farmers and colonial officials perceived dam construction and irrigation as the key towards development for both pastoral and arable farming. As Beinart put it: *"They believed that large-scale water conservation, as it was then called, would be a weapon against drought, enhance pastures, constrain transhumance, expand exports, and ensure that meat markets were fully supplied. In their minds, wise usage of water was closely linked to the conservation of watersheds, of vegetation and afforestation."*<sup>1</sup>

Although western scientific conservation methods (i.e. general resource conservation) concentrated largely on European Settler communities during this period of 19th century, they would soon shift towards African communities and some of these invariably involved water-related innovations. Early twentieth century South African historiography does not specifically focus on techniques of rainwater harvesting, but one gets a coherent picture of progression of this practice throughout primary accounts, which became sources of conservation discourse at the time. Most significant in generation of this knowledge are accounts by some African writers such as D. T. Jabavu, the Drought Commission Report of 1923 and the Commissions on African Areas' social and economic conditions in 1932 and even later in 1955 (Tomlinson). From these accounts the technique of utilization of cement water-wells for storage of either river diverted or underground water is noted. Clearly by this stage knowledge and skills transference within the rural South Africa communities was evident.

Writing on African environments during the early 1990s coincided with a period of rising awareness and mainstreaming of (general resource) conservation discourse in most parts of the continent. During this stage there was a growing realization of a need to investigate African local knowledge within their contexts.

Scepticism on widely asserted, scientific, popularized western literature that emphasizes the negative environmental trends characterizing the recent past and present African practices became evident. This view was demonstrated in images of eroding soils and decaying species, in shrinking forests and vulnerable water resources and it reinforced Africa's past as the pristine that had fallen onto marauding forces, who ironically were referred to be local Africans.

Conversely and simultaneously, William Adams provided a groundbreaking book, *Wasting the Rain* (1993) illustrating how studying the development of indigenous water resources in the African continent was almost inseparable from understanding African environmental history. Adams drew from empirical research and a body of literature on land use, food production and ecology. Whilst he explored the strength and variety of indigenous water development, he concentrated on the potential and role(s) of local knowledge, skills in informing conservation discourse and ventures. However, in South Africa, in particular literature that focused on the 1930s Rehabilitation (Conservation) Schemes that modified to 'Betterment' programme by the 1960s, featured largely in the

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<sup>1</sup>W. Beinart, *Rise of Conservation in South Africa: Settlers, Livestock, and the Environment 1770-1950* (Oxford 2003), p. 158.

state conservation and rural control literature. Ironically, this would be the period that marked an increase rate on modern techniques of rainwater harvesting particularly within the post-betterment village system.

## 2.5 The Legacy of Betterment Planning

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One of the most startling aspects documented in the literature of betterment was the manner in which this policy triggered removal and detached homesteads from natural resources they depended on over a number of years. These disruptions were devastating on both pastoral and crop farming. On most occasions households had to abandon arable lots they had worked on for years and on most times these were located on low-lying valleys where water could be easily diverted on them, as evidenced earlier in a number of mission stations (as discussed earlier). Obviously the emphasis was on concentration of households into bigger larger centralized villages to enable administration and control. Betterment literature is categorical however about subsequent declining agricultural production within these centralized villages (De Wet 1996; Wotshela 2001).

By contrast much of the re-investment of households' wealth and social capital in these new villages concentrated on residential homesteads which mostly had variable sized vegetable gardens, fowl runs, kraals or pigsties. Literature also notes that much investment in these villages concentrated on houses, which took shapes of elaborate structures and more recognizably, had corrugated iron (zinc) and at times asbestos roofs.

As it became increasingly difficult to rely constantly on gradually drying and distant streams or rivers, a number of households invested on zinc and cement tanks and later plastic water tanks. Thus it became quite common and convenient within betterment villages to harvest rainwater from rooftops for domestic and garden use. At times these were even linked to open cement-lined dams (amapitsi), a phenomenon that has continued even to the present times (Wotshela, 2001).

## 2.6 Categorisation of Rainwater Harvesting Practices

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Approaches to categorisation and naming of WH&C were also reviewed from both selected South African and international literature.

### 2.6.1 South African descriptions

In South African literature there is general agreement of the elements that make up a WH&C system. But the subsequent naming of systems (comprising multiple elements) is rather varied. Terms for WH&C systems such as run-on, infiltration trenches, swales, in-field, ex-field, non-field, macro, micro, meso, present a terminological array that appear to have some meaning to the user, but remain with subjective (and varied) meaning for the wider group engaging with these terms. Agreement on the main elements is evidenced by the following and replicated in a wider range of publications:

Gould (1998), who was focussing on water for domestic (rather than agricultural) use categorises RWH systems as follows:

- a) Type of catchment surface (e.g. roof, ground or rock surface)
- b) Type of storage tank (sub-surface, ferrocement, concrete, plastic, earth)
- c) Purpose of the system (domestic, livestock, irrigation).

The Water for Food Movement (2007) uses a similar categorisation but is expanded in the sense it responds more directly to the 'multiple water use' paradigm and is more inclusive in water sources considered and water use that results:

a) Water collection:

- Grey water collection (collecting used water from the house)
- In-situ rainwater collection (catching the rain where it falls and preventing it from flowing away/running off)
- External stormwater run-off collection (from adjacent fields, roads or roofs)

b) Water storage:

- In the soil profile
- In structures, like above and below-ground water tanks
- In groundwater, through recharge of groundwater

c) Water use or application:

- Directly from the soil profile
- Through irrigation, i.e. by applying water to the plants from storage.

Kundhlande et al. (2004) adds an additional element to the description:

d) Nature of the infrastructure used for collection (including trenches, pipes, gutters, etc.)

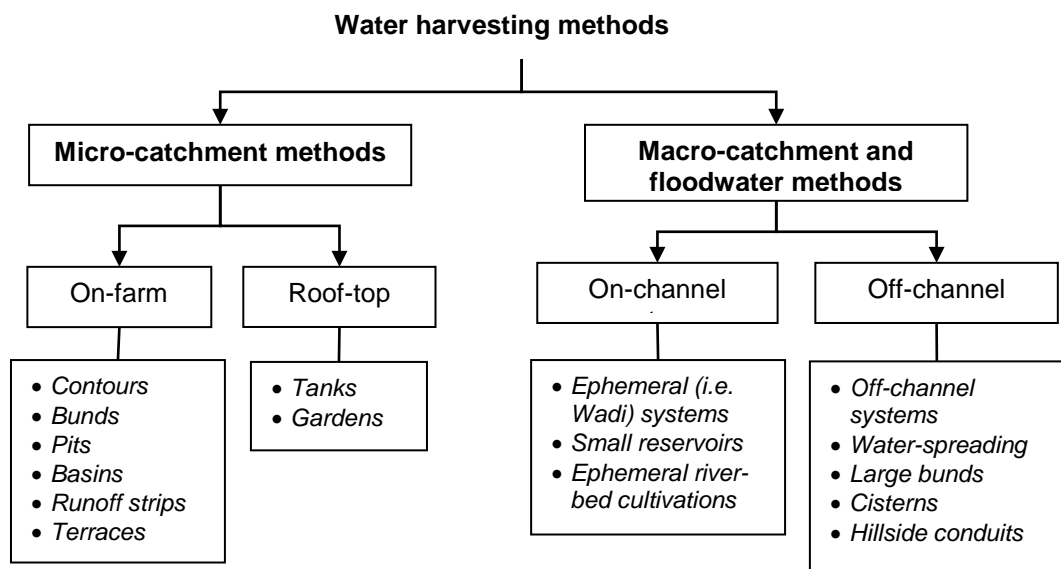
These descriptive elements are useful in that they logically isolate the main elements of a WH&C system and allow these to be identified and discussed with coherence and common understanding. While similarity exists across on the main elements which make a WH&C system, this similarity does not extend to the descriptive names of whole systems which are comprised of these common elements.



There is a need for an agreed nomenclature of water-harvesting systems that ensures commonality of language and meaning. While this is not the intended purpose or even an anticipated collateral focus area of this work, a rationalisation of descriptive terminology is necessary for systematic discussion of the cases that were located and are described here. International work on WH&C presents options on nomenclature and categorisation.

## 2.6.2 International Classifications

Oweiss et al. (2004) classifies WH&C systems from North Africa and West Asia based on a mix of scale and type. While not entirely consistent, the first relates to scale, and the second descriptor is based on a prominent (if not consistent) element of the system. It is justifiable to argue that WH&C practices are in many cases made up of a mix of scale, source and use elements, and this makes consistent grouping impossible, but clearly some categorisations will be more readily applied than others. There is obvious thematic overlap between this categorisation and the elements described in previous South African references, though Oweiss goes one step further towards a systematic categorisation. The types of WH&C are shown below (after Oweiss, 2004, modified for RSA context).



**Figure 2.1: Categorisation of Water Harvesting methods (after Oweiss, 2004)**

Even though Oweiss presents a usable categorisation, this is not, it is proposed here, the most useful for South Africa. More rigorous and applicable is the approach presented in the FAO digital publication (2003). As with Oweiss, the main descriptor is one of scale, but the subcategory is of storage type rather than an inconsistently applied, but prominent feature of the system. The storage type is grouped into those where water is held in the soil (sub-surface interstitial spaces) or in a man-made construction holding a body of water.

### 2.6.3 Proposed Categorisation for South Africa

The FAO categorisation has been modified and systematised by the authors to present an intuitive classification as shown in Figure 2.2.

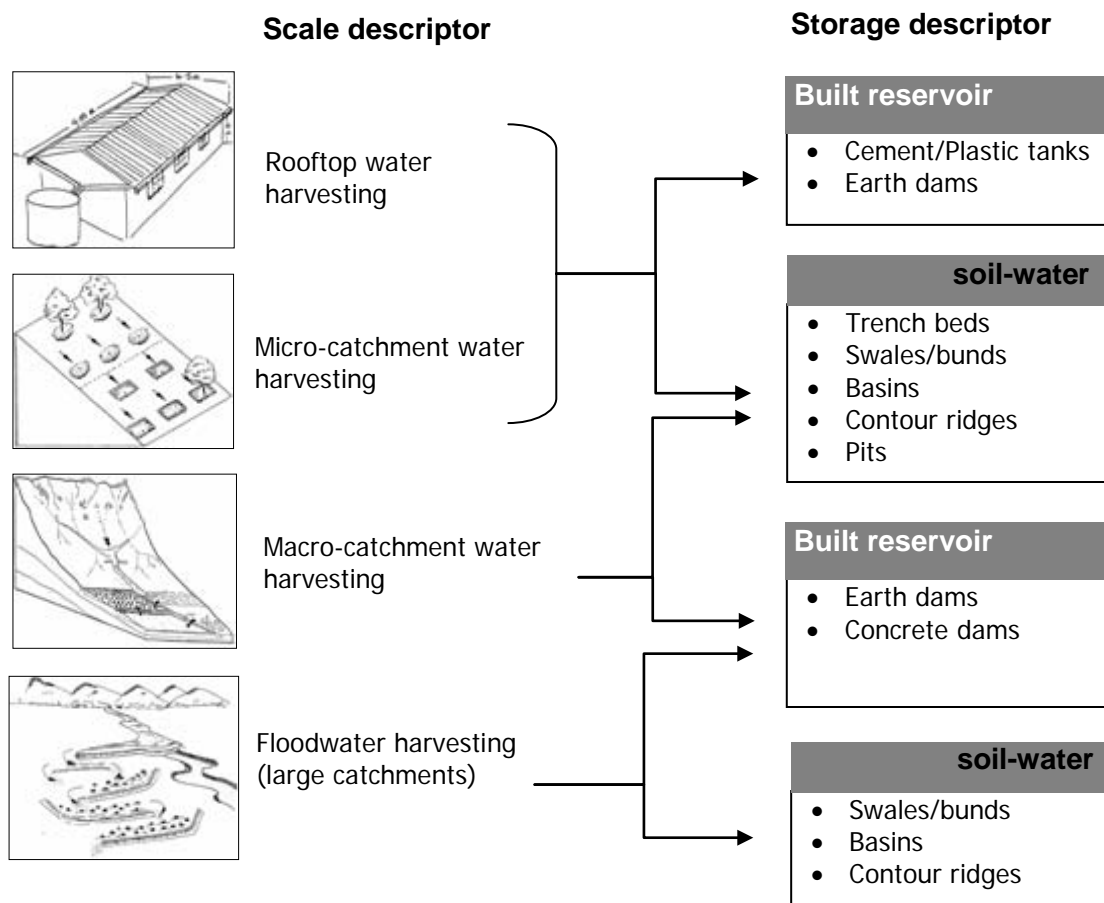




Figure 2.2: Proposed Categorisation of Water Harvesting methods

Any system, including mixed systems (source, use) can be described with the above three simple descriptors; scale, reservoir type (if any) and soil-water storage type (if any). The FAO scale categorisation is used with changes only to the Annual Rainfall column, to fit South African experience and conditions, as show below (from FAO, 2003). Specifically, Micro-catchments in South Africa are used in areas with up to 700 mm (not 300 mm as per the original FAO table). This is based on the experience of Botha et al. (2001).

Table 2.1: Ratio of catchment and field size and flow type for WH&C systems

Type of WH	Kind of flow	Annual rainfall	Treatment of catchment	Size 	Ratio 
<b>Micro-catchment</b>	sheet and rill flow	> 200 - < 300 mm	treated or untreated	- 1000 m	1:1-10:1
<b>Macro-catchment</b>	turbulent runoff + channel flow	> 300 mm	treated or untreated	1000 m - 200 ha	10:1-100:1
<b>Floodwater harvesting</b>	flood water	> 150 mm	untreated	200 ha - 50 km <sup>2</sup>	100:1- 10,000:1

### 3 INDIGENOUS AND INDIGENISED CASE DESCRIPTIONS

#### 3.1 Case 1 – GELESHA: A Soil Preparation Practice

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Gelesha is probably the oldest Southern African recorded practice that entailed water harvesting and soil conservation. Practically the Xhosa terminology *Gelesha umhlaba* means hoeing or the tilling of soil after a crop harvest. The intention of this practice was and is to ensure that any falling rain or dew or even frost infiltrates the tilled soil so that it would be available for the next planted crop in the form of moisture.

Conversely, it is tempting to argue that tilling of or turning over of soil leads to moisture loss through increased evaporation as moist underlayers are exposed to the sun and air. Nevertheless it should be emphasized that post-harvest hoeing was conducted with no intention to re-plant immediately but to break the hardened soil crust that had been carrying crop(s) throughout the then ending sowing season. The primary intention was to loosen this soil crust and enable soil particles to absorb any water that falls or flows over it easily. Generally in the space of weeks or months, that soil would be used for planting without the need for its re-tilling or re-hoeing.

Historically, Gelesha was done when a digging star (the Orion constellation) *Isilimela* appeared in late autumn during and after the harvesting of the summer crops.



Figure 3.1: The Orion constellation (*Isilimela*) signified the time for the Gelesha practice

In a 2003 paper on an outline of 'Optimizing soil water use in the central Eastern Cape' Van Averbeke has also offered a comprehensive summary of the Gelesha practice within the production system of the Xhosa in the 19<sup>th</sup> century:

A crop production system that involved mid-winter ripping of the sod of previous crop, called gelesha in isiXhosa, followed by seed bed preparation after the first good spring rains, evolved. Ripping the soil was done during mid-winter (July), because during that time of the year the cattle (oxen) were still in fairly good condition... Ripping also left the soil surface in a rough, receptive state, improving the infiltration rate of soils.<sup>2</sup>

More recently this historical practice has also been mentioned and acknowledged by Laker who has also developed a general strategy for optimising the efficient use of primary water resource for effective alleviation of rural poverty (Laker, 2004, 23-47). We need to emphasise however that the practice wasn't only confined to the Eastern Cape but was spread out to most crop planting areas in the Southern African region. Symbolically, Isilimela or the star that signified the renewal of the soil hoeing season also marked the renewal of the year for sowing purpose. It is also evident that summer crop cultivation in the south of the Limpopo was already part of food production which was dominated by livestock farming during the later Iron Age. In numerous parts of this region expansion of cattle-keeping led to clearance of woodland and more upland grassland was brought into regular use. In the dry highveld grassland northwest of the Vaal the early Batswana lineages grew fairly large chiefdoms based on central settlements of several thousand people. And so did the Northern Sotho chiefdoms alongside them. The concentration of these groups' population and their farming techniques were related to limited sources of water. Nevertheless, their cultivation practice was even more intense (Shillington, 2005, 138-156).

Southeast of the Drakensberg, where the environment was more varied and rainfall slightly higher, Nguni speaking peoples had wide range of hills and valley grazing, woodlands and probably more land for cropping even though their cultivation intensity was less. All in all, amongst these various land types, rainwater or moisture preservation was exclusively a practice directed to cultivation or crop – land. Many cultivators and herders from various parts of this region were remnants of later Iron Age farmers (post 1400 AD) and most of their settlements never extended beyond the region of regular summer rainfall. Their crop cultivation process then was adapted climatologically to this pattern. At least up to the period of increased contact with missionaries and that of colonial conquest (from late 18th century in the Cape) these African cultivators had largely restricted themselves to summer crops. The most prominent crop prior the mid-1700 was bulrush millet and this was processed for household productions such as flour, bread and beer making (Shillington, 2005, 212-224).

The tendency in contemporary literature is to associate Gelesha practice and crop cultivation with the advent of the use of the plough or late eighteenth and early nineteenth century. This is not necessarily true since hoeing and other cropping techniques that involved rainwater preservation predates this period. For instance, millet

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<sup>2</sup> W. Van Averbeke (2003), 'Optimizing soil water use in the central Eastern Cape'. COSA, Technikon Pretoria, Unpublished, p.1.

was cropped in the high-veld and largely so in the area between the Mbashe River and Delagoa Bay through the use of metal hoes and sharp hard-wooden picks made from *Umthathi* or Sneeze-Wood. It should also be emphasized that the Sotho-Tswana farmers of the high-veld who were also metalworkers, craftsmen and traders had passed on their metal and iron smelting skills to the Nguni speaking people who gradually settled from the Kei to the Pongolo. The earliest written record (based on observations of shipwreck travellers) on farming techniques of this latter group, in particular, indicates that millet was already an established and a stable crop by the sixteenth century. Though it was planted in summer, its ground and soil preparation was conducted through hoeing after every harvest. Moreover, preparation of new portions of cultivation land involved the heavy trampling of ground surface by use of cattle then followed by tilling that was also done by *Mthathi* picks and metal hoes. This activity was done during the winter months enabling the newly cultivated land to absorb much of the winter and early spring rain, before summer cropping.

Land preparation and Gelesha practice intensified with the adoption of maize and other vegetables as well as tobacco cropping by segments of the same group of people and those in the highveld from the mid 1700s onwards. At times maize was introduced onto land that was already used for millet crops but on numerous occasions further new land was prepared for maize and other vegetables cultivation. The land sown by a household was commonly subdivided according to the crops on it. A typical usage from the mid-1700s would be a portion of three different crops; one each for millet and maize and a third for vegetables, tobacco, fruit and even wild sugar cane especially around the Natal area. This was also the beginning of a period of concentrated and more stable settlements as expanding chiefdoms and their lineages competed for natural resources. Moreover cropping and the Gelesha practice had by now adopted a particular established seasonal cycle. However the scale of these practices reached higher proportions with the advent of the use of the plough and animal traction especially from the early to mid-1800s and onwards.

Evidently the use of the plough brought more land under cultivation. It also led to other land and water management technique such as contouring, which is discussed in section 3.4 below. Mission influence, travellers and associated trade networks also contributed in the introduction of variety of vegetable crops. As colonial conquest hemmed in bigger settlements into limited pockets of land, use practices also revolved around physical position of homesteads. Arable lands and homestead gardens continued to accommodate cultivation as much as Gelesha practice. Colonial and Union government records are littered with records of African cultivators and their land preparation (i.e. Gelesha) during winter seasons. The gradual breakdown or discontinuity of arable cultivation in most of the South African countryside in the post betterment period (2nd half of 20th century) has at least consolidated cultivation and Gelesha practice within household gardens. Even so, the knowledge and the technical skill of Gelesha practice still survive though in varying scale as demonstrated in the two settlements in the Eastern Cape and KwaZulu-Natal, where field research was conducted.

Within these two settlements; one Guquka, in the Tyume river valley between Alice and Hogsback in the Eastern Cape and Gogela in the hinterland of Kokstad in KwaZulu-Natal, the practice of Gelesha has been witnessed on residential gardens and on arable fields.

Gogela settlement, which still remain rural and its settlement is still laid out in scattered communal sections, arable allotments are still heavily utilized for summer and autumn crops such as maize, pumpkins brown beans and peas. Homesteads are still at the proximity of arable land and thus this land is secured and easily accessible for labour and other activities. *Ukuphethula Umhlaba* or turning over the soil (or Gelesha) is still a common practice employed by numerous households in Gogela after summer crop harvests in the months of April to early June. The community has also invested on livestock and a number of households own large herds. This is critical in explaining the continued use of draft oxen and ploughs in *Ukuphethula Umhlaba* or turning over the soil.

This particular area of Kokstad receives summer rains that range from 500-750 mm per annum. Most of this rain generally falls during the period from September to March. On average, the area is slightly wetter than the Tyume river valley and its outlying settlement, which receives about 450 mm per year. None the less parts of Gogela are stony and rugged and some of its land is shallow and thus prone to runoff especially during heavy torrents. The stony terrain, snowy winters and the occasional heavy summer torrential encouraged another water management and soil preservation practice in the form of stone terracing, which is discussed in detail later in this section.

Conversely in most parts of post-betterment Ciskei, it has been difficult to secure arable fields and continue with dry-land cultivation. The distant location of these has contributed largely to the current status quo of neglect. As indicated most of the Gelesha practice in present days in these settlements is prevalent within residential gardens that are utilized for a variety of crops. This in turn has also modified the seasonal cycle of Gelesha which is no longer an exclusive winter practice. Moreover, maize is no longer the main crop planted within residential crops but other variety of all seasons - crops which have shorter growth cycle and are harvested regularly.

In these cases Gelesha has also been a constant and regular practice as it has been witnessed in Guquka village of the Tyume valley. One of the interviewed active garden cultivators, Mr. Phazi, who plants vegetables and occasionally mealies, maintains that in recent years Gelesha practice has become more repetitive for those who experiment with variety of vegetable crops than it was the case for primarily maize and millet sowing on dry arable lands. He however acknowledges that the greener vegetables also rely on supplementary irrigation water for healthy growth. This is aptly reinforced by the presence of two ponds in his garden for irrigation purpose. Homestead ponds are detailed in section 3.3 of this report.

It is clear from these two cases that the practice of Gelesha or *Ukuphethula Umhlaba* has survived the test of time and is continued to be practiced by a number of households who still embark on cultivation. Critically, this has been an underwritten subject regarding conservation, water and moisture preservation on local Southern African communities and as history has indicated this is a longstanding practice whose technique and application have modified overtime.

### 3.2 Case 2: STONE TERRACING – Gogela Village (KwaZulu-Natal)

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Stone terracing or the enclosure of specific portions of lands by boulders and stones is a historical practice that was largely geared for water-flow management as well as soil preservation. The practice was and is usually directed on protection and management of arable or cultivation land. It involves the stacking of stones at the bottom base of low-lying crop land. At the base of slopes or downhill areas, stone walls were and are usually stacked high. But generally they had or have spillways for releasing water that comes down in high velocity or flooding. Overtime, these stone enclosures also trapped sediment that collected and contributed to the formation of new layers of soil. Subsequently this soil could be used for various cropping and tree planting.

The nature of terrain has over the years influenced this labour intensive practice. For instance, stone terracing was already a common practice that was extended towards house foundations and livestock enclosures by the Sotho-Tswana of the southern African Highveld, by 1200 AD. Parts of this terrain were known to be prone to flooding and to incursions from water runoffs. Moreover parts of the southern African Highveld were rugged and stony even though suitable for pastoral farming, with valley-lands that carried alluvial soils which were and are still appropriate for cultivation.

Terracing practice has an even longer history of probably more than 2000 years in North Africa, especially on southern areas of Tunisia. Referred to in an Arabic terminology, *Jessour*, in this particular region, this technique was primarily directed to preservation and enhancement of cultivation land especially from mountainous catchments. The system had similarities to wadi-bed cultivation that was prevalent in the Jordan *badia*. Wadi-beds often resulted naturally or from the entrapment of eroded sediment by construction of small dam that slows the velocity of water. This allows soil sediment to settle on the entrapped terrain and in the end creates good agricultural lands for cultivation.

As indicated earlier, throughout the history of their agrarian evolution, southern African herders and cultivators often preferred terrains that were ecologically and pedologically appropriate for their needs. In a number of cases along the foot of the Drakensberg as well as in the upper reaches of the southern Highveld good grazing land at the top of hills were often complemented by stone strewn slopes and valleys. In such cases opening up of new arable land also demanded the removal of stones from the designated cultivation soil. Because stones were and are solid structures they were and are difficult to be penetrated by rainfall and thus water could be lost in the form of runoff. Therefore, the digging and the removal of stones helped loosen soil particles and in the end precipitated the absorption of rainfall. Once removed out of the intended cultivation area the stones may be arranged linearly or in the form of *Jessour* as described above.

The case description of this practice is located in the settlement of Gogela in the Kokstad district. We have already described how the community thrived on mixed farming, particularly livestock and cultivation and were drawn to the fertile and water rich Umzimvubu Valley. Somewhat differently, Gogela was and is generally hilly with stony surface ground. Its vegetation is mainly grass and shrub bushes. Its ecological conditions are influenced mostly by the summer rainfalls, sunny days as well as by the extreme cold short winter cycle that is also accompanied by annual heavy snows.



**Figure 3.2: Stone Terracing at Gogela Village in KwaZulu-Natal**

Since early settlement, Umzimvubu valley lands constituted the important crop production sites. Cultivation expansion also resulted in the increasing demand for more arable land. By the late eighteenth century the extraction and removal of stones from slopes or lands above the valleys had begun. New lands were also cleared followed by tilling and sowing of crops. But there were initially many experiences of in-field as well as crops runoffs. As a result stone terracing at the lower bases of newly opened slope lands had become the common feature during the beginning of the nineteenth century. In the initial stages there was no uniformed pattern or fixed measurement regarding land that could be terraced. Each household tended to construct and manage its terraced piece of cultivation land. Of course other factors that included availability of labour as well as the necessary implements were influential in determining the intensity of the practice as well as the size(s) of land that could be terraced.

The arrival of Methodist Missionaries in the neighbouring settlement of Mount Ayliff, in the early 1800s contributed in patterning terracing practice in a number of ways. For start, mission influence introduced and extended the use of plough(s), draft oxen as well as sledges, carts and even wagons for transportation. Although hoes were already available for land tilling and wood bars as well as metal picks already used for digging up stones, transportation thereof hitherto relied primarily on manual labour. Thus Gogela households who were quick to access this new technology modified their cultivation and terracing methods. Sizes of their arable lands increased, terracing expanded since stones could be moved or transported faster even to distant sites.

The use of ox-drawn ploughs also influenced size(s) of land that could be terraced. It tended to be common that terraces were spaced wide enough to enable ox-spans to negotiate their way around and in between terraced arable lands. As indicated, sizes of these arable portions were largely determined by technology available to families or households involved in cultivation. It was quite familiar that households with more livestock resources and agricultural technology could gain enough community respect, influence on local authority and thus in the process had latitude to accumulate larger portions of arable land. Thus, at the turn of the nineteenth century, Gogela settlement consisted of various uneven sizes of terraced arable portions, that were either large or small on previously slopes and valley lands, which was primarily used for grazing.

Union government schemes to rehabilitate reserves from the 1930s onwards provided a major influence to the initial historical terracing practice in the Gogela settlement. The community had also grown naturally and more significantly it had over the years been recipient of numerous evicted or displaced families from neighbouring and surrounding



white-owned farms. As a result following the 1936 Trust Land Act, Gogela settlement was consolidated further by a portion of an adjoining private farm. This was part of a government's nation wide program to consolidate areas that had been 'scheduled' strictly for African settlement since the application of an earlier land act in 1913. Newly released lands, as well as old existing African settlements were also subjected to rehabilitation measures after 1936. Initially these focused on livestock, particularly the culling down of numbers, dipping, rangelands subdivision and their management. They also extended onto arable land reclamation as well as crop resuscitation measures, which included introduction of contouring and crop rotation techniques.

By mid-twentieth century, these rehabilitation schemes had modified under the new National Party government to a comprehensive betterment program. Whilst retaining some conservation measures from the earlier rehabilitation initiatives, betterment also impacted critically on settlements layout as it strictly enforced the separation and alienation of residential, from arable and from grazing land. Betterment almost fully applied onto the Ciskei territories, but unevenly so on parts of Transkei and even less so in Natal even though the earlier rehabilitation initiatives had been partially extended. As a result even though some of Gogela households gradually concentrated in central villages, a number of homesteads still remained in scattered communal sections at the proximity of their arable lands. The early rehabilitation initiatives however had a significant bearing on the earlier terracing practice. From the 1960s onwards a standard or a patterned terracing practice that has survived and is observable up to the present day in Gogela ensued.

The haphazard or random practice whereby individual cultivating households designated and terraced their arable portions as they see appropriate was replaced by the standard linear demarcation as well as arrangement of stones, quite fashionable of common contour ridging pattern. Keen to foster an egalitarian system in terms of arable portions size, government planners re-demarcated arable plots to fixed size (about 1 hectare or 2.5 acres) per cultivating household. Intervals or dividing portions of some 8 metres between arable fields were also enforced for delineation of boundaries. Critically, arable land owners still continued with terracing practice but they were now compelled to re-terrace stone piles in linear strips that span across the length of their croplands.

New terraces could be as high as a meter and they still served the main purpose of arresting and diverting surface run-off. In serving so, they formed a barrier that prevented runoffs from cascading further down the fields. The debris and top-soil that goes with the run-off gets deposited at the lower portions of most arable fields. As a result these lower portions are the most fertile and moist than the upper ones in almost all Gogela arable lands. Our field research has also established that over the years these portions have also carried healthier and faster growing crops. Moreover it was observed that fruit trees were and are generally planted on these wetter portions along the terrace structures.

Stone terracing is a simple rain-water harvesting and management technique even though labour intensive. It is a historical practice that evolved largely through imported knowledge brought by missionaries in the 18<sup>th</sup> Century combined with land pressure that forced people to move from the flatter, fertile valleys. The practice has been modified over the years by the people at Gogela and as such, has become indigenised.

### 3.3 Case 3: HOMESTEAD PONDS – Thaba Nchu (Free State) & Tyume Valley (Eastern Cape)

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The history of homestead ponds or Matamo in southern Sotho and Pitsi in Xhosa languages respectively is associated more with that of cultivation as well as conservation and irrigation. Elementary techniques of rain water collection and diversion through hand hoes dug rudimentary furrows to cultivated crops were associated with the late eighteenth century cultivators especially on the southern African Highveld. This was the Sotho-Tswana speaking people who by this period had developed a complex social and political organization with more or less stable and larger settlements. Their cultivation practice already ensured the sowing of different types of crops, such as millet or sorghum, pumpkins and beans. Critically these were grown in fields that were cultivated in low-lying valley lands, close enough to the residential settlements to receive regular attention and protection from wild and domesticated animals.

Cultivation lands were often demarcated along the valleys that often served for rainwater catchment and as indicated were easily protected from livestock, which as rule grazed on the plateaus on top of the hills. Unlike the Nguni who were generally in smaller settlement concentrations and in the lowveld Drakensberg and generally higher rainfall region, the expanding Sotho and Tswana groups faced challenges of sustaining their cultivation and other agricultural practices in much drier highveld. At least the southern Sotho south of the Vaal who became settled largely on parts of the present day Free State by the eighteenth century had concentrated in the valleys of the southern tributaries of the Vaal. Some also concentrated settlements in the fertile valley of the Caledon which flowed southwards into the Orange River. Further subdivisions and the southward movement of other groups of chiefdoms from north of the Vaal during the seventeenth and early eighteenth centuries brought more people around the Caledon valley. Despite this, their near proximity to this natural water resource still enabled these particular groups to continue with their cultivation practices for much of the eighteenth century.

The later half of the eighteenth century has been recorded as the period of unusually high rainfall. With ample food, population expanded and more land was brought under cultivation. Cattle thrived as well as herds multiplied on much improved pasture and some wood land was also cut down to expose more pastureland. Farming certainly began to impose itself onto the natural environment. Ironically this ecologically and climatologically induced farming and agricultural expansion also encouraged a number of subgroups to gravitate further onto newer areas, where they felt they could control more grazing and cultivation land. Critically these groups gradually formed their own chiefdoms onto newer territories which in the longer run they begun to claim.

To elucidate this point, at more or less the same period the southern Sotho settlement was expanding around the Caledon and the Vaal tributaries, other southern Nguni groups gradually gravitated away from the wetter and fertile valley lands around the southern Drakensberg. The sustained good rain period already highlighted, probably lulled these migrating southern Nguni groups into 'false sense of security' regarding their continuing farming and cultivation practice. They however faced new ecological challenges as they moved to the south and to the west even though these were largely

sparsely populated Khoisan drier areas. Nevertheless, they were still able to maintain some of their cattle farming and cultivation practices in and around river valley areas, especially nearby the Kei. Steadily, others moved across the Fish and even the Sundays rivers. As some of these Nguni groups (later known as Xhosa) gradually absorbed the Khoisan people, they also adapted their survival and habitual skills that included hunting and gathering of certain plant species.

The closing years of the eighteenth century that replaced the good rainfall cycle with prolonged drought contributed fundamentally to alter the earlier evolving agrarian upsurge. Generally, production that had been accumulated for almost a full generation came to a speedy decline as expanding settlements had to compete for the control of scarce resources for their continued survival. The subsequent period of the early nineteenth century also coincided with conquest of land and greater contacts with advancing Settler and Mission groups. In that period most of the southern Sotho groups around the Caledon and Orange valley lost much of their land to the advancing 'Voortrekkers'. In the south and on the Indian Ocean coastline the southern Nguni (Xhosa) were dislocated by the rapidly expanding British Cape colony. Forced to survive within enclaves of limited tracks of land these groups still retained most of their farming and cultivation practices. Ironically the trans-human activities of these expanding conquest frontiers also radiated networks of ideas and knowledge bases regarding the control and management of natural resources.

Some of these revolved around water and soil management. We have already noted above, the exceptional cultivation skills of Sotho-Tswana groups on the southern Highveld. Overtime they had gradually passed on their techniques of rain water collection and diversion to crops onto their southern lineages who settled around the Caledon and Orange river lands. In turn these skills had gravitated further to the southern Nguni or Xhosa groups and would modify further as they also settled in the drier parts of the Cape. By the early nineteenth century and in the course of conquest, some 'Voortrekkers' had exported their own ideas regarding rainwater management to some of the southern Sotho lands they eventually occupied. Likewise they also adapted to some techniques they in turn learned from the Sotho groups. In parts of the Cape some of the Xhosa Nguni groups who had early mission contacts also passed on as well as received ideas and techniques from these counterparts.

The field interviews on the workings of homestead ponds in Thaba Nchu and the Tyume river valley settlements of the Free State and the Eastern Cape are clear indication of surviving ideas and techniques of rainwater collection and management. Although the Matamo system in the summer rainfall area of Thaba Nchu seems to be neglected in the last 25 years, it is an indication of how the late eighteenth and nineteenth century rainwater collection and management technique modified and survived into the twentieth century period. By the same token, the surviving homestead pond model in one of the Tyume valley village, Guquka reflects the endurance as well as the modification of this long-existing water collection and storage technique.



**Figure 3.3: Homestead Pond - Matamo (Sotho) or Ipitsi (Xhosa)**

The Thaba Nchu Matamo was largely a nineteenth century innovation that involved rainwater collection and storage in form of dams for crop watering as well as livestock consumption. This was a gradual departure from the earlier simple technique of diverting rain water runoffs down the slopes directly to cultivation land or crops. Conquest had effectively shrunk the size of productive land and there were no more abundant natural resources to recycle or sustain the previously existing farming practice. Settlements were cramped in more confined space and had to exploit the only limited resources around them.

The system of Matamo then aimed to bring and concentrate water resources around homesteads and occasionally on agricultural land. In a semi-arid zone of Thaba Nchu that receives an annual rainfall of about 450 mm of rain, they were introduced with the objective to partly sustain subsistence farming and other household activities. Yet their construction was uncomplicated though it involved sustained intensive labour. As a result, the Matamos were hand dug pits mainly, constructed with picks, hoes and shovels. They varied in both depth and diameter though on average were about 2 metres deep and some five meters in diameter. On occasions some households erected stone-work to support the walls and the bottom base against erosion during excessive inflow.

The Matamos collected surface runoff from surrounding land through connecting furrows that were also hand dug. Those Matamos that were constructed with stone cover, along the walls as well as on the base, could store the collected water for a long period since very little was lost through infiltration. Nevertheless, because of its muddy state the Matamo stored water was not recommended for human consumption. None the less, the stored water was still collected with hand containers such as clay buckets and used for supplementary irrigation to crops close to the homestead. On grazing land, livestock were also allowed to drink freely from the uncovered Matamos.

A number of oral testimonies confirmed that the Matamo system sustained Sotho subsistence farmers up to the 1970s and then became less widespread, with only a few being used today. Two reasons are given for this decline. First, around that time South African government, through the Baputhotswana homeland, invested substantially in groundwater development and windmills for village water supply. Secondly, and perhaps more importantly, their uncovered nature made them dangerous to young

children as well as small livestock and the tragedy of children drowning led to matamos being drained and left unused.

We return once more to the home of Mr. Phazi in Guquka village of the Tyume valley settlement in the Eastern Cape. Mr. Phazi has confirmed to us that he had adapted some ideas and knowledge he gained from neighbouring white settlers, the Free State farms as well as from what he learnt from his father regarding rainwater collection and diversion for use in crop cultivation. Although he maintains that this practice is little known in his village, the Tyume river valley itself has been documented in the early history of irrigation. The diversion of river water by well-known historical figures such as Soga, then Kama as well as by other mission groups for much of the early mid-nineteenth century and onwards have been particularly noted. Settlements in this valley have also been exposed to extensive cultivation practices, which have been carried on over the years. As mentioned in section 3.1, in the post-betterment period many of these production practices have concentrated around households where they are secured by members.

In his 30x40 m garden, Mr. Phazi has two dams (or ama Pitsi) of about two meters deep and approximately three meters in diameter. If filled to their full capacity, these dams can supply water regularly for his garden for a period of some five months given the relatively high rainfall in the area (some 1000 mm per annum). He diverts water from a nearby sloping road by two furrows that feed into his dams. At the head of the main receiving dam there is a sediment pit that reduces the velocity of inflow and serves to filter twigs, debris and sediment. This is cleared after heavy rainfall by hand.

Mr. Phazi learnt this technique from an extension agent of the African Christian Action Trust (ACAT) a non government organisation which has been partly instrumental in supporting food production to poor households. As in the case of Matamo construction, Phazi's ama Pitsi were hand dug with the use of picks, shovels and iron bars. To prevent the Pitsi walls from collapsing, he used stones, dry-bonding them vertically along the wall and its bottom base. ACAT also provided him with bags of cement to line the reservoirs and this has also served to limit unnecessary water loss through lateral infiltration (Hebinck and Lent, 204; Van Averbeke, 34-35). The bottom base remains un-cemented but he reports that the rate of infiltration is limited by the rock base of the bottom of the pond, although this does not seem to have a substantial technical explanation.

The outflow of stored water into the crop garden is arranged systematically and is also regulated by the topography on which the dams and the garden are located. Generally the topography is sloping and the dams are located above the beds. Mr Phazi uses hose-pipe siphons to water his crops in the gardens. As indicated above, Mr. Phazi cultivates a number of vegetable crops, maize and has a variety of orange, apple and other fruit trees in his garden. Significantly, other than ACAT's input, Mr Phazi has received minimal extension advice, evidenced by some unusual and not particularly beneficial practices, like nurturing fruit tree seedlings from the seed of purchased fruit, rather than grafted seedlings for example. Despite minimal support and very poor duplex soils (shallow silts on gleyed clays) he produces substantial food for himself and his neighbours.

### 3.4 Case 4 – COUNTOURING

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Much of the literature on the origins of contouring or the construction of contour ridges in rural African areas of Southern Africa focus on the twentieth century, particularly the interwar period. Coincidentally this was the period of introduction and expansion of rehabilitation schemes, especially onto the South African black reserves. Arising out of heavy concerns on environmental degradation, official thinking in this country became convinced that territorial segregation depended on ecological resuscitation. Whilst numbers of livestock were recorded to be on the rise, they were also deemed to have detrimental effect on land. By now officials had also identified territories that required urgent attention and were to be exposed to rehabilitation measures.

At the core of these measures were proposed programs to fill in dongas or the eroded areas. Moreover there was emphasis to build contour banks and promote contour ploughing on arable lands. It should be emphasized from the outset that the promotion of contour ploughing was borne out of official perception that in the process of tilling, African cultivators loosened vast blocks of arable lands and this was prone to further erosion. This notion ignored the fact that pre-conquest African cultivators often practiced shifting cultivation that permitted tilled land to regain its fertility through a period of disuse. It also failed to realize that pre-colonial cultivators did indeed cultivate on the edges of and not on bush land or forests or trees, which on most times they often preserved for soil stability.

In an attempt then to conserve this 'vulnerable land', Union government officials saw the use of contour banks as a technique of supporting the regeneration of forage, grass and other plants. These then would serve to bind the soil together and help prevent and curb soil erosion. In some rural South African villages in the post-rehabilitation period some of these contour ridges were either utilized for fodder cropping but in a number of cases they became zones for thatch-grass and tree growing.

Whilst this appeared to be primarily soil conservation than water harvesting technique, it should be emphasized that the strips of land in between contour ridges were still used for crop cultivation. These strips often constituted loosened particles of soil because of their frequent cultivation. Their crust surface then often contrasted that of the contour ridge, which was hardened by either the forage or the thatch grass that grew on it. In this regard then, contour ridges also served as catchments, which enabled water to flow over and divert onto these cultivated strips of land during rainfalls. Conversely, these strips of cultivation land could absorb water or rainfall more easily and quickly.

For much of the decades of the mid-twentieth century to the early 1980s when cultivation was still practiced but seem to be on a gentle decline in rural homelands, contour ridges continued to serve this cultivation purpose. Nevertheless in the period of neglect of most of arable fields, they have also contributed in the extension of forages, thatch grass, trees and other shrubs onto land that was previously utilized for cultivation. In some ways this has also contributed in keeping moisture intact within the soil whilst simultaneously militating against rapid soil erosion.

### 3.5 Case 5: SAAIDAMME – Northern Cape

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The Saaidamme, which is Afrikaans for 'planting dams' are found in the Northern Cape areas around Clanwilliam, north-east of the Cedarberg Mountains and north of the Roggeveldberge. The area is a harsh and flat desert landscape with annual average rainfall of 100 to 200 mm, but has a high unreliability to the extent that in many years, no rain falls at all. The saaidamme are based on the same model of floodwater irrigation that has taken place along the Nile River in Egypt for thousands of years and is identical to the Wadi floodwater harvesting (North Africa), the flood-spate system (Pakistan) and the Rabta of Morocco. The fertile, silt-laden flood-water from the distant mountains (some 100 to 150 km in this case) is diverted with structures into a series of large, flat basins which extend between 1 ha and 100 ha in size each. Each basin is ringed by a low earth wall of between 1 and 2 metres deep and is effectively a flat, shallow dam. The water is allowed to stand in the basins up to 1 m deep for between 1 and 3 days to saturate the very deep alluvial soils. The GoogleEarth image overleaf of the Fish River east of Calvinia shows the green strip of Saaidamme in this arid landscape.

**Figure 3.4: Ribbon of Saaidamme along the Fish River 80 km east of Calvinia (Northern Cape)**



Rainfall = 180 mm per annum  
Irrigation borehole water = 0  
Main rivers with Saaidamme:

- Fisrivier
- Sakrivier
- Kromrivier

As in most arid areas with some rainfall, the combination of minimal natural vegetation and high-intensity rainfall events found in arid climates, results in high rainfall run-off with short duration floods. The rivers are typified by minimal or zero base-flows (called Wadi's of laga's in North Africa) and infrequent, but high-volume floods. This typical desert hydrological scenario, coupled with the extensive flatlands and deep alluvial soils combine to form the basis for South Africa's largest and most remarkable water-harvesting system. While the system might be replicated at a small scale and presents opportunity to inspire planners and farmers alike, large scale replication seems highly unlikely – given the need for flat deep soils and floodwater that can be diverted. The saaidamme cannot, it seems, be further expanded as suitable slopes, soils and water are limited.

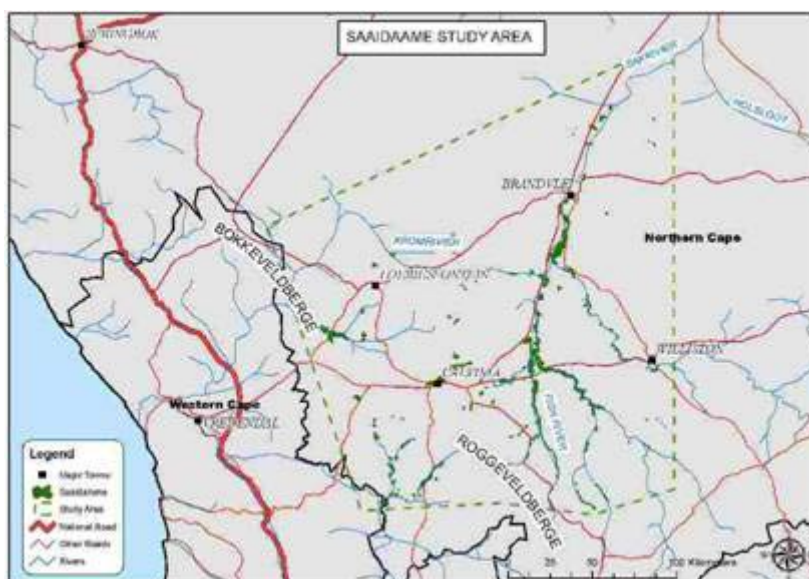
The farming systems revolve mainly around lucerne production for seed as well as for sheep, coupled with extensive grazing (of 1 small livestock unit per 30 ha to 50 ha). The extension officer in Calvinia, Mr Gert Steenkamp, has been working for more than 20 years in the region, reported that some 95% of South Africa's lucerne seed is derived from



the saaidamme. Vegetables are also produced at a smaller scale and are planted immediately after a flood event and saturation of the field. These require no further water whatsoever for the entire growing season and draw on the receding water table for all of the water requirement.

It is somewhat surprising that this sustainable, large scale and rather unusual technical and agricultural system remains largely unresearched and unreported, though it is widely known by name and location. The Department of Water Affairs Strategic planning report for the area (DWAf, 2004) mentions the Saaidamme on only three occasions in passing, and essentially notes that little information is available, and that monitoring and licensing should be introduced. Other literature searches yielded minimal information and where found, was descriptive and historical with little hard data. Interviews with the Northern Cape Department of Agriculture and the Agricultural Research Council at Elsenberg in the Western Cape, also provided no research data on the extent of the system or exact details on how the system functions over time – particularly the soil-water relationship which defies conventional knowledge of evapotranspiration. The soil-water-plant relationship, particularly in the case of the deep rooted lucerne, suggests that a shallow groundwater table (some 8 to 10 metres) forms part of the system – although no documentation on this was located. The fertility and stability of this system is evidenced by the self-seeding lucerne fields at Diepdrif Farm, which were established around 1920 and remained highly productive without any additional seeding until the fields were uprooted in 2006, to allow high-tech laser-levelling of the dams.

In order to gain some further insight and a sense of extent of the saaidamme, an exercise was carried out using GIS with 1:50,000 maps, and Google-Earth images. The study area is shown below, with the identified Saaidamme marked in along the rivers. These were determined with a combination of a slope analysis (demarcating flat areas), overlaid with cultivated areas (from the 1:50,000 maps). Selected visual verification was made using Google Earth images where actual Saaidamme embankments can, in many cases, be seen. This yielded tentative data on the hectarage of saaidamme in the area.



Best estimate of saaidamme = approx **35,000 ha**

Possible additional 6000 ha

Verification of estimate using more rigorous approach is needed

Figure 3.5: Homestead Pond - Matamo (Sotho) or Ipitsi (Xhosa)



Given the infrequent saturations (between 1 and 3 years) and the low average rainfall, there is high reliability on lucerne as the primary crop. Lucerne has the advantage of a long tap root which mainly accesses moisture, and a shallow lateral root system which draws nutrients. These nutrients were replenished historically from the silts in the floodwaters, and more recently also with fertiliser. Lucerne roots have, according to farmers interviewed, measured up to 30 feet long in some cases where lands have been washed away during flood exposing the soil profile in productive fields.

The writer Laurence Green relates in his book *Karoo: Land van Weerbegin* (i.e. Land of Starting Anew in Afrikaans) that Donald Bain, the grandson of the famed 19th Century architect and road-builder, Sir Thomas Bain, was one of the first people to construct saaidamme of size in the area. Green relates an article in *The Farmers Weekly* (24 April 1918) where the owners of Zak River Estates were warned that the high-yielding saaidamme would soon fail due to hydraulic compaction and salination as a result of the massive volumes of water diverted into the lands during flood times. Now, more than 100 years after their initial construction, the saaidamme continue to be highly productive and have been expanded to their maximum capacity, limited by water availability and suitable flat land with deep alluvial soils.

### 3.6 Case 6: KLIPPLAATE EN VANGGATE – Stilbaai (Western Cape)

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This method is a classic approach to water harvesting and dates back, according to farmers interviewed in the area, to the late 19<sup>th</sup> Century. 'Klipplaate en Vanggate' in Afrikaans can be translated as 'paved-rock and catchpits' and is identical to the ancient system of cisterns or Hai-fa found across North Africa and in Jordan and Syria. Historically in South Africa, water from the system was used for both human and animal consumption. The literature suggests there are farmworkers who still rely on this for domestic supply (Houston, 2001) but the practice is now mainly used to provide cattle water.

In simple terms, a natural hardened and impermeable surface (in the Stilbaai case an unusual geological formation of exposed calcrete) is cleaned and compacted and rainwater is channelled from this surface to an underground tank.

In the Stilbaai area, these 'vanggate' were dug into the underlying softer rock to depths of between 1.5 to 5 metres. The runoff-surface was historically a natural one of compacted calcrete, but has been more recently upgraded in many cases with cement, to maximize runoff. Generally, it seems, the hardened collection areas were fenced to minimise pollution from animal manure as well as protect the runoff surface from hoof-damage. A typical example of the system is shown in Figure 3.6.



**Figure 3.6: Klipplaate en Vanggate in the Stilbaai area**

The geology of the area is characterised by an unusual calcrete outcrop, underlain by softer calcareously-cemented sands. The calcrete is mostly porous and rain penetrates quite rapidly to the bedrock emerging as strong springs towards the coast and into the deeply cut rivers, but these are distant from the higher-lying grazing lands. The grazing in this area is good, but the lack of standing water is the limiting factor in raising stock. Cattle production is evidently still almost completely reliant on the rainwater harvesting in the high-lying areas to the west of Stilbaai covering some 1600 km<sup>2</sup>, where limited economically viable alternative sources are found.

The use of the Klipplaate en Vanggate has historically provided domestic water, and still continues to provide a reliable source of stock-water to maximise the grazing resource. While the natural geology (calcareous hardened layer) prompted the technology, this could easily be replicated just about anywhere, with the use of cement for the paved surface.

## 4 OVERVIEW OF CONTEMPORARY METHODS

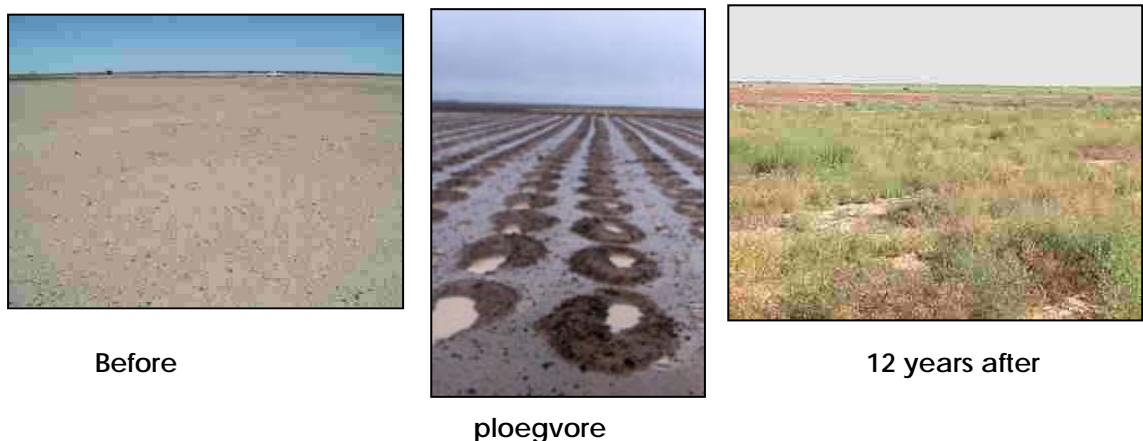
The purpose of providing a summary of contemporary methods is not to provide detailed technical descriptions, but to allow subsequent discussions on the implications of indigenous techniques to be made in the light of contemporary methods. Detailed publications are readily available on each of the methods and are fully referenced in the text that follows.

### 4.1 Ploegvore (Northern Cape)

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Pitting is an ancient technique found in arid areas of both west and east Africa but is a recent introduction to South Africa. Pits are constructed in a variety of circles and ellipses, to depths of 5 cm to 1 metre and with spacings of 2 to 5 m for tree crops and closer for field crops. Pits are invaluable for the rehabilitation of degraded agricultural lands in very low-rainfall areas.

The South African 'ploegvoor', literally translated from Afrikaans as 'plough furrow' was developed and tested as part of the major soil-conservation drive in the arid west of the country in the 1960s and 1970s. The main purpose was to turn vast open, unvegetated desert areas into productive, if low-intensity, grazing land over long timelines of 15 to 20 years. This was a highly successful programme with, according to interviews conducted, ongoing uptake by the arid-Karoo sheep farmers. Visually dramatic outcomes are evidenced by the photos below (courtesy of Gert Steenkamp and Stefan Theron).



**Figure 4.1: Impact of Ploegvore on degraded Greater Karoo lands**

Importantly, success of the technique according to Louw (undated) requires careful mechanisation and selection of appropriate lands.

In general, the ploegvore are constructed with a special double-bladed plough (not a disc plough) and details on the most appropriate technical approach can be obtained from Van der Merwe and Kellner (1999).

## 4.2 Granite Dome Harvesting at Paulshoek (Northern Cape)

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This case was the only one that was not visited in the course of the study. This was partly due to the remote location, and that the technique is not indigenous and that it is sufficiently documented by Houston and Still (1999), replicated below.

Paulshoek is a village of 580 people with 117 households and one school. It is about 35 kilometres due East of Karkams in Namaqualand. The co-ordinates are approximately E180 15' 30" and S30° 21' 30". Two boreholes are used to supply water; a low-yielding borehole powered by solar panels, and a higher yielding borehole powered by diesel. At present the town has stand-pipes and water shortages are experienced. Roofwater harvesting and a ground catchment system using a granite dome is used to supplement this supply. The granite dome rainwater harvesting system was built in 1991. The granite dome was cleared of all loose rocks, soil and vegetation. Cracks and crevices were sealed with cement. A low cement wall up to 0.5 m was built downhill of the cleared area, high enough to contain and channel all the water (see Figure 7). At the lowest point, a catch pit connected to a delivery pipeline conveys the water to a storage dam. The storage dam is built from shaped earth and is lined with welded polyethylene. The dam is covered with a corrugated iron roof.



**Figure 4.2: Granite Dome Harvesting (photo courtesy of Houston et al., 1999)**

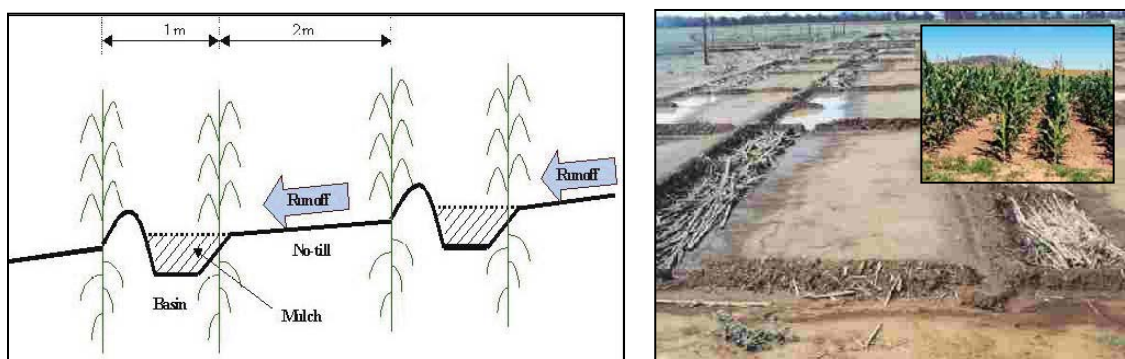
The perimeter of the cleared dome is 670 m which means that there is about 30 000 m<sup>2</sup> of bare rock. If 50 mm (about 1500 m<sup>3</sup>) of rain was harvested, with an average consumption of 30 l/person/day, then this water source would last for almost three months. However, the supply is reported to last for up to four months. This means that either more rain is harvested, i.e. 70 mm, or that the average consumption is 22 l/person/day. The harvested rainwater is not blended with groundwater and is used until finished. Thereafter borehole water is used. Unfortunately, towards the end of the rainy season when the dam is almost empty the water develops a strong organic flavour because of the extensive growth of algae. This occurs despite the dam being fully covered. The residents annually clean the dam by hand, which is an arduous task. Nevertheless, this is possibly the most substantial communal rainwater harvesting initiative undertaken to date in South Africa.

### 4.3 In-field rainwater harvesting (Free State and Eastern Cape)

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The in-field rainwater harvesting technique originates from Hensley et al. (2000) who proposed to combine the benefits of water harvesting, zero-tillage and small basins to minimise runoff and maximise infiltration to the root zone. The resultant increased water availability results in significant increases in crop yield compared with conventional ploughing.

The schematic from Botha et al. (2003) below shows the two distinct areas that form the basis of the system, namely the collection basin (about 2 metres in wide) and the planting area (about 1 m wide). Mulch in the basins, using maize stalks, plastic or stones can be used to reduce evaporation.



**Figure 4.3: Infield Rainwater Harvesting Runoff and Planting areas**

The system has been proven to be successful in the soils and rainfall of the central Free State and is currently being tested in the Eastern Cape. Uptake in the Thaba Nchu area has been impressive and extends to thousands of households, with ongoing promotion and extension support by the ARC team who piloted and expanded the approach. Extensive references on this system are readily available from the WRC notably Botha et al. (2003); Kundhlande et al. (2004) and Botha et al. (2007).

### 4.4 Trench Bed Gardening (across South Africa)

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Trench-bed gardening as it is practiced increasingly in South Africa today was developed by Robert Mazibuko in the 1950s and 1960s in the Valley of a Thousand Hills. This unique system was inspired by, and effectively replicates the functioning of wetlands by creating soils which have very high moisture-holding capacity, are soft and loamy, and have high fertility (Bloch, 1996 in Auerbach, 2003).

Auerbach explains that the trench system is made by removing the soil from the bed (usually 1 m wide, 2 m to 3 m long and 1 m deep). The topsoil is separated from the subsoil and mixed with manure or compost. Organic material (grass, maize stalks, compost) is placed in a thick layer in the bottom of the trench and the soil is returned, topped by the manure-rich topsoil which is mounded above the ground level.



Photographs below show the stepwise development of beds.



*Excavation and filling with scrap metal for iron uptake in base (plants and people)*



*Backfilling with organic material and then compost rich topsoil*



*Completed trench-bed garden*

#### **Figure 4.4: Trench bed process**

In the widespread application of this method by a range of organisations (e.g. Water for Food Movement, DWA Water Harvesting Pilot Programme, Border Rural Committee in the Eastern Cape) the trench-beds have been combined with two other methods of water-harvesting. The first is the diversion of water from surfaces adjacent to the garden into the beds by small cutoff channels. The second is construction of small storage reservoirs (approx. 30,000 litres) for water collection from roofs and the ground, for use in the dry season, with augmentation by grey water (house washing and cooking water).

This combination of methods, i.e. trenches plus micro-catchment direct to soil-reservoir (in trenches) plus micro or macro-catchment to 30,000 litre water-storage reservoirs seems to provide the necessary resilience for home-gardening to survive the generally drier winters. The popularity of the combined approach has seen increasing uptake, in various forms, in food-production programmes across South Africa.

## 5 COMMENTS AND IMPLICATIONS

### 5.1 Implications of the Historical Literature Survey

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Water harvesting has a long history and is the subject of increasing emphasis in the contemporary scientific domain. Literature traces indigenous practices from Ancient civilization, practiced within communities of more-arid Northern Africa and parts of Asia and was predominantly geared towards crop farming. Over an extended period of a few millennia, knowledge and skills were accumulated independently (pre-history) or transferred more directly through conquest and colonialism to settlements in Southern Africa. The techniques moved concomitantly with farming methods and settlement patterns of various groups were determined by ecology as well as climate.

While the literature seems to capture the general picture of these long term changes and progressions, most particularly the pattern of South African historiography to the three different historical levels, there is little technical detail that is evident. The literature mentions water diversion and conservation practices in general locations (for irrigation or supplementary watering) but presents practically no detail on how this was done, where project sites might be found, and what the structures or methods actually looked like.

The literature reviewed did not deliver any specific sites for documenting narratives of truly indigenous case studies, or recording cases on video. While the historical contextual information was valuable for the progress of the research assignment, it was evident that the cases had to be identified through other research processes. Active networking of development and irrigation practitioners, researchers and historians working in the study-field who have knowledge of potential sites, was therefore adopted as the research approach.

### 5.2 Perspective on the Low Prevalence of Indigenous Techniques

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Regional diversifications are almost distinct regarding patterns of livelihoods, habituations and evolution of agriculture in the African continent. Diversifications were also reflected in techniques developed but generally were influenced by a combination of settlement trends, climate and terrain. The earliest tangible and irrefutable evidence of food production on the African continent comes from the Lower Nile region of Egypt and its immediate adjacent areas. Here, by 5000 BC, stable settlements were already in existence, domesticated animals that included cattle, sheep and goats, were already kept. Moreover grains such as wheat and barley as well as other vegetables were already cropped. All of these practices had a longer history in the Middle East, going back to about 7000 BC.

Its close proximity to parts of Egypt also meant that some of its practices were also diffused to this region. Perhaps one of the most influential innovations was Levalloisian, a technique of manufacturing stone tools, which developed in this very same region as early as 150,000 year ago. As it developed and modified over the years, especially in Northern Africa, the Middle East and Southern Europe, the technique became influential in the evolution of agriculture. It became instrumental in the evolution of settlements, construction of canals and water-diversion mechanisms and in the long-run in the gradual evolution of irrigation practices in the drier areas of Egypt, Tunisia and the Middle East.

Conversely, the wetter lush grassland scrub sub-Saharan vegetation and environment presented considerable potential for both hunters-gatherers-fishers and pastoral peoples with their livestock. The sparsely populated Southern Africa especially with mainly mobile hunters and gathers who sustained their natural environment in various habituation cycles wasn't forced into concentrated settlements and sustained agriculture or farming practices until the Early Iron Age period. By this stage, or about the fifth century AD the relatively spread of iron-working and crop production had taken root to the vast regions of central, eastern and southern Africa. Its spread has been mainly attributed to migrations of small farming communities who spoke early forms of the Bantu family of languages. Some of them had over the years been exposed to the early Levalloisian techniques which also gravitated to around the wider Niger-Congo area.

As the southwards migrations continued skills and techniques were also transferred and more particularly more land gradually fell under newer settlements and farming demands. By the late Iron stage much of farming practices, which included water and moisture preservation for cultivation as in *Gelesha* (see below) were already evidenced, but significantly in South Africa, took place on the wetter eastern half of the region. In these areas with rainfall above 700 mm per annum, innovations found in the dry desert areas elsewhere in the world were not required because rainfall was sufficient to support crop-production without the need for such technologies.

### 5.3 Value of Indigenous Techniques

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The findings of the indigenous scoping study presented few cases which were not similar to those from arid areas outside of the country. Perhaps, the most surprising finding was that the number and range of indigenous water harvesting practices within South Africa were small. These, it seems, are mostly variations of much older techniques found in the arid parts of the world. This is perhaps because of the hunter-gatherer ways of life in earlier history, post middle-age settlement in the wetter eastern parts of the country and an emphasis on cattle.

There are two particularly interesting cases that are described: that of *Gelesha* and that of the *saaidamme*. While the other cases (terracing, contouring, etc.) have obvious value in their application and replicability, these are widespread and common in South Africa.



Gelesha (post-harvest tilling for infiltration) has value because of its truly indigenous history and its functional similarity to newer techniques such as mulching or trench-bed gardening. In these the express intention is to create conditions for maximum retention of rainfall and in the case of trench beds, concentrated runoff. Gelesha, like the related contemporary moisture-holding practices of mulching, can be used in any area suitable for crop-production. Perhaps more useful, for contemporary application, than the technology itself is the potential to use the historical practices to demonstrate to those learning a range of contemporary techniques, that these do go back in time and have deep African roots.

The 'saaidamme' (flood-spate irrigation) estimated in this study at some 35,000 ha in size in the dry Northern Cape, are remarkable because of their scale and the dramatic nature of diverting large flood flows which occur only every other year or so. The replicability of the saaidamme at a large scale is limited by the need for deep flat soils in proximity to zones of very high runoff. This seems unlikely to be found in other parts of South Africa at a similar scale as in the Northern Cape, but can be used as an inspirational example of what can be done in areas which seem to have hopelessly low rainfall. Early stage experimentation is currently underway at the University of Free State, where runoff from koppies is being transported in channels to fields with level contours some kilometres distant from the collection source. Saaidamme are an inspiration to the development of these smaller-scale, but conceptually similar techniques, that do have wider replicability across South Africa.

## 5.4 Opportunities for Future Research

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The main opportunities for future research relate to the saaidamme and potential for other more contemporary innovations to be documented and disseminated.

First, in relation to the saaidamme, the total area seems not to have been adequately measured and while an initial attempt was made in this study, the quantification is not sufficiently reliable as to the actual area under production using the saaidamme floodwater harvesting system. Measuring the extent of the saaidamme would require a thorough GIS based process of slope analysis, aerial photo overlay and measurement with field validation.

Secondly, the soil-water-plant relationship in the saaidamme suggests that there is a combination of a flood-recession mechanism and shallow groundwater that is available to plants with deep rooting systems. Flood recession agriculture is widespread in wetlands and floodplains across the world and production relies on a single saturation (flood event) and immediate planting so that root development proceeds downwards as the saturated ground slowly drains and dries from the surface down. Flood recession agriculture typically supports short-term annuals, but not usually perennial crops such as those found on much of the saaidamme. The supplementary groundwater component of the saaidamme system is suggested by the observation of lucerne tap roots in eroded fields after floods of between 8 to 10 metres deep at Hantam and Diepdrif farms outside Calvinia. These deep tap roots are reportedly widespread and farmers interviewed stated that these very deep and permeable soils are an essential requirement for

saaidamme – at least in these low-rainfall areas. This combination of a flood-recession water supply mechanism, and what seems to functionally be a shallow aquifer, albeit not well understood hydro-geologically, is suggested by the survival (and annual cutting of substantial yields) of established deep-rooted lucerne. This production is evident despite minimal rainfall (100 mm to 200 mm per annum) and the essential flood-spate irrigation which occurs only once every 2 or 3 years. The limited information on why the saaidamme system works so well from a soil-water-plant perspective has been hypothesized above as a combination of flood-spate irrigation plus the presence of localised shallow-aquifers, based on discussions with practicing farmers and extension officers in the area, but is not validated and warrants further scientific explanation.

Thirdly, the fact that relatively few indigenous technologies were uncovered by this scoping study could be explored in more detail from a social-historical perspective. Given the thorough scoping process of this study (which included literature review, extensive networking within the research and development community) it seems unlikely that a basket of South-African indigenous techniques has been entirely missed by the research team. This marked difference in prevalence between South African and areas north of our borders, was explained to some extent in this report based on historical migration patterns to the wetter eastern seaboard, combined with a primary reliance on cattle, which in combination did not demand rainwater harvesting interventions such as those in arid North Africa and Middle-East did historically demand. While this explanation provides some insight and rationale, rainwater harvesting is found in wetter parts of East Africa, perhaps through cultural assimilation in North Africa, which did not descend further south. Whatever the case, a more detailed exploration of the marked difference in the prevalence of techniques in South Africa, compared with further North, seems justified in that it could throw light onto challenges or barriers for knowledge assimilation which could assist contemporary initiatives promoting rainwater harvesting and conservation.

Finally, there are a range of contemporary, localised practices which reflect improved practices around water and soil conservation and which show local innovation. The quarterly publication by the NGO Prolinova for example focuses on innovations in agriculture broadly, including water. There are a range of organisations networking around rainwater harvesting nationally, including the WRC's Network for Irrigation Research and Extension in South Africa (NIRESA), and NGOs (including Water for Food Movement, AWARD, Prolinova, LIMA and Eco-Link among others) who are likely to have information on contemporary 'innovations' around agricultural water. These local innovations, are likely to originate from or build on existing indigenous knowledge and it is possible that an opportunity to document 'innovations' around agricultural water use could be translated into a research assignment. Subsequent dissemination through WRC channels would potentially impact a larger population of researchers, practitioners and farmers.

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