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WATER GAME CHANGERS AWARD

FROM WATER SCARCITY TO
WATER SOVEREIGNTY

DECEMBER 2025

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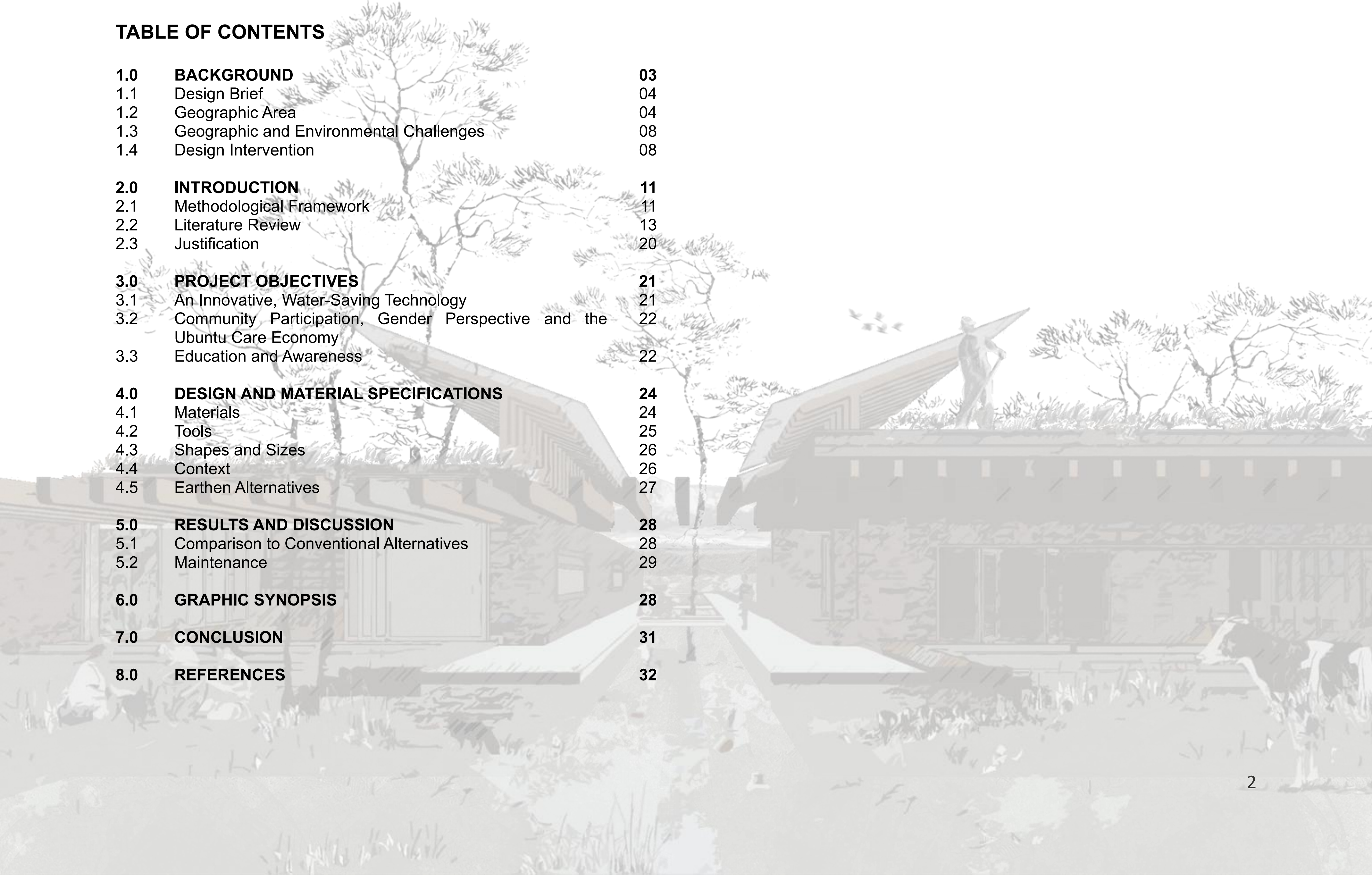

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0.0 ABSTRACT

South Africa faces increasing water scarcity, exacerbated by high levels of consumption and a prevailing culture of water inefficiency, particularly within irrigated agriculture and domestic garden irrigation. These sectors collectively represent a substantial proportion of national water demand, highlighting the urgent need for alternative, water-wise irrigation strategies. This report investigates the olla clay pot irrigation system as a low-skill technology, high water use efficiency (WUE) solution capable of addressing both behavioural and infrastructural challenges associated with water conservation. The olla system delivers water directly to plant root zones through controlled seepage, significantly reducing evaporation, runoff and over-irrigation. Unlike conventional large-scale water infrastructure, which often requires extensive capital investment, energy inputs and specialised maintenance, ollas are affordable, replicable and adaptable across rural and urban contexts, as well as small- and large-scale applications. The system further offers social and educational value by encouraging community participation, knowledge transfer and engagement with traditional terracotta craft practices. By reconnecting users with local water cycles and fostering a human-nature relationship, olla irrigation presents a viable and equitable approach to improving water efficiency while addressing ecological, social and cultural dimensions of water management.

A hypothetical architectural project in Limpopo Province, undertaken as part of an honours architectural degree at the University of Pretoria, served as the basis for investigating a nature-based ecotechnology applicable for this report’s focus on Gauteng and other regions across South Africa.

1.0 BACKGROUND

As part of the requirements for obtaining a degree in Architecture at the University of Pretoria, architecture students are typically required to design a hypothetical architectural project, rather than a real-life project.

1.1 Design Brief

The brief inspired the design of a Biodiversity Skills Centre (BSC) in Ga-Rantlakane, Limpopo, donated to the Lapalala Wilderness School by the community of Ga-Rantlakane. The Lapalala Wilderness School serves as the direct beneficiary, while the Ga-Rantlakane community benefits indirectly. The BSC is an agricultural and environmental skills training hub in the Waterberg District where local environmental knowledge, biodiversity conservation and awareness are fostered. Sustainable subsistence farming supports the local economy, enhances livelihoods and strengthens climate change resilience capacity.

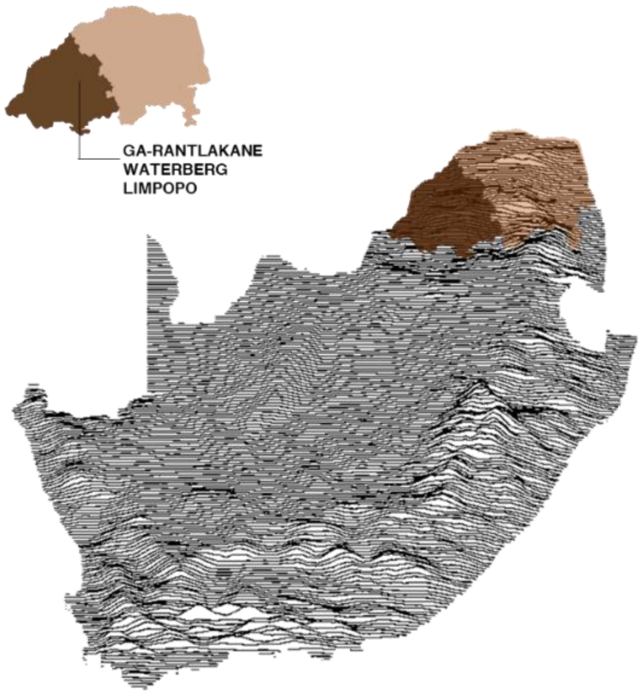
The project developed with a focus on water-sensitive design.

1.2 Geographic Area

Site coordinates: 23°55'30.5"S 28°37'34.1"E (Map 01)

Map 01: Ga-Rantlakane Site Boundary (Google Earth, 2025).

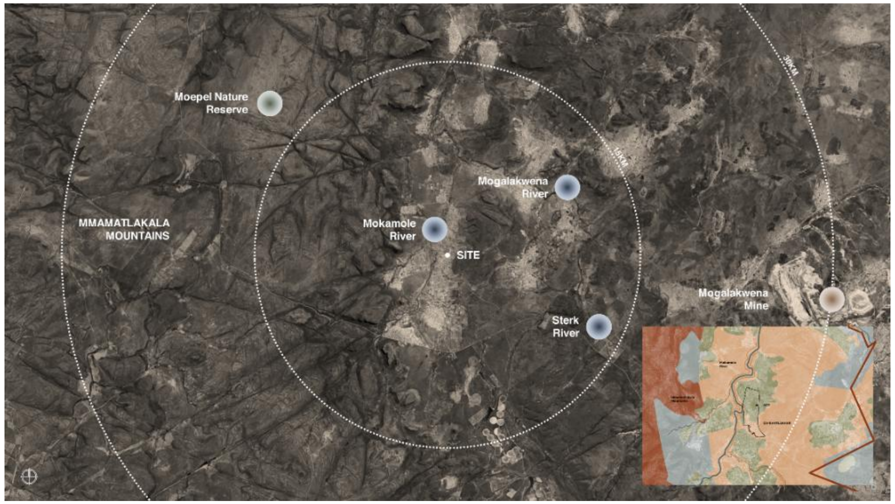
The BSC is situated in rural Ga-Rantlakane, Limpopo Province, within the Mogalakwena Local Municipality and the Greater Bakenberg Area. The site forms part of the UNESCO-designated Waterberg Biosphere Reserve which falls under the Waterberg District (Map 02) – recognised for its high biological diversity and uniqueness (MLM IDP, 2025:91), encompassing the first “savannah” biosphere reserve registered in Southern Africa (MLM IDP, 2025:89). Note that the nature-based ecotechnologies described and implemented are replicable at both rural and urban scales within Gauteng and across South Africa.



Map 02: Ga-Rantlakane in the Waterberg District, Limpopo Province, South Africa.

An extensive site analysis was conducted and is briefly documented, providing background of the context-responsive design and explaining the rationale behind key design decisions and criteria.

a. *Macro Context*



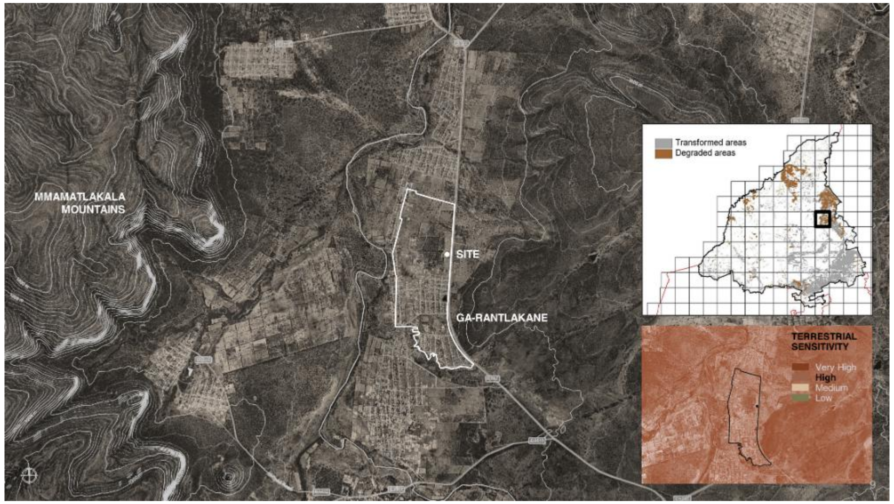
Map 03: Macro context.

The site is surrounded by biodiversity-rich areas within a 15 km radius. The Mmatlakala Mountains are of irreplaceable ecological value and hold significant historical and cultural significance for the Waterberg community along with the nearby rivers (MLM IDP, 2025:99). The Moepel Nature Reserve is one of the most important environmental assets of the Municipality and requires protection (MLM IDP, 2025:91). Roughly 30 km from the site, the Mogalakwena mine – established in 1993 – is the world's largest open-pit platinum mine, operated by Anglo

American (Anglo American, 2015). 70 million tons of waste rock are produced annually. The design project repurposes some of the rocks as primary (structural walls) and tertiary (cladding) architectural material for the construction of the BSC.

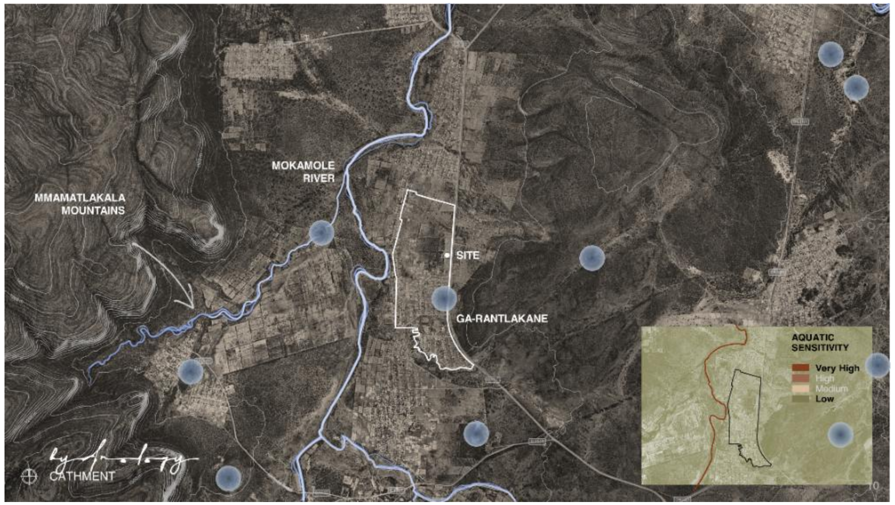
Critical Biodiversity Areas (CBAs) and Environmental Support Areas (ESAs) surround Ga-Rantlakane, with the Mokamole River as a key natural feature bordered by non-natural ESAs.

b. Topography and Hydrology



Map 04: Topography.

Gently to moderately undulating plains slope northward. The Mmatlakana Mountains' steep slopes contribute to the drainage lines in a northerly direction, bisecting the central topography (MLM IDP, 2020:60).



Map 05: Hydrology.

The surrounding waterbodies consist of both natural and artificial rivers and wetlands. The site includes both natural and transformed habitats.

c. Geology and Soils

Map 06: Geology and soil classification.

The Waterberg District's geology forms the foundation for the development of the landscape, soils and vegetation cover. It is the source of minerals that form the economic backbone of the district (WDEMF, 2010:21). According to Waterberg BioQuest (n.d.), the Aasvoëlkop formation is predominantly sandstone with significant occurrences of widely spread conglomerates, while the Diabase consists of post-Waterberg rocks (Dolerite).

The district's soils range from deep sandy to acidic sandy types, while the soils along the rivers have the highest agricultural potential and have therefore been most affected by past agricultural and human activities (MLM IDP, 2020:61).

d. Vegetation

Map 07: Vegetation classification.

The environmental screening tool (DFFE, 2025) locates the site within the Savanna Biome and classifies the vegetation as Makhado Sweet Bushveld (SVcb20). The area is defined by short, shrubby bushveld and a poorly-developed grass layer

(Mucina & Rutherford, 2006:474). Recent deforestation occurred due to development (Figure 01).

Figure 01: Deforestation occurred in 2024 due to development.

1.3 Geographic and Environmental Challenges

Geographic and environmental challenges include climate-related pressures such as global warming, climate change, increased flooding and veld fires; land degradation processes such as soil and wind erosion, deforestation, overgrazing and bush encroachment; biodiversity threats including alien invasive vegetation and poaching of both plants and animals. Human-induced impacts like mining, urban sprawl, informal settlements and inadequate sanitation systems pollute the environment, water, land and air. Further challenges include the poor management of landfill sites and illegal dumping in green open spaces, which collectively exacerbate the decline in environmental quality and ecosystem resilience. (MLM IDP, 2020:64-66; MLM IDP, 2025:117).

1.4 Design Intervention

Educational programmes include water-conscious subsistence farming, permaculture gardens, formal and informal classes, workshops (cooking; weaving; pottery), cattle zones, an amphitheatre and a tuck shop (Figure 02/03).

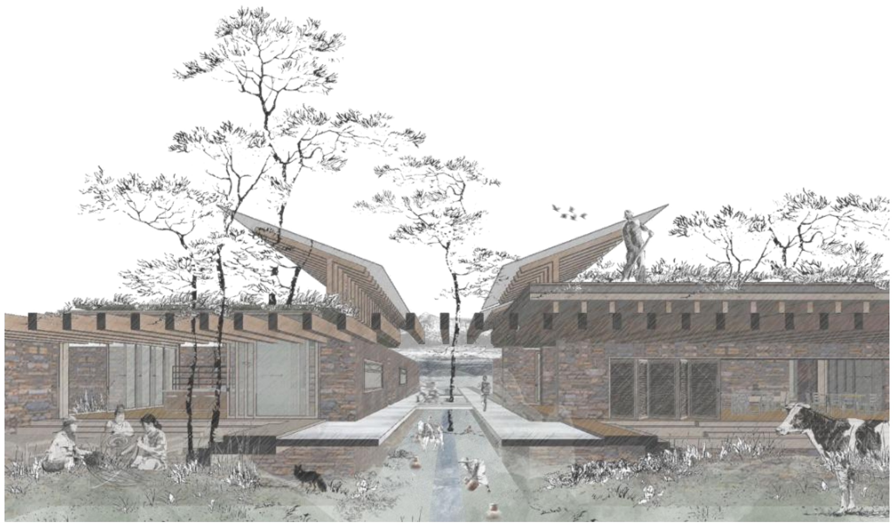


Figure 02: Section through outdoor weaving workshop, bioswale and classroom (Author, 2025).

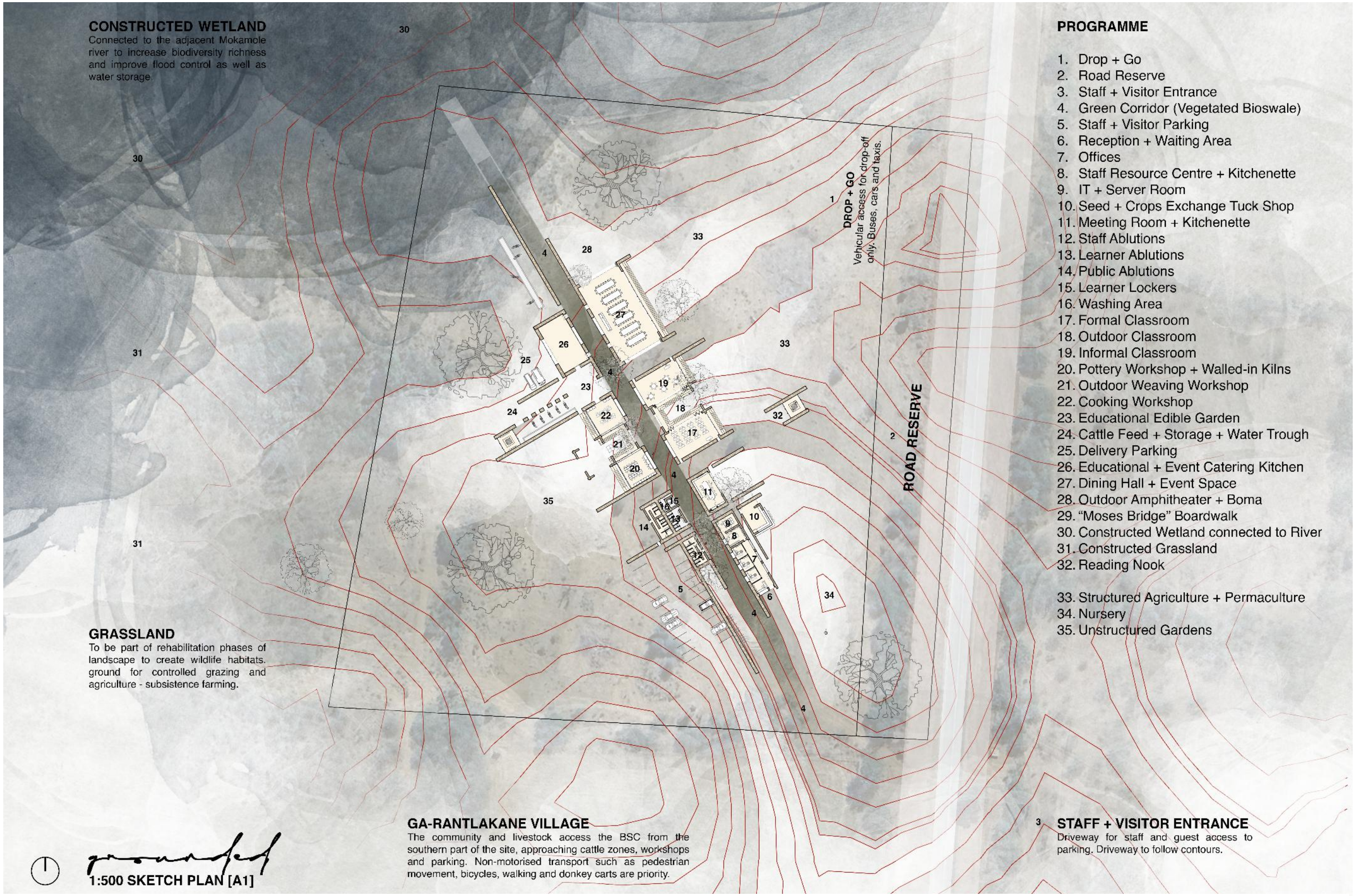


Figure 03: BSC plan and programme (Author, 2025).

BACKGROUND				
GEOGRAPHIC AREA	**GEOGRAPHIC CHALLENGES**	**ENVIRONMENTAL CHALLENGES**	**PROGRAMME**	**BENEFICIARIES**
Ga-Rantlakane, Limpopo (Rural)	**Macro + Meso + Micro Context**		**Biodiversity Skills Centre (BSC)**	**Direct + Indirect**
Mogalakwena Municipality	Global Warming + Climate Change	Transformed + Disturbed Areas	Subsistence Farming + Permaculture Gardens	Direct: Lapalala Wilderness School
Waterberg District	Floods + Veld Fires	Informal Settlements	Formal + Informal Classes	Indirect: Ga-Rantlakane community
Greater Bakenberg Area	Soil + Wind Erosion	Mining & Landfills	Cooking Workshops	
	Deforestation	Biodiversity Degradation	Weaving Workshops	
	Overgrazing	Habitat Loss	Pottery Workshops	
	Bush Encroachment	Water, Land + Air Pollution	Outdoor Amphitheater	
	Alien Invasive Vegetation	Deep Sandy Soils	Exchange Tuck Shop	
	Fauna + Flora Poaching	Hot + Dry (Water-scarce)	Cattle Zones	

Table 01: Background (Author, 2025).

2.0 INTRODUCTION

2.1 METHODOLOGICAL FRAMEWORK

a. Sources Consulted

Multiple resources were consulted, from which key themes were identified for further investigation (Table 02). The design concepts, developed in Quarter Three (Q3), served as the foundation for Quarter Four, which started off with a course introduction outlining the assignment brief and recommended themes for analysis. Guest lecturers presented real-life scenarios supported by relevant legislation and case studies, reinforcing the selected themes.

A virtual site visit facilitated desktop studies that informed a comprehensive site analysis.

Both independent and facilitated learning created opportunities for formal and informal knowledge exchange, enabling the collection and validation of valuable information. Professional landscape architects with first-hand experience of the site were consulted to provide expert insight, while independent studies expanded upon existing research of the site and its broader context. This included both published sources (online reports, articles and projects) and unpublished material (previous student research and documentation).

Building on insights from guest lectures, assessment tools were employed to support the improvement of design performance. These included the:

1. *SITES Rating System and Scorecard V2*
2. *Water Sensitive Urban Design* (WSUD) planning guide
3. *Sustainable Urban Drainage Systems* (SUDS) planning guide
4. *Chief Directorate National Geo-spatial Information* (CDNGI) *Portal* and
5. stormwater calculation spreadsheets provided by industry professionals.

Collectively, these resources enabled rigorous analysis and informed design decisions aligned with both research objectives and industry standards.

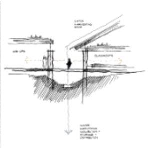
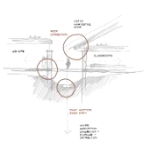
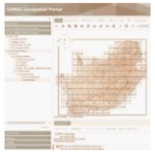
SOURCES CONSULTED					
0	1	2	3	4	5
Q3 DESIGN	COURSE INTRO	SITE VISIT	INDEP. STUDY	DEP. STUDY	TOOLS
					
Preceding research	Assignment brief	Virtual site visits	Desktop studies	Formal consultations	SITES
Design progress	Guest lectures	Virtual site analysis		Informal consultations	WSUDS + SUDS
	Legislation			Peer + progress reviews	CDNGI Geospatial Portal
	Themes				Water Calculations

Table 02: Sources consulted (Author 2025).

b. Criteria Selection Process

The criteria selection process was based on a comparison between the seven themes driving the research and design objectives: biodiversity conservation, environmental quality improvement, ecological footprint reduction, climate change adaptation, social cohesion promotion, green economy and green infrastructure. The main criterion, *water-sensitive design through green infrastructure (GI)*, was selected based on the theme that recurred most frequently and had the greatest influence on and connection to the other themes, as outlined in Table 03.

c. Criteria Application Process

The design included the following ecotechnologies and green infrastructure:

1) three types of green roofs that collectively harvest water, conserve biodiversity and provide a growth medium for sedums, herbs and perennial plant species
2) a constructed wetland
3) a vegetated bioswale (green corridor), connected to the constructed wetland, for capturing and filtering the rainwater harvested from the roof
4) sandbag construction of primary walls (excellent for community participation during the construction phases)
5) sandbag construction for emergency flood prevention along the constructed wetland and existing river
6) permeable surfaces

7) evaporative beehive cooling walls
8) straw checkerboard technique
9) rope wicks
10) olla clay pot irrigation system

For the purposes of this state-of-the-art literature review, only the olla clay pot irrigation system will be discussed, as this system encourages the use of traditional terracotta crafts, indigenous knowledge, natural and locally available materials, low-technological construction skills and maintenance methods, community participation and water-saving practices that are suitable, scalable and replicable for gardens or landscapes in both rural and urban environments in Gauteng and across South Africa.

This makes it easier for everyday individuals to change their water-use behaviour, as the technique is accessible and straightforward. The other ecotechnologies and green infrastructure tend to be more complex, requiring specialised knowledge as well as high-technological skills, which can hinder full community participation and, therefore, long-term practice and maintenance.

2.2 LITERATURE REVIEW

"South Africa is known for water wastefulness."
DWS, 2025:174

2.2.1 Current National Water Statistics

South Africa is a water-scarce country with an average annual rainfall of 450 mm, which is half the world average. Of the world's 195 countries (Worldometer, 2025), South Africa ranks as the 30th driest (DWS, 2025:174).

Nearly half of the water supplied in South Africa is not effectively used, highlighting serious inefficiencies in the system and the urgent need for better water management. DWS (2023:vi) reports that 1.79 million m^3 (40.8%) of potable water losses could have been avoided annually thus far.

a. The Country's Largest Consumer of Water

The **irrigated** agricultural sector consumes more than 61% of South Africa's annual freshwater usage, making the agriculture

CRITERIA SELECTION PROCESS

THEME 0	THEME 1	THEME 2	THEME 3	THEME 4	THEME 5	THEME 6	THEME 7
Q3 DESIGN	**Biodiversity Conservation**	**Environmental Quality Improvement**	**Ecological Footprint Reduction**	**Climate Change Adaptation**	**Social Cohesion Promotion**	**Green Economy**	**Green Infrastructure (GI)**

Preceding Themes	Sensitive Environmental Features	Identifying and Protecting Sensitive Areas	Sustainable Site Initiatives	Water-sensitive Design	Access and Equity	Renewable Resources	Green Infrastructure (GI)
Design Progress	Sensitive and Protected Areas	Phased Rehabilitation and Restoration	Low-impact Development	Manage Extreme Flooding Events	Community Participation in Design	Community Participation	
	Critical Support Areas			GI to Manage Heat Waves	Community Participation in Implementation	Co-creation	
					Community Ownership	Management	

Table 03: Criteria selection process (Author, 2025).

sector the largest consumer of water (DWS, 2025:175). The sector irrigates 1.6 million hectares, using up to 13.6 billion m^3 of water each year (NWRS3, 2023:20).

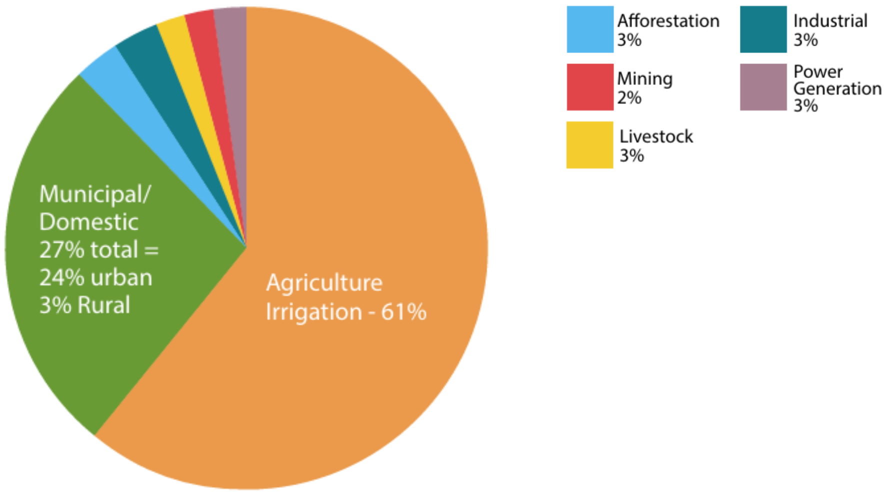


Figure 04: Water resource use by sector in SA (NWRS3, 2023:15).

The sector's reliance on water-intensive irrigation systems, outdated irrigation practices and general water use inefficiencies place significant strain on already limited water resources (DWS, 2025:175). Water use efficiency (WUE) differs markedly across regions, with substantial losses attributed to inadequate in-field irrigation practices, as well as conveyance inefficiencies in canals and pipelines (DWS, 2025:175). According to the NWRS3 (2023:15), average water losses across known irrigation schemes (25% unknown) are estimated at approximately 30%.

Agriculture is essential to national food security and the livelihoods of many rural communities, including Ga-Rantlakane, facing high levels of poverty.

Both large- and small-scale, urban and rural farmers are forced to find alternative water sources, adopt water-saving irrigation methods or reduce cultivated areas to conserve water. Yet, these measures often further reduce crop yields, placing severe financial strain on farming communities DWS (2025:80). To ensure long-term agricultural productivity and sustainability, the sector must therefore transition towards more conservative and efficient water management approaches.

b. The Country's Second Largest Consumer of Water

An **irrigated** garden or landscape can consume over half of the municipal water supplied for domestic or household end-use.

As illustrated in Figure 04, municipal and domestic water use is the second largest consumer of water at 27% (NWRS3, 2023:15). DWS (2025:174) states that South Africans currently consume approximately 218 litres of water per person per day, which is 26% above the global average of 173 litres. Gauteng records the highest use at 266 litres per day, followed by the Northern Cape at 247 litres. Garden irrigation is often reported as a significant portion of total per-capita water use (Meyer & Jacobs, 2019:447).

Meyer and Jacobs (2019:448) found that garden irrigation accounts for approximately 40% to 60% of annual household water end-use in South Africa, with some data indicating levels of up to 70%. According to The Gardener (n.d.), an average household with a garden can use 150 to 200 litres of water per person per day indoors, plus an additional 200 litres per day for garden irrigation.

Food for thought: the typical South African garden features mowed lawns – short grass that supports little biodiversity and requires minimal watering. According to Contours Landscapes (2024), such lawns typically need 25 to 40 mm of water per week, including rainfall – not 200 litres per day.

During water restrictions, outdoor use is the primary target (Meyer & Jacobs, 2019:447). Level One water restrictions issued by the City of Tshwane (CoT) state that gardens may not be watered or irrigated with a hosepipe or sprinkler system between 06:00 and 18:00 (Mostert, 2024).

Meyer and Jacobs (2019:447) identify three primary irrigation methods: hand-held hoses, manual sprinklers and automated sprinklers, with automated systems contributing the largest share of garden irrigation volumes in end-use.

Du Plessis and Jacobs (2015:803), Meyer and Jacobs (2019:447) and Du Plessis *et al*. (2020:3) note that outdoor household water end-use (irrigation and evaporation from swimming pools) is less predictable than indoors, as outdoor water use presents a combination of seasonal and behavioural aspects. Seasonal examples include increased garden irrigation during hot, dry periods with low rainfall (Meyer & Jacobs, 2019:447). Du Plessis *et al*. (2020:13) states that water use increases in more arid regions. South Africa, one of the dryest countries globally, is largely arid or semi-arid with 85% of the country classified as drylands (Le Roux & Makhalanyane, 2024) receiving low rainfall – well below the global average. Behavioural aspects can range from religious events, to residents' sense of social status, mental health and monetary value (Du Plessis *et al*., 2020:3).

South Africans must adopt a water-conscious culture. Citizens should be made aware of the short- and long-term impacts of disruptions to the water cycle by understanding the primary sources of water loss and pollution.

2.2.2 Current Challenges – The Problem

> *"The Department of Water and Sanitation (DWS) has reiterated a call for continuous* ***action from all citizens*** *to secure the country's scarce resource* ***through a change of behaviour towards water usage****."*
>
> *SANews, 2024*

Change starts with the individual's behaviour towards water.

While expensive, large infrastructure-scale projects play an important role, their implementation rate is often slow. Examples include constructing dams, restoring waterbodies such as rivers and wetlands, converting solid concrete stormwater sidewalks into permeable surfaces, introducing bioswales and even smaller, but more complex projects like installing green roofs. Long-term impact can be achieved more rapidly through collective behavioural change by everyday individuals adopting accessible water-saving techniques. Collective action by individuals can therefore catalyse more immediate and widespread water-saving outcomes.

For this reason, the existing ecotechnology presented in this report aim to encourage garden and farm owners to adopt an unconventional hybrid irrigation method, significantly reducing water use for landscaped garden irrigation.

2.2.3 The Proposal: Uncommon Irrigation Methods in South Africa

The ecotechnology recommended is based on the must-read book *Gardening with Less Water: Low-Tech, Low-Cost*

Techniques; Use Up to 90% Less Water in Your Garden by David Bainbridge.

The author's research into super-efficient irrigation originated in the 1980s at the Dry Lands Research Institute, University of California, Riverside, where ancient buried clay pot irrigation methods were examined and experimentally adapted. Drawing inspiration from historical precedents, notably Chinese agricultural practices and Middle Eastern Nabatean water-management systems, the irrigation systems were developed and tested primarily in the western Sonoran Desert under extreme arid conditions, with annual rainfall of approximately 75 mm, high temperatures, remote sites and limited water access often requiring transport by truck. The systems were designed for resource-constrained contexts and targeted small-scale farmers, gardeners and landholders – particularly those with limited land, poor-quality or saline water and minimal technical skills. The overarching aim was to create low-cost, locally constructible irrigation solutions suitable for arid, semi-arid and seasonally dry regions, with particular relevance for resource-limited farmers globally who face increasing water scarcity and climatic variability.

a. The Olla Clay Pot Irrigation System

An ancient North-African and Chinese watering method (Showmia *et al*., 2022:1756; Bainbridge, 2015:7,18) using porous, unglazed terracotta pots (ollas) (Figure 05) filled with water, buried in soil to slowly release water through controlled irrigation by capillary flow to plant roots (Bainbridge, 2015:7,18), reducing evaporation and runoff while encouraging deep root growth.

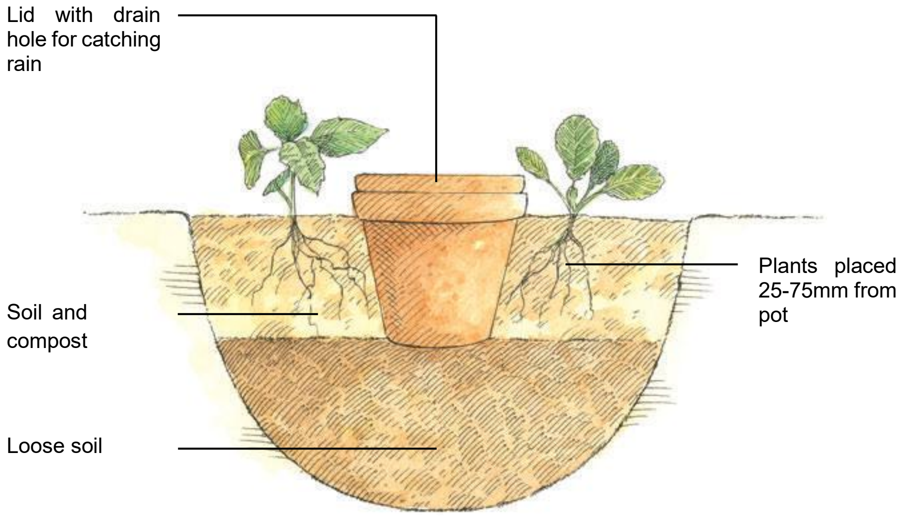


Figure 05: A closed olla buried in soil (Bainbridge, 2015:28).

Figure 06: An open olla buried in soil with crops (Bainbridge, 2015:20).

It is a self-regulating, low-cost and environmentally friendly irrigation technique with a high potential for both water and energy savings, especially suitable for WUE in arid regions (Showmia *et al*., 2022:1755). Up to ten times more efficient than conventional surface irrigation (Bainbridge, 2015:18), olla irrigation conserves 60% to 70% more water when compared to modern drip and sprinkler irrigation systems (Showmia *et al*., 2022:1756, 1759).

Ollas can operate without pressurised or filtered water and can be produced almost anywhere in the world using locally available materials and skills (Bainbridge, 2015:18), encouraging low-technological craftmanship in both rural and urban communities. The pots vary in shape and size, allowing potters – both men and women; adults and children – to incorporate their own personal expression and identity. This enables replicability across multiple project scales.

Bainbridge (2015:20) highlight that the consistent, steady water supply provided by buried clay pots enhances germination, promotes crop growth, accelerates maturity, reduces disease incidence and increases yields, even under conditions of high temperatures, low humidity and drying winds. This method is also effective in sandy or gravelly soils with rapid drainage, as well as in saline or alkaline soils or water (Bainbridge, 2015:20; Showmia *et al*., 2022:1755). By delivering water and soil amendments directly to plant roots rather than across entire plots, the system suppresses weed growth and lowers fertiliser use (Bainbridge, 2015:20), while reducing the labour required for weeding (Showmia *et al*., 2022:1755).

2.3 JUSTIFICATION

Conventional water infrastructure approaches have proven insufficient in addressing water scarcity, inequality and ecological degradation (DWS, 2025:177). Large-scale engineering solutions often require significant capital investment, ongoing energy inputs and specialised maintenance, placing them beyond the reach of underprivileged communities. Furthermore, such systems tend to externalise environmental costs by transferring pollution downstream and disconnecting settlements from local water cycles.

The innovation of the project lies in the integration of existing, proven ecotechnologies into a closed-loop, nature-based water system that supports indigenous knowledge and locally available materials, skills and craftsmanship across rural and urban contexts.

The olla irrigation technique is justified by the need for an alternative approach to water-wise agriculture or gardening – one that is regenerative rather than extractive, decentralised rather than centralised and participatory rather than top-down. The proposed ecotechnology responds to this need by integrating nature-based and traditional systems into a coherent water-cycle framework that operates at community scale, encouraging community participation, education, awareness and economic benefits.

3.0 PROJECT OBJECTIVES

3.1 AN INNOVATIVE, WATER-SAVING TECHNOLOGY

The primary objective of the project and nature-based solution (NBS) is to save water and cultivate a water-conscious culture. As previously mentioned, ollas can be up to ten times more efficient than conventional surface irrigation (Bainbridge, 2015:18), conserving 60% to 70% more water.

The olla watering technique is a promising irrigation method that has proven effective under climatic conditions comparable to those of South Africa. The use of clay pots offers potential to alleviate water demand pressures associated with both irrigated agriculture and household garden irrigation.

3.2 COMMUNITY PARTICIPATION, GENDER PERSPECTIVE AND THE UBUNTU CARE ECONOMY

The community can co-create the water-saving solution, as pottery is a widespread traditional and cultural craft practiced in many communities. This facilitates skills training, knowledge transfer, implementation and replication across the country. Communities can take ownership of the technology once they fully understand the making and maintenance process, enhancing stewardship and local resilience. Pottery is inherently diverse in nature, existing on a spectrum ranging from low-cost, functional objects to high-value luxury goods, and from high-technology, energy-intensive firing processes to basic, low-technology methods such as open-fire kilns.

It is, however, important to note that the olla pots must adhere to certain design and material specifications, as discussed in Section 4.0, in order to be effective.

Benefits of NBS often favour the most disadvantaged and vulnerable, such as minority communities, rural communities and women (WWAP, 2018:67). Decentralised water access reduces the burden on women and children, supporting gender equity. Pottery, and therefore the olla clay pot irrigation method, is not limited to gender and age. Due to its diversity, replicability and scalability, people of all ages and genders can build a water-conscious culture through pottery.

3.3 EDUCATION AND AWARENESS

Community participation offers a hands-on learning experience to community members.

By designing water infrastructure that is visible, legible and intertwined with daily life, the olla pots serve an educational function, increasing awareness of water cycles and human impacts on them. Tangible water flows support environmental education – replicating NBS, lessons and traditional knowledge in community contexts (WWAP, 2018:vi,6,48,59).

Community members are not positioned as passive consumers of water services, but as active custodians of water systems that support both human and ecological well-being. Empowering local communities through the transfer of management rights enhances their capacity and creates increased opportunities for economic growth (WWAP, 2018:81).

The approach demonstrates how nature-based ecotechnologies, grounded in indigenous knowledge and community participation, can contribute to water autonomy and sovereignty while restoring ecosystems. The approach offers a replicable model for townships and rural areas in Gauteng and beyond, capable of addressing immediate water needs while laying the foundation for long-term transformative change.

3.4 WATER AS HUMAN AND ECOLOGICAL RIGHT

As per the Constitution of the Republic of South Africa, Section 29, every person has the right to education, awareness and knowledge (The Constitution, 1996:12). Access to water-saving knowledge, methods and techniques will ensure broader access to safe water practices and mitigation strategies for climate change adaptation as a basic human right (WWAP, 2018:24). Decentralised water access through rainwater harvesting and reuse supports both human and ecological rights.

For watering methods to be truly sustainable, it has to give back to nature and nature's ecosystems. By conserving a significant amount of water, ollas help reduce the over-extraction and excessive use of potable water for irrigation, contributing to more sustainable water management and alleviating pressure on local water resources.

According to Showmia *et al*. (2022:1755), the system relies on soil moisture tension. When the surrounding soil is dry, water seeps out directly to the root zone under the surface, keeping the top soil layer relatively dry, which inhibits weed growth. When the surrounding soil is wet, the flow stops and prevents overwatering.

UC (2024) states that plants grown with ollas develop deeper, more robust root systems, as they grow towards the underground moisture source, making them more resilient to drought and environmental stress through enhanced nutrient and water uptake.

Bainbridge (2015:20) highlight that the consistent, steady water supply also enhances germination, promotes crop growth, accelerates maturity, increases yields and reduces disease incidence. By maintaining consistent moisture levels, ollas improve soil structure and prevent the extremes of wet and dry, which can cause soil compaction or erosion.

For ollas to be effective, certain design and material specifications should be taken into consideration.

4.0 DESIGN AND MATERIAL SPECIFICATIONS

4.1 MATERIALS

Irrigation clay pots are handmade from unglazed terracotta across the globe. Standard red terracotta pots are ideal because they come in many sizes and are widely available. Clay pots should be unglazed and free of wax, paint or other coatings which can prevent porosity. Porosity can be easily tested by spraying the pots with water to see if they dampen quickly or by submerging them in water to ensure they absorb it fully. Two to four litres pots are convenient, though smaller or larger sizes can also be used. 200mm diameter by 250mm tall pots are practical and their bases work well as lids.

Figure 07: A standard red terracotta pot (Bainbridge, 2015:22).

While terracotta is most common, similar permeability can be achieved using alternative materials such as concrete by adjusting the fine aggregate and sand content (Bainbridge, 2015:24). However, unlike earthen materials, concrete is a well-known carbon-intensive material whose production generates high greenhouse gas emissions, thereby contributing significantly to environmental degradation.

The firing conditions directly influence porosity, durability and performance, with porosity controlled through the clay mix and firing temperature. Potters can adjust permeability by varying the proportions of clay, sand, grog (crushed fired pottery) and other additives, noting that higher grog content generally increases porosity. Wall thickness, clay type and additives all affect water seepage and should be tested through small-scale trial firings before full production. Firing temperatures should remain below approximately 1000°C to prevent vitrification and loss of porosity, yet be sufficiently high to avoid structural degradation in saline or alkaline soils. (Bainbridge, 2015:24).

4.2 TOOLS

In today's digitally connected world, modern technologies develop at a fast rate.

Although irrigation clay pots can be handmade, advanced technologies allow creatives to explore high-technological alternatives like 3D printed clay.

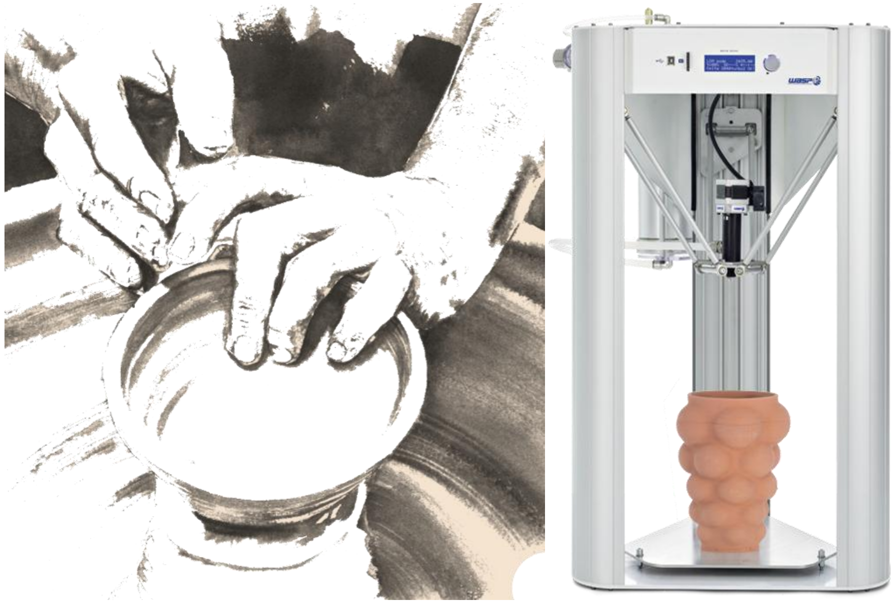


Figure 08: *Left*: Handmade pottery. *Right*: 3D printed pottery by WASP 3D Printer.

Whether handmade or 3D printed, unglazed terracotta pots should still be fired in a kiln to ensure the pot does not crumble to its original raw form. Different kilns, both primitive and modern, are available. Primitive kilns include pit, surface, trench, self-built brick and basic convection kilns. Modern kilns include electric, gas, wood-fired, top-loading, front-loading, industrial tunnel, shuttle, raku, dual media and soda kilns.

Figure 09: *Left*: Self-built sawdust brick kiln. *Right*: Modern electric SKUTT kiln.

4.3 SHAPES AND SIZE

Although the pots vary in shape and size, it is important to understand the implications thereof. They tend to be round pots with narrow necks, cylinders or standard terra-cotta nursery pots (Bainbridge, 2015:18). Once buried up to the neck in the soil and filled with water, pots are closed with terracotta lids or even rocks to reduce evaporation. Ollas take up a portion of the available garden space, which can present a constraint in very small gardens (Nickel & Brischke, 2021:3). It is important to plan ahead of installation and implementation.

If incorrect pot sizes are installed, seedlings and new transplants will need supplemental water for some time until their roots can find their way towards the olla in order to tap into the consistent water source – a process that may take a month or longer before the plant can rely solely on the olla for irrigation (Nickel & Brischke, 2021:3).

Narrow-necked vessels with small openings are easier to seal and plant around, whereas wider openings simplify filling and allow rainwater capture. Additional design considerations include handles for lid removal, taller necks for use in containers and glazed or painted rims to improve durability, visibility and ease of maintenance without compromising overall permeability (Bainbridge, 2015:24).

4.4 CONTEXT

The pot’s form should respond to its context and planting scale: smaller volumes (1 to 2 or 4 to 7.5 litres) suit garden beds, while larger pots (10 to 15 or 15 to 20 litres) are appropriate for trees (Bainbridge, 2015:24; Showmia *et al*., 2022:1756,1757). The pot's wall thickness determines the rate at which water seeps through the clay and is, in turn, partly determined by the plant's water requirements (Bainbridge, 2015:18).

The type of plant plays a role, as plants with woody roots can break the olla (UC, 2024). Plants or crops that are suitable for the olla irrigation system include, but is not limited to, a wide range of annual and perennial plants such as melons, tomatoes, chilli, onion, squash, corn, sunflower, peas, cucumbers and marigold (Showmia *et al*., 2022:1758).

Depending on the area of the garden or field, the number of ollas should create an even coverage across the planting area UC (2024). In addition to this, hand filling can be time consuming and unreliable if one leaves the ollas unattended for a long time as salts may build in and clog the pores of the olla (Nickel & Brischke, 2021:3). However, Bainbridge (2015) presents the reader with earthen alternatives that involve minimal modifications or small additions to the olla clay pot system, without compromising WUE.

4.5 EARTHEN ALTERNATIVES

The following alternatives are extracted from Bainbridge's book: *Gardening with Less Water*.

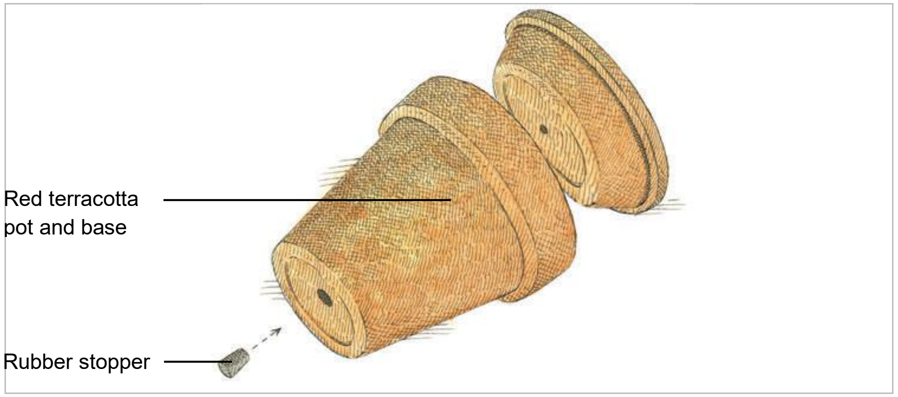


Figure 10: A typical olla clay pot with a rubber stopper (Bainbridge, 2015:23).

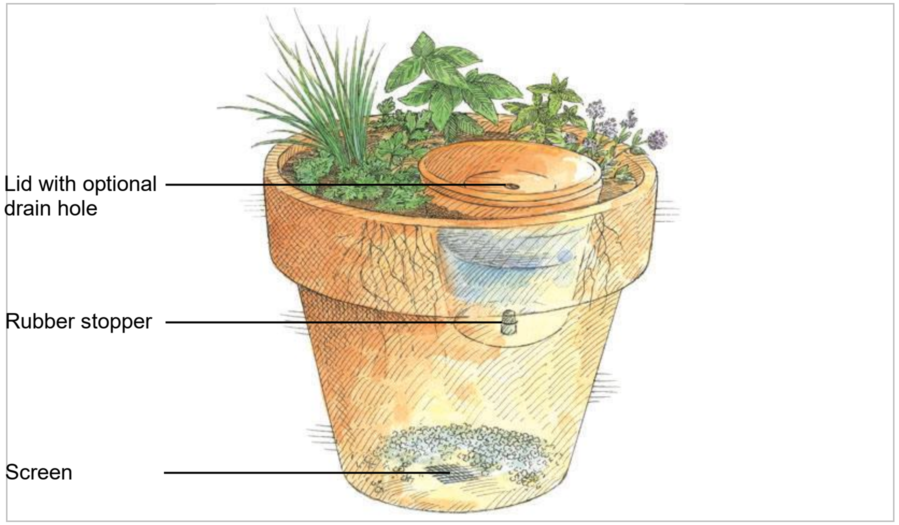


Figure 11: Double olla clay pots for container plants (Bainbridge, 2015:25).

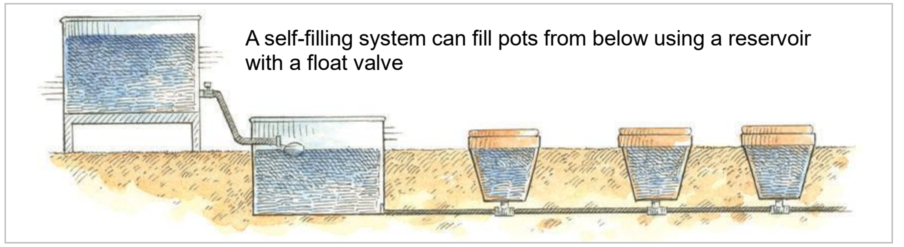


Figure 12: Self-filling olla clay pot system connected to reservoir (Bainbridge, 2015:31).

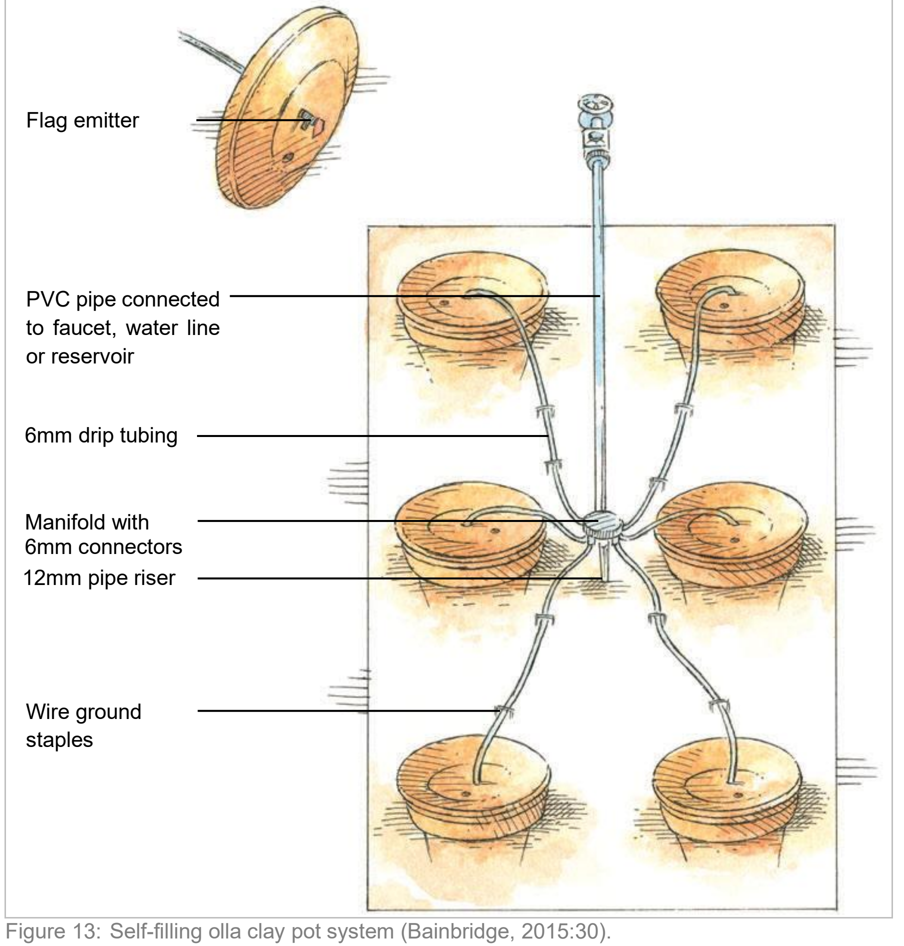


Figure 13: Self-filling olla clay pot system (Bainbridge, 2015:30).

Other alternatives are further discussed in the book, but these examples illustrate the versatility of the olla clay pot system, making it suitable for both small gardens, which require manual refilling, and large farms, where automated refilling can be implemented.

5.0 RESULTS AND DISCUSSION

5.1 COMPARISON TO CONVENTIONAL ALTERNATIVES

It is difficult to provide exact quantities as case studies on different irrigation systems are limited and irrigation systems depend on numerous aspects. Conventional irrigation sprinklers depend on the type of sprinkler, its age and condition, water pressure and flow rate, nozzle size as well as head-to-head spacing. Ollas depend on the pot size, plant type, rainfall, growing season and type of earthen system (for example, a self-filling reservoir olla system will last much longer).

Larger ollas (20+ litres) can be replaced once every week to three weeks (Bainbridge, 2015:20,29), while smaller ollas (1 to

2 litres) can be replaced every two to five days (Bainbridge, 2015:29).

Standard garden hoses and irrigation sprinklers can use approximately 1000 litres of water per hour (Irrigreen, 2023), an amount equivalent to what one person would typically use over the course of an entire week (Manning, 2020; GWMWater, n.d.). Pop-up and oscillating sprinklers typically use 500 to 1000 litres per hour (Irrigreen, 2023).

According to a study conducted by Meyer & Jacobs (2019:447), an average automated garden irrigation event of 2 hours and 16 minutes used around 1.39 m^3 (1390 litres) of water, which is approximately 10 litres per minute or 600 litres per hour.

The olla clay pot irrigation system and its earthen alternatives clearly demonstrate strong potential as water-wise irrigation techniques. Given South Africa's water constraints, the system warrants serious consideration across both rural and urban contexts. Although it is a primitive and ancient method with a long record of successful use, its application today remains limited.

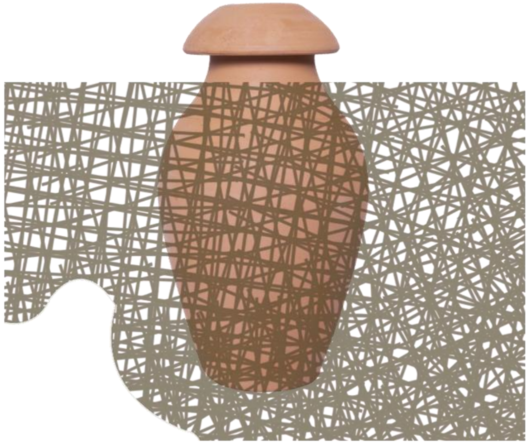
5.2 MAINTENANCE

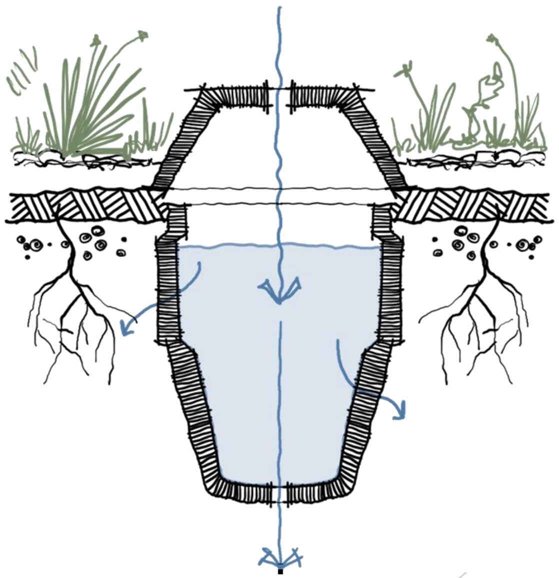
Fertiliser should not be added directly to the pot water, as this can clog the pores and promote algae growth. Instead, liquid fertiliser or manure tea should be applied to the surrounding soil. At the end of the growing season, pots should be thoroughly scrubbed and stored upside down to prevent water retention and insect breeding. If calcium deposits develop, the pots can be soaked in vinegar to remove buildup. Where rubber stoppers are used, these may be removed after approximately one year to encourage deeper water penetration into the soil. Pots can typically be removed and repositioned after two to three years of use.

If watering and refilling of ollas become more frequent, inspect the pots for any leaks resulting from cracks or defective rubber stoppers.

6.0 GRAPHIC SYNOPSIS

Refer to the following illustrations for a summary of the written content above.





10 times more efficient than surface irrigation

Saves up to **70%** garden water use

Water only seeps out when the soil is dry and when the plants need water

Roots **absorb moisture only when needed**, never wasting a single drop

Once the soil is wet, the clay pot stops seeping

OLLA CLAY POT IRRIGATION

An ancient North-African and Chinese watering method using unglazed terracotta pots (ollas) buried in soil to slowly release water to plant roots, reducing evaporation and runoff while encouraging deep root growth.

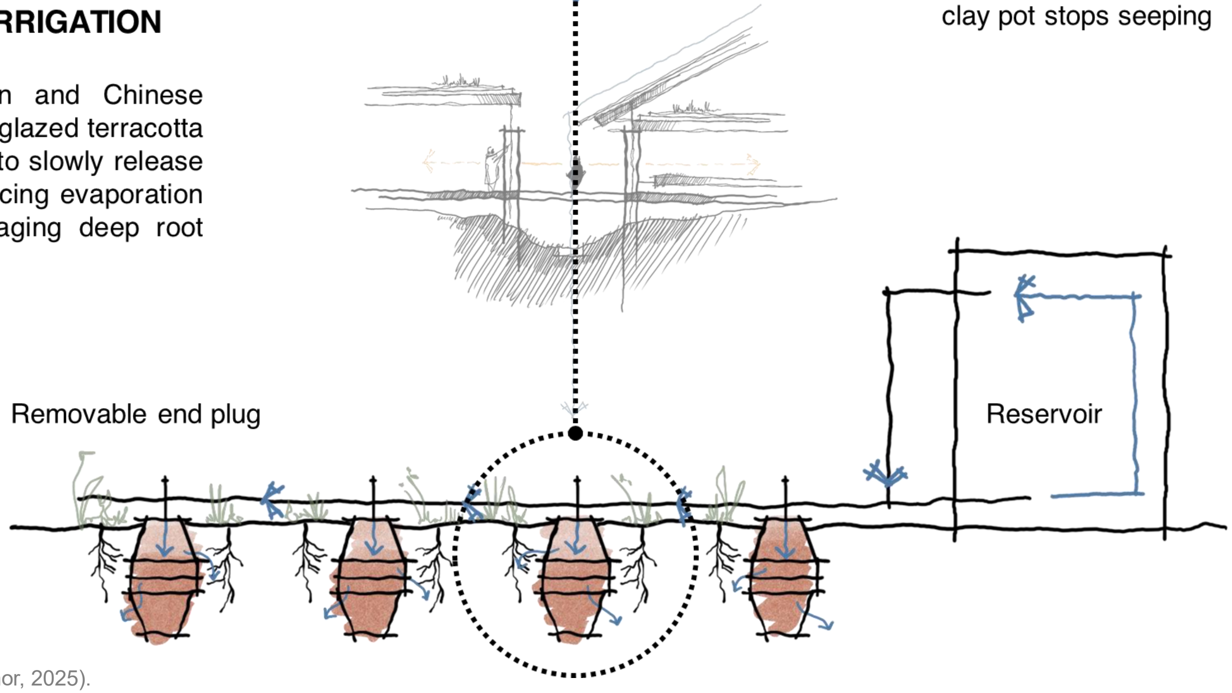


Figure 14: Olla clay pot irrigation summary (Author, 2025).

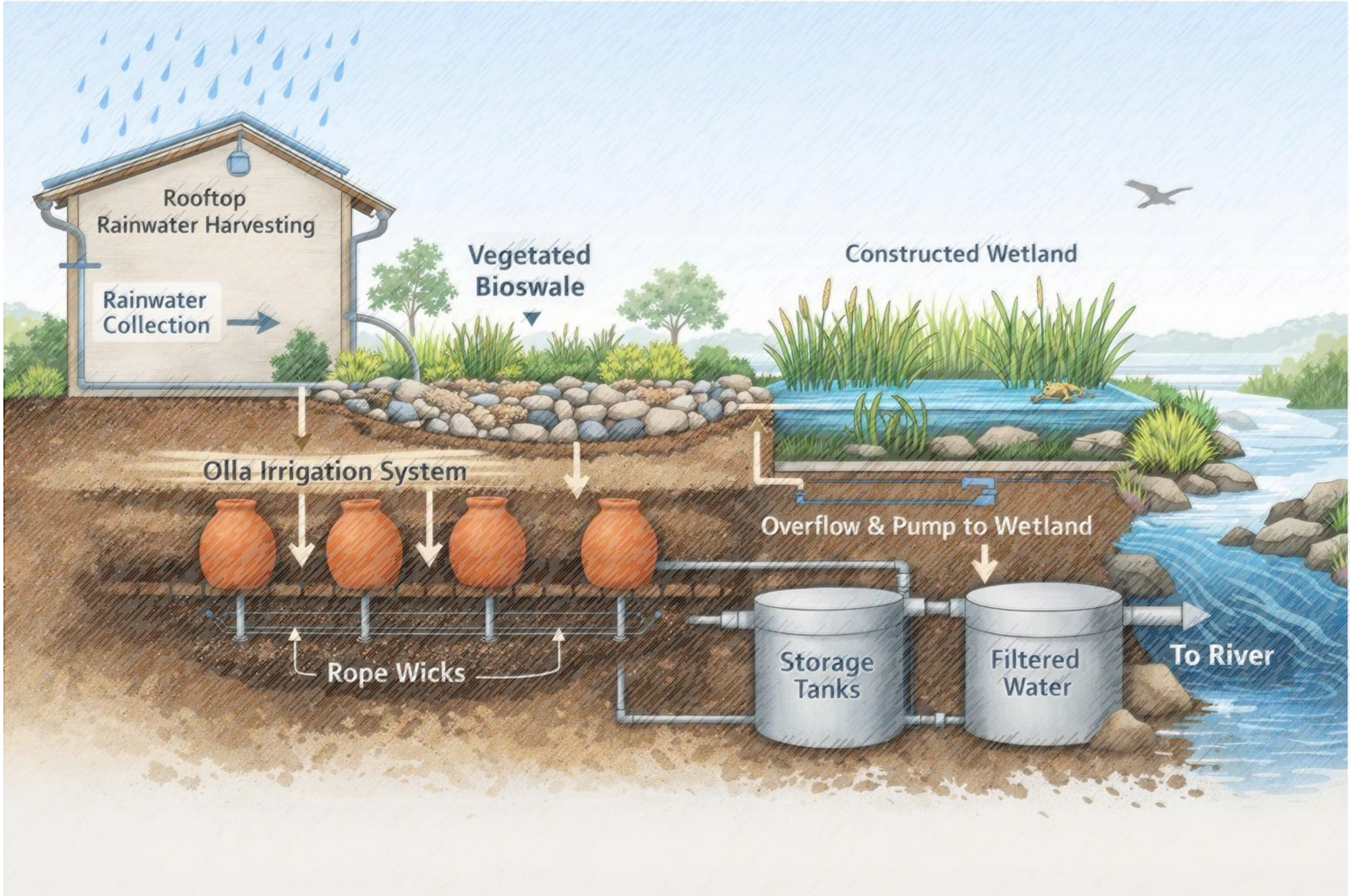


Figure 15: Illustration showing a larger-scale project that incorporates more echotechnologies than ollas (ChatGPT, 2025).

7.0 CONCLUSION

This report demonstrates that the olla clay pot irrigation system offers a highly water-efficient alternative to conventional irrigation methods, particularly within contexts marked by water scarcity, inequality and infrastructural limitations. In contrast to large-scale engineered solutions, which are often costly, energy-intensive and slow to implement, ollas provide an accessible, low-impact technology that significantly improves water use efficiency by minimising evaporation losses and delivering moisture directly to plant roots. Their scalability and replicability allow for application across diverse settings, from small urban gardens to larger agricultural plots, with minimal modification. Beyond their technical performance, ollas serve an important educational and social function by addressing behavioural aspects of water use, promoting awareness and encouraging community participation and co-creation. The integration of traditional terracotta crafts further supports cultural identity and introduces a gender-sensitive dimension to water management practices. When appropriate design, material selection and maintenance considerations are considered, olla irrigation systems effectively bridge primitive and modern technologies, offering a sustainable, inclusive and ecologically responsive approach to water-wise irrigation in South Africa.

8.0 REFERENCES

Anglo American. 2015. Mine profile – Mogalakwena. [Online] Available at: https://www.angloamerican.com/our-stories/innovation-and-technology/mine-profile-mogalakwena [Accessed 20 October 2025].

Bainbridge, D. A. 2015. Gardening with less water: low-tech, low-cost techniques – use up to 90% less water in your garden. Berkshires, MA: Storey Publishing.

Contours Landscapes. 2024. *Lawn mowing 101: inspiration for a beautiful lawn*. [Online] Available at: https://www.capecontours.co.za/lawn-mowing-101/#:~:text=Step%203:%20Watering%20Wisely%20to,mowing%20easier%20and%20more%20efficient [Accessed December 2025].

DFFE. 2025. *National web based environmental screening tool*. [Online] Available at: https://screening.environment.gov.za/screeningtool/#/pages/welcome [Accessed 3 April 2025].

Du Plessis, J. L. & Jacobs, H. E. 2015. Procedure to derive parameters for stochastic modelling of outdoor water use in residential estates. *Procedia Engineering.* 119(2015). [Online] Available at: https://www.sciencedirect.com/science/article/pii/S1877705815026120 [Accessed December 2025].

Du Plessis, J. L., Jacobs, H. E., Ilemobade, A. & Crouch, M. 2020. Establishing a household water consumption benchmark for South Africa. *Water Research Commission – June 2020. (No. 2980)*. [Online] Available at: https://wrc.org.za/?mdocs-file=59800 [Accessed December 2025].

DWS (Department of Water and Sanitation). 2023. *The status of water losses, non-revenue water & water use efficiency in South African municipalities (2012/13 to 2022.23)*. Pretoria, South Africa.

DWS (Department of Water and Sanitation). 2025. *National state of water report 2024. Integrated water resource studies report number WII/IWRS/NSoW-2024*. Pretoria, South Africa.

GWMWater. n.d. *How much water you use*. [Online] Available at: https://www.gwmwater.org.au/conserving-water/saving-water/how-much-water-you-use#:~:text=A%20garden%20sprinkler%20uses%20approximately,measure%20the%20amount%20of%20water. [Accessed December 2025].

Irrigreen. 2023. *How much water does a sprinkler use?* [Online] Available at: https://irrigreen.com/blogs/sprinkler-systems/water-usage#:~:text=Table_title:%20Monthly%20Water%20Usage%20For%20Pop%2DUp%20and,minutes:%202%2C560%20%7C%2020%20minutes:%205%2C120%20%7C [Accessed December 2025].

Le Roux, P. & Makhalanyane,T. 2024. *Arid conditions stimulate plant trait diversity – UP part of worldwide study that offers hope for biodiversity conservation*. [Online] Available at: https://www.up.ac.za/research-matters/news/arid-conditions-stimulate-plant-trait-diversity-part-of-worldwide-study-offers-hope#:~:text=%E2%80%9CThese%20sites%20provided%20unique%20data,found%20any where%20else%20on%20Earth.%E2%80%9D [Accessed December 2025].

Manning. 2020. *Save water in your garden*. [Online] Available at: https://www.stwater.co.uk/wonderful-on-tap/save-water/gardeners/ [Accessed December 2025].

Meyer, B. E. & Jacobs, H. E. 2019. Garden irrigation as household end-use in the presence of supplementary groundwater supply. *Water SA*. 45(3). [Online] Available at: https://www.watersa.net/article/view/6741 [Accessed December 2025].

MLM IDP. 2020. *Mogalakwena Local Municipality – integrated development plan review*. [Online]. Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.cogta.gov.za/cgta_2016/wp-content/uploads/2020/12/Mogalakwena-Final_IDP_2020-21-1.pdf [Accessed 7 October 2025].

MLM IDP. 2025. *Mogalakwena Local Municipality – final 2025/26 integrated development plan*. [Online]. Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.mogalakwena.gov.za/mogalakwena-admin/pages/sites/mogalakwena/documents/idp/2025-26%20IDP.pdf [Accessed 7 October 2025].

Mostert, A. 2024. *Level 1 water restrictions*. [Online] Available at: https://www.tshwane.gov.za/?p=79020 [Accessed December 2025].

Mucina, L. & Rutherford, M.C. 2006. *The vegetation of South Africa, Lesotho and Swaziland*. Strelitzia, 19. South African National Biodiversity Institute, Pretoria.

Nickel, A. & Brischke, A. 2021. Irrigating with ollas. *Cooperative Extension*. az(1911). [Online] Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1911-2021.pdf [Accessed December 2025]. The University of Arizona.

NWRS3. 2023. *National water resource strategy third edition*. Pretoria, South Africa: Department of Water and Sanitation.

SANews. 2024. *Citizens urged to change behaviour towards water usage*. [Online] Available at: https://www.sanews.gov.za/south-africa/citizens-urged-change-behaviour-towards-water-usage [Accessed December 2025].

Showmia, N., Rajalakshmi, S., Tharani, K. & Indianraj, N. 2022. Olla irrigation – using water wisely. *The International journal of analytical and experimental modal analysis*. XIV(XI). [Online] Available at: https://www.researchgate.net/publication/366135863_OLLA_IRRIGATION_-USING_WATER_WISELY [Accessed December 2025].

The Constitution of the Republic of South Africa. 1996. *Chapter 2: Bill of rights*. [Online] Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.justice.gov.za/constitution/SAConstitution-web-eng.pdf [Accessed December 2025].

The Gardener. n.d. *Water saving*. [Online] Available at: https://www.thegardener.co.za/the-gardener/maintenance/water-saving/ [Accessed December 2025].

UC. 2024. Olla irrigation. *The Coastal Gardener*. University of California – Agriculture and natural resources. California.

Waterberg BioQuest (n.d.) *Geology*. [Online] Available at: https://www.waterberg-bioquest.co.za/geology.html [Accessed 7 October 2025].

WDEMF. 2010. *Waterberg District environmental management framework report*. [Online] Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://screening.environment.gov.za/ScreeningDownloads/EMF/WDEMF_Final_EMF_Report.pdf [Accessed 7 October 2025].