

Food security under unreliable rainfall: the case study of a rural community in Limpopo Province, South Africa

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ABSTRACT

The present study assessed the use of a geothermal hot spring water flow as an adaptation practice to improve subsistence crop production. The aim of this study is to contribute towards natural resource use and management as an adaptation measure to the problem of rainfall scarcity in subsistence production. Focus group discussions with 45 subsistence farmers were conducted in a community garden in which subsistence crops are grown and maintained through a hot spring irrigation system. The study results show that the farmers are aware that rainfall in Sagole community is becoming scarce. The scarcity of rainfall is impacting negatively on subsistence crop production which is characterised by poor productivity. However, the farmers developed an irrigation system downstream of the geothermal hot spring in which the water is farrowed to the garden to irrigate vegetables and fruits throughout the year.

Key words | climate change, food security, geothermal hot spring, rainfall scarcity, subsistence farming

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INTRODUCTION

Many rural communities are referred to as natural resource-based societies because they survive through self-provisioning food production mechanisms (Madzivhandila 2016). Their knowledge of the social and physical environment intercedes in the use and management of natural resources to adapt to the negative impacts of climate change (Banerjee 2015). Indigenous irrigation systems, drought forecasting and preparedness, mixed cropping and food processing mechanisms are among key adaptation practices (Lebel 2013) acknowledged by the Intergovernmental Panel on Climate Change (IPCC 2007) that they could be helpful towards building adaptive capacity and resilience in the face of climate change.

The development of indigenous irrigation systems out of natural water resources is a major adaptation response to

unpredictable rainfall. Davivongs *et al.* (2012) report that this type of adaptation practice enables small-scale farmers to produce and secure food under unfavourable weather and climate conditions. The indigenous irrigation systems are the mitigation practices against drought where subsistence crops suffer from moisture stress (Chizovachii 2012; Maponya & Mpandeli 2013). This observation corroborates Shrestha & Tiwari (1992) that utilization of indigenous irrigation systems is a common climate change adaptive response in western Nepal, mostly initiated and developed by independent groups of local farmers.

In areas where there is scanty rainfall, subsistence farming is accomplished through an indigenous irrigation system to sustain a rain-fed agricultural system as a strategy to alleviate poverty and enhance food security (Musetha 2017). Such indigenous irrigation systems are adapted to specific climatic conditions to sustain subsistence farming (Lebel 2013). Nepalese indigenous irrigation systems involve diversion of water from the main source through indigenous

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technology structures directly to the agricultural fields (Uprety 1989). Sen *et al.* (2015) support that in the northeast of India, indigenous irrigation systems are cultural and social tools to sustain society along a desired trajectory. The common small irrigation furrows in the SADC turned farmers into natural water resource managers seeking to increase crop water supply to sustain livelihood in the semi-arid regions (Muzeregi & Muparanga 2017). For example, the Chagga people of Tanzania rely on hill furrows' diversion irrigation system, which leads water out of the stream valleys to be used for arable crop irrigation (Tagseth 2008).

In the light of growing concerns about an increased change in climatic conditions in Vhembe District, a more complex approach, to examine subsistence crop production under extreme impacts of unpredictable rainfall and increased temperatures on subsistence production, is essential. The objective of this study was to explore subsistence farmers' perception of rainfall scarcity, its impact on subsistence farming and adaptation practices for sustainable production of subsistence crops to ensure consistent household food supply. The focus of this study is how the farmers, regarded as subsistence farmers, plant and maintain subsistence crops in a community garden for household consumption.

METHODS

Study location and demography

A qualitative study was conducted in Sagole rural community in the Vhembe District Municipality of Limpopo Province, South Africa. Sagole community is located in Mutale Local Municipality along the northern border of South Africa in Limpopo Province. The community has an estimated population of 1,052 (703.13/km²) in 306 households (Mutale Local Municipality 2014/2015 IDP).

Climate

The annual temperature in the study area ranges from a minimum of 10 °C during winter to a maximum of up to 40 °C in summer (Mutale Local Municipality 2014/2015 IDP). The highest evaporation occurs from October to January, and the lowest in June (Tshibalo 2010). The mean annual

rainfall is less than 300 mm. A change in seasonal rainfall onset makes the rainfall shorter (Mpandeli 2014) and scarce with the projected negative impact on agriculture and water resources (Olivier *et al.* 2010; Tshibalo & Olivier 2010). Kabanda & Nenwiini (2016) confirm that rainfall in Vhembe is unpredictable and is likely to result in decreased farming, loss of livestock, shortage of drinking water, low yields and shortage of seeds for subsequent cultivation (Mpandeli 2014). Tshibalo & Olivier (2010) corroborate that rainfall paucity is the most common climate hazard in Sagole community. The main impacts of prolonged erratic rainfall in the study area are cessation of production of livestock and crops, disease and death of livestock, and lack of water (Tshibalo & Olivier 2010). Water demand in the community is higher than the supply because the community depends on the geothermal spring water for household consumption and livestock drinking (Olivier *et al.* 2010).

Data collection and analysis

A qualitative study was conducted to examine the farmers' perceptions of rainfall inadequacy, how it impacts on crop production and the use of human-made irrigation systems to ensure sustainable production of crops. Focus group discussions were conducted in the community garden operated by 45 farmers, referred to as participants in the study. Data were collected through group discussions in five groups, each consisting of nine members. Participants were interviewed in groups to enable them to share knowledge of changing rainfall patterns and the effectiveness of the irrigation in sustaining production of crops. Each discussion lasted for about 2 h, during which time notes were taken. A list of questions was developed to guide the discussions to obtain relevant data. Participation during the discussions was vigorous. Content analysis was used to generate data. Common words and phrases were sorted from field notes to facilitate data analysis. Themes such as perceptions of changing rainfall timing and availability, the impact of changing rainfall on farming practices, and use of the spring water to grow and maintain the crops emerged from recorded data. All participants gave their informed consent for participation in the study. Credibility and dependability of collected data were obtained during follow-up meetings held in the garden.

RESULTS

The farmers

Crop production is done by 45 farmers in a community garden, which is about 3 ha and well fenced to prevent intruding animals. The farmers were permanent residents of Sagole community. Affiliation to this group is by permanent residency, need, willingness and dedication to provide for household food security. The farmers are aged between 26 and 63 years, with majority (71%) aged 41 years and above, which is an indication that the farmers are in the key age groups to take the responsibility of ensuring food security in their households. They are married (40%), single (31%), widows (11%) and divorced (18%). Of the farmers, three could neither read nor write. The majority (88%) obtained primary education. None of the farmers was employed, other than subsistence farming in the garden. Production from the garden is a source of food and income. Their household sizes range between 3 and 12 members, with the majority living in households with membership of below 10. Three farmers live in traditional huts, one in a shack and the rest of the farmers in modern conventional brick houses with corrugated or tiled roof.

Farmers' perception of rainfall scarcity

The first question asked was about the perception of rainfall. The responses were that the last period of good rain in Sagole community was over 30 years ago and since that time rain has become unpredictable, and there is noticeable variation in its timing and availability. Forty-two participants said:

'Rain does not fall at the expected time. We are experiencing less rain, which comes late during the months of December and January. We used to have the first rainfall between September and November.'

Observations by 75% of participants were that:

'Generally the first rain falls after the agricultural season between October and December, followed by consistent fall, which marks the beginning of the ploughing season. Recently the first rain falls in late November to

late December, and if by this time it has not fallen, we may not experience any rainfall for the year.'

All participants pointed to several factors as indications of rainfall variation in the community:

'Our boreholes are dysfunctional due to declining groundwater level. Our crops in the home gardens do not grow well and the yields are less and poor. Our fields are lying fallow, and have not been ploughed for more than twenty years due to rainfall insufficiency. Fewer of us are raising livestock as a result of depleted stock feed in the form of grass, leaves and pods. Shortage of rain also resulted in scarcity of food resulting from the natural flora and fauna, which led to diversified livelihood patterns from a subsistence to cash economy.'

Farmers' perceptions of the impact of rainfall scarcity on subsistence farming

All participants reported that farming in the community is rarely practised due to many years of rainfall insufficiency. Thirty-five participants articulated:

'We do not receive adequate rainfall to enable us plant the crops in the home gardens and fields. The crops we plant do not do well because rainfall does not fall much. Unreliable rainfall is adversely affecting crop yields, which are recently characterized by low production.'

Forty participants mentioned:

'It is difficult to plan and make agricultural decisions. We are unable to produce enough food from our gardens and fields. We only collect naturally growing vegetables in the gardens and fields.'

Food production under rainfall scarcity

The reasons provided for planting in the community garden were that:

'Despite the late coming and scarcity of rainfall in the area, we continue to plant and maintain the crops by

using our indigenous irrigation system. The system derives water from the hot spring water down-flow. This supplies us with water to grow and maintain the crops. The water collected from the main eye of the spring (Figure 1) is used for household consumption. The spring flow is developed into three spas; one spa for men, another for women, which is used for bathing and washing, and lastly the private spa protected as a tourist attraction.'

Arrow A in Figure 1 shows the spring eye and Arrow B shows the collection point from which community members collect water for household consumption. Arrow C shows two pipes through which warm water is routed to the men, women and private spas. The spring water has a down-flow which, together with used water from the spas (Figure 1), gets collected into a livestock drinking pool, then flows into a sand-dam developed to harvest the water for irrigation purpose.

Forty participants added:

'Water from the sand-dam is our main source of irrigation. From the dam it is transported through furrows and ditches to a community garden. The previous farmers have purposely planted a common river reed (*Phragmites australis*) to filter the water in the sand-dam. We are aware that water gets cleaned here by the reeds. The dirt is absorbed by the tiny roots of the reed. The water furrowed to the garden is purified and suitable for planting and maintenance of the crops.'

Participants reported on the irrigation system usage:

'The spring irrigation system supplies enough water required to grow and maintain the crops. We use more water when we plant and to maintain the crops. At the moment the water is flowing constantly and we have enough water for irrigation. When the spring water level drops, less water becomes available for irrigation. Water demand varies across the crops, but we use more water for planting and irrigation of vegetable than fruit crops. We water the crops twice in a week during winter, and three to four times a week during summer. Bigger fruit crops are rarely irrigated. We do not have any knowledge about the amount of water we use daily or weekly for irrigation.'

When asked about the irrigation system management, they said:

'We have dug furrows in the garden to prevent water loss through run-off. We rely on a check-dam and spring eye to monitor availability of water in the sand-dam.'

This management strategy was further elaborated by 28 participants:

'The natural plant debris regularly blocks the spring down-flow at the end of the livestock drinking pool and thus affect the quantity of water flowing into the sand-dam. Very often we collect garbage around the irrigation system to avoid blockage of the system.'

A further question was asked about the type of crops produced in the garden. Thirty-five participants said:

'The most dominant crops we grow are the nuts, pumpkin and melons. We grow these crops all year round. We have increased the type and amount of crops grown in the garden. For example, recently we also grow spinach, maize, beans, groundnuts, cabbage, onion, tomato, chilies, mango, banana, avocado and papaya to maximize food availability and accessibility. These crops grow well until they mature and are harvested for consumption. The amount of crops harvested surpasses the quantity of crops harvested under rain-fed cultivation, which ranges from 1–3 bags of maize. The estimated quantity of the crops harvested from the garden in a season is about 2–5 × 50 kg bags of maize, and about 1–3 grades (1 grade is about 20 kg) for each of the other crops. Although production is for household consumption, we are able to sell surplus avocado, banana, mango and maize to local households and hawkers at about \$50 per grade of either of the crops.'

DISCUSSION

The farmers understand that there is change in the timing and availability of rainfall in the area. They observe that rainfall has become unpredictable and erratic, which has negatively impacted on rain-fed crop production. There is



Figure 1 | Sagole geothermal spring. Arrow A: Spring eye. Arrow B: Household consumption water collection point. Arrow C: Pipes taking water to the spas (photo by the researcher).

general agreement among the farmers that rainfall is delayed and has declined. Rainfall deterioration is confirmed by fields which have not been planted for a longer period, scarcity of native plant and animal species, as well as depleted water resources. This type of understanding of climate change corroborates the Department of Science & Technology (2010), Tshibalo (2010), Limpopo Economic Development & Tourism (2013), and South African Weather Services (2015) that rainfall in the Limpopo Province has become erratic, occasional and delayed (Kruger & Sekele 2012; Musetha 2017). Lebel (2013)

supports that herders in the Asian Pacific are clear that rainfall has become patchier and delayed. Rankoana (2016) attests that local communities are aware that rainfall timing and availability have changed, and have negatively impacted crop production, water resources and biodiversity. Rainfall is a driving force for rain-fed crop production, which is currently suffering under unpredictable rainfall (Goh 2012). Limited precipitation renders rural poor households' food production efforts unavoidably compromised (Madzivhandila 2016). Tshibalo & Olwoch (2010) add that when rainfall is scarce for rain-fed crop

production, households usually would have minimal harvesting.

In the study, rainfall degeneration has led the farmers to produce crops through the use of an indigenous irrigation system. The system is fed by the hot spring down-flow, which is the main water source in the community simultaneously used for household consumption, livestock drinking, entertainment and ritual purpose. This type of water usage corroborates the multiple-use water services (MUS) approach, given by van Koppen *et al.* (2006), that rural communities' needs are met from a single water source. The farmers ensured that the spring water supply is constant and the water quality is suitable for planting. In summer, the spring discharges more water resulting in a higher flow into the irrigation system than in winter. The farmers use the hot spring water despite Olivier *et al.* (2010) report that this spring water is not suitable for supplemental irrigation because most geothermal springs have a pH value of about 8 and a sodium absorption ratio of more than 1. For Yibas *et al.* (2011), the use of hot springs is usually determined by factors such as accessibility, ownership of the resource and distance to a potential user other than external factors.

The use of *Phragmites australis* species to purify the water in the sand-dam is supported by Usher (1988) that indigenous filtration is a community-based adaptation practice to water scarcity in which available water resources are sustained for a livelihood. Guntenspergen *et al.* (1989) attest that the species is commonly used in the treatment of grey water from lavatories and kitchens. Greywater from lavatories and kitchens is routed to an underground septic tank-like compartment where solid waste is allowed to settle. The water trickles through a constructed wetland or artificial reed-bed, where bacterial and physico-chemical action at the surface of roots and leaf litter remove the nutrients (Guntenspergen *et al.* 1989). The water at this stage is suitable for irrigation, groundwater recharge, or released to natural water-courses (Hoffmann *et al.* 2011). A further observation by Frank & Buckley (2012) is that reed-beds and constructed wetlands are applied to treat domestic effluents in the rural communities, where small volumes of effluent may mean that conventional systems are not cost-effective.

The farmers use the irrigation system to plant and maintain varieties of crops throughout the year. The crop yields

are satisfactory. Surplus of crops is sold locally. The quantity of crops produced by the farmers is corroborated by Tilahun *et al.* (2011) that agricultural production is usually higher for irrigated agriculture than for rain-fed agriculture. Hamdan & Salman (2005) observe that irrigated land has a higher yield potential than rain-fed land. The farmers grow different crops and are making better use of the hot spring water, following food security strategies suggested by Maponya & Mpandeli (2013), Frank & Buckley (2012) and Rankoana (2016) that crop variation is the most efficient adaptation strategy trusted by small-scale farmers.

Management of the irrigation system rests with the farmers. The system is monitored through the collection of garbage similar to the system observed by Banerjee (2015) in India, where the farmers make occasional check-dam and availability of canal water for irrigation as the most useful practice. Olivier *et al.* (2010) propose that thermal hot springs are natural resources that, if developed optimally, could make a considerable contribution to the local and regional economy of people living in the poor communities. For example, villagers from Chimwara Village in Lupane District, Matabeleland North Province in Zimbabwe developed an irrigation scheme through harnessing water from a hot spring situated within a former safari farm in their area (Nsingo 2016). Therefore, the hot springs, which are about 37 °C used mostly for entertainment in the Nigerian Precambrian crystalline province and the Kitagata hot springs in Uganda, could be used for irrigation purpose to boost rain-fed farming (Kurowska & Schoeneich 2010). In Kenya's Olkaria area, the hot springs with varying temperatures from 22 °C to 98 °C could be used to develop irrigation systems as adaptation practices to unpredictable rainfall for the local pastoral peoples suffering from lack of water for domestic use and for the animals (Cataldi *et al.* 1999).

CONCLUSION

The present study was conducted to examine subsistence farmers' perceptions of rainfall scarcity, how it impacts crop production, and their adaptation practices to rainfall scarcity to sustain subsistence crop production. The study shows that the farmers are aware of rainfall shortage,

which is a major threat to subsistence farming. However, the farmers developed a sustainable irrigation system from Sagole geothermal hot spring down-flow as a supplemental irrigation system to grow and maintain the crops. This adaptation practice is sustainable in response to rainfall scarcity and enhances resilience of rain-fed agriculture.

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CONFLICT OF INTERESTS

I do not have any conflicting interests.

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