Adapting peri-urban agriculture to climate change in Bulawayo, Zimbabwe: A qualitative assessment

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Abstract: Peri-urban agriculture plays a critical role in sustaining food security and livelihoods in urban communities. In spite of the critical role it plays in food security, peri-urban agriculture has not received adequate attention with regards to its interface with climate change in Zimbabwe. Using a sample of thirty peri-urban plots selected through snowballing, this study investigated the farmers’ perceived effects of climate change on peri-urban agriculture in Bulawayo, and how farmers were adapting to climate change. The findings of the study revealed that peri-urban farmers perceived and observed significant climatic and related changes that were negatively impacting their farming activities. Observed changes included reduced precipitation levels, increased atmospheric temperature and diminishing borehole yields. Farmers were adapting with a variety of methods which included repeated planting, watering plants during the night, renting animal space in other farms with more water sources and purchasing supplementary feed for livestock. Among other issues, this study recommends the promotion of the use of drought tolerant seed varieties, improved water harvesting and a more rationalised system in managing livestock numbers in the plots.

Subjects: Agriculture and Food; Climate Change; Urban Development; Urban Geography

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PUBLIC INTEREST STATEMENT

Climate change threatens to reverse the global gains made in human well-being over the years including in food security and nutrition and sustainable development in general. Urgent action is required to understand how agricultural systems are being impacted and how they are adapting to climate change effects at local scales. In particular, it is important to understand the peri-urban context which has largely been ignored in scientific literature although it contributes immensely to food security and human well-being for urbanites. This study contributes to the expansion of the knowledge base on climate change impacts on agricultural systems in peri-urban areas and the effectiveness of adaptation options and pathways that are available for implementation. The study is therefore important to policy makers, scientists and agricultural practitioners. Sustainable Development Goal Number 13 urges that urgent action should be taken against climate change and its impact.
Keywords: Climate change; adaptation; peri-urban agriculture; costs; precipitation

1. Introduction
Peri-urban agriculture plays a critical role in sustaining food security and livelihoods and building resilient urban communities (Chihambakwe et al., 2018; Frayne et al., 2014; De Zeeuw et al., 2011). It has been argued that urban and peri-urban food production increase resilience to climate change by reducing the distance between urban communities and the farms where food is procured and thus keeping food prices low. Peri-urban and urban food production also increases income and provides employment (Anaofo & Akolgo 2018). The fast rate of urbanisation in Africa has put pressure on food supply systems. Peri-urban and urban agriculture play a key role in closing the food supply demand gap (Andres & Lebaill, 2011). A rapidly growing proportion of the world’s population now lives in urban settlements, hence food production by urban residents has become an increasingly important strategy in mitigating food insecurity. As stated by FAO (2008), climate change negatively affects food availability, accessibility, utilisation and stability. Other notable stressors driving food insecurity alongside climate change are high unemployment rates and increasing food prices fueled by volatile economies and rising inflation (Hungwe, 2004). Such scenarios have driven urbanites towards urban farming. Some researchers have argued that urban and peri-urban agriculture also play a role in climate change mitigation through carbon fixation (Brinkley, 2012).

Climate change is defined by the IPCC (2014, p. 126) as;

‘…a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.

It is widely accepted the main cause of climate change currently being experienced globally is human induced through the burning of fossil fuels and the release of greenhouse gases (IPCC 2014). In spite of the role that peri-urban agriculture plays in food security, peripheral attention has been paid to studying its adaptive interface with climate change (Lwasa et al., 2014). Research across some nine African cities has shown that climate change impacts on urban agriculture are intensifying (Padgham et al., 2015). Some studies have argued that urban and peri-urban agriculture have generally not been seen as being climate related but rather the concern has been on how urban and peri-urban agriculture affect urban planning and management in general (Lwasa et al., 2015).

1.1. Impact of climate change on agriculture in Sub-Saharan Africa
Climate change is threatening agricultural systems and processes world-wide (IPCC 2007; Brown et al., 2012; Drechsel & Dongus, 2009). Climate change has become a major concern worldwide, more so in the Sub Sahara Africa which is dependent on rain fed agriculture (Brown et al., 2012). The Southern African region has experienced some devastating droughts in the past 30 years as a result of climate change. According to Dube & Phiri (2013) predictions, climate change is anticipated to increase the frequency and severity of extreme weather conditions such as droughts and floods. The average global maximum temperature shows a warming trend of 0.85 degrees Celsius for the years between 1880 and 2012. The rate of warming has been faster in tropical countries including those in Southern Africa (Mall et al., 2017). There is high confidence that the warming trend will continue and that it will result in longer heatwaves in parts of Africa (IPCC 2014). Warming trends in Africa have been as high as twice the global average with the most significant warming happening in Southern Africa (Mall et al., 2017).

According to IPCC (2014), climate records demonstrate that Sub Sahara Africa is already experiencing the effects of climate change, notably through rainfall variability and other extreme
weather events. These conditions, combined with warming temperature trends, are expected to render land increasingly marginal for agriculture. This scenario poses a major threat to the economy and the livelihoods of the poor due to Africa’s heavy dependence on rain-fed agriculture and climate sensitive resources (Famine Early Warning Systems Network. (FEWS NET), 2009). Globally, climate projections show that developing countries will face increased food insecurity as a result of climate change (Mall et al., 2017; Pereira, 2017). Productive arable land will be lost to floods and droughts (causing aridity and water scarcity) and shifting seasonal patterns (Lwasa & Dubbeling, 2015). Some studies have projected that countries like Zimbabwe in Southern Africa could lose as much as 50% of grain yield by 2030 due to climate change (Dubbeling & De Zeeuw, 2011). The main factor that links peri-urban agriculture with climate change is the urban heat island phenomenon (Dubbeling & De Zeeuw, 2011).

1.2. Effects of climate change on crops
Simulations show various levels of crop yield reductions in different parts of the world induced by climate change (Wang et al., 2018). Studies have demonstrated the negative effects of reducing precipitation and increasing temperature on crops in already hot regions (Wang et al., 2018). Simulations also indicate the potential of the emergence of new pests and pathogens (Najafi et al., 2018; Wang et al., 2018). Model simulations across the globe show a variety of crop reactions to climate change depending on geographical location and local conditions (Wang et al., 2018). This necessitates localised climate change impact and adaptation assessments to ensure appropriate response strategies specifically adapted to local conditions are identified. Some researchers have noted that in spite of improving agricultural technology, climate change is the reason why some agricultural regions may be recording a decline in crop yields (Kukal & Irmak, 2018).

In a study conducted in the United States of America, temperature alone was used to explain a reduction in maize yield variability in parts of Nebraska and Iowa (Kukal & Irmak, 2018). Some studies have found out that shifting agricultural practice spaces prompted by climate change have led to food production locations being located increasingly further away from locations that consume the food (Najafi et al., 2018). This will lead to high food prices and thus exacerbating food and nutrition insecurity. This points to the need for studying peri-urban agricultural adaptation to climate change in order to support food production closer to the urban market.

Precipitation trends are a cause for concern both in areas where there is a reduction of precipitation and where there is excess precipitation caused by climate change. When the minimum and maximum thresholds of precipitation are not honoured, crop yields are reduced (Najafi et al., 2018). Emerging evidence also points to the fact that climate change will negatively alter plant microbe interactions and other important soil system functions. In particular, the reduction of water would reduce the mineralisation of organic matter and nutrient processing in the soil (Mall et al., 2017).

Scientists agree that the vulnerability of Africa’s agricultural systems to climate change largely derive from the over-dependence on rainfed agriculture. This dependence on rainfed agriculture is, in part, driven by limited financial resources and lack of information (Mall et al., 2017). In the African context, particularly southern Africa, agriculture is affected by increasing temperatures and a reduction of variation of precipitation, mostly towards the lower seasonal rainfall (Pereira, 2017).

1.3. Effects of climate change on livestock
It has been observed that climate change affects livestock in various ways including changes in the feed resources (quality of the feed, its distribution and quantity) (Fabio et al., 2019). The effects of climate change have been very significant on rangelands (Karimi et al., 2018). Rangeland quality is affected by rainfall distribution and temperature levels (Descheemaeker et al., 2018). Increasing temperatures result in animal heat stress. Literature indicates that animal heat stress has negative effects on the physiology of animals as it affects reproductive, productive and health functions of animals (Zhang et al., 2017). It has been observed that heat stress is a major contributor to declines in
the fertility of dairy cows. Some studies have noted that conception rates can decrease to as high as 20–30% due to heat stress (Sinha et al., 2017). Heat stress has been observed to affect feed intake, productive and reproductive efficiency, rectal temperature, pulse rate and respiration rate in animals under hot and dry conditions (Sinha et al., 2017). Heat stress is defined as the situation where the body temperature of an animal is higher than the threshold required for the normal animal activities. In other words, the total heat being received is greater than the capacity of the animal to dissipate it (Fabio et al., 2019). One primary effect of heat stress is reduction of rumination time leading to a reduction in animal growth rates (Fabio et al., 2019). Coupled with poor rangelands, the poor quality of water associated with droughts can be a source of animal diseases. (Descheemaeker et al., 2018). In general revenue from livestock is simulated to be negative as a result of hot-dry climatic conditions in Southern Africa (Descheemaeker et al., 2018).

1.4. Defining peri-urban agriculture

The question of what constitutes peri-urban agriculture remains significantly contested (Padgham et al., 2015). It has been argued that the problem in demarcating peri-urban agriculture arises from the fact that there is a deep-seated dichotomy between rurality and urbanity (Arif & Gupta, 2020, 2018; Padgham et al., 2015). The emphasis on the dichotomy has left the transitional space between the two main reference points trivialised and with little recognition. Arif et al. (2019) have demonstrated that peri-urban areas have unique characteristics in terms of population density, infrastructural development, land use management and livelihood dynamics. They thus require specific studies to understand them separately from urban and rural studies. In this study we adopt the definition of urban and peri-urban agriculture “…as the production of crops, livestock agriculture, and cultivation of fish within and around metropolitan areas, for local sale and consumption” (as cited in Padgham et al., 2015). In Zimbabwe urban agriculture is practised in residential stands, open municipal spaces and peri urban plots.

Current studies on the impact of climate change have focussed on rural small holder farmers to the neglect of peri-urban and urban farming systems (Lwasa et al., 2014). Given the difference in the nature of the farming systems, it is reasonable to assume that the climate change induced shocks on peri-urban agriculture may be different from what studies on small-holder rural farmers have revealed to-date. Urban and peri-urban agriculture is defined by particular characteristics determined by, amongst other things, the destination of products, the location of production, the scale of production and the nature of economic activities (Amafo & Akolgo 2018). This study investigated the effects of climate change on peri-urban agriculture in Kensington, Bulawayo. It sought to understand how farmers are adapting to climate change as they experience it. The study focussed significantly on the main cost drivers in the adaptation processes. Although the assessment was not quantitative, it is indicative of the main areas of intervention required to strengthen resilience and adaptation efforts in peri-urban agriculture. We ask the following questions in this study;

1. What are the farmers’ perceptions and experiences about climate change in the peri-urban area of Kensington plots in Bulawayo?
2. What adaptation measures are farmers taking in the light of their experiences?
3. How can the resilience of peri-urban agriculture be promoted in the face of climate change?

2. Conceptual framework

Although urban and peri-urban agriculture is under intense pressure from climate change, Lwasa et al. (2014) point out that evidence gathered from some cities around Africa including Ibadan, Dakar and Kampala also suggests that when properly implemented, adaptation strategies can reduce the vulnerability of these agricultural systems and strengthen the resilience of urban and peri-urban communities. Climate change adaptation may be defined as “adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate...
harm or exploit beneficial opportunities” (Robinson et al., 2018). In the terms of Moser and Ekstrom (2010, pp. 220,026), “Adaptation involves changes in social-ecological systems in response to actual and expected impacts of climate change in the context of interacting nonclimatic changes” (Moser & Ekstrom, 2010, pp. 22,026).

Moser and Ekstrom (2010) indicate that climate change adaptation fails largely due to two types of factors, i.e., limits to adaptation and barriers to adaptation. Limits to adaptation are defined as obstacles that are absolute such as land size or water scarcity. These obstacles are usually physical, environmental and ecological and may be difficult to solve through innovation. Barriers to climate change adaptation are defined as obstacles that can be overcome with planning and effort. These may be changes in land use policies and associated institutions. (Moser & Ekstrom, 2010). This article examines climate change adaptation in Kensington in the light of the factors that enable or limit adaptation.

3. Study setting
Kensington peri-urban plots are located on the outskirts of Zimbabwe’s second largest city, Bulawayo along the road to Gwanda. According to the latest National Census Statistics conducted in 2012 Bulawayo had a population of 653,337 in total, constituted by 303,346 males and 349,991 females (Zimbabwe National Statistics Agency, 2012). Bulawayo City is located to the South of Zimbabwe at a latitude of 20.7 degrees south and is 439 kms from the country’s capital Harare. Its hinterland is relatively dry with rainfall of around 500 mm per year and temperatures of a maximum monthly average of 22 degrees Celsius in October and 13 degrees in June. The city is positioned on the highveld of Zimbabwe. It is situated closely to the watershed that divides the Zambezi and Limpopo basins. As a result of the elevated altitude, the city benefits from a subtropical climate. Three broad seasons are recognisable in the city’s climate. Between the months of May and August, the city experiences a cool dry winter. This is followed by a hot dry season between August to early November. Between early November and April, the city has a warm wet season where most agricultural activities take place (Parliament of Zimbabwe Research Department, 2011).

The City falls under the Natural Farming Region IV of Zimbabwe. This region is suitable for semi-extensive beef production. Given the semi-arid nature of this region, it is important to assess how farming systems are adapting to increasingly hotter and drier climatic conditions. Kensington, which is the specific area of study, falls under the peri-urban zone. It is located in the eastern side of the city along the Bulawayo-Beitbridge road. The agricultural holdings studied are mostly plots ranging between one hectare to two hectares in size.

Kensington plots in Bulawayo were suitable for this study for two main reasons. Firstly, it is located in Zimbabwe where climate change has had a significant impact on food agricultural productivity and food security (Dube & Phiri, 2013). Climate data shows that between 1902 and 2012, the climate in Zimbabwe has warmed by 0.9 degrees Celsius (USAID, 2020). Rainfall has fallen by approximately 5% since 1915 and there has been an increase in the frequency and length of dry spells (USAID, 2020). The second reason why Bulawayo was chosen is that it lies in one of the driest semi-arid ecological region IV of Zimbabwe. This region is bound to be more vulnerable when compared to Zimbabwe’s other big cities including Harare, Gweru and Mutare. Therefore, the choice of Bulawayo gives researchers an excellent opportunity to understand how peri-urban farmers adapt to climate change under the most climate change stressed environments.

3.1. History of peri-urban and urban agriculture in Bulawayo
According to Mbiba (1995) and Zero (2003) peri-urban agriculture is not new in Zimbabwe. The concept was introduced by black migrant workers who wanted urban settlements that resembled their rural homes and also wanted to supplement their food budgets. Peri-urban and urban agriculture in Bulawayo is practiced in residential stands, peri urban plots and on any available space.
According to Hungwe (2004) the drive behind urban and peri-urban agriculture in Bulawayo was the economic hardships brought about by the closure of the city's industries. The accelerated land reform program and the political instability which affected the investor confidence in the country, contributed to the closure of the industries and of the resultant unemployment (Kutiwa et al., 2010; Mawoneke & King, 2000). Peri-urban agriculture in Bulawayo provides the City with fresh vegetables and dairy produce. The United Nations Development Program (United Nations Development Program (UNDP), 1996) highlighted that peri-urban and urban agriculture helps to increase disposable incomes for the poor and at the same time reduces household food bills. This type of agriculture also contributes to employment creation.

In 2000 the Bulawayo City Council (BCC) approved an urban agriculture policy which aimed to reduce destitution and improve nutritional status of vulnerable groups in the urban community. It was noted that urban and peri-urban gardens promote household food security and ensure affordability, availability and accessibility of unprocessed food. Urban and peri-urban agriculture encourage self-reliance and self-production among the vulnerable groups leading to income generation through sale of surplus produce. (United Nations Development Program (UNDP) (1996).

3.2. Map showing Kensington plots in Bulawayo peri-urban

4. Research methods and materials
The study primarily adopted a qualitative approach in gathering and analysing data. Thirty semi-structured interviews were administered to household heads of selected plots in the peri-urban area of Kensington in Bulawayo. The data was collected between July and September 2019. The farmers that were interviewed were selected using an adopted snowballing technique that also incorporated some purposive decisions. The researcher started by identifying five farmers who then identified other farmers in the neighbourhood who practiced different types of farming. The identified farmers made further references to other farmers until thirty farmers were interviewed. Data saturation was reached when about twenty farmers had been interviewed. However, the researchers continued collecting data up to the initial target of thirty farmers. The study used semi structured interviews to understand the farmers’
experiences about climate change in their agricultural practice. Data was gathered on the nature of the farming system in each of the plots that were selected. The interviewers also sought to understand whether the farmers were perceiving any climatic changes and how these were affecting their agricultural activities and production. Finally, the research sought to understand how the farmers were adapting to the perceived climate change effects and the cost of such adaptation. The qualitative semi-structured interviews allowed the researchers to have an in-depth appreciation of each farmer’s experiences in their plot. Therefore, while the size of this sample may not allow for generalisation of the experiences of farmers, it gives a detailed appreciation of how individual farmers were responding to climate change in the Kensington area. The researcher also interviewed six key informants who consisted of extension officers from The Department of Agriculture Technical and Extension Services, The Department of Livestock Production and Development, The Department of Meteorological Services, Zimbabwe National Water Authority and The Women in Agriculture Forum, a non-governmental organisation operating in the Kensington area. The researchers also utilised the unstructured observation method by physically visiting agricultural plots to observe activities and noting activities of interest.

Qualitative data from semi structured interviews with farmers and in-depth interviews with key informants was thematically analysed. Interviews were initially transcribed. After transcription, the researchers read through all interviews to identify emerging patterns in how farmers interpreted climate change and how they were adapting to it. The researchers observed the common themes and those that were isolated. This gave a general interpretation of the question under study by farmers and key informants.

5. Findings and discussion

5.1. The agricultural profile of Kensington peri-urban plots

The study established that 100% of the sampled households in Kensington practiced agriculture to varying levels. From the sample, 43% of the households that were interviewed practiced mixed farming. They grew vegetables including chomolia, onions and tomatoes alongside the rearing of poultry, goats and cattle. Only one farmer (3%) out of the sample of thirty households majored in livestock exclusively (cattle). Sixteen farmers (54% of respondents) were focused on crops only. The labour used in the agricultural enterprises was mostly family based. However, additional labour would be engaged seasonally especially during the rainy season when there was greater demand for labour. Most of the work in these plots was manual. The plot owners would also frequently hire tractors and donkeys for land preparation as common practice.

5.2. Table showing farm enterprise details of the sampled plots

The motivation to engage in agriculture varied across different households although a general trend could be noted. In general, most household heads indicated that they took the decision to engage in urban agriculture for food security. Years of persistent downturns in the economy had left most households unable to purchase food because they either had no one formally employed or, those that were employed were not earning enough to purchase food for the family. Own food production was thus an attractive pathway to ensure food security for households that had some arable space. However, in the majority of cases, although own food production for consumption was dominant as a motive for practicing agriculture, the profit incentive was also a major factor. A number of households were identified where the individuals had decided to rent a plot in order to engage in agriculture for financial gain. In most instances, these individuals kept poultry and practiced market gardening. A less important but significant motivation was cultural. Amongst the elderly household heads, agriculture was crucial for both food security and as part African life and culture. As one elderly farmer indicated;
... I have always loved agriculture. As a young boy I would help in the fields and also tend to my father’s cattle. . . . . . we had lots of food to eat and we always had plenty of fresh milk, and sour milk and therefore relish was not scarce. . . . . . In those years agriculture was a lucrative business venture. I left my job to do urban farming and I managed to educate my children up to university with money earned from the sale of farm produce . . . . . (Interview with a local urban farmer in Kensington)

This view was reinforced by another farmer who noted that:

... we know that a black person must survive through the sweat of their labour. When we grew up our elders used to till the land and get meaningful harvests. Our school fees were paid through farming proceeds. I like farming because it food security and income. When the rains are good, a farmer’s profits can surpass those who are formally employed because he can sell his produce and use the cash to cover his various needs. (Interview with a local urban farmer in Kensington)

Some farmers traced their involvement in urban agriculture back to the beginning of the economic structural adjustment program in Zimbabwe in 1991 which left some workers unemployed. These findings resonate with literature that indicates that after the Structural Adjustment Programs (SAPs) thousands of people were laid off from work as companies were forced to downsize and restructure (Mawoneke & King, 2000). Some of those who got meaningful retrenchment packages managed to buy land in the peri-urban areas of Bulawayo including Kensington. As also buttressed by Kutwi et al. (2010), ESAP caused jobs losses for a lot of people of Zimbabwe; as a result, some urbanites got involved in agriculture as a sustainable livelihood. One farmer indicated that they had acquired the plot when the husband lost his job. They bought the plot to engage in agriculture at that point in order to mitigate poverty and also create employment.

5.3. Farmers’ perceived effects of climate change on urban agriculture

All the farmers that were interviewed indicated an awareness of the concept of climate change. The phrase they commonly used in the local isiNdebele language to refer to climate change was “ukuguquka komuma womkhath’i” (the change of the state of the atmosphere). They indicated that they had learned about the phrase mostly from television and radio programs. Respondents were asked to comment on any changes that they had observed over the years in relation to precipitation and temperature.

All respondents indicated that they had observed notable changes in precipitation and temperature trends. Respondents noted that they had noted a significant reduction in the levels of precipitation during the rainy season. This reduction in precipitation was accompanied by increasing atmospheric temperatures. Farmers noted that the combination of increasing temperatures and a reduction in precipitation was catastrophic for their crops and animals as it resulted in reduced harvests and animal productivity. These observations by farmers were consistent with findings from key informants and scientific literature (Dube & Phiri, 2013; USAID, 2020). Responses from the key informants indicated that climate change was manifested in reduced rainfall amounts, increasing temperatures and increasing uncertainty about seasonal rainfall distribution patterns. Expert key informants indicated that increased warming of the atmosphere was leading to new seasonal trends in the climate. As one respondent pointed out;

The climate has deviated from the norm as we know it. We are seeing an increased incidence of dry spells and a higher frequency of dry seasons. When it does rain, the rains are now very intense coming in heavy down pours with lots of thunder and lightning. Climate change also manifests in increased floods and hailstorms. The rainy season used to commence in October and intensify in December which was the cropping period. Now the temperatures have increased tremendously and we even experience heat waves. (Interview with a Department of Livestock Production and Development official)
Respondents made their observation by making comparisons between what they knew the climate used to be like many decades ago to what it was now. Their observations corroborated expert scientific opinion. Respondents stated that in the past they could predict with reasonable accuracy when the rainy season would start, and this made planning relatively easy. These findings were in concordance with the findings of other researchers who found that in nine other African cities urban farmers noted significant increases in temperature, stronger winds and increasingly unpredictable seasons (Padgham et al., 2015).

The farmers’ and extension experts resonated with Simatele and Binns (2008) and IPCC (2007) who noted that generally the beginning of the rainy season in Sub Sahara Africa has shifted from October to late November. IPCC (2007) posited that climate records demonstrate that Sub Sahara Africa is already beginning to experience the effects of climate change, notably rainfall variability and extreme events. These conditions, combined with warming trends, are expected to render land increasingly marginal for agriculture, which poses a major threat to the economy and the livelihoods of the poor due to Africa’s heavy dependence on rain-fed agriculture and climate sensitive resources.

Findings in this study are similar to other studies in Africa that show that farmers are aware of the changing climate in their environments. In a study conducted in Ghana about farmers’ perception of climate change, it was found out that farmers were able to tell correctly that temperatures had increased and that rainfall seasons were becoming inconsistent, and that droughts were increasing in frequency. (Lawson et al., 2020). Some researchers have established that the way farmers perceive climate change is important as it determines their risk assessment and consequent adaptive actions taken. They argue that farmers who perceive climate change as real are more likely to take adaptive decisions than those who do not perceive it as real. However, they note that there are other factors that determine adaptation including income levels, sex, education and credit access amongst others (Tetteh et al., 2020). In summary, the ability to perceive climate change is closely related with the likelihood of coping and adapting to it (Budhathoki & Zander, 2020). The supposition that climate change risk perception is a precursor of adaption is widely supported by behavioral theories (Bradley et al., 2020). Farmers’ perceptions of climate change are a pre-requisite for adaptation. Several findings in Africa show that farmers are generally aware of climate change taking place in their environment (Dube & Phiri, 2013; Singh, 2020)

5.4. Adapting to the effects of climate change on crops

Farmers observed that the lack of predictability in the rainfall seasons was making the growing of crops difficult. For example, one farmer noted that the rainfall pattern was increasingly confusing. He observed that it was now quite common to experience an extended dry spell after the initial rains which sometimes begin in October or November. This break in precipitation interrupts healthy crop growth which requires a consistent supply of moisture to produce a good yield. The break in precipitation can lead to poor germination, or where germination was good, scorching of the crop under high temperatures in the absence of rain. These climatic conditions affected both field crop producers and those farmers involved in market gardening. One farmer involved in market gardening indicated that;

... too much heat affects the horticulture business. Because of the increased heat, vegetables need to be watered more frequently; for example, we are now forced to water every day yet before these increased temperatures we used to water our crops every other day (Interview with a market gardening farmer in Kensington, Bulawaya).

It is evident from the above submission by farmers that increased heat leads to an increased rate of water loss through evapotranspiration, and thus aggravating an already dire situation where there was reduced rainfall and water availability. In some instances, these dry spells led to a complete write-off for some crops. Some farmers indicated that the maize seed which they
had planted in the previous season succumbed to the heat during the dry spell. As a result they had no harvest to take them through the year. Furthermore, they could not manage to buy more seed to replant. Those farmers who had enough resources managed to replant and they had a better harvest. The majority of the farmers lamented the failure of the maize crop as it meant they could not gather fodder for their cattle which they prepared from the maize stock and residue.

Farmers noted that, in general, the observed climatic changes were increasing the costs for their farming enterprises and reducing their profits. Where there were prolonged dry spells, those farmers with the requisite infrastructure resorted to irrigating their crops. Farmers noted that, compared to rainfed agriculture, irrigation brings with it significantly higher production costs. As one local farmer pointed out;

The prolonged use of boreholes means we have to pay more to electricity bills to the ZESA (Zimbabwe Electricity Supply Authority) as we are using more electricity. My electricity bill is up by about 30% because of irrigation. In an effort to reduce evapo-transpiration we now water our vegetables in the evening and our salary bills are going up since the workers are forced to work extra hours and thus they have to be paid for the extra hours they put in. My wage bill has gone up by at least 20% because of these extended working hours. (Interview with Local Market Gardening Farmer in Kensington, Bulawayo).

According to this farmer’s response there are a number of costs that come with adapting to the effects of climate change in urban agriculture. Firstly, there is the issue of increased electricity bills as a result of increased irrigation using electricity powered borehole pumps. Secondly, there is the issue of increased labour requirements. As one of the farmers noted, the most efficient time to water the plants was the evening when evaporation was minimal and the retainment of water would take longer on the ground for plants. This meant that the workers who were tasked with irrigation were then required to work into the night and thus increasing labour costs. A more structured and systematic study would be required to assess the precise economic costs of adaptation at plot level.

Although, several farmers were resorting to irrigation to ensure that their crops were supplied with water, some farmers noted that they were having challenges with their boreholes which were low yielding. They indicated that the low-yield boreholes were easily affected by consecutive seasons of low rainfall. Low rainfall led to an increase in water drawn from the boreholes and a consequent lowering of the water table. When the water table was lowered, it resulted in some boreholes yielding inadequate water. One respondent indicated that,

Borehole output has been reduced as a result of lack of adequate rains to recharge the under-ground water levels. When it rains, the rains we have flush floods resulting in high run-off and very little seepage. Also, the water from the boreholes has become salty leading in poor quality vegetables that are likely to fetch very less on the market. So, as you can see, these vegetables are producing very small leaves because they are not receiving adequate water. The vegetables do not look healthy at all. We will not get much out of this vegetable crop. People want to buy fresh and healthy looking vegetables. We will not be able to sell this (Interview with a vegetable farmer in Kensington, Bulawayo).

The effect of borehole water on irrigated plants has not received much attention in the studies that these authors are aware of. It will be important to investigate the impact of borehole water on crops when compared to rainwater and dam water.

Most of farmers indicated that their harvest had steadily been reduced over the years due to what they perceived to be the effects of climate change. They indicated that it was now very frequent that they would not have any surplus maize to sell, or enough to take them to the next harvest season. They indicated that this started way back as the early 1990s. Most respondents
agreed that prior to the 1990s, the boreholes would provide adequate water throughout the dry period. However, this seemed to have changed according to their assessment. Borehole yields were now less. These findings are consistent with findings elsewhere in Africa that have predicted a fall in crop yields due to climate change (Kukal & Irmak, 2018).

It was noted that in view of the persistently poor wet rainy season, some farmers had adopted climate smart agricultural practices. Some of the urban farmers put mulch in their vegetable beds so as to conserve moisture. Other respondents indicated that they now practice planting in basins. They develop basins annually and place seed on each basin as this method helps to trap water. Another farmer indicated that he had stopped planting maize because of reduced precipitation which had led to poor harvests for a number of successive seasons. The farmer indicated that he had shifted attention to focus on horticulture. His success in the new venture was aided by having a high yielding borehole for irrigation.

5.5. Adapting to the effects of climate change on livestock
Most respondents raised concerns about the deprecating quality of pastures due to the impact of climate change. They noted that prolonged consecutive poor rainfall seasons in the area were causing grass to fail to grow and mature fully. Following every poor rainy season, pastures would remain particularly unable to sustain animals throughout the dry season starting from May to October. In responding to poor pastures, farmers would adapt by purchasing extra feed to ensure the survival of their herd. However, in some instances the resources to procure supplementary feed would not be available. This resulted in animals being at a risk of nutritional stress or starvation which could culminate in the death of some livestock. As a coping mechanism, in times of severe drought farmers would also resort to distress sales of livestock where livestock were sold at low prices to avoid losing all the livestock due to starvation. Farmers indicated that in the past there was no need for supplementary feeding as natural grazing was adequate and crop residues from harvests were readily available as supplementary feed. Consecutive poor harvests meant that farmers had little or no stover to provide supplementary feed for their cattle. One farmer respondent pointed out that,

Pastures for our animals have been deteriorating over the years. We have had many seasons where the rains did not fall as well as we expected. So our cattle are now starving. That is the reason why you see their condition is not looking very good. Even when we sell them, we do not get very good returns (Interview with a Livestock Farmer 1, Kensington Bulawayo).

Can you see how small these cattle are? When we grew up we took pride in our parents cattle because they were big and fat. Now these cattle are small and thin. Their poor condition is due to the poor pastures. This little grass that you see here will wither due to the cold temperatures and it will be blown away by the wind. The rains stopped when this grass had not reached its maturity. When winter comes, the ground will be bare, the grass will have disappeared. Climate change is negatively affecting us farmers. Those who do not have money to buy extra feed for their cattle may lose them due to starvation. The years when the maize crop did well were better because we gathered the maize stover to use as feed later. (Interview with Livestock Farmer 2, Kensington, Bulawayo)

These findings resonate with global findings that have shown that high temperatures and reduced precipitation has negative effects on animal feed because they affect the condition of pastures. Some researchers have suggested that dedicating part of the farm to forage production may be an important part of the array of adaptation strategies to improve animal production (Descheemaeker et al., 2018). However, we argue that given the small sizes of peri-urban farms, this is an option that small mixed farms cannot afford. Similarly, other strategies suggested to improve pasture quality such as rotational grazing would not be feasible under peri-urban agriculture due to space limitations (Karimi et al., 2018).

Amongst the farmers that were interviewed was one farmer who had ventured into commercial cattle fattening business. The farmer was buying cattle from surrounding farmers and
keeping them in a feedlot for a period of time. After controlled feeding, he would then sell the cattle at a higher price as they would have gained more mass. The farmer indicated that when he started this business in 2006, he believed that he had found a niche. However he explained that he was beginning to experience the impact of climate change on his business venture. He indicated that he had observed a consistent decline in the amount of precipitation over the years. He indicated that 2018 had been the worst year on record for him as the borehole water output reduced very quickly. By January, the output was so low that he had to find alternative ways to sustain his cattle. January was supposed to be in the middle of the rainy season. He responded by temporarily renting some space in a nearby farm which had a big dam. For the cattle that remained at the plot, the farmer had to resort to pumping water from a neighbour’s plot at a fee of $55.00 USD per month. This raised his overhead costs significantly and thereby reducing his profit margin. He indicated that cattle need a lot of water to drink especially when the temperatures are high as had become the norm in Zimbabwe. The farmer eventually had to scale down on the number of cattle because of water limitations. The number of cattle at the feedlot had been reduced from 400 to 100 on the day that the researcher visited the feedlot.

There were other costs that came with adapting to the effects of climate change. These costs included, hiring of extra labour to look after cattle at the new rented plots, transport costs for ferrying the feed to the different farms where the cattle were now separated. The time factor was another hidden cost which could not be quantified. The farmer explained that he was spending time travelling to the various feed lots. Spreading the cattle across different farms increased different types of costs.

With respect to livestock production, key informants cited an upsurge in drought related diseases and other opportunistic infections such as anthrax and botulism as livestock are forced to feed on very low grass and bones as a result of the shortage of grazing. This exposed the livestock to disease forming spores that can survive in the soil for long periods of time. These findings are consistent with previous findings that project an increase in animal pests and diseases due to climate change (Holness, 1988; Najafi et al., 2018; Wang et al., 2018). High temperatures lead to heat stress in pigs and poultry resulting in compromised health, poor feed intake and consequently poor growth and poor meat quality from the pigs. The chickens were said to be manifesting stress through reduced egg production, hyperventilation, slow growth, poor quality meat and sometimes death. Lassiter (2014) posits that livestock being hot blooded animals are negatively affected by increased heat. Increased heat results in low appetite which leads to low productivity.

The key informants noted that although they were mostly in agreement with the farmer respondents on the effects of climate change on urban livestock, the poor condition of the calves and kids was also attributable to over milking of cows and goats. The farmers did this to sell the milk to get the much-needed cash for the survival of their families. Thus, the calves were deprived of nutrients. Lack of adequate milk and feed would slow down the calves’ growth rate. Poorly fed calves and kids were more susceptible to disease and pest infestations. The key informants also noted that farmers tended to neglect the major contribution of management practices such as vaccination and dosing in the production of healthy livestock. There were also questions about the correct stocking levels on the different plots.

Although farmers were able to observe the various effects of climate change on the pastures and crops, they did not seem to observe the effects of heat stress on animals as this was a hidden effect that could only be identifiable through the use of measuring instruments. Therefore, the effect of heat stress as observed in other literature did not emerge in the findings. Scientists have identified various effects of heat stress (Sinha et al., 2017; Zhang et al., 2017). Interventions to reduce the effect of heat stress on animals may include the construction of shelter to protect animals from heat. Sprinklers and cooling fans may also be utilised to reduce the effect of heat on animals (Sinha et al., 2017; Zhang et al., 2017).
Another important factor that expert key informants raised was the issue of urban farmers who did not understanding the effects of inbreeding. The key informants raised the point that the farmer respondents are correct to link the small sizes of the animals to lack of adequate feed and water but were quick to mention the contribution of inbreeding. Inbreeding is practiced when closely related animals are mated by choice or by default and this should be avoided (Also see Chinembiri & Friedrichs, 2006). In cattle and goat production this is the case where one bull or ram is kept in the same herd for long periods leading to it mating with its own offspring and grand-daughters or allowing siblings to mate. The phenotypic characteristics that are severely negatively impacted on by inbreeding are reproduction, survival, fitness and body size. It is understood that problems such as decreased fertility, weakness and a reduction in body size are linked to the problem of inbreeding.

Some farmers indicated that they had now planted trees that provide forage for their animals such lucerne and acacia. Those farmers who continued to plant maize were collecting the maize stalks and using it later as cattle feed. Some farmers indicated that they were of the view that their options to adapt would soon all be failing given the rate of climatic change. Expert key informants highlighted the need for farmers to make use of information provided through seasonal climate forecasts as they plan their agricultural activities. However, it seemed that most farmers did not have the information on seasonal forecasts. Expert key informants recommended the use of drip irrigation as an approach to adapting to the impacts of climate change. This is in line with global findings that drip irrigation can reduce the amount of water usage by as much as 50% (Wang et al., 2018). The advantages of drip irrigation are that it efficiently applies water directly to where it is required by the crop resulting in savings in energy and water bills. However, most farmers indicated that while they appreciated the advantages of drip irrigation, it was significantly more expensive to install the equipment required compared to flood irrigation. Farmers were also advised to use recycled water for the growing of different horticultural and ornamental crops. More research is required to understand the use of recycled water in urban agriculture.

6. Conclusion
The study established that peri-urban farmers in Kensington in Bulawayo were aware of the climatic changes taking place in their environment. They particularly noted increasing atmospheric temperatures and diminishing precipitation as being issues of concern as they directly affected their agricultural activities. However, most farmers who were part of the study were taking a decision to adapt to the effects of climate change. The adaptation pathways taken by farmers largely depended on their main line of business. Livestock farmers focussed on buying supplementary feed and securing new pastures and water sources for animals. Crop farmers mentioned stopping the cultivation of crops like maize, repeating planting, opting for drought tolerant seed varieties and irrigating at night. Mixed farming was also seen as a strategy that aided adaptation within the plots where profits from one line of business were utilised to support other business lines. For example, profits obtained from rearing pigs were channelled into cattle fattening and other costs. The study established that climate change adaptation, in general, was being conducted at a significant cost to the farmers. All farmers that were interviewed were of the opinion that their profits had been reduced by the costs associated with climate change adaptation. We noted that climate change adaptation options in peri-urban agriculture were limited by available land space and high technology costs. More structured studies will be required to quantify the cost of adaptation to peri-urban and other types of farmers. Future studies should also focus on the efficacy of other adaptation strategies in urban agriculture such as the use of water harvesting and supplementary feeding for cattle. Questions remain about the efficacy of borehole water in irrigation in peri-urban agriculture. Further investigations are required to understand the issue.

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