Advances in Modern Agriculture 2025, 6(3), 3144.
https://doi.org/10.54517/ama3144

Article

Smallholder farmers in dryland agroecosystems: Understanding vulnerability to climate change and developing effective coping strategies in South Western Zimbabwe

Mgcini Moyo[1,*], Emmah Gonye[1], Ruth Dube[2], Never Assan[3]

[1] Department of Educational Foundations, Lupane State University, Lupane 081, Zimbabwe
[2] Ministry of Agriculture, Lands and Rural Development, Department of Research and Extension Services, Tsholotsho 029, Zimbabwe
[3] Department of Agriculture Management Bulawayo Regional Campus, Zimbabwe Open University, Bulawayo 029, Zimbabwe
* **Corresponding author:** Mgcini Moyo, mmoyo@lsu.ac.zw

CITATION

Moyo M, Gonye E, Dube R, Assan N. Smallholder farmers in dryland agroecosystems: Understanding vulnerability to climate change and developing effective coping strategies in South Western Zimbabwe. Advances in Modern Agriculture. 2025; 6(3): 3144. https://doi.org/10.54517/ama3144

ARTICLE INFO

Received: 9 December 2024
Revised: 13 March 2025
Accepted: 18 March 2025
Available online: 1 July 2025

Abstract: This study aimed to determine the perceived effects of climate change on the livelihoods of farming communities in the semi-arid regions of southwestern Zimbabwe. A qualitative approach was used to investigate smallholder farmers' views and experiences regarding climate change and its impacts in two wards in the Tsholotsho district, Matabeleland North province, Zimbabwe. The primary data collection methods were key informant interviews and focus-group discussions. Participants were selected using purposive sampling from established farmer groups in the study area. Most focus group discussion participants agreed that they were aware of and experienced climate-related risks in their community. They observed climate variability, particularly in the occurrence of extreme events, such as drought and insufficient rainfall, including mid-season dry spells. The 2023/2024 season was marked by very low rainfall, mid-season dry spells, and challenges to crop sustainability. Smallholder farmers in the study area indicated that they were experiencing crop failure, livestock mortality, and reduced crop yields, all of which contribute to declining agricultural productivity. In response to drought, smallholder farmers primarily employed coping strategies, such as land management through Pfumvudza, a conservation land management coping strategy; crop diversification; the use of drought-tolerant crops that are early maturing; and seeking alternative non-farming income sources.

Keywords: dryland agriculture; climate change; vulnerability; sustainable livelihoods; Zimbabwe

1. Introduction

The risks and impacts of climate change are increasingly becoming a significant threat to smallholder farmers practicing dryland agriculture in drought-prone environments [1–4]. Dryland agroecosystems are home to over 40% of the world's population [3,5–7]. Drought, characterized by prolonged periods of insufficient precipitation, continues to affect agricultural production, resulting in crop failure, livestock loss, and depletion of water sources [8,9]. It is predicted that the impact of climate change will be more severe among farming communities with weather-dependent and climate-sensitive livelihoods [2,10–12]. Dry-land farming yields are projected to decline by 20%–50% by 2050 [12]. This has a direct impact on the attainment of Sustainable Development Goals (SDGs) and undermines global efforts to address two of the UN SDGs of eradicating hunger and poverty [13].

Sub-Saharan Africa is at greater risk of experiencing periods of prolonged drought, often triggered by the El Niño phenomenon [3,14]. Climate change impact studies have demonstrated that farming communities in sub-Saharan Africa are threatened by climate change with persistent mid-season dry spells, increased temperatures, widespread poverty, and food insecurity [15–17]. A report on the state of food and nutrition security and vulnerability in Southern Africa indicates that in 2015–2016, there was El Niño; in 2018–2019, there was a drought; and in 2019–2020, some countries experienced a cyclone [17]. The dependence of these farming communities on rainfed farming systems renders them vulnerable and raises concerns regarding food availability and security [18,19].

Zimbabwe and other Southern African countries have recently experienced frequent droughts and mid-season dry spells, alternating with periods of very high rainfall [20–23]. Drought-prone areas, such as the Tsholotsho district [24,25], are the most severely affected because of fragile soils and the low adaptive capacity of smallholder farmers. Investigating and understanding farmers' perceptions of climate change and their coping strategies is crucial for supporting efforts and developing interventions tailored to the local context. Within this context, this study sought to explore and understand local smallholder farmers' perceived and experienced impacts of climate change on the livelihoods of local communities, focusing on Tsholotsho district in Zimbabwe.

2. Dryland agroecosystems and its impact of rural livelihoods

Dryland agriculture remains essential for food security and livelihoods for farming communities residing in arid environments. According to CGIAR [26], dryland agro-ecological zones support 50% of the world's livestock and sustain 44% of the world's cultivated ecosystem. Dryland ecosystems are lands characterized by limited and low annual rainfall that are not only unreliable but also highly inconsistent and variable [27]. It is the practice of cultivating crops solely with natural rainfall and without irrigation [28]. A typical dryland agro-ecological zone is characterized by low and erratic rainfall and nutrient-depleted soils [29]. Crop growth is limited to a portion of the year owing to insufficient moisture [30].

According to [3], dryland agriculture and food security are projected to be significantly affected by climate change and variability in most Southern African countries [3]. Given that the majority of dry-land smallholder farmers depend on rainfed agriculture, projections indicate that climate change impacts could be severe if effective climate-smart adaptation interventions are not implemented [31,32]. The agricultural sector in Zimbabwe is predominantly characterized by smallholder rainfed production systems in drought-prone marginal dryland agroecosystems [3,11,33,34]. Unsustainable crop yield, frequent mid-season dry spells, and weather variability are among the most significant challenges faced by farmers in dryland agroecosystems [32,35–37].

The increased occurrence of erratic rainfall patterns and seasonal shifts adversely affects crop and livestock nutrition, as well as productivity [38,39]. To a significant extent, most farming communities in dryland agroecosystem environments have observed changes in the timing and pattern of seasons as evidence of climate change [31], with poor plant germination resulting in crop damage [40,41], livestock mortality, and soil erosion [11]. There is evidence of reduced animal productivity and higher mortality rates in some livestock species due to heat stress and reduced pasture production [42]. It is within this context that the study sought to explore and understand the impact of climate change on dryland agroecosystems as a strategy to inform the design of appropriate adaptation options for communities in arid environments.

3. Description of study area

The study was conducted in Tsholotsho district, (**Figure 1** below) a dryland agroecosystem with communal land tenure, located in Matabeleland North province in Zimbabwe. The district falls under Natural Region IV, according to the Zimbabwe Classification system [43,44]. The district is primarily rural, and people derive their livelihood from subsistence farming of drought-resistant crops [45]. It is a semi-arid agro-ecological zone, with low and erratic rainfall, an annual rainfall range of 450–650 mm, and high temperatures [43,44]. Tsholotsho district lies between geographical coordinates 19°46′0″ South and 27°45′0″ East, with an average altitude of 1072 m above sea level. A Zimbabwe agency [46] observes that Tsholotsho is one of the food-insecure regions with a food poverty prevalence of 45%. Land use in the study area includes settlement, croplands, grazing, and woodland. Agriculture is the primary source of livelihood in Tsholotsho [47]. According to [43], the district is an extensive livestock production area, with some drought-tolerant crops such as sorghum, millet, and rapoko being grown. Farmers also grow some short-season maize varieties.

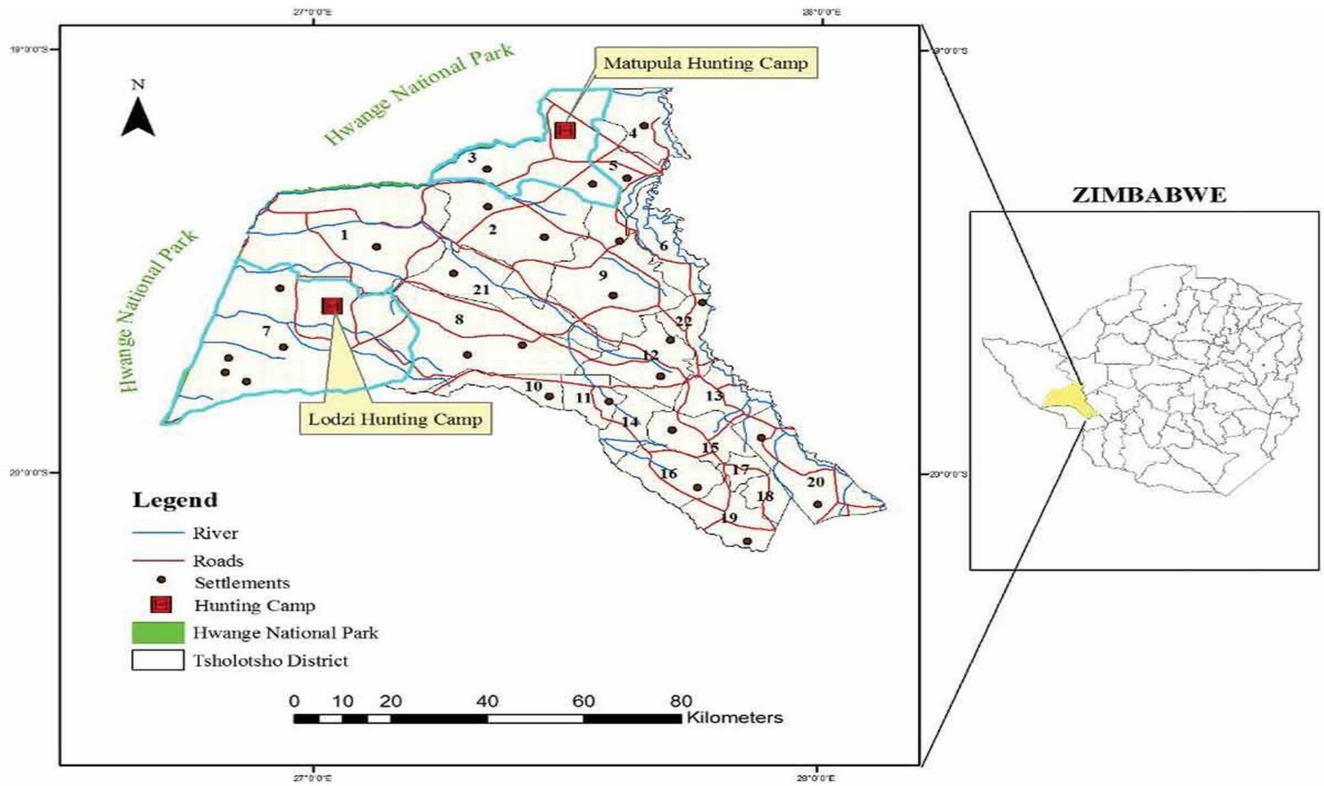

Figure 1. Location of Tsholotsho district.

The district was purposively selected for the study because of its classification as a drought risk zone, where there is evidence of the adverse impacts of climate change

[48]. Although the district has a total of 22 wards, the study focused on wards 13 and 22, areas characterized by significant levels of poverty, with farming communities in the district highly dependent on subsistence farming [25,49] and development relief from humanitarian agencies in collaboration with central government and remittances from mainly South Africa and Botswana [50,51] to sustain their livelihoods. The villages in the study area are dominated by smallholder farming systems with low adaptive capacity to climate change [25,49].

4. Methodology

This study employed a qualitative methodology to explore smallholder farmers' perceptions and experiences of climate change [52,53]. This approach allowed the study to collect data directly from participants in their natural settings. Purposively sampled smallholder farmers participating in the Zimbabwe government-initiated Pfumvudza/Intwasa program provided the data presented in this study. Pfumvudza/Intwasa is a resilient program against climate change-induced drought impacts put in place to augment food shortages and mitigate against [25]. These are individuals that have been residents for between fifteen and twenty years in the study area and have expertise and experience in dealing with the effects of climate change. Each extension officer is given a target of 350 households to train, implement, and monitor the adoption of this conservation agriculture initiative. Key respondents included two AARDS officers, a ward councilor, a kraal head, and two NGO climate change experts in the purposively selected wards. Three FGDs consisting of eight to ten participants were carried out.

Permission to work in the study area was granted on 21 July 2024 by the Tsholotsho District Development Coordinator's office and the traditional leadership in the targeted villages before starting the survey process. Upon obtaining permission to collect data, the survey was conducted between August and September 2024 in liaison with the resident AARDS officer. Informed consent was obtained from the participants after being briefed about the purpose and objectives of the research in compliance with research ethics norms. With the help of the AARDS officer, participants in FGDs were purposively selected at each study site to ensure the sample size consisted of only smallholder farmers participating in the Pfumvudza/Intwasa drought-resilient program. The FGDs focused on exploring smallholder farmers' perceptions of climate change, climate change impacts on crop production and livestock systems, and adaptation strategies within the locality [54,55]. The discussion sessions were conducted in a community setting after acquiring farmers' consent to participate. One village was randomly selected from Ward 13 with three villages, and two villages were randomly selected from Ward 22 with six villages.

The FGDs were conducted in the local language by the author and research assistant, who understood the local language and cultural dynamics. The data, which were collected in the form of field notes and through audio recording, were transcribed and translated into English for analysis. The findings were derived through thematic analysis, where data sets were compared within and across cases to identify converging and diverging themes or patterns [56,57]. These themes were used to draw conclusions about the vulnerability of smallholder farmers and their coping strategies in dryland agroecology to climate change. Secondary sources were also used to corroborate primary data, which included peer-reviewed publications from key experts and internet articles on climate change and climate-smart agriculture.

5. Results and discussions

This section presents and discusses the results of the study. The presentation of the results is in line with the themes. The themes were chosen so that the findings of the study are in line with the research objectives.

5.1. Smallholder farmers' views on climate change: Insights and concerns

The majority of individuals in FGDs concurred that they were aware of and experiencing climate-related risks in their community over the past five to ten years. They all indicated having observed and experienced the impacts of rising temperatures, unpredictable rainfall, and extreme weather events on crop yields and animal production in their locality. The most commonly perceived change among the smallholder farmers in FGDs over the past decade was temperature rise and lower annual rainfall. They also reiterated the fact that there is greater uncertainty in the onset of rains. This resonates with a study conducted by [15] that indicated that farmers were aware of and experiencing extreme weather events on crop yields. This also concurs with [58] who noticed altered patterns of rainfall, increased frequency of mid-season dry spells, and rising temperatures as some of the extreme weather events that are prevalent in sub-Saharan Africa. This also confirms Bedeke's [59] assertion that climate change has severely affected most of sub-Saharan Africa's dryland-based agroecological regions through increased temperature, erratic rainfall variability patterns, and recurrent droughts and floods.

It is evident that the majority of smallholder farmers were exposed to multiple climatic stresses during the El Niño-induced drought during the 2023–2024 agricultural season. The resident AARDS officer reiterated that the noticeable climate changes in the two wards are the mid-season dry spells, the late onset of rainfall, and the shortened length of the growing season. This was corroborated by two local NGO field experts in the study area. The key climate-related concerns of the farmers were the delay in the onset of rainfall and mid-season dry spells, which have become more prominent within the past five to ten years. The findings agree with results from previous studies by [60], who found that climate change is affecting the fundamental basis of agriculture through changes in temperature and rainfall and by intensifying the occurrences of floods, droughts, and heat stress in South Asia. The findings further verify a study by [61] in Food Security and Climate Change, which showed that climate-induced factors such as floods and drought are causing food insecurity in the drylands of Africa. The high incidence of drought and poverty has endangered the livelihoods of many farming communities that depend on subsistence farming [15,24,25]. It is evident that smallholder rain-fed dry-land agroecological regions are inherently risky due to frequent droughts and mid-season dry spells associated with climate change and variability in the study area.

5.2. Smallholder farmers' experiences and perceptions of climate change impacts on their livelihoods

Respondents perceived climatic and rainfall distribution to have undergone changes over the past five to ten years, as evidenced by erratic rainfall patterns and distribution as well as temperature increases, resulting in a decline in crop productivity and increased livestock mortality. This concurs with scientific evidence that agriculture-based livelihoods are significantly affected by climate change [8,62]. The local AARDS officer noted that the rainfall distribution in the study area has been erratic over the past decade. She emphasized that the 2023/2024 season was characterized by very low rainfall and mid-season dry spells, which led to the delayed planting of all crops. This is also substantiated by [63], who observed an increased frequency of droughts, especially increased mid-season dry spells and increased temperatures. Participants in FGDs reported poor crop establishment and high animal mortality owing to poor veld conditions during the 2023/2024 growing season.

A climate change specialist from a local NGO working in the study area asserted that crop sustainability is highly challenging under given circumstances. The delay in the commencement of the agricultural season is causing tremendous yield losses as a result of the frequent occurrence of droughts, floods, and dry spells [64]. This observation is supported by [49], who posited that smallholder farmers in the dryland tropics face temperature-induced declines in crop yields and an increasing frequency and severity of drought. In agreement with [25], smallholder farmers reiterated that climate change was a source of their food insecurity and diminished livelihoods. This is also confirmed by [20], who found that climate change-induced droughts have increased the vulnerability of smallholder farmers due to an overall reduction in food production. Unpredictable rainfall patterns have resulted in droughts, impacting crop and livestock productivity. The observed trend in rainfall and its distribution, as reported by the respondents, indicated that their area is becoming increasingly arid, characterized by a higher frequency of seasonal droughts, mid-season dry spells, and a shortened rainy season with late onset and early cessation.

This phenomenon was also observed during the 2015/2016 agricultural season, when sub-Saharan Africa experienced an El Niño-induced drought, resulting in a humanitarian crisis that affected the food and income security of the Southern African population [65]. Respondents reported that temperature records indicated a consistent increase in recent years. There was a strong consensus among respondents in FGDs that climate change alters the variability of rainfall and temperature in their region. This corroborates the Meteorological Services Department forecast, which predicted that El Niño events would have the most significant impact on the southern parts of the country. Reports indicate that the western and southern regions, typically considered "arid zones", received less than 100 mm of rainfall, a marked deviation from the normal range of 450–650 mm [66]. This observation is consistent with the [62] forecast, which suggests that the upward trend in the globally averaged temperature demonstrates that warming occurs in more areas than cooling.

A seasoned agricultural specialist working in the district noted the extreme temperatures prevalent in the region. The specialist elaborated that heat waves contribute to crop failures and threaten the livelihoods of agricultural producers and food security of dryland-based agroecosystems. This observation agrees with studies conducted by [67], who demonstrated that extreme heat exposure can stress plants, impede development, and cause plant mortality, often resulting in reduced quality and yield in agricultural crops. The finding also agrees with a study conducted in Matobo district, southwestern Zimbabwe, by [24], who argue that declining precipitation and rising temperatures are making farming increasingly more difficult and thus aggravating food insecurity in dryland farming communities. This is also reiterated by [68] in a study in Nepal who indicated that the rise in maximum temperature has decreased agricultural productivity, resulting in an increased threat of food insecurity. It was also observed that some of the impacts of climate change experienced by smallholder farmers in Tsholotsho include crop failure, livestock mortality, and low crop yields, all of which have led to declining agricultural productivity. It confirms observations made by [60], who noted that climate change variability is having an impact on both crop and livestock production systems and consequently has an impact on long-term food security.

The resident AARDS officer confirmed that El Niño-induced drought resulted in widespread crop failure and depleted pastures. The officer reported that the 2023–2024 Crop Assessment Report indicated an eighty-eight percent (88%) crop failure, with households harvesting 0.02 tonnes per hectare. The El Niño events experienced during the 2023–2024 agricultural season exacerbated agricultural production challenges in the southwestern part of Zimbabwe, rendering the community vulnerable and food insecure. This finding is supported by [69], who indicated that insufficient rainfall and prolonged dry spells negatively impact agricultural production. There was consensus among FGD participants that the high frequency and intensity of drought, depletion of dams and wells, and alterations in the timing and patterns of seasons constituted direct evidence of climate change in their constituency. This observation is corroborated by [23], who noted that frequent droughts in Africa resulted in extremely low crop yields and livestock mortality. Among the FGD respondents, livestock farmers reported that livestock were affected by El Niño-induced arid conditions, which led to widespread depletion of pasture and reduced water availability across the district. This assertion was reiterated by the director responsible for livestock production and development, Dr. Sibanda, in the Chronicle, 11 September 2024, stating that the herbage did not regenerate due to El Niño-induced drought in the 2023–2024 agricultural season. These findings are substantiated by [70], who posit that smallholder farmers in marginal areas remain highly vulnerable because of their dependence on climate-sensitive livelihoods and rain-fed agriculture.

5.3. Adaptation strategies adopted by farmers in response to climate change

In response to climate change and variability, smallholder farmers have developed various adaptation strategies in the context of climate change-induced shocks. The contribution of Pfumvudza/Intwasa to household food security was affirmed by a local AARDS officer. She emphasized that the initiative has enabled farmers to obtain yields despite the challenges posed by climate change. She further stated that access to extension services had a positive and significant impact on crop diversification and adoption of the Pfumvudza/Intwasa concept. This is also substantiated by [71], who found that Pfumvudza increased resilience against climate change-induced drought impacts and improved yields in rural communities of Zimbabwe where it was implemented. This also concurs with findings by [72], who found that conservative agriculture, as opposed to conventional farming, boosts food production and household food security in semi-arid settings. A climate expert from a local NGO advised farmers to increase their access to climate and weather forecasts as a strategy to enhance disaster preparedness and improve their crop management responses. Participants in FGDs confirmed having access to information on climate change and indicated that this has increased their likelihood of diversifying and adopting soil conservation measures to mitigate the risk of complete crop failure.

In the context of unpredictable weather patterns, the majority of smallholder farmers perceive off-farm income as a crucial risk-coping strategy. They reported engaging in alternative enterprises that are not entirely climate-dependent, such as poultry farming and household goods retail. This concurs with [73], who found that creating opportunities for non-farm income sources is important as this helps farmers to engage in activities that are less sensitive to climate change. Focus group discussions (FGDs) indicated that farmers cultivate a variety of crops to diversify their resource base as a coping strategy to mitigate the risk of harvest failure. Smallholder farmers confirmed modifying their cropping calendar to incorporate dry planting, as well as early and late planting outside the conventional planting period. This is also reiterated by a study by [74] in Nepal that recommended that dryland agriculture farming communities should develop contingency crop planning and make changes to the crop cultivation cycle. This shift aims to minimize risk and maintain crop productivity, ensuring that critical crop growth stages do not coincide with severe climatic conditions, such as mid-season drought.

The resident AARDS officer in the study area reported encouraging farmers to adopt the cultivation of drought-resistant or early-yielding crops as a strategy to cope with drought. Participants in FGDs concurred that they were adopting drought-resistant varieties, notably sorghum, millet, and cowpeas, and diversifying their livelihoods and economic activities. The above findings concur with a study conducted by [75], who found that smallholder farmers in Bulilima, Gokwe South, and Lupane, semi-arid regions in rural Zimbabwe, are adopting drought-resistant traditional grains, notably sorghum, millet, and cowpeas. This concurs with [76], who assert that planting drought-resistant crops has emerged as one of the major adaptive strategies to address the impacts of climate change. This is also substantiated by [76], who assert that sorghum production is particularly well suited for dryland agriculture because of its high and constant water-use efficiency and comparable nutritional value.

6. Conclusions

Climate change and variability pose significant threats to agricultural productivity, livelihoods, and food security, particularly in communities residing in dryland agroecosystems. Delayed onset of rainfall, drought, and mid-season dry spells remain major climate hazards in the southwestern part of Zimbabwe. The impacts of drought on affected households include poor yields or harvests, destruction of crops and livestock, and water shortages. It is evident that the adverse effects of climate change and variability are indeed reversing developmental progress and impacting climate-sensitive livelihoods that depend largely on rain-fed agriculture. The majority of smallholder farmers have experienced an increasing trend in rainfall variability, rising temperatures, and mid-season dry spells over the past five to ten years. This disrupts the normal cropping calendar, resulting in frequent crop failure, yield loss, and increased animal mortality. This study highlighted the urgent need for climate-resilient agricultural practices, policies, and support systems. In response to drought, smallholder farmers primarily employed coping strategies, such as land management through Pfumvudza, a conservation land management coping strategy; crop diversification; the use of drought-tolerant crops that are early maturing; and seeking alternative non-farming income sources. Crop management strategies such as changing planting dates, crop diversification, and the use of drought-tolerant and fast-maturing crops are part of the coping strategies smallholder farmers are adopting in the study area to improve crop yields and reduce risks associated with climate change. The roles of AARDS and climate experts have been fundamental in creating awareness and suitable conditions for the adoption of farming practices appropriate to climate change and variability. The different adaptation measures practiced by farmers aim to overcome or minimize the effects of climatic adversities. The adopted adaptation policy should build on existing coping and adaptation strategies and focus on addressing barriers to the adoption of coping and adaptation measures at different scales.

Author contributions: Conceptualization, MM; writing—original draft preparation of subtopics, MM and NA; edited subtopics, MM, EG, RD and NA; proof reading, NA; grammar checking, NA; plagiarism checking, NA; reference style, NA; ethical issues consideration, NA. All authors have read and agreed to the published version of the manuscript.

Institutional review board statement: The study was conducted in accordance with the Declaration of Helsinki. Ethical approval RB 08/ 62/ 24 for this study was obtained from The Ethics Review Committee at Lupane State University on 25 March 2024.

Informed consent statement: Informed consent was obtained from all subjects involved in the study.

Data availability statement: Due to confidentiality agreements, access to the data that support the findings of this study is restricted to bona fide researchers and is subject to a non-disclosure agreement.

Conflict of interest: The authors declare no conflict of interest.

References

1. Chakauya R, Materechera SA, Jiri O, et al. Climate change impacts on agriculture, adaptation and resilience: Insights from local farmers in South-East Zimbabwe. In: Routledge Handbook of Climate Change Impacts on Indigenous Peoples and Local Communities. Routledge; 2023. pp. 273–286.
2. Chinokwetu V, Togo M. Climate change impacts on the livelihoods of smallholder farmers in Buhera District, Zimbabwe. OIDA International Journal of Sustainable Development. 2023; 16(10): 41–54.

3. Ahmed M, Hayat R, Ahmad M, et al. Impact of Climate Change on Dryland Agricultural Systems: A Review of Current Status, Potentials, and Further Work Need. International Journal of Plant Production. 2022; 16(3): 341–363. doi: 10.1007/s42106-022-00197-1
4. Wang L, Jiao W, MacBean N, et al. Dryland productivity under a changing climate. Nature Climate Change. 2022; 12(11): 981–994. doi: 10.1038/s41558-022-01499-y
5. Singh S, Devi S. Vulnerability of dryland agriculture over non-dryland agriculture toward the changing climate. In: Enhancing Resilience of Dryland Agriculture Under Changing Climate: Interdisciplinary and Convergence Approaches. Springer Nature Singapore; 2023. pp. 45–53.
6. Kumar KM, Sridhara CJ, Hanumanthappa M, Marimuthu S. A Review of Impacts and Mitigation Strategies of Climate Change on Dryland Agriculture. Current Journal of Applied Science and Technology. 2019; 33(4): 1–12. doi: 10.9734/cjast/2019/v33i430085
7. Huang J, Li Y, Fu C, et al. Dryland climate change: Recent progress and challenges: Recent progress and challenges. Reviews of Geophysics. 2017; 55(3): 719–778. doi: 10.1002/2016rg000550
8. IPCC. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Intergovernmental Panel on Climate Change Climate Change. 2014.
9. United Nations Environment Programme. Emissions Gap Report 2021: The Heat Is On—A World of Climate Promises Not Yet Delivered. The Emissions Gap Report. 2021. doi: 10.18356/9789210011181
10. Awazi NP, Tchamba MN, Temgoua LF, et al. Climate-smart and agro-ecological farming systems of smallholder farmers. In: Environment and Climate-Smart Food Production. Springer International Publishing; 2022. pp. 31–72.
11. Gwenzi J, Mashonjowa E, Mafongoya PL. Coping with extreme weather in arid areas, a case study of Uzumba Maramba Pfungwe District, Zimbabwe. In: Climate Change, Hazards and Adaptation Options: Handling the Impacts of a Changing Climate. Springer International Publishing; 2020. pp. 701–716.
12. IPCC. Climate Change 2007: Impacts, Adaptation and Vulnerability. Intergovernmental Panel on Climate Change. 2007.
13. Khanal U, Wilson C, Rahman S, et al. Smallholder farmers' adaptation to climate change and its potential contribution to UN's sustainable development goals of zero hunger and no poverty. Journal of Cleaner Production. 2021; 281: 124999. doi: 10.1016/j.jclepro.2020.124999
14. Funk C, Davenport F, Harrison L, et al. Anthropogenic Enhancement of Moderate-to-Strong El Niño Events Likely Contributed to Drought and Poor Harvests in Southern Africa During 2016. Bulletin of the American Meteorological Society. 2018; 99(1): S91–S96. doi: 10.1175/bams-d-17-0112.1
15. Madamombe SM, Ng'ang'a SK, Öborn I, et al. Climate change awareness and adaptation strategies by smallholder farmers in semi-arid areas of Zimbabwe. International Journal of Agricultural Sustainability. 2024; 22(1). doi: 10.1080/14735903.2023.2293588
16. Serdeczny O, Adams S, Baarsch F, et al. Climate change impacts in Sub-Saharan Africa: From physical changes to their social repercussions. Regional Environmental Change. 2016; 17(6): 1585–1600. doi: 10.1007/s10113-015-0910-2
17. SADC. Synthesis report on the state of food and nutrition security and vulnerability in Southern Africa. SADC. 2018.
18. Amir S, Saqib Z, Khan MI, et al. Determinants of farmers' adaptation to climate change in rain-fed agriculture of Pakistan. Arabian Journal of Geosciences. 2020; 13(19): 1–19. doi: 10.1007/s12517-020-06019-w
19. Khatri P, Kumar P, Shakya KS, et al. Understanding the intertwined nature of rising multiple risks in modern agriculture and food system. Environment, Development and Sustainability. 2024; 26(9): 24107–24150. doi: 10.1007/s10668-023-03638-7
20. Harvey CA, Rakotobe ZL, Rao NS, et al. Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar. Philosophical Transactions of the Royal Society B: Biological Sciences. 2014; 369(1639): 20130089. doi: 10.1098/rstb.2013.0089
21. Kumalo J. The Impact of Climate Change on Food Security and Livelihoods In Zimbabwe: Assessing the Sustainability of Intervention Strategies Adopted In the Matabeleland South Province, Zimbabwe. American Scientific Research Journal for Engineering, Technology, and Sciences. 2022; 90(1).
22. Mutengwa CS, Mnkeni P, Kondwakwenda A. Climate-Smart Agriculture and Food Security in Southern Africa: A Review of the Vulnerability of Smallholder Agriculture and Food Security to Climate Change. Sustainability. 2023; 15(4): 2882. doi: 10.3390/su15042882
23. Nciizah T, Nciizah E, Mubekaphi C, Nciizah AD. Smallholder farmers' adaptation strategies and food security: Experiences from Zimbabwe. In: Food Security for African Smallholder Farmers. Springer Nature Singapore; 2022. pp. 267–280.

24. Dube T, Intauno S, Moyo P, Phiri K. The Gender-differentiated Impacts of Climate Change on Rural Livelihoods Labour Requirements in Southern Zimbabwe. Journal of Human Ecology. 2017; 58(1–2): 48–56. doi: 10.1080/09709274.2017.1316958
25. Phiri K, Nhliziyo M, Madzivire SI, et al. Understanding climate smart agriculture and the resilience of smallholder farmers in Umguza district, Zimbabwe. Cogent Social Sciences. 2021; 7(1). doi: 10.1080/23311886.2021.1970425.
26. CGIAR. The World's Dry Areas. CGIAR Research Program on Dryland Systems. Available online https://hdl.handle.net/10568/51670.(Accessed 23 February 2025).
27. Mwenzwa EM. Dryland farming and food security in Kenya: Challenges and research priorities. Elixir Soc. Sci. 41 (2011) 5832-5836. URI: http://41.89.164.27:8080/xmlui/handle/123456789/829.
28. Trivedi A, Nandeha N, Mishra S. Dryland agriculture and farming technology: Problems and Solutions. In: Climate Resilient Smart Agriculture: Approaches & Techniques. Vital Biotech Publication; 2022. pp. 35–51.
29. Tui SHK, Descheemaeker K, Valdivia RO, et al. Climate change impacts and adaptation for dryland farming systems in Zimbabwe: A stakeholder-driven integrated multi-model assessment. Climatic Change. 2021; 168(1–2): 10. doi: 10.1007/s10584-021-03151-8
30. Peterson GA, Unger PW, Payne WA. In: Dryland Agriculture. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America; 2006.
31. Mbow C, Toensmeier E, Brandt M, et al. Agroforestry as a solution for multiple climate change challenges in Africa. In: Climate change and agriculture. Burleigh Dodds Science Publishing; 2020. pp. 339–374.
32. Ndlovu E, Prinsloo B, Le Roux T. Impact of climate change and variability on traditional farming systems: Farmers' perceptions from south-west, semi-arid Zimbabwe. Jàmbá: Journal of Disaster Risk Studies. 2020; 12(1): 1–19. doi: 10.4102/jamba.v12i1.742
33. Malhi GS, Kaur M, Kaushik P. Impact of Climate Change on Agriculture and Its Mitigation Strategies: A Review. Sustainability. 2021; 13(3): 1318. doi: 10.3390/su13031318
34. Lawrence PG, Maxwell BD, Rew LJ, et al. Vulnerability of dryland agricultural regimes to economic and climatic change. Ecology and Society. 2018; 23(1): 34. doi: 10.5751/es-09983-230134
35. Rani S, Tiwari P. Climate change vulnerability assessment for adaptation planning in Uttarakhand, Indian Himalaya. International Journal of Disaster Risk Reduction. 2024; 114: 104938. doi: 10.1016/j.ijdrr.2024.104938
36. Sindani BB. Impacts of Climate Variability on Livelihoods Sustainability in Kapsokwony Division, Mt. Elgon District, Kenya [PhD thesis]. University of Nairobi; 2023.
37. Shoko Kori D, Musakwa W, Kelso C. Understanding the local implications of climate change: Unpacking the experiences of smallholder farmers in Thulamela Municipality, Vhembe District, Limpopo Province, South Africa. PLOS Climate. 2024; 3(10): e0000500. doi: 10.1371/journal.pclm.0000500
38. Chimwamurombe PM, Mataranyika PN. Factors influencing dryland agricultural productivity. Journal of Arid Environments. 2021; 189: 104489. doi: 10.1016/j.jaridenv.2021.104489
39. Devi NB, Lepcha NT. Carbon sink and source function of Eastern Himalayan forests: Implications of change in climate and biotic variables. Environmental Monitoring and Assessment. 2023; 195(7): 843. doi: 10.1007/s10661-023-11460-x
40. Homann-Kee Tui S, Valbuena D, Masikati P, et al. Economic trade-offs of biomass use in crop-livestock systems: Exploring more sustainable options in semi-arid Zimbabwe. Agricultural Systems. 2015; 134: 48–60. doi: 10.1016/j.agsy.2014.06.009
41. Liliane TN, Charles MS. Factors Affecting Yield of Crops. In: Agronomy—Climate Change and Food Security. Intech-UK; 2020.
42. Hirwa H, Li F, Qiao Y, et al. Climate change–drylands–food security nexus in Africa: From the perspective of technical advances, challenges, and opportunities. Frontiers in Environmental Science. 2022; 10. doi: 10.3389/fenvs.2022.851249
43. Mugandani R, Wuta M, Makarau A, Chipindu B. Re-classification of agro-ecological regions of Zimbabwe in conformity with climate variability and change. African Crop Science Journal. 2012; 20: 361–369.
44. Vincent V, Thomas RG, Staples RR. Book Review By Dml-An Agricultural Survey of Southern Rhodesia Part I. Agro-Ecological Survey. Tropical Agriculture. 1962; 39(2).
45. Zimbabwe Election Support Network. A Profile of Constituencies: Understanding Elections in Zimbabwe. Government of Zimbabwe. 2008.
46. Zimbabwe National Statistics Agency (ZIMSTAT). In: The Food Poverty Atlas: Small area food poverty estimation: Statistics for addressing food and nutrition insecurity in Zimbabwe. UNICEF, Harare; 2016.

47. TRDC. Description of Tsholotsho district. Government of Zimbabwe. 2024.
48. Viceisza A, Aflagah K, Abner J, Hippolyte K. Poverty and Malnutrition in Zimbabwe: Findings from Matabeleland North Province. 2020. Research Technical Assistance Center: Washington, DC.
49. Dube T, Phiri K. Rural livelihoods under stress: The impact of climate change on livelihoods in South Western Zimbabwe. American International Journal of Contemporary Research. 2013; 3(5): 11–25.
50. Nzima D, Duma V, Moyo P. Migrant Remittances, Livelihoods and Investment: Evidence from Tsholotsho District in the Matabeleland North Province of Zimbabwe. Migracijske i etničke teme/Migration and Ethnic Themes. 2016; 32(1): 37–62. doi: 10.11567/met.32.1.2
51. Maphosa F. The impact of remittances from Zimbabweans working in South Africa on rural livelihoods in the southern districts of Zimbabwe. Forced Migration Studies Programme, University of the Witwatersrand. 2005.
52. Teddlie C, Yu F. Mixed Methods Sampling: A Typology With Examples. Journal of Mixed Methods Research. 2007; 1(1): 77–100. doi: 10.1177/1558689806292430
53. Leavy P. In: Research design. The Guilford Press; 2017.
54. Morgan DL. Focus Group Interviewing. Handbook of Interview Research. Published online 2002; 141–159. doi: 10.4135/9781412973588.n10
55. Dilshad RM, Latif MI. Focus group interview as a tool for qualitative research: An analysis. Pakistan Journal of Social Sciences. 2013; 33(1): 191–198.
56. Butina M. A Narrative Approach to Qualitative Inquiry. American Society for Clinical Laboratory Science. 2015; 28(3): 190–196. doi: 10.29074/ascls.28.3.190
57. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology. 2006; 3(2): 77–101. doi: 10.1191/1478088706qp063oa
58. Chanza N, Gundu-Jakarasi V. Deciphering the Climate Change Conundrum in Zimbabwe: An Exposition. Global Warming and Climate Change. 2020; 1–25. doi: 10.5772/intechopen.84443
59. Bedeke SB. Climate change vulnerability and adaptation of crop producers in sub-Saharan Africa: A review on concepts, approaches and methods. Environment, Development and Sustainability. 2022; 25(2): 1017–1051. doi: 10.1007/s10668-022-02118-8
60. Rasul G. Twin challenges of COVID-19 pandemic and climate change for agriculture and food security in South Asia. Environmental Challenges. 2021; 2: 100027. doi: 10.1016/j.envc.2021.100027
61. Yadav SS, Hegde VS, Habibi AB, et al. Climate Change, Agriculture and Food Security. In: Yadav SS, Redden RJ, Hatfield JL, et al. (editors). Food Security and Climate Change. Wiley; 2018. pp. 1–21.
62. IPCC. Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems (SRCCL). IPCC. 2019.
63. Gbegbelegbe S, Serem J, Stirling C, et al. Smallholder farmers in eastern Africa and climate change: A review of risks and adaptation options with implications for future adaptation programmes. Climate and Development. 2018; 10(4): 289–306. doi: 10.1080/17565529.2017.1374236
64. World Metrological Organization. State of the global climate 2022. UN. 2023.
65. Food and Agriculture Organization, International Fund for Agricultural Development, UNICEF, World Food Programme and World Health Organization. The state of food security in the World. Available online: https://www.fao.org/3/I9553EN/i9553en.pdf (accessed on 25 November 2024).
66. MS Department. Weather forecast and status. Zimbabwe. 2023.
67. Hatfield JL, Prueger JH. Temperature extremes: Effect on plant growth and development. Weather and Climate Extremes. 2015; 10: 4–10. doi: 10.1016/j.wace.2015.08.001
68. Pant KP. Climate Change And Food Security In Nepal. Journal of Agriculture and Environment. 2013; 13: 9–19. doi: 10.3126/aej.v13i0.7582
69. Mugiyo H, Magadzire T, Choruma DJ, et al. El Niño’s Effects on Southern African Agriculture in 2023/24 and Anticipatory Action Strategies to Reduce the Impacts in Zimbabwe. Atmosphere. 2023; 14(11): 1692. doi: 10.3390/atmos14111692
70. Kapari M, Hlophe-Ginindza S, Nhamo L, Mpandeli S. Contribution of smallholder farmers to food security and opportunities for resilient farming systems. Frontiers in Sustainable Food Systems. 2023; 7. doi: 10.3389/fsufs.2023.1149854
71. Mavesere F, Dzawanda B. Effectiveness of Pfumvudza as a resilient strategy against drought impacts in rural communities of Zimbabwe. GeoJournal. 2023; 88(3): 3455–3470. doi: 10.1007/s10708-022-10812-3

72. Mujere N. An Assessment of the Contribution of The Pfumvudza Concept Towards Climate Smart Agriculture in Zimbabwe: A Review. Journal of Agriculture and Horticulture Research. 2022; 5(2): 69–76. doi: 10.33140/jahr.05.02.01
73. Belay A, Recha JW, Woldeamanuel T, Morton JF. Smallholder farmers’ adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. Agriculture & Food Security. 2017; 6(1): 1–13. doi: 10.1186/s40066-017-0100-1
74. Neupane N, Paudel S, Sapkota R, et al. Enhancing the resilience of food production systems for food and nutritional security under climate change in Nepal. Frontiers in Sustainable Food Systems. 2022; 6. doi: 10.3389/fsufs.2022.968998
75. Dube N, Sithole M, Ngwenya T, et al. Impact of climate change on sustainability in semi-arid, rural Africa: Lessons from rural Zimbabwe. Cogent Social Sciences. 2018; 4(1): 1553327. doi: 10.1080/23311886.2018.1553327
76. Mwamahonje A, Eleblu JSY, Ofori K, et al. Sorghum Production Constraints, Trait Preferences, and Strategies to Combat Drought in Tanzania. Sustainability. 2021; 13(23): 12942. doi: 10.3390/su132312942