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Water in Agriculture:
Rainwater Harvesting as a Sustainable Agricultural Practice

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Abstract

Agriculture is a key sector in South African economic development, a sector that is highly dependent on water resources, with linkages to the rest of the economy. Climate changes have impacted rainfall distribution, timing and amount of precipitation under the drought conditions in recent years, influencing the reliability of rainfall for agricultural purposes. Changes in extreme weather events are expected to increase in South Africa as a result of climate change. There is a need for more efficient capture and use of scarce water resources in semi-arid countries and the industry will need to increasingly focus on climate-smart technology to mitigate risks due to extreme weather. This study looks at the technological opportunity of rainwater harvesting for mitigating climate change under drought conditions.

"Sustainability is a journey, not a checklist."

Mary Shelman, Agribusiness Programme, Harvard Business School

Water capture in catchments

1. INTRODUCTION

South Africa is diverse in climate and farming regions but remains a semi-arid country with variable rainfall. Agriculture is exposed to extreme weather and use over 60% of the total water resources of the country therefore these impacts pose significant challenges to the agricultural sector and have the potential to undermine productivity and agricultural sustainability. Agricultural activities range from intensive crop production in high summer and winter rainfall areas, to livestock farming in more arid regions (WWF, n.d.). With an increase in population growth of around 2% per annum, production needs to increase using the same or fewer, constrained natural resources. Recent years have been characterised by unprecedented hot and dry weather and climate change will lead to continued water scarcity in the country. Frequency and intensity of drought and heat stress are expected to increase as a result of climate change (Stern, 2007). The effects will mainly be observed on annual temperatures (3.4-3.7°C in spring) and on rainfall (decrease of 23% in winter and 13% in spring). The drought currently being experienced across the country is a result of the cyclical El Nino weather pattern and with the Western Cape being prone to hazards such as floods, fires, drought and heavy rain, the likelihood of more intense and more frequent extreme events are projected for the province (Smart Agri, 2016). According the research under the Smart Agri Project (2016), the vulnerability of many agricultural communities has increased due to:

- Reduced recovery time between extreme events,
- Limited access to affordable agri-/disaster- insurance,
- Lack of disaster preparedness and prevention,
- Delayed and/or inadequate disaster relief and recovery, and
- Low productivity and soil fertility as a result of poor land practices.

Agriculture is also important for employment in SA, particularly in rural areas (a third of SA's population) and the over 800 000 employed in the commercial agriculture sector across the country (Ndlovu, 2016). It follows that the current experience of drought, increasing fuel prices, depreciation of the rand and investor uncertainty, should stimulate responses to climate change and greater protection of the agricultural sector and threatened food security (Ndlovu, 2016).

This paper gives an overview climate change in South Africa and how it impacts on agricultural production. It also looks at strategies for mitigating risk, particularly rain water harvesting as an option in certain agro-climate conditions.

2. THE IMPACT OF CLIMATE INDUCED RISKS IN SOUTH AFRICAN AGRICULTURE

There is widespread consensus on both the fact that global warming is happening and also that this is causing extreme weather events to become more frequent and more severe (Stern, 2007). It is expected that SA's rainfall patterns will be more unpredictable with less but more intense rainfall events. Agriculture is particularly sensitive to climate change and as such should adopt more sustainable farming practices (Ndlovu, 2016). Crops (extending to cultivar choices and cropping calendars) and selection of livestock are influenced by these variables in different geographic areas.

The International Panel on Climate Change (IPCC) predicts that going forward temperatures over South Africa may rise faster than the global mean temperature. Under their A2 scenario[1], parts of the interior are projected to warm up to 3-5 °C by the end of the century. The summer rainfall areas in the eastern part of South Africa are projected to experience more intense rainfall events, whilst the south-west of the country can expect drier winters (DST, 2010).

Agricultural producers face significant risk as a result of being reliant on environmental conditions for production. Some examples of how farmers can mitigate risk include:

- Diversification and crop rotation
- Intercropping
- Crop choices in favour of more tolerant, but lower yield crops
- Tillage systems
- The sharing of tenancy
- Contractual inter-linking
- Earning income through non-farm activities

[1] A2 Scenario: Relatively slow demographic transition and convergence in fertility patterns; Relatively slow convergence in inter-regional GDP per capita differences; Relatively slow end-use and supply-side energy efficiency improvements; Delayed development of renewable energy; No barriers to the use of nuclear energy (IPCC, 2000)

- Other informal risk-sharing arrangements within communities (Smart Agri, 2016).

Ndlovu (2016) suggests that farming practices respond with the use of drought resistant seeds and/or irrigation practices that minimise water use which has long been recognised. There is also a challenge to go beyond a few pilot projects and together with incentives to save water, sufficient extension service support. Desalination is another opportunity discussed by Ndlovu (2016) as a means to increase water supply and access. The significant capital investment with high energy use is noted; however there remains opportunity to leverage the growing capacity of renewable energy in the use of this technology (Ndlovu, 2016). A further suggestion is that there should be a shift in view about the importance and benefits of rain water harvesting, as a complimentary system for providing fresh water (with similarly recycling water at household level) (Ndlovu, 2016).

3. RAINWATER HARVESTING

Agriculture in spans a vast majority of South Africa's natural environment and the sector is known as an intense water user. With increasing population growth, production needs to increase using the same or fewer, constrained natural resources. Farmers will have to double their water use by 2050 if they are to meet the growing food demands under current farming practices. (WWF, n.d.). Frequent droughts exacerbate the probability of crop failure which impacts food security and poverty (Yosef & Asmamaw, 2015). Another general concern in semi-arid regions is the high level of runoff, which is associated with nutrient losses and erosion (Nyamadzawo, et al., 2013). The industry is called upon to move, with greater urgency, towards sustainable farming practices, and consider how natural resources are used across the value chain.

Technological advances can support optimising agricultural production with reduced impact on the environment. Nyamadzawo et al. (2013) notes the importance of investigating options to increase water productivity in rain-fed agriculture for increased food production. Various in-field water conservation practices are used across the continent, such as earth bunds, contour earth ridges and planting pits, to sustain crop production under dry conditions.

The sustainability of rainwater harvesting is based on supply and production, effectiveness of water use (increasing rainwater productivity) and minimising negative environmental impact (Pachpute, 2009). Rainwater harvesting is a general term used to describe the collection and concentration of runoff for many uses. Macrocatchment rainwater harvesting includes the collection of water from areas far from cropped areas whereas microcatchment rainwater harvesting is a system where collection and the cropped area are in close proximity to each other. Rooftop runoff is the collection of runoff from slanted roofs and is mostly used for domestic consumption.

In situ water harvesting (also known as water conservation) enhances soil infiltration and water holding capacity. This type of rainwater harvesting falls in the category of microcatchment techniques, an alternative for semi-arid regions where rainfall is low or variable during the dry season. It looks at methods to increase the amount of water stored in the soil by collecting and holding rainwater where it falls, and transferring the water as surface runoff to where it is required (Yosef & Asmamaw, 2015). In-field water harvesting and conservation is of the many climate change adaptation strategies that can be adopted in semi-arid regions like South Africa and could be integrated with other management practices that promote sustainable farming e.g. conservation agriculture principles, timing of operations, cropping systems etc. The practice can potentially improve soil moisture and contribute to crops surviving drought conditions. As such, water harvesting may improve crop yields, livelihoods and food security.

Improved rainwater management can have many potential benefits for agriculture in reducing vulnerability and improving productivity. Other examples of potential benefits include:

- increased infiltration and soil moisture
- reduced runoff
- reduced crop moisture stress and improved yields (implications for food security and livelihoods)

- improve resilience in a changing climate

In-field water harvesting is one of the many climate change adaptation strategies that can be adopted in semi-arid regions like South Africa and should be integrated with other management practices that promote sustainable farming e.g. conservation agriculture principles, timing of operations, cropping systems etc. The practice can potentially improve soil moisture and contribute to crops surviving drought conditions. As such, water harvesting may improve crop yields, livelihoods and food security.

Rooftop rainwater harvesting is not without challenges. Bacterial pathogens can be present in varying amounts, depending on the roof type and the catchment area. The bacteria and chemicals present in the harvested water might exceed the guidelines for drinking water in South Africa (Moodley, 2015). While the water tank market is expanding given the current drought conditions in South Africa, it is expanding in the absence of a legal framework and guidelines. There begs the question of whether the installation of these systems are being met with education and awareness.

The benefits for farmers are available in case studies in countries such as Zimbabwe, Ethiopia (Yosef & Asmamaw, 2015) and Kenya. In South Africa, water-related legislation does not provide a clear legal framework and guidelines for the adoption of rainwater harvesting. The National Water Resource Strategy 2 (NWRS2) set out the strategic direction for water resource management in South Africa for the next 20 years. However, the guidelines do not present a roadmap for sustainability of water resources in agriculture (El Chami & El Moujabber, 2016). The suggested strategy considers four main dimensions: crop research, agricultural practices, irrigation management and sustainability research. There is a need to do research on water harvesting in South Africa, across soil types, textures and depth and for research to clearly show the benefits of improved water harvesting towards increased yield and food security. There is a need to incorporate water harvesting with crop management and for policies to promote uptake of in-field water harvesting, including incentives to increase adoption of in-field water harvesting.

Case Study: Rainwater harvesting in Free State, South Africa (Everson, et al., 2011)

Everson et al. (2011) conducted a study on sustainable techniques and practices for water harvesting in agricultural production, specifically cabbage and Chinese cabbage, in the Free State Province. The study found that in using micro-catchment techniques, soil water content was improved. Mulching improved soil water content, the run-off plot with no mulch had very poor soil retention and the run-off mulch plot had the highest water content in the top metre of the soil profile. The trials also showed that having ridges and troughs in treatment plots also increased soil water content throughout the growing period. The benefits of water harvesting techniques in general were also evident in the plant height and leaf number. The study also notes an increase in yield cross crops where water harvesting techniques were used (Everson, et al., 2011).

Case Study: IRWH Rainwater harvesting technique on small plots in the central region, South Africa (Botha, et al., 2007)

The study by Botha et al (2007) looked at the benefits of in-field rainwater harvesting in rural communities in the Central Karoo. The region is characterised as semi-arid with marginal crop production as a result of low and erratic rainfall. High water losses and evaporation rates exacerbate conditions for low yields. The technique discussed in the study promotes rainfall runoff (in no till system) to include mulch in basins between alternate crop rows. The mulch serves as Water collects and infiltrates deep below the surface soil and reduces evaporation (Botha, et al., 2007). The study showed that rainwater harvesting can have positive impact on backyard crops and contribute to food security.

Botha et al. (2007) noted the following benefits from rainwater harvesting:

- Higher crop yields,
- Greater crop biodiversity,
- Household food security,
- Job opportunities,
- Higher incomes,
- Better health,
- Educated farmers,
- Reduction in crime in the community, and

- Better social lives.

Another valuable outcome of this study was the communication of the techniques used to support extension officers and farmers in applying the successes of this project (Botha, et al., 2007). Communication strategies should be included in further studies on water harvesting.

4. CONCLUSIONS AND RECOMMENDATIONS

South Africa needs better environmental practices to ensure sustainable, productive agricultural systems (WWF, n.d.). The difficulty has become particularly severe in recent years as climate change has resulted in increased occurrence and severity of extreme weather events which threaten agricultural production (Stern, 2007).

In-field water harvesting is one of the many climate change adaptation strategies that can be adopted in semi-arid regions like South Africa and should be integrated with other management practices that promote sustainable farming e.g. conservation agriculture principles, timing of operations, cropping systems etc. The practice can potentially improve soil moisture and contribute to crops surviving drought conditions. As such, water harvesting may improve crop yields, livelihoods and food security.

There is a need for:

- research on water harvesting across soil types, textures and depth to incorporate water harvesting with crop management,
- policies to promote uptake of in-field water harvesting,
- guidelines for farmers to use as references for water harvesting in local context, and
- incentives to increase adoption of in-field water harvesting.

This paper serves as only a brief consideration of rainwater harvesting that could be useful during droughts. Given the conditions that the agricultural sector is operating under, there is a clear need for innovation in the sector so as to have improved crop yield in the South African context. The main outcome of this paper should be to stimulate further research in water harvesting in the South African context, as farmers need responses that are suited to their specific needs to contribute to improved sector growth, improved livelihoods and food security.

5. REFERENCES

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