GreenCape

'Greening' your farm

WATER FOCUS

1 A decision-making guide for farmers looking to become water-resilient

Increasingly unpredictable climate changes, tending towards hotter and drier conditions in southern Africa, are pushing farmers to consider their current water use and invest in technologies that secures water availability over the long term. Successive droughts (most notably the "Day Zero" crisis of 2015 - 2018) has fundamentally shifted patterns of water use in the Western Cape, particularly in the agricultural secotr and many have started on the journey of water resilience. This guide is intended for farmers who are situated in a rual area and farming for comemrcial purposes and would like to explore additional opportunities to become more water resilient.

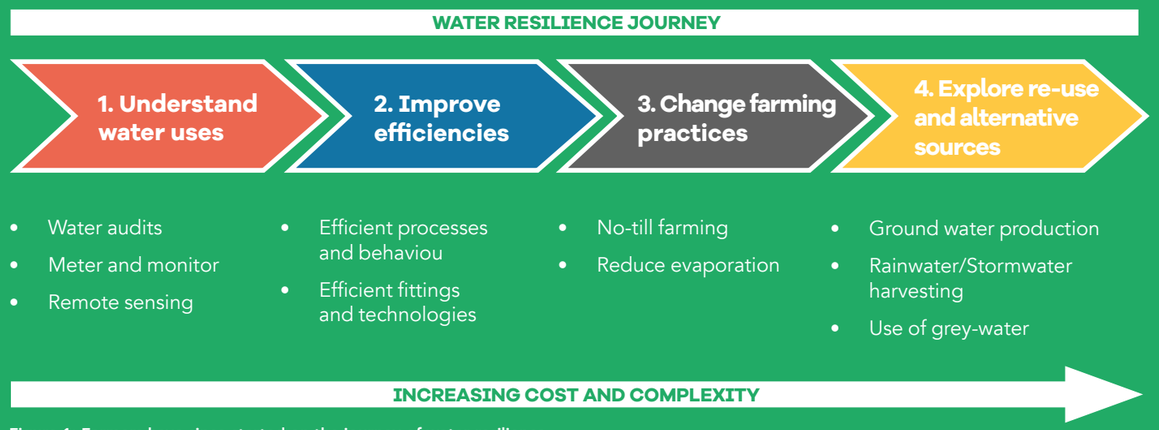

Figure 1: Farmers have since started on the journey of water resilience

As seen above, the journey to water resilience is progressive, having increasing cost and complexity implications so a farmer wanting to start on their journey must also conduct an accounting of their own capital and skills resources as well as where they are currently situated on their journey.

2 Context

Resilience is the "capacity of individuals, communities, institutions, businesses and systems within a city to survive, adapt and grow no matter what kind of chronic stresses and acute shocks they experience." (100 Resilient Cities, 2019). South Africa is already a water-scarce country – and climate change will reduce our already strained water supply[1]. There is limited opportunity for farmers to increase their water allocation for irrigation, whilst much of productive land is rain-fed and so, farmers wanting to continue to farm profitabily will need to use their current sources more efficiently, re-use wastewater streams and as a last resort, explore other water supplies.This guide is to assist farmers in these endeavours.

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3 Water-resilience **guidelines**

3.1. Understand water use

The National Water Act, Water Services Act and Municipal Act are the primary bills that govern and regulate water provision in South Africa. These laws support the rights of all South Africans to access to basic wate rsupply, not only for direct consumption but also consumption to do with activities within agriculture, manufacturing, recreation etc. The South African Water Quality Guidelines were developed to set water quality criteria – the Target Water Quality Range (TWQR) – for the physical, chemical, biological and aesthetic composition for water used in different sectors. There are eight volumes of these Guidelines for:

- Domestic Water Use (Volume 1)
- Recreational Water Use (Volume 2)
- Industrial Water Use (Volume 3)
- Irrigation Water Use (Volume 4)
- Livestock Watering (Volume 5)
- Aquacultural Water Use (Volume 6)
- Aquatic Ecosystem (Volume 7)

The final volume, Field Guide, is the consolidated list of the TWQR for all these water use sectors. Farmers should consult these guidelines to determine whether their water quality is fit-for-use. Using water that falls out of the recommended quality criteria can have serious ramifications: there is the potential of it affecting the yield of crops or livestock, destroying diversity of life in the soil and surrounding ecosystem or even detrimentally affecting the health of those who consume the products.

Different types of water will be described in this document according to the descriptions outlined in Table 1.

POTABLE WATER	Also known as drinking water, this water is treated and provided by a Water Service Provider (typically a municipality) to meet South African standards for human consumption. This water matcches the TWQR for Domestic Water Use
RAW WATER	Raw water is untreated water, most commonly obtained from natural sources, such as rainwater harvesting, groundwater sources and large bodies of water like lakes, rivers and dams
GREYWATER	The discharge from domestic (e.g. laundry) or industrial (e.g. fertiliser leaching, cleaning products) use
TREATED EFFLUENT (TE)	Treated wastewater that has been treated in municipal wastewater treatment works (WWTW) and can be accessed via TE pipeline networks or collected from WWTW

Table 1: Description of water types[2]

The vast majority of farms in South Africa use raw water for their production. It is important for farmers to test the water they use for irrigation and livestock watering to confirm that the water composition complies with South African Water Quality Guidelines. If it does not, farmers might have to invest in water treatment systems that can process water to be suitable for use. Applicable technologies can be found later in this document.

3.1.1 WATER AUDITS

Auditing your water use is the most essential first step in moving towards water-resilience on farm. It allows for better management of water by providing insight around the water needs for each specific use throughout each months and the available water sources to ensure sufficient water is available year-long.

SAPWAT is a computer programme developed to calculate irrigation requirements of specific crops for 712 climatic zones that occur in South Africa5. SAPWAT4 uses the FAO four-stage crop development curve procedure, linked with the weather database to support decision-making for the estimation of crop irrigation requirements by irrigation engineers, planners, agriculturalists, administrators, teachers and students[6]. SAPWAT4 is available free from the WRC; contact info@wrc.org.za for more information.

3.1.2. METER AND MONITOR

The agricultural sector is one of the largest users of water in South Africa and can rapidly realise savings by investing in smart water metering technologies and water monitoring systems for their irrigation and animal watering systems. The primary benefit of these technologies is being able to identify leaks and water losses early and apply interventions that save water. Especially for large farms, leakages can occur in corners not frequently visited, and thus large volumes of water can be lost unintentionally. Running a night flow analysis is a useful first step when installing wate rmeters, as this will very quickly identify if water is being lost in pipelines.

Important to note: according to the Department of Water and Sanitation (DWS), all farmers should have installed water meters and submit monthly wate rmeter readings, published in the "Notice to Install Water Measuring Devices for Water Taken for Irrigation Purposes and to Monitor Compliance with Government Notice No. 131 of 2017 (Government Notice 34 of 17 January 2020). AgriSA compiled a comprehensive infographic (that can be found here) that provides answers to farmers wanting to find out: who should be measuring their water use; why one should measure; where measurement should be taken ; and user guidelines for greater clarity.

3.1.3. REMOTE SENSING

There are a number of remote sensing tools available that can enhance existing metering and monitoring efforts (as described in Section 3.1.2). Previously, farmers would apply a single irrigation programme across a farm; however, often different irrigation blocks experience varying environmental conditions and/or have different soil typologies and topologies. Thus, there is a high probability of certain areas experiencing overwatering or underwatering, resulting in unnecessary water usage as well as reduced quality and quantity of yields. Soil sensors, drones, satellite imaging are some of the technologies that can be used to evaluate whether an irrigation block may be overwatering or underwatering. It is important for farmers to gather this information regularly, and use it as a foundation for decisions made on irrigation infrstructure and scheduling.

3.2. Improve efficiencies

3.2.1. REVIEW IRRIGATION OPTIONS

Choosing the correct irrigation system is at the centre of water efficient technologies. Before investing in an irrigation system, it is important to understand the benefits of the different irrigation systems options, and how these might apply to your situation and needs. The most popular systems are:

- **Flood or furrow:** This surface irrigation technology where farmers flow water down small trenches running through their crops. This type of irrigation method is uses the most water (often inefficiently) but is cost-effective and requires very little technology investment[9].
- **Sprinklers:** Sprinkler irrigation provides rainfall-like irrigation, as water is pumped through a system of pipes with spray heads as outlets. They are adaptable for the majority of irrigable soils, but are prone to clogging due to sedimentation and can be inefficient when used during hot days[10].
- **Micro spray:** Low-pressure, low-volume irrigation system, that sprays water on a specific area[11].
- **Drip irrigation:** Water is applied directly where it is needed, near the roots through a slow release device. When correctly designed, installed and managed, this type of irrigation vastly decrease water losses due to evaporation and instances of fungicide and/or pesticide due to overwatering/ pooling of water[12].
- **Big gun/travelling irrigator:** Mobile irrigation system that can be operated by one person. However, the design makes spraying vulnerable to wind drift and evaporations[13].
- **Centre pivots and linear move:** Another surface irrigation technology, CPLM irrigation consists of an overhead sprinkler system spanning between two towers that can move across large spans of land[14]. When a large area needs to be irrigated, these are the ones to use[11].

AGRI-PROCESSING CASE STUDY 1

In 2017, Excellent Meat installed a water monitoring system and five smart water flow meters to track their water consumption and to detect leaks with the assistance of the National Cleaner Production Centre and Energy Assist7. In the period of 2017 to 2020, they were able to achieve a 30% reduction in water consumption and garnered estimated total saving of R1 500 312, at an investment cost of only R360 958.

CASE STUDY 2

FruitLook is a farm management tool that gives farmers an overview of their crop production, biomass production and water consumption. Funded by the Western Cape Department of Agriculture, it provides Western Cape farmers with insights to cut costs and reduce losses at exact locations and exact time frames. According to Andrew Roux, the director of sustainable resource management at the Western Cape Department of Agriculture, using the FruitLook portal can help reduce production costs by about 10%, which translates to R4 130, R23 590/ha and R25 160/ha savings for vine producers, table grape producers and deciduous fruit producers respectively[8].

LEGEND
No limitation
Little limitation
Moderate limitation
Severe limitation
Requires further investigation by an expert

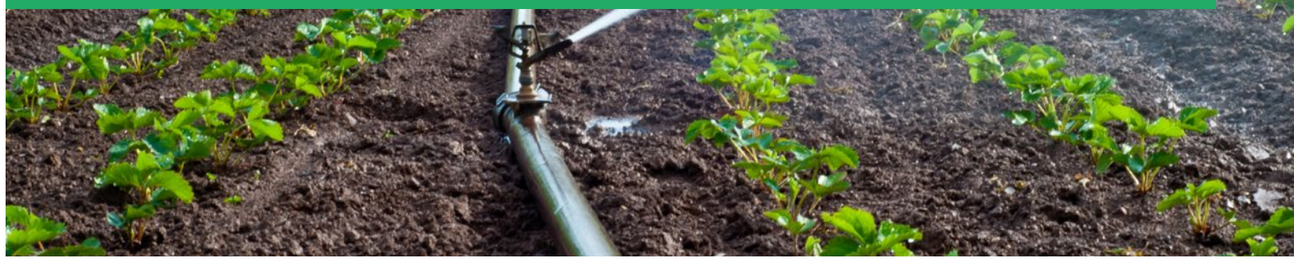
The South African Irrigation Institute (SABI) has developed a comprehensive document establishing the norms for the design of irrigation systems (downloadable here). This document is a great resource to guide decision-makers in the planning and design of agricultural irrigation systems that are fit-for-purpose. Table 1 below is the criteria SABI recommends designers consider having collected and assessed five aspects of the farm: i.) climate; ii.) site; iii.) water; iv.) soil; and v.) crop

Table 2: Comparison of systems for various farm conditions

CRITERIA	FLOOD	SPRINKLER	MICRO SPRAY	DRIP	BIG GUN/ TRAVEL-LING IRRI-GATOR	CENTRE PIVOT AND LINEAR MOVE
1.1. Temperature > 30°C						
1.2. Relative humidity < 40%						
1.3. Wind speed > 15 km/h						
1.4. Rainfall < 300 mm/year						
2. SALINITY						
2.1. Salinity > 2 000 ppm						
FLOW RATE						
2.2. Flow rate < 100 m3/h						
3. WATER QUALITY						
3.1. Turbidity (silt, fine sand)						
3.2. Lime, iron						
3.3. Algae						
4. SOILS						
4.1. > 20% clay						
4.2. 10 – 20% clay						
4.3. < 5% clay						
4.4. < 600 mm deep						
4.5. 600 – 1 200 mm deep						
5. INITIAL INFILTRATION RATE OF SOIL						
5.1. < 20 mm/h						
5.2. > 150 mm/h						
6. CROPS						
6.1. Nursery						
6.2. Row crops						
6.3. Bed crops						
6.4. Field crops						
6.5. Orchards, vineyards						
7. OPERATION CONSIDERATIONS						
7.1. Water usage						
7.2. Energy requirements						
7.3. Labour						
7.4. Managerial inputs						
7.5. Application of chemicals						

For small-scale farmers, the Water Research Institute has developed a Design Manual that discusses applicable irrigation technology in small-scale agriculture and the limitations that exist in applying those technologies (available here).

Learn more: HORTGRO Science held an Irrigation Seminar at Allée Bleue in Groot Drakenstein in 2017. The seminar was held to address the then drought conditions in the Western Cape, and to provide producers with coping strategies. ***To view all the complete presentations, visit their YouTube channel here.***

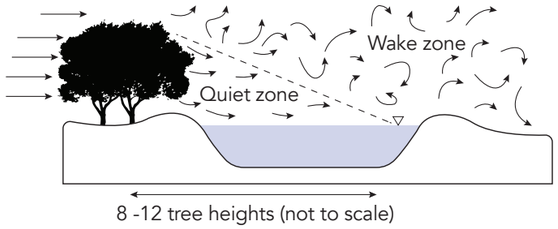


3.2.2 REDUCE EVAPORATION

The immediate environment aroudn water sources and destinations should be controlled to protect not only against contamination but also wate rlosses. In particular, high temperatures and wind speeds result in greater water evaporation, leading to water losses. Below, farmers can find some easy solutions:

Mulching is a simple, low cost solution to prevent evaporation at soil level for field crops. Mulching means to cover the soil around a plant with a layer of material e.g. veld grass, leaves, soft cuttings, seasweed, straw, tree bark and manure. Mulching is a sustainable solution as the mulches can decompose into the soil and has the additional benefit of suppressing weed growth through blocking out sunlight. Undercover farming is an umbrella term for farming under overhead structures such as shade nets, greenhouses and tunnels. Shade netting, in particular, has seen a massive uptake especially for high value commodities like citrus, table grapes, deciduous fruit, pomme fruit, berries etc. The density of the shade netting can reduce water loss by 30% with a cost range of betweeen R90 000 to R250 000 per hectare. Wind breaks (also see cover crops) can be planted between rows of crops to provide shade, reducing direct sunlight and wind that hits the soil and thus reduces evapotranspiration. The estimated cost of windbreaks/covercrops is between R1 000 to R2 500 per hectare. Well positioned windbreaks can reduce evaporation by 20 - 30% (see Figure 2)

Figure 2: Illustration of dam windbreak system



In designing the position of windbreaks, it is important to consider:

- **Height:** the ratio of the height of the windbreak to the protection zone can be smaller than 1:8;
- **Density and continuity:** the density of the windbreak directly affects the efficacy of wind speed reduction. Density can be controlled by choice of species, spacing of tree and number of rows in the windbreak. It is important to eliminate any gaps in a windbreak, as these can act as a wind tunnel
- **Orientation:** windbreaks must be orientated perpendicular to the prevailing winds. In the Western Cape, the summer prevailing wind and the winter prevailing wind are the South Easter and North Wester respecitvely.
- **Speicies selection:** having a varied selection of species in the windbreak is recommended, so as to minimise risk of loss due to disease or pests as well as promoting greater biodiversity around the farm. The most common species used in windbreaks are beefwood, eucalyptus and pine but these species are considered invasive as they compete with indigenous plants for water and space. Farmer who want to consider more sustainable option can try Leyland Cypress, Yellowwood, Milkwood and Camphor Bush among others.

3.3.
Change farming practices

3.3.1. NO-TILL FARMING

It is possible to achieve even better reductions in water losses associated with evaporation from land surface, by increasing the soil's ability to retain moisture over the long-term. This principle falls under regenerative agriculture, which is a holistic farm management concept promoting minimum tillage, plant diversity and reduced use of synthetic chemical inputs18. Applying the principle of zero tillage can increase water retention, result in less water runoff and has several additional benefits such as reduced diesel usage and need for synthetic inputs and increased carbon sequestration and nutrient density of products19,20. No-till farming, when applied with other regenerative agricultural practices such as crop rotation, covercropping, organic composting, rotational grazing, can result in increased yields by as much as 34.21%, but these benefits are only observed after Year 5 with a yield reduction observed before then[19]. It is also important note that shifting to no-till requires an upfront capital investment of no-till machinery such as no-till drills, post-hole digger etc.

3.3.2. IMPROVED GENETICS

Whether it's through conventional breeding techniques or biotechnology like CRISPR, there is an ever-expanding database of drought tolerant crops and animal breeds that farmers should consider. Underutilised indigenous crops such as amaranth, Bambara, cowpea, maize, pearl millet, taro and wild watermelon are crops that are well-suited to farming in local conditions of low water availability[21]. Again, SAPWAT (included in 3.1.1) is a useful tool – one can look through the database of crops to select the most water-efficient species. In terms of livestock, cattle breeds like Sanga, Afrikaner, Bonsmara and Nguni and goat breeds like Eastern Cape Xhosa Lob-ear, Northern Cape Speckled and Mbuzi Nguni types[22] are well-known drought-hardy breeds that can increase the resilience of the herd.

3.4.
Explore re-use and alternative sources

3.4.1 GROUNDWATER PRODUCTION

Groundwater is the most common water supply for farmers after rainfall. Farmer who wish to use groundwater for irrigation and watering needs must adhere to the National Water Act and register their water use with the DWS. The cost of applying can vary significantly from to R100 000 or more, depending on the need for more technical hydrological studies23. The steps for registration are as follows:

1. Evaluation and Preparation

2. Borehole/Wellpoint Drilling and Registration

3. Application for Alternate Water System and Water Use Licence (Phase 1)

4. Application for Effluent Discharge Permit and/or Water Services Intermediary (WSI)

5. Inline and Effluent Installation, Inspection and Approval and Water Use Licence (Phase 2 and 3)

6. Water Services Intermediary (WSI) and Water Use Licence Finalisation and Monitoring

Figure 3: WULA application process24

It should be noted that groundwater supply is incredibly constrained in South Africa and so, new applicants for water use licences may find it difficult to secure supply at present.

3.4.2. USE OF GREYWATER

Water use for agricultural products destined for human consumption must adhere to the water quality requirements described in the TWQR (See Section 3.1). Greywater is still considered as a waste stream to most, but given adequate management, it is can be recycled back into use for irrigation. Small scale farmers, in particular, are well placed to take advantage of greywater as an alternative to augment their water supply.

Greywater can be used without having treated it with minimal risk as long as: i.) only laundry rinse water (not the wash water) and bath/shower/basin greywater is used; ii.) it is used for growing non-food plants or crops that will be cooked before consumption; iii.) farmers stop irrigating with greywater 2 weeks before harvesting; and iv.) all crops are well-washed in soapy water after harvest and left to dry in the sunlight[25].

It must be noted that these recommendations pertain only to household greywater; those looking to use industrial greywater should consult with experts who can perform a full analysis and offer expert opinion on the feasibility of use for irrigation and watering.

3.4.3. RAINWATER HARVESTING AND STORMWATER MANAGEMENT

Rainwater and stormwater management relates to the management of surface runoff – whether that is harvesting precipitation like rain or directing run-off to storage sites for possible use later.

The advantages of adopting these type of practices include proper drainage of surface run-off, the possibility to recharge groundwater and (re)use precipitation water and flood prevention to name a few[26]. It is not without its drawbacks though – stormwater and rainwater management requires expert planning, implementation, operation and maintenance and with that, high capital costs.

Examples of storage of stormwater and rainwater are:

DETENTION AND RETENTION PONDS

Detention (or dry) ponds are reservoirs either excavated or constructed in natural depressions, that are usually dry during low flow periods, providing temporary storage of stormwater[15]. In comparison, retention ponds are permanent pools of water and whilst they also play an important role controlling stormwater runoff, they can also control stormwater quality[18]. As a permanent feature, pollutants can be removed through the settling of solids over a long time frame.

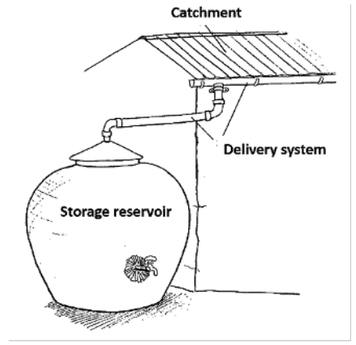


Figure 4: Simplest rainwater harvesting system

RAINWATER HARVESTING

As is clear from the name, rainwater harvesting (RWH) is a low-cost technique of collecting rainwater from roofs and transporting it to a reservoir using gutters. Suitable rooftops that can be used as catchment areas are those made of hard material that does not absorb the rain or pollute the run-off. The most basic RWH system can be made up of just three components – a catchment area, delivery system and storage reservoir (as seen in Figure 4)[19].

The above practices can be implemented in such a way that farmers are able to recycle collected water for use in irrigation and/or watering livestock. However, as described in 3.1.3, water used to irrigate crops or given to livestock must be potable. Thus, any water harvested must undergo treatment to be restored to potable standards.

3.5 SUSTAINABLE WATER CYCLE

The practices and technologies listed above are great tools for implementing water-resilience on a farm; but it is important to note that agricultural sector is just one player in a wider ecosystem that supplies and consumes water. In this sense, farmers should also consider investing in practices and technologies that improve water use in their surrounding environment so water readiness improves in both volume and long-term availability.

These solutions are described below:

- Clearing invasive species is a cost effective measure for minimising non-productive water losses. Invasive alien plants negatively impact the environment by over-utilising water resources. Invasive species consume significantly more water than the average indigenous plant, decreasing the flow of stream and reducing the amount of water that reaches dams. It also spreads quickly through agricultural land, limiting space available for crop and livestock production and negatively impacting on the agricultural economy29.

- **Constructed wetlands** can be engineered to manage flood peaks, naturally filter through the water (thus improving the water quality of the run-off) as well as improving biodiversity of fauna and birdlife. They can be combine with **surface** and **subsurface ground water recharge systems** or **soil aquifer treatment**

- **Pervious pavements** are sometimes referred to as **"no fines concrete"** where porous materials are packed as a pavement surface with a stone reservoir underneath. This reservoir temporarily stores water before it infiltrates the subsoil or enters sub-surface drainage. The figure below provides a good illustration of how pervious pavements work.

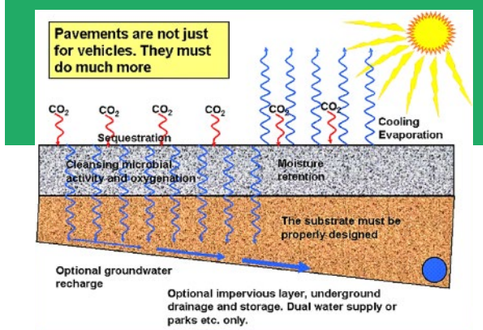


Figure5: Theoretical and actual cross section of pervious pavement[15]

4

Next Steps

For more information about implementing water resilience on farm, please visit the GreenAgri website (**greenagri.org.za**). A wider pool of resources can be found on the site under the Water section of the Agri Resilience tab.

Moreover, feel free to contact us at GreenCape's Sustainable Agriculture sector desk: agri@green-cape.co.za, for further information and support on any of the content provided here.

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