

# Climate change impacts on water resources in a rural community in Limpopo province, South Africa: a community-based adaptation to water insecurity

Community-based adaptation to water insecurity

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## Abstract

**Purpose** – The study explored the impacts of climate change on water resources, and the community-based adaptation practices adopted to ensure water security in a rural community in Limpopo Province, South Africa.

**Design/methodology/approach** – The study was conducted in Limpopo Province, South Africa. The participatory approach was used to allow community members to share their challenges of water scarcity, and the measures they have developed to cope with inconsistent water supply.

**Findings** – The study results show that the community obtains water for household consumption from the reticulation system supplied by Mutale River and the community borehole. These resources are negatively impacted by drought, change in the frequency and distribution of rainfall, and increased temperature patterns. The water levels in the river and borehole have declined, resulting in unsustainable water supply. The community-based adaptation practices facilitated by the water committee include observance of restrictions and regulations on the water resources use. Others involve securing water from neighbouring resources.

**Originality/value** – This type of community-based action in response to climate change could be used as part of rural water management strategies under climate change.

**Keywords** Climate change, Water resources, Rural community, Community-based adaptation, Limpopo province

**Paper type** Research paper

## 1. Introduction

The World Meteorological Organization Assessment Report (WMO, 2013) shows that the years 2001–2012 were the warmest years, with an expected 2°C increase in global average temperature over the next two decades. The latest predictions suggest that global temperatures could rise between 1.1°C and 6.4°C by 2100 (Allen *et al.*, 2018; Kirby, 2014).

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To the community of Maheni in Limpopo Province for their kindness and interest in taking part in the study.

This paper forms part of special section “Climate change impacts and adaptations in arid and semi-arid regions”, guest edited by Zhihua Zhang, Qiang Zhang and Muhammad Jawed Iqbal.



The International Panel on Climate Change (IPCC) reports have shown that climate change is real and Africa is the most vulnerable continent ([Intergovernmental Panel on Climate Change \(IPCC\), 2013](#)). The African continent is likely to warm during this century and the warming would be larger than the global annual mean warming with drier subtropical regions warming more than the moist tropics ([WMO, 2013](#)). The climate of most parts of the African continent may be classified as arid and semi-arid with high drought risks. Parts of Africa are also endowed with humid tropical climate that receive substantial amount of rain throughout the year ([United Nations Economic Commission for \[UNECA\], 2011](#)). Several transboundary rivers from the glacial mountains and humid climate zones are the only sources of water in some arid and semi-arid lands ([IPCC, 2014](#)). Among the risks the continent faces are increased water stress and reduction in food security and agricultural productivity ([IPCC, 2014](#)).

Analyses of climate data from 26 weather stations across South Africa found that, between 1960 and 2003 the country's average annual temperatures increased by about 0.13°C per decade, with varying increases across the seasons ([Kruger and Shongwe, 2004](#)). Climate change resulted in higher temperatures and sporadic rainfall patterns with frequent droughts ([Kruger and Sekele, 2012](#)). South Africa is particularly vulnerable to these variations because of its dependence on climate-sensitive economic systems ([Madzwamuse, 2010](#)). [Ziervogel et al. \(2014\)](#) support that the country is experiencing a gradual, steady changing climate with significant increased temperatures over the last 60 years. Limpopo Province, where the study was conducted, is already experiencing warmer and wetter winters, and hotter and drier summers with a possibility to increase in the future ([Tshiala, 2011](#)). Heat waves and heavy rainfall are expected to become more frequent and intense ([Tshiala, 2011](#)). In addition to the multiple pressures from poverty, inadequate housing and poor access to services, change in climate conditions may have negative effects on Limpopo's natural resources, and community livelihoods ([Limpopo Climate Change Response Strategy, 2016-2020](#)).

The IPCC and assessed climate scenario in South Africa suggest that water availability, accessibility and quality are based on favourable climatic conditions ([Intergovernmental Panel on Climate Change \(IPCC\), 2014](#)). [The Climate Change Adaptation in Southern African Development Community \(SADC\) \(2011\)](#) reports that the impacts of climate change on water resources are already perceived, and are expected to result in severe floods and drought. [The Intergovernmental Panel on Climate Change \(IPCC\) \(2007\)](#) purports that water and its availability and quality will be the main pressures under climate change. [The Lancet \(2009\)](#) supports the projections by showing that changing rainfall and temperature and related impacts on the provision of clean water. [The Climate Change Adaptation in Southern African Development Community \(SADC\) \(2011\)](#) argue that the water cycle is affected by increased evaporation and disrupted rainfall patterns ([Intergovernmental Panel on Climate Change \(IPCC\), 2014](#)). Climate change is likely to exacerbate water availability and quality, which will have a wide range of implications for household food security, hygiene and well-being ([United Nations Global Compact \(UNGC\), 2009](#)). [Zhu and Ringler \(2010\)](#) study on the effects of climate change on hydrology and irrigation in Botswana, Mozambique, South Africa and Zimbabwe found that the Limpopo River Basin water resource are already stressed under climate conditions.

There has been increasing emphasis on the bottom-up approaches that climate change studies should be conducted at the local level where risks and impacts are mostly felt ([Bardosh, 2014](#)). [The Climate Change Adaptation in Southern African Development Community \(SADC\) \(2011\)](#) supports that climate change adaptation cannot be achieved by individuals alone, but must be accomplished by society as a whole by sharing a common

understanding of the risks, impacts of climate change, and the measures necessary to adapt. A community-based adaptation approach empowers people to plan for and cope with climate change impacts by focusing on community led processes grounded in the priorities, needs, knowledge and capacities of communities (Midgley *et al.*, 2012). The strategies might be used to empower communities to use their own knowledge and decision-making processes to cope with the impacts of climate change (Mugambiwa, 2018). The incorporation of these culture-specific practices into the national climate change policies might be helpful to better understand climate change, its impacts and local strategies that could be used to mitigate the impacts (Cooper *et al.*, 2008). This possibly will help communities better prepare for and respond to the risks of climate change (Mugambiwa, 2018). This is so proposed because many communities that are vulnerable to climate change have been dealing with climate variability for decades and have a wealth of knowledge of adaptation practices (Bardosh, 2014). Kruger and Sekele (2012) concur that the report that indigenous communities have been confronted with changing environmental condition, and have responded to climate disasters through the indigenous coping strategies and practices.

Community-based adaptation competence comprises the rich knowledge about natural resources and established traditional methods of managing vulnerability through, for instance, migration, crop and livelihood diversification and small-scale enterprises, all of which are reinforced by traditional knowledge systems for sustainable resource management (Macchi *et al.*, 2011; Nielsen, 2010). On the contrary, Niang *et al.* (2014) believe that Africa is one of the regions of the world most vulnerable to the impacts of climate change owing to its high exposure and poor adaptive capacity. Community-based adaptation efforts improve access to water and energy and in modern development society (UNECA, 2011). These include traditional and modern water harvesting techniques, water conservation and storage, improved recycling and re-use of water (Osman-Elasha *et al.*, 2006). McCartney and Smakhtin (2010) and UNECA (2011) add that water storage in tanks and sand-dams is the mostly known and practiced community-based adaptation practices that ensure sustainable provision of water, important in poverty reduction, food security and improvement of human wellbeing.

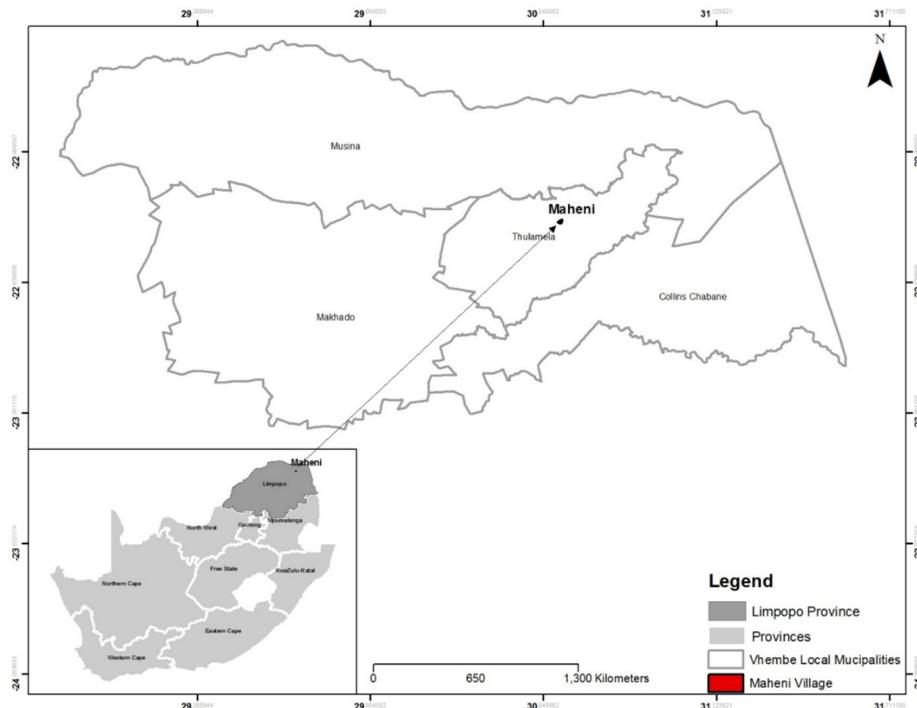
The present study explored the status of water resources, how the resources are impacted by climate change and the community-based adaptation practices adopted to ensure the availability and accessibility of quality and safe water for household consumption. The study results prove that a community-based participation in addressing water scarcity could be important in climate change adaptation to improve climate resilience in the local communities through integrated and adapted water resource management. The research questions were:

- RQ1. What are the main water resources in this community?
- RQ2. What are the current status/conditions of the resources under climate change?
- RQ3. Which adaptation practices are used to ensure water availability and accessibility?

## 2. Description of the study location

### 2.1 Study area

The study was conducted in Maheni community in Vhembe District Municipality of Limpopo Province, South Africa (Figure 1). The district shares borders with Zimbabwe to the north and Mozambique on the east. The Kruger National Park forms the eastern



**Figure 1.**  
Study Location

boundary with greater Limpopo River forming the north eastern boundary of the district. The north eastern part of the district has a dry climate, and is predominantly semi-arid with frequent droughts ([Mutale Local Municipality Integrated Development Plan, 2016/2017](#)). The area experiences annual rainfall of approximately 500 mm per annum out of which about 87.1% falls between October and March. The rainfall is erratic and is largely influenced by the orographic rain effect of the Drakensberg Mountains joining the Soutpansberg perpendicularly hence decreases from east to the west of the district. The mean annual temperature ranges from about 18°C in the mountainous areas to more than 28°C in the northeast. Maximum temperatures are experienced in January and the least occur on average in July ([Mutale Local Municipality Integrated Development Plan, 2016/2017](#)).

Vhembe District is one of the drought stricken municipalities in South Africa. However, borehole yields and groundwater monitoring are major problems in the district. The poor quality (salty) and drying of groundwater at Masisi area and insufficient funding to cover all dry areas are the main challenges ([Statistics South Africa, 2018](#)). Thengwe area experiences drinking water scarcity due to drought ([Musina Local Municipality Integrated Development Plan, 2016/2017](#)). The area around Maheni community is the driest in the district. The 2017 Community Water Management Plan (CWMP) for Maheni community by Wellfield proved that groundwater levels in the river and boreholes have dropped and as a result the community does not have sustainable water resources. This finding motivated the researcher to explore the impacts of climate change on the water resources in Maheni.

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Administratively, Maheni community falls within Thengwe Local Authority under Chief Nethengwe. Nemaheni is headman of Maheni and political head of the community. Settlement pattern is largely rural with most of the households living in modern brick-houses. Traditional mud huts are retained by fewer households used either as the traditional health practitioners' dispensaries or the main huts of elderly family members. Subsistence economy is still relevant and the dominant dryland crops are groundnuts, peanuts, beans and varieties of pumpkins intercropped in the home-gardens and fields. Stock farming of cattle is practiced by fewer households as a result of lack of natural stock-feed and drinking water (Mutale Local Municipality Integrates Development Plan (2016/2017)).

### 3. Methodology

#### 3.1 Study design

A community participatory research was used to explore the impacts of climate change on water resources and the measures taken to cope with water scarcity. Community-based participatory research actively involved members of the community as participants in the research activity. It emerged as part of the search to render development assistance which is more responsive to the needs and opinions of the community (deVos *et al.*, 2010). It is a partnership approach to research that equitably involves, for example, community members, organizational representatives, and researchers in all aspects of the research process and in which all partners contribute expertise and share decision making and ownership. It increases knowledge and understanding of a given phenomenon and integrate the knowledge gained with interventions and policy and social change to improve the health and quality of life of community members (Bergold and Thomas, 2012). A participatory approach was used to explore the impacts of climate change on the community water resources among the members of a rural community in Vhembe District Municipality of Limpopo Province, South Africa. In participatory research, the study is conducted together with the affected members of the community (Bergold and Thomas, 2012). It is generally argued that those persons, groups, and institutions who are affected by the research theme and the expected outcomes must be involved. However, people from all sectors of the community, are important to participate in the study. These are the people whose inclusion is most important to a participatory effort – both because it is their inclusion that makes it participatory, and because of what they bring to it (Bergold and Thomas, 2012).

#### 3.2 Population and sampling

The study population was adult members of Maheni community. Sampling in a participatory study relies on the utterances of the local participants (Bergold and Thomas, 2012). Sampling of participants was carried out through a convenience selection method. The water committee members were identified and recruited through convenience sampling. These were identified by the headman, and subsequently provided with their contact details. Community members volunteered to participate in the study during a community meeting attended by 150 members. The meeting was requested by the researcher to introduce the study and invite volunteers to make up the study sample.

##### 3.2.1 Sample composition

3.2.1.1 Maheni community. Hundred members of the community were part of the study sample. They were 48 males and 52 females. These were the residents of Maheni community, who have been staying in the community for more than ten years.

3.2.1.2 Six Maheni water committee members. The water committee was made up of three males and three females. The committee is responsible for monitoring the use of water resources, alerting the community on any matter relating to the status of the water

resources, ensuring adherence to restrictions on water resource use, and reporting of damage and leakage to the municipality water division. Inclusion of the committee as part of the sample was informed by the fact that the researcher was aware that as a body of knowledge representing the community at the local municipality, they should be given the opportunity to share their knowledge of status of the water resources in the community.

### *3.3 Data collection*

The study was conducted in an ethical manner firstly, by explaining the purpose of the study to all participants, secondly by letting participants sign the consent form as an agreement to participate in the study, thirdly by explaining how data would be collected, analysed and interpreted in such a way that the procedure does not harm the participants, and that their privacy was protected. Community members were brought together to share experiences about the current status of their water resources and how changing climate affect the water resources and water supply, as well as measures to adapt to water scarcity. The researcher conducted twelve group focused group discussions (FGDs) made up of seven members each, plus two groups made up of eight members each, with community members, followed by one group discussion with the water committee members. The discussions were audio-recorded with permission from the participants after which they were transcribed and analysed through discourse analysis. The discussions were followed by a larger community meeting with all the stakeholders including the headman the, water committee, and members of the community. This general community meeting was convened at the end of the study, and was used to make the community aware of the water resources' current status, water scarcity and its causes, and the types of adaptation and coping mechanisms available to share the community experiences of water scarcity, adaptation practices and encourage ensure sustainable supply of safe drinking water. The purpose of the meeting was to encourage the people to adhere to the adaptation measures, and to offer support to the water committee at all times.

### *3.4 Data analysis and presentation*

Analysis of data was accomplished through a thematic content approach where data were categorised under three main themes namely; the main water resources and their status, the impacts of climate change on the water resources, and the community-based adaptation practices. Data were translated from *Tshivenda* and *Sepedi* to English, transcribed, analysed, presented and edited by experts in the Department of Translation Studies at the University of Limpopo.

## **4. Results and discussion**

### *4.1 Community water resources and their status*

Participants were asked to name the water resources and their status. The responses to this question provided a borehole and the municipality reticulation system as the main water resources in Maheni community.

*4.1.1 Reticulation system.* This system utilizes the surface water drawn from the Mutale River to the reservoir at Thengwe. It is served by the bulk water supply scheme operated and maintained by the local municipality. It supplies water to the community through several standpipes connections. The current water supply through the systems is inconsistent as the community gets water for three times in a week.

*4.1.2 Borehole.* There is one main borehole that supplies the community with water when the bulk supply scheme shuts down. The borehole serves as an alternative water supply when the demand on the reticulation system rises. The borehole does not form part of the

reticulation supply, but forms a stand-alone installation that delivers water to communal standpipes. It is not only important for the Maheni community, but also for other surrounding communities. The borehole is subjected to over-utilization by both local and external users with consequent breakdown.

#### 4.2 Perceived impacts of climate change on community water resources

The responses to the question about climate change impact on the current status of the water resources were that the borehole and the reticulation system no longer provide consistent water supply for household consumption. The main reasons for distracted water supply were increased temperatures coupled with less rainfall and drought. Participants were aware that the river and borehole water gets recharge by rainfall, and that hotter temperature lead to excessive water evaporation in the river. Specific impacts of climate change on each water resources were the following:

*4.2.1 Reticulation system.* More than half of the participants (76 %) understood that lack of rainfall with persistent drought negatively affect water availability. As a result, the river streamflow is low and therefore, less water is supplied from the river to the reservoir. The reservoir capacity has decreased as it is never full, even though the water is pumped daily. Sometimes the municipality closes the water supply to the community to allow the reservoir to get full, so more water can be supplied to the community. Another reason for inconsistent water supply is that Maheni community shares the reticulation system with several other communities within Thengwe Local Authority.

Participants responded that drought has affected the river flow by decreasing the water level, thus negatively impacting on constant water supply to the community. [Mutale Local Municipality Integrated Development Plan, 2016/2017](#) reports that approximately 26% of Mutale population does not have access to clean potable water due to persistent drought. A large percentage of households within the municipality have no access to secured sources of water suitable for human consumption, because many people have to travel a distance of about 500 m to fetch water from a public source. [UNECA \(2011\)](#) observes that one third of the world's population lives in water shortage areas, of which about one billion people live without access to safe drinking water as a result of climate change. Climate change projections provide ample evidence that water resources are vulnerable and have the potential to be negatively impacted by drought, with extensive consequences for human societies and ecosystems ([Shaw and Krishnamurthy, 2010](#)).

Fewer participants (37%) added that drought enhanced drinking water scarcity and increased the water demand in the community, and that neighbouring villages such as Mangaya and Makwididja obtain water from the system, thus adding pressure to the supply. These communities obtain water from the same water resources without competing nor fighting for the scarce resource. This type of practice is different from the observations by [Miller et al. \(1997\)](#) that increased water demand has the potential to cause competition and conflicts over transboundary water sources. Five participants mentioned that raising of livestock is curtailed due to drop in the river water level. [Abedin et al. \(2014\)](#) support that fisheries and livestock-based livelihoods are curtailed due to lack of safe water in the rural communities.

The water committee reported similar perceptions of climate change impact on the water resources. They agreed that the river flow has decreased as a result of persistent drought, thus decreasing water supply from the reticulation system. [Yamba et al. \(2011\)](#) support this observation by showing that increased drought will not only result in decreased water availability, but will also increase low storage episodes, which will affect hydro power generation from reservoirs. A further observation by three elderly participants (74, 87 and

89 years) was that excessively hot temperature is also responsible for decreased level of river flow, with escalating temperature that lead to changing patterns of rainfall resulting in drought. This response is in line with the findings of [Warburton \*et al.\* \(2010\)](#) that as the temperature becomes hotter and drier, it will directly affect the quantity of the evapotranspiration on the quality and quantity of the river flow ([Mujere and Mazvimavi, 2012](#)).

*4.2.2 Borehole.* Three water committee members responded that the community does not have enough water for household consumption. They assured that they do not have consistent supply of fresh water for cooking, bathing, washing and general basic hygiene. Eighty-five per cent of participants (community members) corroborated that inconsistent supply of water from the main borehole is attributable to the following:

We experience water shortage because of drought, which led to the lowering of groundwater level. The borehole yield is very low. It takes more than 8 hours to fill up a 10 000 l tank. Sometimes the pump-operator does not open water for the community for a day to allow the water to fill up the tank. A full tank supplies the community for a full day.

[Abedin and Shaw \(2013\)](#) support that groundwater depletion and drought are major difficulties for the rural people to get safe drinking water from groundwater sources. Climate projections provide abundant evidence that water resources are vulnerable and have the potential to be strongly impacted by climate change, with wide-ranging consequences for human societies and ecosystems ([Bates \*et al.\*, 2008](#)). The water committee responded that temperatures have changed, rainfall is erratic and that these are responsible for a decline in water level in the boreholes. Increased pumping and reduced recharge can greatly accelerate water scarcity. [Mathetsa \*et al.\* \(2019\)](#) show that climate change outcomes such as increased temperature and drought episodes have implications for water availability, which in turn affects energy production in countries dependent on hydropower, pump-storage or coal-generated electricity, including South Africa.

#### *4.3 Community-based adaptation strategies*

This section was intended to describe adaptation practices adopted by the whole community to ensure water availability and accessibility. The practices described in this section are embraced by all community members as they are meant to ensure water availability and accessibility for all community members. The practices embrace the following:

*4.3.1 Restrictions on water use.* Inconsistent reticulation water supply and low borehole output motivated the community to appoint a water committee to monitor the water resources use. The committee, through involvement of Maheni community, laid down restrictions on water uses during increasing water stress periods. The community agreed and the members comply with the restrictions and regulations to endure sustainable water supply. During this time, available water is prioritised for domestic and sanitary use. These include restrictions on:

- household supply from connections;
- washing at the main borehole and standpipes;
- watering of vegetables in the home-gardens; and
- livestock drinking from standpipes.

Other regulatory practices include:

- supply of water between particular hours per day, for example the pump operator switches the borehole pump on between 5am to 1pm;
- locking of stand-taps at night;
- leakages and breakages repaired immediately; and

- fines (about \$12) instituted for misuse of water resources, such as leaving the tap opened, and washing at the standpipes.

Further practices involve collecting and storing water as it becomes available from the borehole or standpipes and collection of water from neighbouring villages whenever water is not available in Maheni community. To these practices, [Habiba and Shaw \(2012\)](#) agree that community-based efforts to sustainable safe drinking water supply and access can never be achieved without involving the local community in the planning and development processes. Involvement and ownership by local communities are the key to any successful program, since communities respond first to any kind of natural disaster that happens in their locality. Moreover, community participation and control are essential for successful implementation, orientation, and maintenance of any disaster risk reduction project. There is tremendous potential for well-targeted water interventions to enhance livelihood and support rural development even in water-scarce environments ([Khanal et al., 2014](#)).

## 5. Conclusion

### 5.1 Study objective

The study goal was to describe the status of water resources in Maheni community, the potential impacts of climate change on the water resources, and the adaptation practices to ensure water security. The study results from the water committee and community members show that Maheni community obtains water for household consumption from the reticulation system and the community borehole. These resources, although negatively impacted by persistent drought and excessive temperature, they still provide water to the community. Observable and potential effects of climate change on these water resources include drought, unpredictable rainfall, and increased temperature patterns. The water scarcity is negatively affecting the community livelihood as some cultural practices such as livestock production are nearing extinction. Additionally, the community health conditions are compromised as water scarcity prohibits maintenance of proper hygiene. Community-based adaptation practices are observed by all the members of Maheni community. The practices embrace observance of restrictions and regulations on the water resources use. Others involve securing water from neighbouring resources. The combined effort to save water is best facilitated by the water committee whose responsibility is to monitor the water resources usage and maintain the resources to ensure water security for household consumption. This type of a community-based action in response to climate change, could be used as part of rural water management strategies under climate change.

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#### **Further reading**

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