Factoring water harvesting into climate change adaptation: Endogenous responses by smallholder farmers in Gwanda district, Zimbabwe

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SOCIOLOGY | RESEARCH ARTICLE

Factoring water harvesting into climate change adaptation: Endogenous responses by smallholder farmers in Gwanda district, Zimbabwe

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Abstract: Climate change in the form of temperature increases and rainfall variability has intensified in the last three decades. Recent studies in Southern Africa (of which Zimbabwe is part) have indicated the extreme vulnerabilities of smallholder farmers to the impact of climate change and recommended that appropriate adaptation measures be put in place. In-field rainwater harvesting is one of the adaptation strategies that has been adopted by some smallholder farmers in drought-prone regions. The study examines the effectiveness of in-field rainwater harvesting as a climate change adaptation strategy for smallholder farmers in Gwanda district, Zimbabwe. Data was collected through semi-structured questionnaires (administered to 45 smallholder farmers) and five key informants. We find that most respondents adopted pit planting and mulching in-field rainwater harvesting techniques. A few respondents practised deep tillage, dead level contours, ephemeral stream diversion, ridges/furrows and hillside sheet runoff. In-field

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PUBLIC INTEREST STATEMENT

Climate change has adversely affected agricultural production leading to food insecurity in many African countries. Smallholder farmers who are dependent on rain-fed agriculture continue to experience low yields and widespread crop failure. This study examines the effectiveness of in-field rainwater harvesting as a climate change adaptation strategy by smallholder farmers. Water harvesting techniques reduce surface runoff thereby promoting water conservation and soil fertility. Findings of this study suggest that most respondents adopted water harvesting techniques such as pit planting, mulching whilst a few respondents practised deep tillage, dead level contours, ephemeral stream diversion, ridges/furrows and hillside sheet runoff. Smallholder farmers are reluctant to adopt in-field rainwater harvesting techniques as they are labour intensive and some require technical expertise. We recommend that the government of Zimbabwe and its development partners should equip smallholder farmers with some technical know-how which will enable them to adopt appropriate in-field water harvesting techniques.
rainwater harvesting techniques increase the time required for crop moisture to set in resulting in improved crop yields. However, farmers are reluctant to adopt in-field rainwater harvesting techniques as they are labour intensive and some require technical expertise. We recommend the implementation of programmes that will enhance the capacity of smallholder farmers to implement various adaptation strategies.

**Subjects:** Development Studies; Sustainable Development; Rural Development

**Keywords:** climate change; in-field rainwater; adaptation; smallholder farmers; Zimbabwe

### 1. Introduction

The African continent is more vulnerable to the impact of climate change than other regions (Gemeda & Sima, 2015; United Nations Development Programme, 2018). Climate change has influenced (and will continue) rainfall patterns, altering the amount of precipitation received and distribution of precipitation over the years (Dube et al., 2016; Gbegbelebe et al., 2018; Phiri et al., 2014). Projections show that temperatures in the African continent will rise at a faster rate than the global average. Average temperatures in the African continent are expected to increase by 1.5–3°C by year 2050 (Gemeda & Sima, 2015). There is substantial evidence that climate has been changing in recent decades, both in terms of means and extremes, and this trend will not only persist, but will also intensify in the near future (Denkyirah et al., 2017; Dube & Phiri, 2013; Gandure et al., 2013). Extreme weather events including droughts, floods and heat waves are likely to become more frequent and more severe. Predictions indicate that southern Africa will become drier, whilst eastern and western Africa will become wetter, with more intense rain and increased risk of floods (United Nations Development Programme, 2018).

Climate change has devastating and far-reaching effects on agriculture in Africa (Arora, 2019; Donatti et al., 2019; Ombogoh et al., 2018; Phiri et al., 2019). The increasingly unpredictable and erratic nature of weather systems has placed an extra burden on food security and rural livelihoods. Temperature increase and/or rainfall declines have translated into widespread crop failure. Most livelihoods in the continent depend on agriculture in one way or the other. Approximately 60% of the African population rely on agriculture for their livelihoods (Phuong et al., 2018; United Nations Development Programme, 2018; Yosef & Asmamaw, 2015). Agriculture is mostly practised under rain-fed conditions thereby making crop production in Africa more vulnerable to climate change and variability. Areas suitable for agriculture have been negatively affected by climate change, thereby adversely affecting food security and exacerbating malnutrition in the region. A number of countries in Africa already face semi-arid conditions that make agriculture challenging (Gemeda & Sima, 2015). Climate change has reduced the length of farming seasons and has forced many smallholder farmers out of production. Studies in South Africa have shown that every 1% decrease in annual rainfall might translate to a 1.1% reduction in maize production (Gandure et al., 2013). It has been estimated that climate change will reduce agricultural production in Sub-Saharan Africa by 10–20% by 2050 (Ombogoh et al., 2018). Agriculture's sensitivity to climate-induced stress has intensified existing problems of declining agricultural outputs, poverty and food insecurity, with smallholder farmers mainly affected (Gbegbelebe et al., 2018; Ngondjeb, 2013; Phiri et al., 2019). Smallholder farmers have limited resources to maintain or increase agricultural productivity and are more vulnerable to climate change due to their dependence on rain-fed agriculture (Donatti, Harvey, et al., 2019; Gbegbelebe et al., 2018). The rise in hunger levels in the African continent is constantly increasing year after year due to the impact of climate change. It will be impossible to eradicate hunger in line with the Sustainable Development Goals due to the impact of climate change on agriculture.

Climate change adaptation strategies are very crucial in saving the lives of the vulnerable communities in the African continent who are dependent on agriculture for their livelihoods.
(Gemeda & Sima, 2015). Adaptation is a process by which individuals, communities and countries seek to moderate and cope with the consequences of climate change, including variability (United Nations Development Programme, 2018). Various climate change adaptation strategies have been employed by smallholder farmers with the support of governments and their development partners. These include livelihood diversification (Donatti, Harvey, et al., 2019), shifting to drought-resistant crops such as small grains and early maturing crops (Debray et al., 2019; Phiri et al., 2019), crop diversification (Gezie, 2019; Legesse et al., 2013) use of appropriate technology, improved water conservation methods, changing planting times (Dube et al., 2018) and soil fertility management (Gezie, 2019). According to Arora (2019) climate-smart agriculture such as the cultivation of resilient varieties of crops which can withstand abrupt stresses of temperature and precipitation is one of the important adaptation strategies. Adaptation strategies have been adopted and implemented with mixed results in many resource-constrained communities.

Climate change adaptation by improving water conservation and management practices for agriculture is important in reducing crop production vulnerability to climate variability (Gezie, 2019). This is important in attempting to reduce the vulnerability of smallholder farmers through enhancing and upscaling in-field rainwater harvesting techniques so as to increase crop yields. The concept of in-field rainwater harvesting, as used in this paper, refers to a basket of soil and water conservation techniques designed to enhance rainwater infiltration (Tolossa et al., 2020). There are several in-field water conservation practices that have been used in several regions of Africa, including earth bunds, planting pits or planting basins, mulching, dead level contours and their modifications (Tolossa et al., 2020). Nyamadzawo et al. (2013) note that, after substantial donor funding targeting improved food security for vulnerable households, there has been renewed effort to promote soil and water conservation. This has increased the uptake and adoption of climate change adaptation strategies such as in-field rainwater harvesting techniques by farmers in most drought-prone regions. Drought-prone areas experience recurrent periods of below-average rainfall. In recent years, droughts have become frequent taking place every two to five years in the drought-prone regions (Bayissa et al., 2019). As droughts become frequent, it is projected that by 2100, arid and semi-arid regions of Africa are expected to expand by 5–8% (Gemeda & Sima, 2015). Rain-fed agriculture in the advent of climate change has exacerbated the already precarious living conditions of many smallholder farmers (Donatti, Harvey, et al., 2019); hence, the importance of small-scale systems of in-field rainwater harvesting in sub-Saharan Africa has recently been recognised.

Climate change adaptation is of importance to smallholder farmers in Zimbabwe like all other countries that are experiencing deteriorating agricultural yields due to the frequency of droughts. Zimbabwe’s agricultural production is largely rain-fed and the sector is one of the most vulnerable sectors to climate change and variability (Phiri et al., 2019). Food insecurity has become a perennial problem for rural communities in the country. The government of Zimbabwe and Non-Governmental Organisations have provided support to help and encourage smallholder farmers to adopt in-field rainwater harvesting techniques in adapting to the impact of climate change. In spite of several calls for smallholder farmers to implement various adaptation strategies, the uptake of in-field rainwater harvesting techniques remains low. It is important to note that most smallholder farmers in Zimbabwe continue to practice conventional farming practices regardless of low agricultural yields or crop failures realised from such practices. A few smallholder farmers have implemented in-field water harvesting techniques to improve food production. In this regard, this study examines the effectiveness of different in-field rainwater harvesting techniques adopted by smallholder farmers in Gwanda district, Zimbabwe. In so doing this study answered the following questions:

(1) What are the various in-field rainwater harvesting techniques utilized by smallholder farmers in Gwanda district?

(2) How effective are these in-field rainwater harvesting techniques in improving crop production?

(3) What factors influence the adoption of in-field rainwater harvesting techniques and strategies?
2. Methods

2.1. Location and Geography

The study was conducted in ward 4 of Gwanda district, Zimbabwe. Gwanda district is located 126 km Southeast of Bulawayo, along the Bulawayo-Beitbridge road. Shake community was chosen because many smallholder farmers have adopted various in-field water harvesting techniques. Gwanda district has a population of about 155 778 and ward 4 has estimated 1,600 people (Zimbabwe National Statistics Agency, 2012). Zimbabwe has five agro-ecological regions (Table 1) and Gwanda district falls under agro-ecological region IV and V. The region receives very low and erratic rainfall. The annual rainfall is less than 450 mm (Food and Agriculture Organisation, 2006). Due to the high frequency of droughts in the area; rain-fed cropping is often risky as mid-season dry spells often lead to complete crop failure.

2.2. Sampling and Data collection methods

Data were collected in March and April 2017. The study utilised semi-structured questionnaires and key informant interviews to collect data. Study participants were purposively selected (i.e. households practising in-field water harvesting techniques). Purposive sampling was well suited as the sampling technique involves selecting certain units or cases based on a specific purpose rather than randomly (Teddlie & Fen, 2007). Semi-structured questionnaires were administered by a team of four researchers to a total of 45 smallholder farmers. Farmers that did not adopt in-field water harvesting techniques were excluded from the research. The structured sections of the questionnaires were used to collect household data on demographics, effects of climate change, size of land cultivated using in-field water harvesting techniques. Questionnaires were administered in the local language (IsiNdebele). A five-point scale (do not know, poor, fair, good and excellent) was also used to assess the effectiveness of the various in-field rainwater harvesting techniques. The use of this scale enabled the researchers to capture individual perceptions of the farmers on the effectiveness of in-field rainwater harvesting techniques such as mulching, pit planting, contours, deep tillage, ridges/furrows. Farmers were also asked whether they had experienced a significant yield increase due to the adoption of in-field rainwater harvesting techniques. If the answer was yes, they were asked to quantify the increase.

Table 1. Description of Agro-ecological zones of Zimbabwe

| Natural Region | Area (000 ha) | % of total land area | Annual rainfall (mm) | Farming Systems |
|----------------|---------------|----------------------|----------------------|-----------------|
| I              | 613           | 1.56                 | > 1000. Rain in all months of the year, relatively low temperatures | Suitable for dairy farming forestry, tea, coffee, fruit, beef and maize production |
| II             | 7 343         | 18.68                | 700–1 050. Rainfall confined to summer | Suitable for intensive farming, based on maize, tobacco, cotton and livestock |
| III            | 6 855         | 17.43                | 500–800. Relatively high temperatures and infrequent, heavy falls of rain, and subject to seasonal droughts and severe mid-season dry spells | Semi-intensive farming region. Suitable for livestock production, together with production of fodder crops and cash crops under good farm management |
| IV             | 13 010 036    | 33.03                | 450–650. Rainfall subject to frequent seasonal droughts and severe dry spells during the rainy season | Semi-extensive region. Suitable for farm systems based on livestock and resistant fodder crops. Forestry, wildlife/tourism |
| V              | 10 288        | 26.2                 | < 450. Very erratic rainfall. Northern low veldt may have more rain but the topography and soils are poor | Extensive farming region. Suitable for extensive cattle ranching. Zambezi Valley is infested with tsetse fly. Forestry, wildlife/tourism |

Source: (Food and Agriculture Organisation, 2006)
Table 2. Key Informants

| Organisation                                      | Number of Key Informants |
|--------------------------------------------------|---------------------------|
| Department of Agricultural Technical and Extension Services | 1                         |
| Department of Mechanisation                       | 1                         |
| Dabane Trust                                      | 1                         |
| Ward Development Committee                        | 2                         |
| Total                                             | 5                         |

Note: all quotations used in the paper are translated from IsiNdebele.

The questionnaire (through open-ended questions) also enabled an in-depth exploration of experiences, views and knowledge of smallholder farmers on climate change and adoption of in-field rainwater harvesting techniques as an adaptation strategy and factors affecting the adoption of these techniques. Smallholder farmers’ perceptions on; the various in-field water harvesting techniques utilized by smallholder farmers, the effectiveness of the in-field rainwater harvesting techniques and factors that influence the adoption of in-field rainwater harvesting techniques and strategies were sought through open-ended questions.

In addition to the questionnaires, a total of five key informant interviews were conducted to complement the data (Table 2). The key informants include three officers from; Department of Agricultural Technical and Extension Services, Department of Mechanization, Dabane Trust and two members of the Ward Development Committee. The purpose of utilizing key informant interviews was to gather information from respondents with technical expertise on in-field rainwater harvesting techniques. Key informant interviews provided the researchers with valuable information which substantiated findings extracted smallholder farmers through the interviews and questionnaires. Key informants were also asked open-ended questions in relation to the various in-field rainwater harvesting techniques utilized by smallholder farmers in the ward, their effectiveness and factors influencing their adoption.

2.3. Respondents’ profile

Of the targeted 45 smallholder farmers, 67% of the respondents were females and 33% being males. Women constituted a larger proportion of the respondents due to factors such as rural to urban migration, international migration (as men migrate to neighbouring countries such as South Africa and Botswana) in search of employment. Most of the households were also labour constrained which has inhibited the adoption of labour-intensive water harvesting techniques. On average respondents were 53 years, with the eldest being 72 years and the youngest 33 years. This means that the smallholder farmers practising in-field rainwater harvesting techniques are experienced. We found that most respondents (93%) were literate, whilst 7% were illiterate. It is important to note that 49% of the literate had acquired primary school education, and 44% had secondary school education. Only 7% of the respondents had tertiary education. Literacy is important in climate change adaptation as it enables farmers to have access to appropriate information (Brown et al., 2019; Dang et al., 2019).

3. Results

3.1. Awareness of Climate Change

We found that the majority of smallholder farmers are aware of the climate change phenomenon. The smallholder farmers indicated that they had observed some changes in their community such as; unpredictable weather conditions, increases in temperature, decrease in rainfall, high prevalence of droughts and floods. Figure 1 shows that most (86%) smallholder farmers perceived increases in temperature over the past 10 years. Very few (4%) farmers perceived a decrease in temperature and 10% were not aware of any changes. Additionally, 92% of the smallholder
farmers indicated that they had noted decreases in rainfall over the past 10 years (see Figure 2). One of the farmers pointed out that “we now receive rainfall late and the rainfall season is now short. On the other hand, this area is now extremely hot” (Smallholder farmer 1, April 2017). This shows that farmers have distinguished changes in rainfall patterns and temperature due to climate change. One of the key informants also pointed out that:

The high temperatures in this region contribute immensely to the low yields attained by the smallholder farmers. High temperatures expose crops to moisture stress which inhibits their growth and maturity. In most cases crops are exposed to high temperatures during the flowering stage leading to total write off. (Key Informant 1, March 2017)

Smallholder farmers in Gwanda experienced a significant decrease in agricultural yields and crop failure due to climate change. Resultantly, climate change has been the impetus behind the adoption of different in-field rainwater harvesting techniques by smallholder farmers in the study area. Hence, awareness of climate change is crucial in influencing adaptation.
3.2. In-field rainwater harvesting techniques used by smallholder farmers in Gwanda district

An analysis of common in situ water-retaining opportunities at the disposal of smallholder farmers revealed that there are a number of techniques and strategies available. Most smallholder farmers adopted mulching (96%) and pit planting (96%) as in-field rainwater harvesting techniques (see Table 3). In addition to pit planting and mulching, a few farmers practised deep tillage, dead level contours, ephemeral stream diversion, ridges/furrows and hillside sheet runoff. These techniques were adopted to enhance infiltration and prevent runoff. One of the key informants reported that:

The widely adopted water harvesting techniques in this ward are a pit planting and mulching. This is attributed to the fact that these techniques improve rainwater storage. Mulching and pit planting have enabled poor households to produce enough yields for their households. (Key informant 2, March 2017)

One of the smallholder farmers without draught power indicated that:

For the past five years, pit planting and mulching have been the agricultural techniques to turn to as these techniques make farming easier and despite the uncertainties of the rains I am always assured of a yield, or sometimes even harvest more that those who have draught power. (Smallholder farmer 2, April 2017)

This means that in situ water harvesting techniques in the form of mulching and pit planting are widely practised by smallholder farmers who participated in the study. Pit planting and mulching play a significant role in preventing runoff of the inadequate rainfall received in Gwanda district. Pit planting and mulching are part of conservation farming methods that have been supported by Dabane Trust (an NGO). Dabane Trust and other NGOs support smallholder farmers in water conservation techniques to improve agricultural yields in the drought-prone areas in Gwanda district.

Farmers adopted more than one water harvesting technique in averting the impact of climate change. Most (96%) respondents reported that they adopted two water harvesting techniques. Such farmers adopted pit planting and mulching. The smallholder farmers pointed out that they adopted more than one technique to cater for the different crops cultivated. Pit planting, mulching and ridging were mainly used for cereal crops, whilst legumes were grown using ridges or furrows. Pit planting was found to be the widely adopted water conservation technique and improves soil fertility. Planting pits are a form of freestanding water harvesting structures consisting of small pits in which individual or small groups of plants are sown. The high preference of pit planting was attributed to its simple construction, and that the technique saves manure and conserves more water. A smallholder farmer who preferred this technique highlighted that:

I prefer using pit planting because it saves manure. I apply manure in the planting basins instead of wasting it by applying in land without crops. I usually re-use the pits for two farming seasons. (Smallholder farmer 3, April 2017)

| Infield Water Harvesting Technique       | Percentage |
|------------------------------------------|------------|
| Mulching                                 | 96%        |
| Pit planting                             | 96%        |
| Dip tillage                              | 13%        |
| Ridges/Furrows                           | 5%         |
| Dead Level Contours                      | 11%        |
| Hillside Sheet Runoff                    | 2%         |
| Ephemeral Stream Diversion               | 9%         |

Note: Multiple responses were allowed
This shows that in addition to conserving water, pit planting requires less manure as compared to the conventional farming approach. Farmers also re-use the planting basins which enables them to extend the area under pit planting. Conservation agriculture, which includes pit planting improves the storage of rainwater in the soil and thus facilitating longer crop growth periods in areas with inadequate rainfall (Dube et al., 2018). However, it is important to note that pit planting is labour intensive and hence not suitable for labour-constrained farmers.

More so, many smallholder farmers also adopted mulching as it is a reliable source of manure which is readily available in their fields. Mulching reduces direct raindrop impact such as soil erosion, water runoff. It was established that mulching is a water harvesting technique that aids water to seep into the soil and reduces evaporation and conserves moisture for the crops. Furthermore, mulching was adopted by smallholder farmers who are labour constrained and those without draught power. One such farmer highlighted that;

I use the mulching method to reduce water loss from the soil surface. Mulch is readily available. As a farmer I place crop residues, leaves and grass between rows during land preparation in the dry season. (Smallholder farmer 4, April 2017)

Mulching is an in-field water harvesting technique that enhances proper management of crop residues. As the organic mulch decomposes it increases soil fertility and improves plant growth. Mulching is widely adopted by most smallholder farmers as it is a simple and cheap water conservation technique.

Deep tillage, dead level contours, ephemeral stream diversion, ridges/furrows and hillside sheet runoff were adopted by a few farmers. Dead level contours and ridging were adopted by framers who practised agriculture on slopes. Contour farming and ridging were adopted by a few farmers for sweet potatoes and groundnuts. The study found that the availability of labour, technical knowledge and skills were the major factors that influence the adoption of these techniques. Some key informants indicated that

Ridges and earth bunds are labour intensive and complex in their implementation and this has made their adoption and preference to be minimal as most households are labour constrained as a result of migration to urban areas or South Africa. (Key informant 3, March, 2017)

... these techniques (i.e. ephemeral stream diversion and hillside sheet runoff) are adopted by a very few smallholder farmers due to high construction costs (labour) and the need for technical knowledge. (Key informant 1, April 2017)

Technical knowledge such as a basic understanding of factors such as soil type, landscape and slope is pre-requisite elements needed in constructing in-field water harvesting techniques such as ephemeral stream diversion. Resultantly, a few smallholder farmers adopted such water harvesting techniques. With reference to ridges, Dube et al. (2018) concluded that the construction and maintenance of contour ridges require a physically strong labour force and more human labour as it is a demanding exercise. However, it should be noted that these techniques conserve more water although they are not practised by many farmers.

The effectiveness of the in-field water harvesting techniques was assessed in the manner in which they enhance soil water moisture retention. Moisture conservation increases the period water is available for crops, considering perceived decreases in rainfall and increases in temperatures reported by the farmers. Soil moisture retention is important for crops to survive during mid-season droughts. Smallholder farmers observed that dead level contours retain more moisture with the highest range/number of days (seven days and above). However, it is important to note that the technique was adopted by a few smallholder farmers due to the
need of technical knowledge and expertise for their construction. An AGRITEX officer highlighted that “dead level contours are an effective rain-water harvesting technique. They retain water and moisture for more than a week and they feed the entire field” (Key informant 1, March 2017). Dead level contours are an adaptation strategy designed to harvest excess runoff water from upslope areas and have it stored and infiltrated into the soil rather than drained and diverted out of the field (Mugabe, 2004). The water slowly percolates into the field on either side of the contour and provides vital moisture to the field over a period of time. The dead level contours vary in size, with a majority of farmers adopting those that range from 0.3–0.6 m deep and 0.5–1 m wide (Practical Action, 2012).

It was also noted that pit planting and mulching techniques keep and retain moisture in the ground for a period of about five days to seven days. Pit-planting was adopted by most smallholder farmers as a technique that store and retain moisture for more than five days up to a week. They often use 30 cm in diameter and 20 cm deep planting pits that permit the concentration of water allowing its infiltration. Smallholder farmers pointed out that mulching restricts runoff and exposure of the ground to the high temperature, thereby limiting the occurrence of evapotranspiration. More so, ridges/furrows were pointed out as other in-field rainwater harvesting techniques with the potential to retain moisture for five days up to a week, allowing crop production even during the drier agricultural seasons.

Smallholder farmers adopted varied in-field rainwater harvesting techniques for different crop types. The commonly grown crops in Gwanda district include maize (staple crop), sorghum, round nuts, cowpeas, groundnuts, millet and sweet potatoes. For cereal crops, the commonly adopted techniques included pit planting, mulching and contours, whereas legumes were grown using techniques such as ridges or furrows. Most farmers adopted pit planting and mulching for cereals such as maize, sorghum and millet. Techniques such as dead level contours were observed to cut across the fields hence benefitting a major proportion of the cultivated land. Improvements in yields were recognised by smallholder farmers as a result of adopting the in-field rainwater harvesting techniques. Smallholder farmers indicated that they had observed a yield increase in maize, groundnuts, round nuts, cowpeas, sorghum, sweet potatoes and millet crops. In line with yield increases, one respondent indicated that;

The adoption of in-field rainwater harvesting techniques, other than assuring smallholder farmers of yield has on average resulted in 50-150kg yield increases in cereals and 50-100kg yield increases in legume. (Key informant 5, March 2017)

To further explain this one smallholder farmer echoed that;

Ever since I adopted conservation agriculture (in form of pit planting and mulching), hunger has become a thing of the past, my family has access to food almost throughout the year. (Smallholder farmer 5, April 2017)

Smallholder farmers attributed the reason behind the increase in yields of the maize crop to the shift from conventional methods to the adoption of moisture-retaining farming techniques. Through the conventional farming techniques, zero or low yields were obtained for some crops such as maize. Maize crop is rendered inappropriate in the region due to erratic rainfall. However, farmers continued to plant maize as it is preferred than other cereals such as sorghum and millet. Climate change has increased the probability of maize crop failure across Sub-Saharan Africa (Gbegbelege, 2018). Smallholder farmers acknowledged the effectiveness of in-field rainwater harvesting techniques and how these assured households of yields annually. The adoption of in-field rainwater harvesting techniques enhanced the availability of food by smallholder farmers. Most respondents indicated that they had observed notable changes in food availability as a result of the adoption of these techniques. Water harvesting techniques increase soil moisture thereby increasing yields.
3.3. Factors influencing the adoption in-field rainwater harvesting techniques

Smallholder farmers in Gwanda district identified a number of factors influencing and affecting the adoption of in-field rainwater harvesting. Labour was identified as a major factor influencing the adoption of the various techniques. Most (96%) farmers indicated that the application of in-field rainwater harvesting techniques is labour intensive. All techniques demanding annual and consistent labour were not adopted by households with labour-constrained members. In this regard, households headed by the elderly were observed to prefer less labour demanding techniques such as mulching and deep tillage. It was highlighted that;

The ward is dominated by the elderly who are taking care of their grandchildren. Most young people have migrated to South Africa. This makes it difficult for such households to put in place and maintain planting pits and other techniques. (Smallholder farmer 6, April 2017).

Smallholder farmers’ adoption of soil and water conservation practices is significantly influenced by the availability of family labour. The labour and age bracket factor also influenced the size of land set aside for the implementation of in-field rainwater harvesting techniques. Most farmers (62%) only set aside 0.1–0.5 hectares of land, with 36% farmers cultivating 0.6–1.0 hectares and a minority of farmers (2%) cultivating 1.1 hectares and above. Study findings established that it was a commonality that with an increase in land cultivated under in situ water conservation techniques, the highly and more likely that less demanding techniques are adopted (for example, deep tillage and mulching). As a result farmers with inadequate family labour opted for conventional farming practices. However, low or no yields result from conventional farming methods.

Smallholder farmers also indicated that lack of knowledge and skill was a factor inhibiting the adoption and uptake of in-field rainwater harvesting techniques. Respondents indicated that they had the minimum knowledge hence did not have the basic and necessary skills. Hence, farmers had no capacity to situate and peg dead level contours. One key informant reported that;

Some rainwater harvesting techniques involve processes such as pegging, which requires a set of skills. However, most of the community members in this ward do not have the skills. (Key informant 3, March 2017)

A set of skills and techniques is a prerequisite for some in-field rainwater harvesting techniques. This has hindered the uptake and adoption of techniques such as dead level contours, ephemeral stream diversion, ridges/furrows and hillside sheet runoff. Water harvesting techniques become sustainable if they fulfil a number of basic technical criteria (Hatibu & Mahoo, 1999). Lack of technical know-how also affected pit planting (regardless of its wider adoption) as farmers did not use systematic pits.

Household perceptions were also identified as another factor influencing the adoption of the in-field rainwater harvesting techniques. Some farmers believed that in-field rainwater harvesting techniques were strenuous and labour intensive but with little or no benefit. This is largely due to the fact that conventional farming still dominates in the study area and it is deeply rooted in their farming culture. This indicated the need for programmes to shift some perceptions. One of the key informants indicated that;

In-field rainwater harvesting techniques such as pit planting have a tainted historical background of being associated with poor households without drought power. This attitude has had a negative impact on the adoption and uptake of in-field rainwater harvesting techniques by smallholder farmers in this ward. (Key Informant 4, March 2017)

Another group of farmers perceived some in-field rainwater harvesting techniques as strategies that can be adopted by the well-off households that have the necessary capital and resources to hire more labour and technical assistance. Such farmers made reference to techniques such as
dead level contours, ephemeral stream diversion, ridges/furrows and hillside sheet runoff. These techniques were adopted by a few farmers in the study area.

Smallholder farmers also pin-pointed gender disparities as determinants in adopting in-field rainwater harvesting. Due to the labour demanding nature of in-field rainwater harvesting techniques, most female-headed households indicated that it was a challenge to adopt the techniques which were labour demanding and which were in constant need of maintenance. One female smallholder farmer indicated that;

We as women already have a lot of roles and responsibilities such as fetching water, collecting firewood, cooking ... some of these water retaining techniques overburden us with more workload, hence the common trend in our community is that women prefer the less labour intensive and less strenuous techniques. (Smallholder farmer, 7, April 2017)

Respondents alluded that in-field rainwater harvesting techniques overwhelm them with more agricultural tasks and activities. Water harvesting techniques affect men and women in different ways, which in turn determines willingness and ability to adopt and implement the practice. This explains why most framers in the study area are reluctant to adopt rainwater harvesting techniques as an adaptation strategy in the face of the adverse impact of climate change.

4. Discussion
Evidence from the above analysis indicates that smallholder farmers in Gwanda district are aware of climate change. The farmers pointed out perceived changes in line with decreases in rainfall and increased temperatures. Most of the smallholder farmers who participated in the study are seasoned farmers which is the reason why they have been able to notice the changes in temperature and rainfall patterns. Climate change in the form of temperature increases and reduction in rainfall has adversely affected food production in Africa (Gbegbelege et al., 2018; Gemeda & Sima, 2015; Gezie, 2019; Oluwatusin, 2014; United Nations Development Programme, 2018). Climate change has negatively affected crop production for farmers who are dependent on rainfed agriculture. The findings from Gwanda show that farmers associated the low crop production with climate change. Projections have shown that significant yield reductions would be recorded in many poor countries due to climate change (Donatti et al., 2018; Gbegbelege et al., 2018). Therefore, some smallholder farmers in Gwanda district have been forced by low or no yields to adopt various in-field water harvesting techniques at varying scales. Studies have concluded that farmers’ awareness of climate change is important in influencing their adaptation strategies (Chun-xiao et al., 2019; Denkyirah et al., 2017). An understanding of smallholder farmers’ perceptions of climate change is important in analysing the adaptive strategies they adopt. However, the adoption of various in-field rainwater harvesting techniques remains low in the study area. The few smallholder farmers who have adopted these adaptation techniques have done so with the support of various NGOs. These NGOs have provided trainings and inputs to the smallholder farmers. Farmers are reluctant to implement the adaptation strategies without and inputs from NGOs in the form of seeds and fertiliser.

The study found that pit planting and mulching are frequently used by most (96%) smallholder farmers who adopted in-field water harvesting techniques in the study area. Most farmers adopted more than one in-field water harvesting techniques. The majority of farmers adopted two techniques, mulching and pit planting. This corroborates findings from a study by Teklewold et al. (2019), who concluded that smallholder farmers adopt multiple in-field water harvesting techniques jointly so as to exploit the potential advantage of complements, substitutes or supplements to deal with their overlapping constraints. There is general consensus among researchers that pit planting and mulching are the most common soil and water conservation techniques (Grabowski & Kerr, 2014; Probst et al., 2019; Swanepoel et al., 2018; Telles et al., 2019). Mulching and pit planting are important in moisture retention in semi-arid environments such as Gwanda district. With reference to Ethiopia Tolossa et al. (2020) concluded that the most commonly implemented
technology is pit planting which aims to maximize the amount of soil moisture within the root zone. More so, Ngwira et al. (2020) argue that mulching has played a significant role in conserving more soil moisture which in turn increases crops’ resilience to soil moisture stress. Therefore, pit planting and mulching are widely adopted by smallholder farmers due to moisture conservation capacity given the erratic rainfall patterns and high temperatures.

Study findings revealed that smallholder farmers in Gwanda district adopted various in-field water harvesting techniques to improve yields which have declined over years due to climate change. In-field rainwater harvesting strategies contribute to climate change adaptation through increased soil and moisture conservation. In-field rainwater harvesting reduces surface runoff, thereby improving soil fertility, water conservation and agricultural productivity. Resultantly, increases in yields are expected by framers who adopt water conservation techniques. In this study, smallholder farmers reported a yield increase in crops such as maize, groundnuts, round nuts, cowpeas, sorghum, sweet potatoes and millet. With reference to West Africa, Danjuma and Mohammed (2015) argued that the pit-planting technique can increase production by about 500% if well executed. However, it is important to note that farmers in Gwanda district did not realise such improved yields as some of the pits were not constructed systematically. More so, most farmers in the study area planted maize which demands more water. Although farmers also planted low water demanding crops such as millet and sorghum it was at low scale. Yosef and Asmamaw (2015) also concluded that the adoption of in-field rainwater harvesting techniques has benefitted smallholder farmers by improving agricultural production. According to Rivera-Ferre et al. (2016) field-based water and soil conservation technologies are highly effective in drought alleviation and in enhancing land productivity. In this regard, rainwater harvesting techniques have the potential to reduce the vulnerability of smallholder farmers in semi-arid regions (such as Gwanda district) to climate change and variability, and to increase the resilience to climate change. There is a need for identifying strategies for upscaling the adoption of various water harvesting techniques together with low water demanding crops to improve yields.

Several factors influence the adoption of in-field water harvesting techniques by smallholder farmers. Intensive demand of family labour is a major determinant of the adoption of various in-field water harvesting techniques. The study found that labour-constrained households were reluctant to implement labour-intensive techniques such as dead level contours, ephemeral stream diversion, ridges/furrows and hillside sheet runoff. It is also important to note that although pit planting was adopted by most of the respondents in some cases it was not done properly due to the shortage of family labour. Such findings echo those of Rajasekharan and Veeroputhran (2004) who in a study concluded that the decision-making behaviour of farmers in adoption of soil and water conservation practices was significantly and positively influenced by the availability of family labour and the perception of the profitability of the techniques. Dube et al. (2018) also argued that smallholder farmers are reluctant to adopt adaptation strategies which demand intensive labour. Grabowski and Kerr (2014) also noted that most farmers do not implement conservation agriculture on a large scale considering the tedious work of measuring and digging basins. Lack of technical expertise has also hindered the adoption of some in-field water harvesting strategies such as dead level contours, ephemeral stream diversion, ridges/furrows and hillside sheet runoff. From the study findings, it was noted that these were adopted at a low scale as there were largely technical. This explains the low scale adoption of in-field rainwater harvesting techniques by smallholder farmers in Gwanda district.

5. Conclusions
In conclusion, we found that smallholder farmers in Gwanda district have adopted several in-field rainwater harvesting techniques such as pit planting, mulching, deep tillage, dead level contours, ephemeral stream diversion, ridges/furrows and hillside sheet runoff in their efforts to adapt to climate change. Pit planting and mulching were adopted by most smallholder farmers. Water harvesting techniques reduce surface runoff thereby promoting water conservation and soil fertility. These techniques have been adopted to improve agricultural yields as the study area is
prone to drought. Farmers have realised improvements in yields due to the adoption of various water harvesting techniques. Yield increases in crops such as maize, groundnuts, round nuts, cowpeas, sorghum, sweet potatoes and millet were noted by the respondents. Although in-field rainwater harvesting techniques have the potential to improve yields and crop production, there are a number of pertinent factors that affect and influence the adoption of these water harvesting techniques by smallholder farmers in the study area. These include the availability of household labour, technical know-how and farmers’ perceptions. Such factors should be taken into consideration designing and implementing strategies for upscaling the adoption of water harvesting techniques. These factors greatly impact the uptake and effectiveness of the in-field rainwater harvesting techniques. We recommend that: firstly, the government of Zimbabwe and its development partners should equip smallholder farmers with some technical know-how which will enable them to adopt appropriate in-field water harvesting techniques; secondly, the government and its development partners should invest in programmes that enhance the capacity of smallholder farmers to adapt to climate change; and lastly, there should be continuous dissemination of information on climate change risks and vulnerabilities to influence the adoption of various adaptation strategies by smallholder farmers.

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