

Research Article

Climate Variability Impacts and Coping Strategies in Malipati Communal Area, Chiredzi District, Southeast Zimbabwe

Itai Dhliwayo ¹, Chiedza Ngonidzashe Mutanga ², Clayton Mashapa,¹ Never Muboko,^{1,3} and Edson Gandiwa ³

¹School of Wildlife and Environmental Science, Chinhoyi University of Technology, Private Bag 7724, Chinhoyi, Zimbabwe

²School of Hospitality and Tourism, Chinhoyi University of Technology, Private Bag 7724, Chinhoyi, Zimbabwe

³Zimbabwe Parks and Wildlife Management Authority, P.O. Box CY 140, Causeway, Harare, Zimbabwe

Correspondence should be addressed to Itai Dhliwayo; itaidhliwayo@gmail.com

Received 23 August 2021; Revised 10 June 2022; Accepted 8 July 2022; Published 5 September 2022

Academic Editor: Chenxi Li

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The spatial-temporal impacts and coping strategies to climate variability vary across human communities. Focusing on Malipati Communal Area in Chiredzi District, southeast Zimbabwe, the study analysed the impacts of climate variability and coping strategies adopted by local communities. Data were collected between May and June 2018 in five (5) villages in Ward 15 of Malipati Communal Area, where a total of 133 participants were involved through focus group discussions, questionnaires, and key informant interviews. The results showed an increase in livestock mortality and in contrast no significant changes in crop yields between 1990 and 2018. Further, the study established that local communities have negative perceptions towards the adaptive coping strategies to climate change, especially on the production of small grains. There is a need for other innovative strategies to enable communities to continuously buffer the impacts of climate variability inclusive of diversifying economic activities.

1. Introduction

Climate change is rapidly emerging as one of the most serious global problems affecting many sectors. It is considered to be a serious threat to sustainable development with adverse impacts on the environment, human health, agriculture, food security, economic activities, natural resources, and physical infrastructure [1–3]. Climate change refers to a statistically significant variation in either the mean state of climatic patterns or its variability, persisting for an extended period, typically four (4) decades or longer [4, 5], whereas climate variability refers to variations in the mean state and other statistics such as standard deviations and the occurrence of extremes of the climate variables at all temporal and spatial scales beyond that of individual weather events [6, 7]. Besides an increase in average temperature, climate change and climate variability cause significant changes in rainfall patterns and an increase in extreme

weather events giving rise to floods and droughts [8, 9]. Floods and droughts affect a cross section of sectors including agriculture. Bhattacharya [10] points out that globally rain-fed agriculture is practiced in 80% of the total physical agricultural area and generates 62% of the world's staple food. Tadross et al. [11] explained that climatic conditions may become erratic, extreme, and uncertain as a result of global climate change, thereby altering the biophysical environment in which crops grow.

Climate change and climate variability are a major threat to food security in Africa and many regions of the developing world, which are largely dependent on rain-fed and human labour-intensive agricultural production [7, 12, 13]. In sub-Saharan Africa, agriculture plays a very important role in providing food and income for most of the population. Over 75% of rural populations within sub-Saharan Africa rely on rain-fed smallholder agriculture [14]. Mapfumo et al. [15] reported that climate change and variability

in African smallholder farming systems can be considered as an additional threat and burden to pressures of population, poverty, and killer diseases. As part of southern Africa, Zimbabwe is experiencing significant effects of climate change as evidenced by increased temperatures and rainfall variability, posing threats to agricultural, environmental, and socioeconomic priorities that feed into the sustainable development goals [16].

Agricultural production in rural communities in Zimbabwe has largely declined in the past three decades with climate change being attributed as being one of the main contributing factors mostly in the form of extreme weather events such as erratic and subnormal rainfall amounts, droughts, floods, and lately cyclones [17, 18]. For instance, due to the drought of the 1991/1992 season, maize crop production in Zimbabwe decreased by almost 75% leaving a large percentage of the population food insecure [19]. The 1991/1992 drought was associated with a huge die-off of livestock. This drought scenario was again experienced in 1993, 1994, 2002, 2004, and 2012 seasons causing food and nutrition insecurity in most parts of Zimbabwe [1, 18].

In Chiredzi District, southeast Zimbabwe, where Malipati Communal Area is located, changes of over 2.5°C could be experienced [9]. Already sustained warming and increasing rainfall variability have incrementally negatively affected key sectors of Chiredzi District's agriculture-based economy. For example, over the last 30 years, Chiredzi District has experienced a trend towards reduced rainfall with intermittent periods of heavy rainfall accompanied by floods or cyclones, negatively affecting agricultural production and human livelihoods [9, 20]. Such extreme weather events now form an integral part of the semiarid climate of Malipati Communal Area.

It has been observed that while there is a lot of research in relation to the subject of climate change, little is known regarding factors hindering coping mechanisms in response to climate change. It is against this background that this study was undertaken to achieve the following objectives: (i) to assess the impact of climate variability on crops and livestock production for the period 1990 to 2018 and (ii) to analyse the coping strategies adopted by Malipati community in response to climate variability with a focus on agriculture.

2. Materials and Methods

2.1. Study Area. Malipati Communal Area covers Ward 15 of Chiredzi District and is located to the south of Gonarezhou National Park (GNP), southeast Zimbabwe (Figure 1). Malipati Communal Area, GNP, and other surrounding areas form part of the Great Limpopo Transfrontier Conservation Area (GLTFCA). As part of the southeast Lowveld of Zimbabwe, Malipati Communal Area lies in agro-ecological natural region V and is characterized by low elevation, high temperatures, and low and erratic rainfall, which averages <600 mm/year [22]. The major vegetation type is typical of semiarid mopane (*Colophospermum mopane*) woodland and is predominantly dry deciduous savanna woodland of varying types [23]. Chiredzi Ward 15

recorded a lower human population density in 2012 (over 12 people per km²) when compared to the Zimbabwe national average of about 33 people per km² with a population growth rate of 2.4% for the period 1992 to 2012 [24]. The Government of Zimbabwe [25] notes that this study area is generally marginally suitable for dry land cropping and extensive livestock production or game ranching.

The main crops produced are maize (*Zea mays*), sorghum (*Sorghum bicolor*), tomatoes (*Solanum lycopersicum*), sugarcane (*Saccharum officinarum*), and vegetables [26, 27]. Livestock mainly in the form of cattle (*Bos taurus*) and goats (*Capra hircus*) are kept usually for meat and milk production. Livestock density is relatively high (53 cattle/km² and 95 goats/km²) given the nutritious nature of the pastures and ranges of southeast Zimbabwe [26, 28].

2.2. Research Design and Data Collection. A case study design was used, where Malipati Communal Area was selected as the case. The selection of Malipati Communal Area was based on the fact that people in this area rely on crop production and livestock rearing, but incessant droughts have negatively impacted on their livelihoods [29]. Yin [30] notes that a case study provides an empirical inquiry about a contemporary phenomenon, which results in one arriving at valid findings, conclusions, and recommendations. Cresswell [31] points out that a case study uses several different research methodologies. Using diverse methodologies in research enables one to gather data in different forms (quantitative or qualitative).

Mixed methods were used to collect data in this study. First, secondary data on livestock and crop yields were collected from the Agricultural Technical and Extension Services (AGRITEX) and Veterinary Department in Chiredzi District in May 2018. These departments have reliable information and have the technical expertise in the subject under study. Second, a questionnaire was administered to 20 selected key informants in Malipati Communal Area who comprised 10 purposively selected district officials and 10 conveniently selected irrigation committee members from Manjinji and Magogogwe irrigation schemes in June 2018. Questions in the questionnaire included number of irrigation schemes (functional and nonfunctional), number of boreholes in the ward (functional and nonfunctional), and coping mechanisms in relation to drought. The key informants were given questionnaires, and they completed them at their convenient time. A total of 20 (100%) completed questionnaires were collected from key informants. The questionnaire focused on assessing perceptions in relation to climate change and variability, coping strategies, and factors constraining coping mechanisms. Third, in focus group discussions, the perceptions of farmers towards small grain production were recorded on a three-point Likert scale: positive, neutral, and negative. A total of five focus group discussions were held with an average of 22 people participating in each focus group discussion. The focus group discussions comprised traditional leaders, irrigation committee members, and ordinary community members.

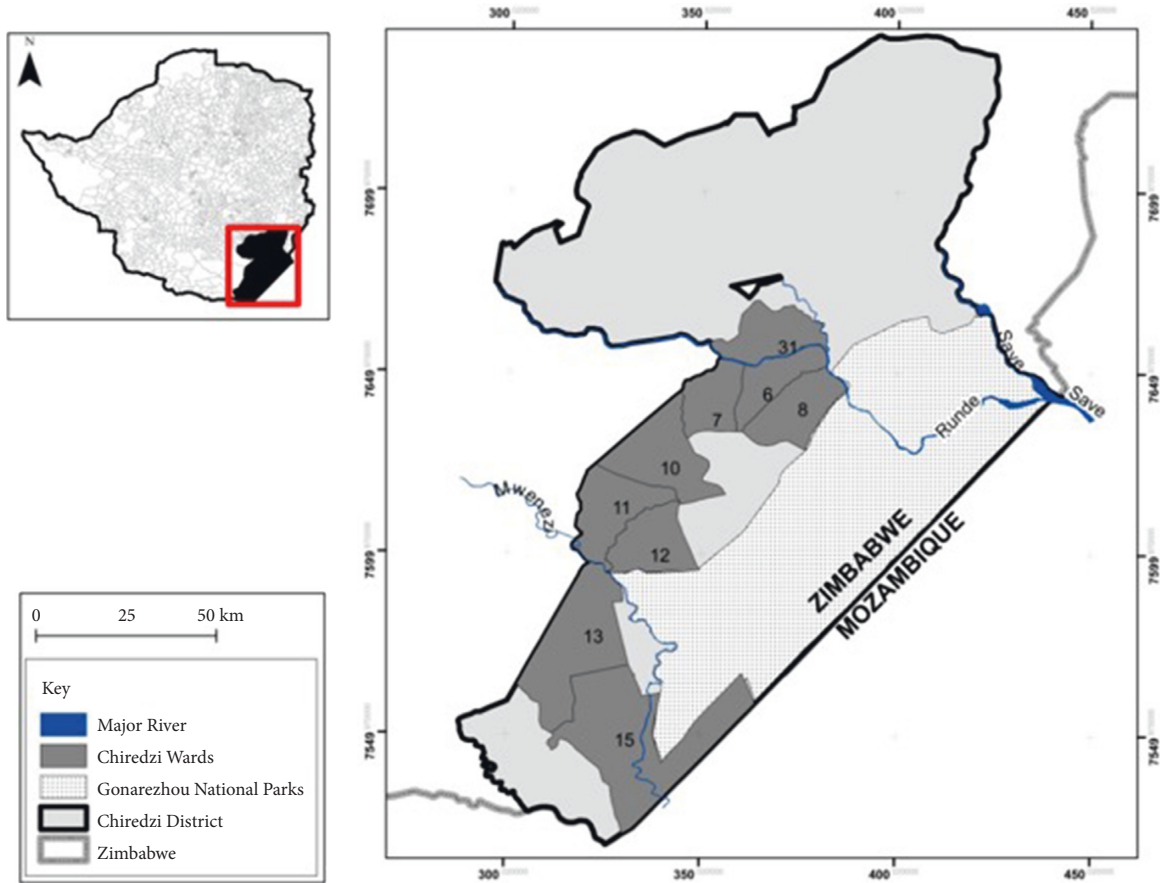


FIGURE 1: Location of the study area, i.e., Malipati Communal Area (Ward 15), southeast Zimbabwe. Source: Mwera [21]. Local community perceptions of riparian based ecosystem goods and services in the face of climate change: a case study of rural communities living on the edge of Mwenezi River, southeast Zimbabwe. Unpublished MSc thesis. Chinhoyi University of Technology, Chinhoyi.

Fourth, an observation method was used during visits to the area. During the field visits, the researchers observed dry water sources including dams, rivers, and boreholes. Pictures of the study area were also taken showing the impacts of climate change and variability.

Overall, the study sample size comprised of 45% ($n = 60$) males and 55% ($n = 73$) females (Table 1). Data were collected between May and June 2018. Permission to conduct the survey was granted by the Chiredzi Rural District Council, Chief Sengwe, and clearance from Chinhoyi University of Technology. Participation was voluntary, and participants gave consent before participating in this study. Prior to data collection, a pilot study was conducted in Ward 22 in Chizvirizvi Village in Chiredzi District to assess whether the questionnaires and interview guides were measuring what they were intended to measure, that is, the impact of climate change and coping strategies. Carrying out a pilot study enabled researchers to make necessary changes to the questionnaire and interview guides, and issues including poor translation and length of interviews were corrected.

2.3. Data Analysis. Secondary quantitative data on livestock and crop yield were analysed using simple linear regression analysis in Microsoft Office Excel. Questionnaires from key

informants were checked for completeness before being coded. Coding was done on all questions for easy analysis using the Statistical Package for Social Sciences (SPSS) version 23.0 for Windows (SPSS Inc., Chicago, USA). Close-ended questions were precoded given that they are given over a range of anticipated responses. Key informant data were descriptively analysed. Regarding climate change and variability, the participants' views were put into three categories: negative, positive, and neutral. Microsoft Excel was used to analyse the perceptions of farmers in relation to climate change and variability. Thematic content analysis was used to analyse data obtained in relation to coping mechanisms.

3. Results

Our results showed no significant changes in crops and livestock production in Chiredzi between 1990 and 2018. For small grain harvest for a 10-year period, i.e., 1991 to 2000, in Chiredzi District no significant change in yield was recorded over the study period ($r = 0.20$; $F_{1,8} = 0.35$, $P = 0.572$, $R^2 = 0.04$; Figure 2), with a harvest mean of 0.55 ± 0.39 ton/ha per annum. The same was recorded for larger grains such as maize, which had a mean harvest of 0.56 ± 0.54 tons/year. Overall, there was no significant change in yield for maize for

TABLE 1: Participants' demographics in this study.

Variable	Number (%)
Sex	
Male	60 (45)
Female	73 (55)
Age (years)	
20–29	5 (4)
30–39	27 (20)
40–49	52 (39)
50–59	38 (29)
60+	11 (8)
Marital status	
Single	3 (2)
Married	83 (63)
Widow/er	39 (29)
Divorced	8 (6)
Education level	
None	13 (10)
Primary	69 (52)
Secondary	30 (22)
Advanced level	2 (1)
Vocational	9 (7)
Tertiary	10 (8)

the study period ($r=0.42$, $F_{1,8}=1.18$, $P=0.213$, $R^2=0.19$; Figure 2). On average, 3633 ± 3032 livestock mortalities were recorded annually for the period 2015 to 2017 in Chiredzi District. Statistics show that livestock deaths in Chiredzi District were on an increase with 1200 livestock deaths in 2015, 2972 livestock deaths in 2016, and 7000 livestock deaths in 2017.

Some respondents (18%, $n=23$) reported that water availability was a challenge with more droughts having been witnessed between 1990 and 2018, attributed to changing climate. The study recorded only two major sources of energy in use in the study area, i.e., firewood (97%, $n=129$) and electricity from the national grid (3%, $n=4$). Hence, the uptake of solar energy and petroleum, e.g., paraffin, was still very low in the study area. However, of concern was the challenge of overreliance on firewood as this would lead to deforestation and land degradation.

Observations from fieldwork showed that all the rivers in Malipati Communal Area were dry, an indicator that the area had received low rainfall. Mwenezi River, for example, was observed to be having the challenge of siltation (Figure 3), and this has negatively impacted the availability of water for irrigation schemes. Mwenezi River used to be the only reliable source of water for the irrigation schemes in Malipati Communal Area, but this had changed due to recurrent droughts. This impacted negatively on crop production under irrigation schemes. In response to water shortage in Malipati Communal Area, boreholes were sunk, but most of them could not provide adequate water throughout the year because the water table was mentioned by key informants to be very low. It was also observed that

the grazing areas were bare grounds due to overgrazing and poor rainfall. There was poor vegetation cover, and most trees were observed to be dry.

This growing of drought-resistant crops, such as small grains, which included sorghum, was reported by 31% ($n=38$) of the respondents as one important coping mechanism that the local people adopted in the study area. 31% ($n=38$) of the respondents who grew the small grains reported that they were mostly guaranteed of a modest harvest despite the low rainfall and frequent droughts in the study area. On the other hand, 69% ($n=92$) said that they were not interested in growing sorghum because it is considered to be labour-intensive and less palatable. It was found that there were balanced views on embracing growing of small grains by the respondents with 31% ($n=38$) reporting interest, 36% ($n=44$) reporting no interest, and 33% ($n=41$) were neutral. Respondents, however, acknowledged the important role that the small grains could play in mitigating the negative effects of climate change as these were generally drought-resistant.

Investment in livestock was reported by 54% ($n=46$) of the respondents as another coping mechanism as these provided “insurance” during the drought years as people would sell these and procure food in addition to paying for children’s school fees. The respondents explained that rearing small livestock including goats was a preferred coping mechanism. Small livestock is resistant to drought and has high quick returns unlike cattle. 54% ($n=46$) of the respondents pointed out that cattle rearing was no longer a favourable activity in the area due to frequent droughts; cattle were perceived as being less resistant to drought in comparison with small livestock.

To buffer against unpredictable rainfall and reduced surface water, irrigation was adopted for growing all-year-round horticultural and cereal crops (Figure 3). Two irrigation schemes, i.e., Magogogwe and Manjinji, were observed in the study area, and these were established to be partially functional at the time of this study. According to 42% ($n=36$) of the respondents, the other important coping mechanisms were remittances and food support received from family members, especially those from neighbouring countries.

A total of 54 boreholes were drilled and installed in the study area. However, only 56% ($n=30$) were still functional at the time of this study with the rest being nonfunctional due to various reasons. Some of the nonfunctional boreholes were reported to have been filled up during the 2000 Cyclone Eline, whereas others lacked maintenance. Accordingly, some respondents (44%, $n=37$) reported that most local people use unsafe water sources such as rivers, and consequently, disease outbreaks such as cholera and typhoid are common. However, 5% ($n=4$) respondents also reported that surface water dwindled during the summer due to increased siltation and evapotranspiration with the reduced

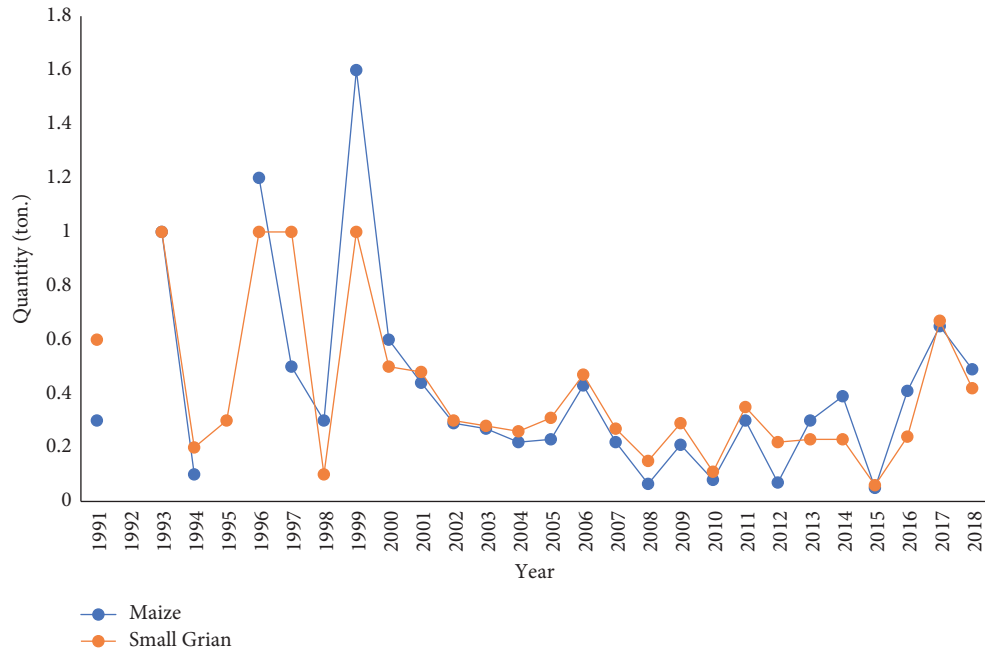


FIGURE 2: Crop production trends in Chiredzi District from 1991 to 2018. Source: AGRITEX Department—Chiredzi District.



FIGURE 3: (a) Siltation of Mwenezi River, which is the only convenient source of water for the two irrigation schemes in the study area, (b) small garden sustained by a shallow well in Muhlekواني Village, (c) a defunct borehole in Ngwenyeni Village as the water table was reported to be very low due to climate change and variability, and (d) World Food Program project partnering communities in resuscitating an irrigation scheme. Photo credits: Joseph Antipas, 2018.

flow in rivers. Figure 4 shows community members pulling resources together, which includes the human capital to resuscitate Magogogwe irrigation scheme, and wilting legume crops failing at the partially functional Manjinji irrigation scheme.

4. Discussion

Although this study recorded nonsignificant changes in crop production, there was, however, some evidence that showed an increase in the death of livestock between 2015 and 2017,



FIGURE 4: (a) Community members pulling resources together, which includes the human capital to resuscitate Magogogwe irrigation scheme. (b) Wilting legume crops failing at the partially functional Manjinji irrigation scheme. Photo credits: Joseph Antipas, 2018.

which could be attributed to climate variability, particularly local droughts that would negatively impact forage resources [18]. During the survey, it was found that most communal farmers in this area have low knowledge about feedlots or fodder for animals. This study established that farmers in Malipati Communal Area were indifferent regarding climate change and variability, and as a result, they have not fully embraced ideas to cope with climate change and variability. It was found that ideas including production of small grains, having feedlots, and growing fodder crops have not yet been embraced by farmers in Malipati Communal Area. Hence, there is a need for the construction of cattle feedlots and creation of an animal feeding surplus facility where communities could easily access fodder for their animals during dry seasons.

The farmers in Malipati Communal Area were sceptical about small grain production, and they regard it as labour-intensive. This could have a negative bearing on food security in Malipati Communal Area. Uganai and Murwira [32] reported that sorghum and millet are drought-resistant crops of great importance for food security in the semiarid tropical environments of sub-Saharan Africa. Ahmed [33] explains that knowing the threats of a system is the first step towards controlling the drought losses and minimizing the gap between attainable and actual yields. There is a need for a shift in mindset; farmers need to embrace the idea of growing small grains because they are drought-resistant. It was also found that most farmers in Malipati Communal Area prefer maize production, despite that it is not drought-resistant, because they consider it to be more palatable to sorghum.

Previous sensitivity analysis on crops recorded that Malipati Communal Area is becoming unsuitable for the local staple crops such as maize, sorghum, and millet production under the worst climate change scenario where temperatures would rise by up to 5°C and rainfall would decline by about 50% by 2050 [18, 34]. Rising mean temperature is the most direct and observable signal of climate

change for agricultural regions around the world, with many regions showing robust trends that are distinct from the signal of natural variability [35].

Despite having two irrigation schemes in Malipati Communal Area, it was found that the irrigation schemes were partially functional. This impacts negatively on food security in the area. Irrigation schemes play a critical role in enhancing food security in areas, which cannot rely on rainfall for crop production. Frequent droughts have severely strained surface and groundwater systems, contributing to the country's deteriorating water supply. Surface water (mostly rivers and dams) is the major source of water in Zimbabwe accounting for 90% of supply [36]. According to Oweis and Hachum [37], in the dry areas, water, not land, is the most limiting resource for improved agricultural production. Maximizing water productivity, and not yield per unit of land, is therefore a better strategy for dry farming systems. Irrigation schemes play a critical role in enhancing food security since relying on rainfall for crop production is now a challenge due to frequent droughts and unpredictable rainfall patterns. However, drought conditions created by climate change are expected to reduce run-off, further reducing the water levels required to support the operation of dams [36]. This study also corroborates with Nhemachena and Mano [38] who in their findings indicated that irrigation is an important adaptation option to help reduce the impact of further changes in climate.

The study found that there is over-reliance on firewood by communities as a source of energy, and this is a threat to environmental sustainability while on the other hand worsening climate change and variability. In the twenty-first century, communities are encouraged to shift to environmentally friendly energy sources such as solar. The literature on energy and climate change focuses largely on the potential of "green" technology to contribute to a new low-carbon economy [39]. Dependence on firewood as the major source of energy poses a threat to environmental sustainability and disrupts the ecosystem. As a way of adapting to climate change and preservation of the environment, there is

a need to resort to clean and environmentally friendly sources of energy such as solar. This is possible in Chiredzi District given that the area has high temperatures throughout the year. However, communities in Ward 15 are yet to fully embrace this idea.

5. Conclusion

The study showed that there was an increase in livestock deaths likely due to shortage of pastures caused by climate variability, and no significant changes in crop yields are found. Further, respondents in Malipati Communal Area were not fully aware of potential climate change phenomenon in the area. The study has also established that the community members have negative perceptions regarding small grain production and people are failing to adequately cope with these changes. There is a need to (i) educate people about the importance of small grain production and the government should consider distributing small grain inputs; (ii) educate community members about the importance of fodder crop production to reduce the number of livestock deaths; and (iii) rehabilitate and expand irrigation schemes in Malipati Communal Area to enhance food security [39–44].

Data Availability

The data are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest in this article.

Acknowledgments

The authors thank AGRITEX, District Development Fund, Meteorology Services Department Chiredzi, Malipati Community, Chief Sengwe, Blessing Bhaiseni, and Joseph Antipas for the support and contributions during the study.

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