AN ASSESSMENT OF CLIMATE CHANGE IMPACTS ON LIVELIHOODS IN MAHUNGUHWI VILLAGE (SOUTH AFRICA) WITH AN EMPHASIS ON SUBSISTENCE FARMING, NATURAL RESOURCE EXTRACTION, AND EDUCATIONAL LIVELIHOODS

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Abstract. People in rural areas depend on the natural environment for survival due to limited means for sustenance. This study assessed the impacts of climate change on livelihoods in Mahunguhwi village (South Africa) with an emphasis on subsistence farming, natural resource extraction, and educational livelihoods. This study employed both qualitative and quantitative research methods. Since the households were fewer than 100, all households were handed the questionnaires as well as evaluating the area of each household. The most dominant economic activities are subsistence farming and natural resource extraction. Socioeconomic factors such as age, education, gender, and employment status influence the household economic activities. Climate-induced challenges in agriculture are forcing households to reduce the size of occupation areas and farmland. 59% of the farming land was planted during the study period. From the study, subsistence farming is declining and extraction of natural resources such as rocks, firewood and wood provides an alternative source of income. Smart agriculture in the area was recommended due to the large areas that are left uncultivated.
Keywords: *climate change, impact assessment, sustainable livelihoods, monitoring, environmental sustainability, subsistence farming, natural resource extraction and educational livelihoods*

Introduction

It is unequivocal that the increase in carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), in the atmosphere since the beginning of the industrial era is the result of human activities and that human influence is the principal driver of many changes observed across the atmosphere, ocean, cryosphere, and biosphere (IPCC, 2007, 2013, 2022). Scientific evidence confirming that the climate system is warming is now unequivocal, with scientific consensus on the role of human activities. Anthropogenic greenhouse gas (GHG) emissions have increased sharply since the pre-industrial era and atmospheric concentrations of carbon dioxide, methane, and nitrous oxide are at levels unprecedented over at least the last 800,000 years (IPCC, 2014, 2018; WMO, 2021). The recognition of anthropogenic GHG emissions gave rise to Sustainable Development Goal 7 (affordable clean energy) to mitigate emissions.

Climate change creates the risk of persistent poverty and widespread inequality in society (Moellendorf, 2022). Furthermore, poverty has a detrimental effect on environmental pollution in Sub-Saharan Africa. In South Africa, the percentage of people experiencing hunger decreased from 29.3% in 2002 to 11.1% in 2019. People in rural areas depends on the natural environment for survival due to limited options for sustenance. In addition, the flourishing of the natural environment is the key to their sustainable livelihood. Deforestation, soil erosion, flooding, and drought are among

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the environmental disasters that threaten livelihoods in rural areas. Climate change is likely to worsen these environmental disasters together with other additional impacts (IPCC, 2019; FAO, 2021). Sustainable development goal no 1, no 2 and no 3 tackles poverty, hunger, good health and wellbeing. Climate change can influence all these goals.

Agriculture is a critical aspect of Africa's economic growth and development. Agriculture is estimated to account for more than a fifth of sub-Saharan economic output. Livestock and croplands still depend on natural rain and it is estimated that rainfed agriculture accounts for 95% of agriculture in this region. The use of machinery is limited because most farmers rely on manual labour and draught animals. Agriculture development is expected to be challenging in many places as climate change brings less favourable weather patterns (FAO, 2021; McKinsey Global Institute, 2020; Xie et al., 2019). Water and land are essential for development in agricultural dependent regions and hence they are highly susceptible to climate change impacts.

According to Birkmann et al. (2022), the main factors that affects rural livelihoods are the sudden and slow onset of severe weather events such as changing rainfall, rising sea levels, coastal erosion, flooding, salinity intrusion, and droughts. However, there is limited information on the extent and duration of such impacts on the livelihood of people. Extreme climate events occur at the municipal level but are managed through Disaster Management Plans (DMPs) as required by the Disaster Management Act (section 53). DMP should provide the relief effort within 72 h in case of emergencies associated with disaster risks (Memabubuni, 2023; Nishimura, 2019).

The Rural Resilience Initiative (R4) is introduced to reduce and mitigate the risks of climate change in vulnerable rural areas. More than 1.2 billion people in the developing world live below the poverty line and depend on agriculture for their livelihoods (IPCC, 2019; R4 Rural Resilience Initiative, 2018, 2021). Sustainable Development Goals (SDGs) set clear goals that allow proper objectives that help identify challenges in livelihoods and their mitigations. Sutstainable Development Goal 1, 2, and 3 aimed to end poverty, zero hunger, and good health and wee-being respectively (*Fig. 1*).

There are several targets and indicators in SDG 13 that are either relevant to water or dependent on water (13.1, 13.2, 13.B) without necessarily specifying that they are related to water (UN, 2018; UNCCD, 2015). The natural environment provides ecosystem services that are critical for livelihood activities. In South Africa, the National Environment Management Act 107 of 1998 (NEMA) governs and protects the natural environment against human development.

This study assessed the impacts of climate change on land-based livelihoods and the coping strategies people explored. It examined the potential impacts of alternative livelihoods that were being explored in the area. The extent to which natural resources such as water, forests, and soil are being modified by climate change was also examined for monitoring and mitigation purposes. The study addressed the impact of climate change on land-based livelihoods such as agriculture and explore sustainable responses or solutions to the challenges that were identified. It also seeks to understand the potential impact that comes with the coping strategies people explore to cope with climate change. The use of natural resources as monitoring targets for climate change was also explored through natural resource profiling.

This study aims to assess climate change impact on livelihoods in Mahunguhwi village (South Africa) with emphasis on subsidence farming, natural resource extraction and educational livelihoods.

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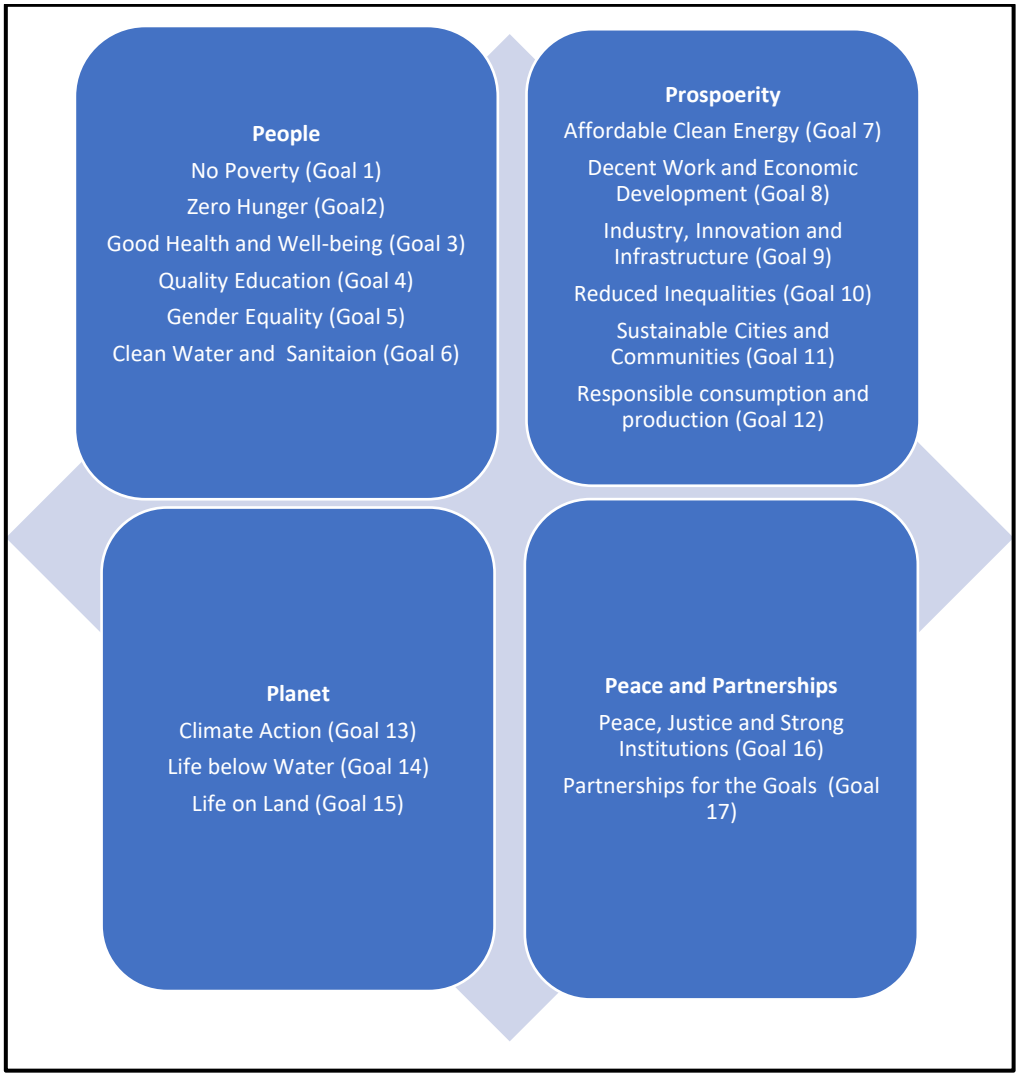

Figure 1. *Flow chart highlighting the SDGs. (Adapted from Morton et al., 2017)*

Specific objectives

- Assess the socio-economic factors in Mahunguhwi village that leads to dependence in subsidence farming and natural resources bound livelihoods.
- Assess the sustainability of subsidence farming and natural resource extraction in relation to climate change impacts and coping strategies.
- Identify and evaluate the natural resources that can be used to monitor climate change in the area.
- Assess climate change extreme events impacting the food security and educational livelihoods.

Materials and method

Study area

The study area was Mahunguhwi village (South Africa) which is situated within the radius of 5 km from Tshitavha as indicated on the map. It is situated about 55 km from

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Thohoyandou (*Fig. 2*). The area is mountainous and isolated from other villages. The nearest village is Tshitavha which is 5 km away. In between the villages are the mountains and patches of small farms. The study area is a semi-rural area with poor provision of roads, water and other municipal services. Mahunguhwi comprise of landlocked villages that are easily isolated by flooding. In 2000, the community relied on military services for the supply of food and water as roads were destroyed. These attributes suggest the area which is highly vaulnerable to climate change impacts. It is this reasons that the area was selected as the study area.

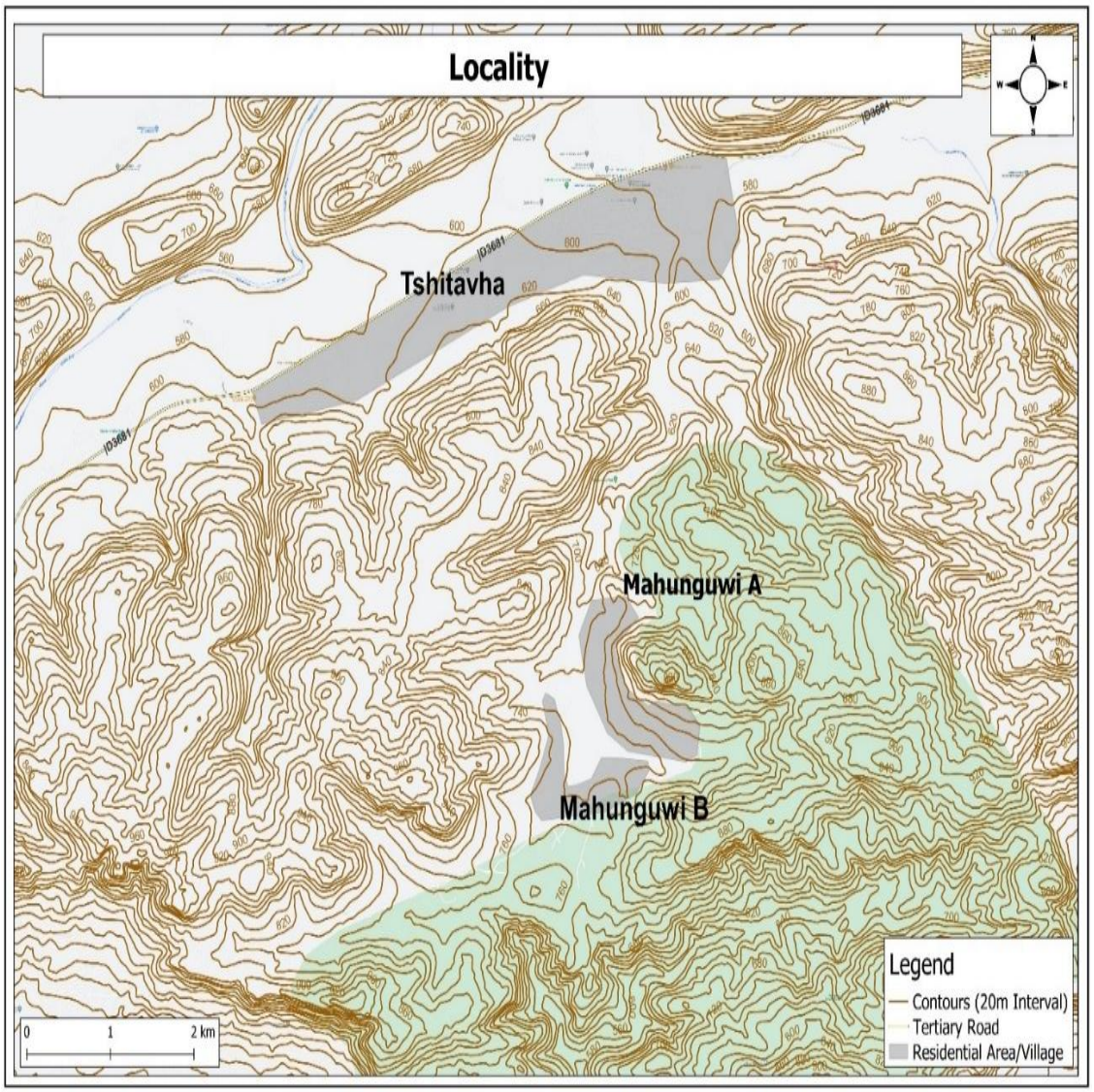

Figure 2. *Location of the study area. Note: the ragged terrain in the area. Created from ArcGIS*

Research design and sampling

The research design for this study involved surveys. In survey research, you ask a group of respondents a series of questions and record their responses to gather information about different characteristics, beliefs, experiences, and perspectives (Creswell, 2014; Leedy and Ormrod, 2015). Generally, the survey aimed to discover more information about the sample

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of the population under study (Leedy and Ornmrod, 2015). According to Mbulayi (2014), research design is a master plan or blueprint describing the steps and ways in which the researcher will approach their research project. In this research, both qualitative and quantitative research approaches were utilised. Non-probability sampling was used because it focuses on small samples and is intended to examine a real-life phenomenon rather than to make statistical inferences (Yin, 2003). Non-probability sampling does not require that the participants be representative. The study used a non-probability sampling method called judgmental sampling or purposive sampling. According to Maxwell (1996), a purposeful sampling approach is conducted in a setting or event chosen intentionally to provide information that cannot be obtained through other choices. In Mahunguhwi village, the targeted participants were farmers, schools and natural resource gathers.

This study employed both qualitative and quantitative research methods. Since the households were fewer than 100, all households were handed the questionnaires as well as evaluating the area of each household.

Devices, instrumentation and information gathering

Global Positioning System (GPS) is required to determine the size of agricultural space that is being utilized in the area. The information gathered through the GPS were plotted into the Google Earth Pro software to provide geospatial references of the area. Using the Google Earth Pro, a virtual presentation of features on the ground were visualised. ArcGIS was used to produce the terrain map of the study area.

In this study, the primary method for obtaining data was a self-administered questionnaire. The questionnaire was administered to the households that took part in the research. Apart from demographics, the questionnaire will include aspects of agricultural livelihoods. The type of farming, number of livestock, type of field crops, purpose of farming, farming methods, challenges, assistance required, infrastructure availability were included. Natural resource extraction livelihoods were assessed based on type of natural resource, purpose of extraction, method involved in extraction.

Results and discussion

Economic activities in Mahunguhwi village

From *Figure 3,* the results indicated that economic activities in the area were primarily centred around subsistence farming and natural resource extraction. Subsistence farming was a dominant economic activity, with a focus on both crop farming (maize as the staple food) and livestock farming. Livestock farming included cattle, goats, and pigs.

During the study, natural resource extraction was an important economic activity that involved the collection of rocks, firewood, and wood. Firewood gathering was the most prevalent commodity, with 19% of households actively involved. Rock harvesting was carried out by 7% of households, while wood harvesting involved a smaller percentage, approximately 3% of households.

Crop farming

Figure 4 suggested that around 72% of people are farming on their homesteads. Only 9% are farming in orchards. Approximately 90% of households own the land where they are farming. 10% inherited the land for farming from their parents. Approximately 65% of the crop farming households were married. About 22% were single.

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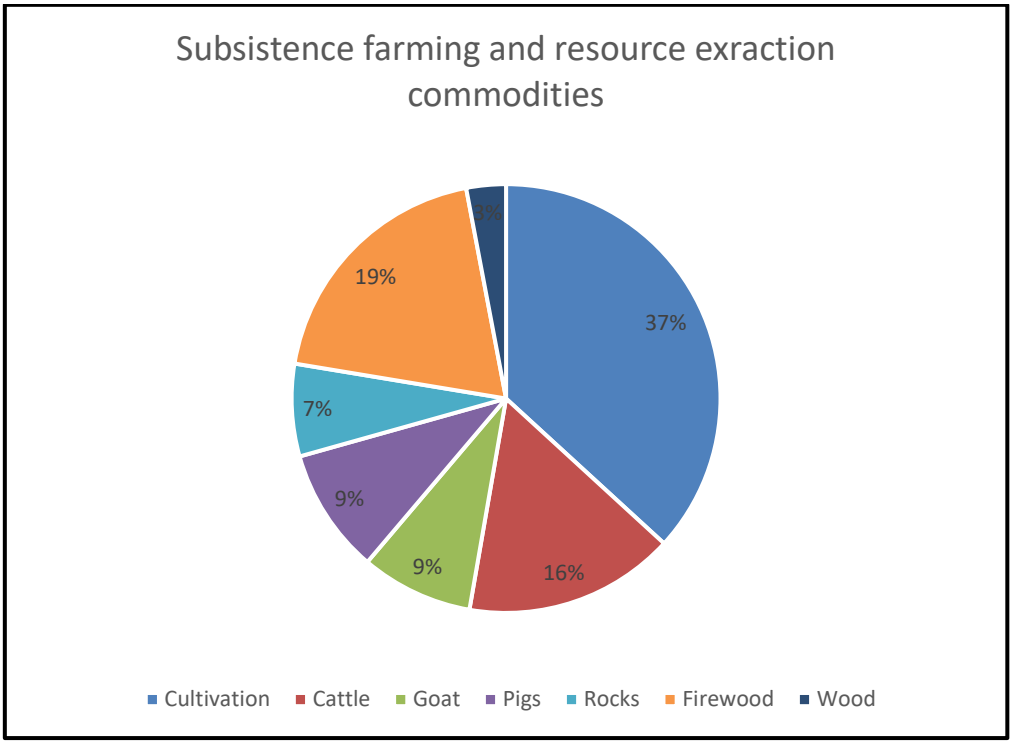

Figure 3. *Subsistence farming and resource extraction commodities in Mahunguhwi village*

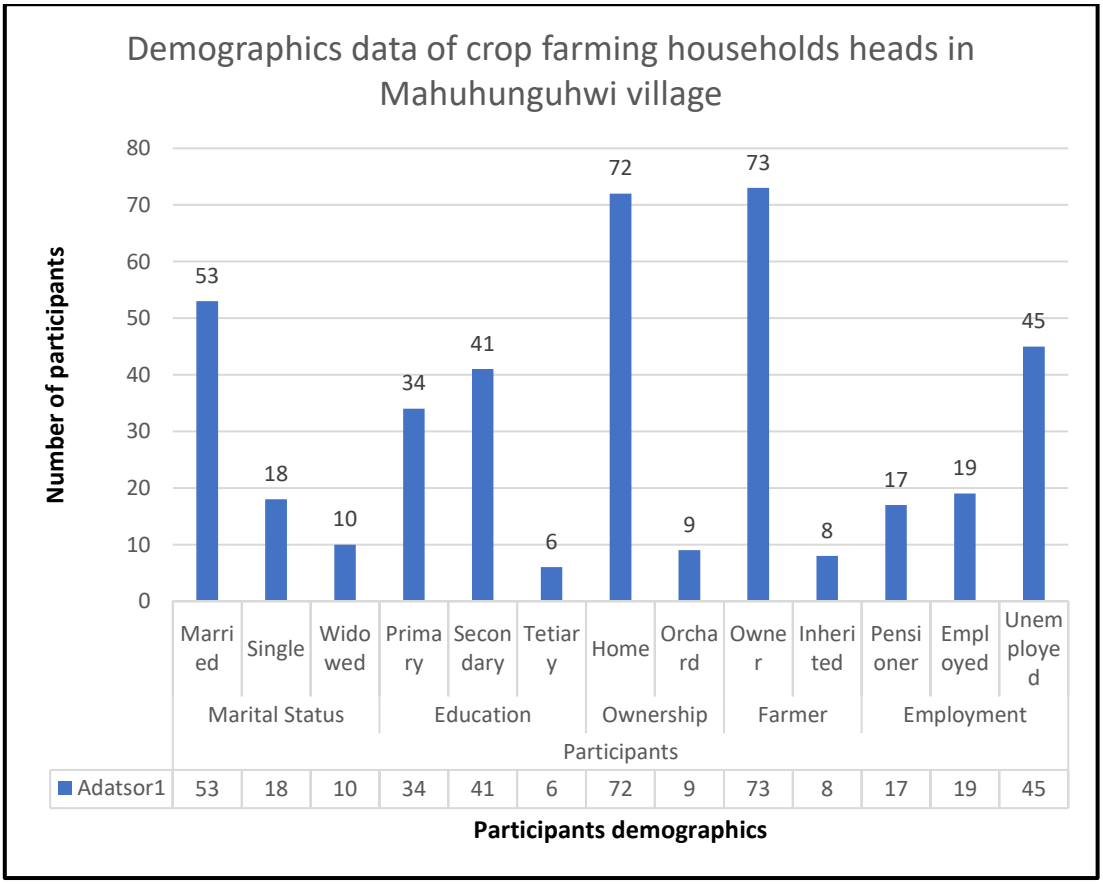

Figure 4. *Demographic data of crop farming households heads in Mahunguhwi village*

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Around 13% were widowed. Education levels among the household heads were a concern: Approximately 51% have a secondary level of education. About 42% have a primary level of education. Only 7% of the households were led by individuals with tertiary qualifications. The study considers only the education level of the house owner or household head.

The employment status of the households heads was as follows: Roughly 56% of households heads were unemployed. About 23% were employed. Approximately 21% were pensioners, specifically those who were previously employed, not grant pensioners.

These factors provided the composition of crop farming households in the community, including their marital status, education levels, farming locations, land ownership, and employment status. It can be useful for various purposes, such as community development planning and agricultural policy formulation.

The researcher observed that maize is the primary crop grown in the community. It serves as a staple food source and can be used for both immediate consumption as corn and later for milling into products like sour porridge and maize meal. The primary reasons for cultivating maize are food security and the potential for monetary gains, particularly when there is a surplus harvest. Most households own land with an average size of about 0.2 hectares (ha). Orchards have larger plots, with some reaching up to 5 ha (*Fig. 5*).

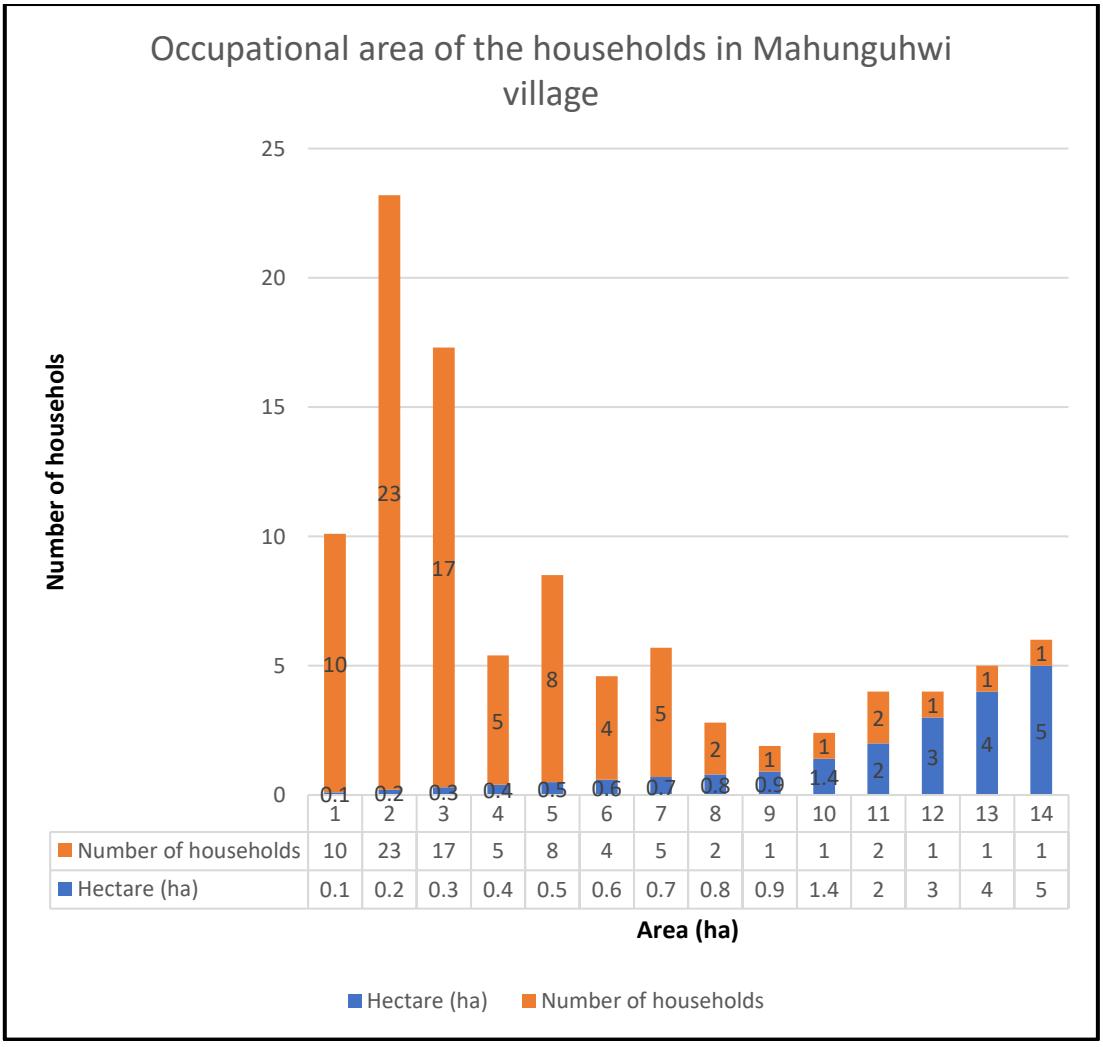

Figure 5. *Ocupational area of the households in Mahunguhwi village*

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Orchards are sometimes used for extended family housing. Participants prefers smaller cultivation areas because they are easier to maintain in terms of fencing, seedling planting, weed control, ploughing, and harvesting. Maize cultivation is perceived as demanding and uncertain, especially given current climatic conditions. On average, households own about 0.3 ha of land, with some owning multiple plots (*Fig. 5*).

There is a growing trend of households planting less than their full available land. *Figure 6* illustrates the total area of land owned by households (48 ha), the area cultivated (28.32 ha), and the area left uncultivated (19.68 ha). Participants mentioned various reasons for planting less, including climatic conditions, which can lead to unpredictable harvests. Resource availability, which may limit their ability to cultivate larger areas. Economic considerations suggested that smaller-scale farming is more feasible or less risky. The IPCC forecasts 20-50% reduction in yields of staples in southern Africa. Mahunguhwi village is also on the downward planting trend.

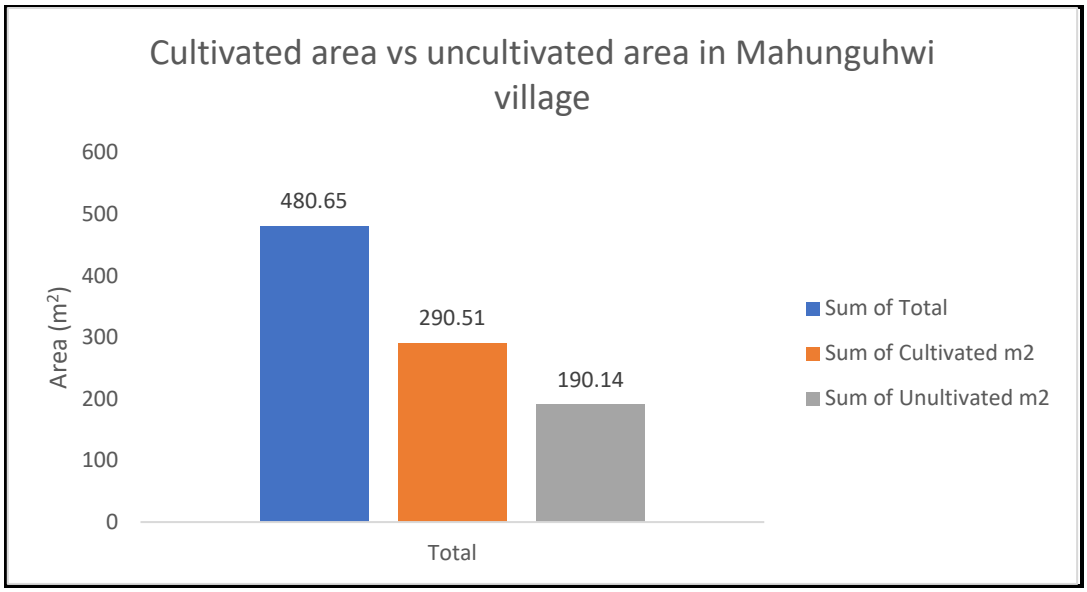

Figure 6. *Cultivated area vs uncultivated area in Mahunguhwi village*

The above information highlights the importance of maize as a staple crop, the challenges associated with its cultivation, and the factors influencing land use decisions in the community. It also underscores the impact of climatic conditions and resource constraints on agricultural practices.

Climate change impacts affecting crop farming

The participants reported that the area is experiencing changing rainfall patterns, with a reported increase in the gap between rainy days. This irregular rainfall pattern makes it challenging for participants to plan their planting and harvesting schedules.

Climate changes affected this planting schedule due to erratic rainfall distribution. Flooding also affected farming by washing away plants or reducing yield. Weeds spread easily during flooding and nutrients are washed away. The soil in the area is described as reddish-loamy and it takes two to three days for it to become tillable after rain. Higher temperatures reduce the number of ploughing days, and participants must wait for the next rain. The area has a steep gradient, ranging from 502 meters above sea level (msl) in

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river areas to 802 msl in mountain bottom areas. This steep terrain is associated with erosion, which can wash away soil nutrients, posing a challenge to agriculture.

Armyworms are present in the farming regions and can significantly reduce maize yields. The particpants confrimed the present of the armyworms during the period of study. There are no current strategies to combat armyworms in Mahunguhw village except the naural rainfall. Traditionally, rain helped control these pests, but delayed or irregular rainfall has led to increased damage and reduced harvests. About 40% of the area that used to be cultivated (19 hectares) was left unploughed during the current study. This may indicate a declining interest or capacity for agricultural activities in the community. The data presented at the National LED conference in 2017 shows a steady decline in the number of smallholders since 2011, which is concerning for the agricultural sector.

The comparison between the number of agricultural households as per the 2011 population census and the 2016 Community Survey, shows a decline of 19% in the number of subsistence producers.

The government has ambitious goals for job creation and agricultural expansion by 2030 through initiatives like the National Development Plan (NDP) and the New Growth Path (NGP). However, these goals may face challenges due to the downward trend in agricultural production land and the shift of households away from agriculture toward natural resource harvesting.

Livestock farming

The study findings suggested that livestock farming is an important part of the community's livelihood, providing various benefits, including investment, draughting (ploughing), meat, and compost. Additionally, targeting livestock sales for functions like funerals and other ceremonies is a profitable market. Cattle, goats, and pigs are livestock that dominate subsistence farming in Mahunguhwi village.

Figure 7 shows that most of the participants have no preferred bulls that are used as sires. In some cases, where the livestock is few, the participants relied on other farmer's bulls since they graze on communal land. Even those who purchase quality bulls do not really benefit from the actual breed due to less control during breeding. The bull to cow ratio of 1:25 is recommeded in beef cattle farming, although they are other factors such as bull fertility and nutrition that needs to be considered (Timlin et al., 2021; Filipini et al., 2020).

There was no livestock farming plan in place as the proportion of male to female were not controlled. This can lead to in-breeding, affecting the overall genetic quality of cattles. Bulls that have already passed their prime selling time are kept at cost (herding and medication). Cattle have an average street value of R8 000 each and are only sold on the informal market.

Goats were farmed for investment purposes because of their relatively lower cost of maintainance and ease management. This could be seen as a financial buffer for households. The average street value of goats at R1500 indicates that there is a market for goat sales. Despite lower maintainance cost, goats are highly vulnerable to climate change impacts such as flooding and temperatures. Social factors such as stock theft also plays a role in discaraging farmers to farm goats. In addition, there are a lot of predators that prey in goats. In Mahunguhwi village, baboons were reoprted to snittch goats from the households yards. From *Figure 8,* it is evident that there was fewer households which were interest in goat farming (17% of the households).

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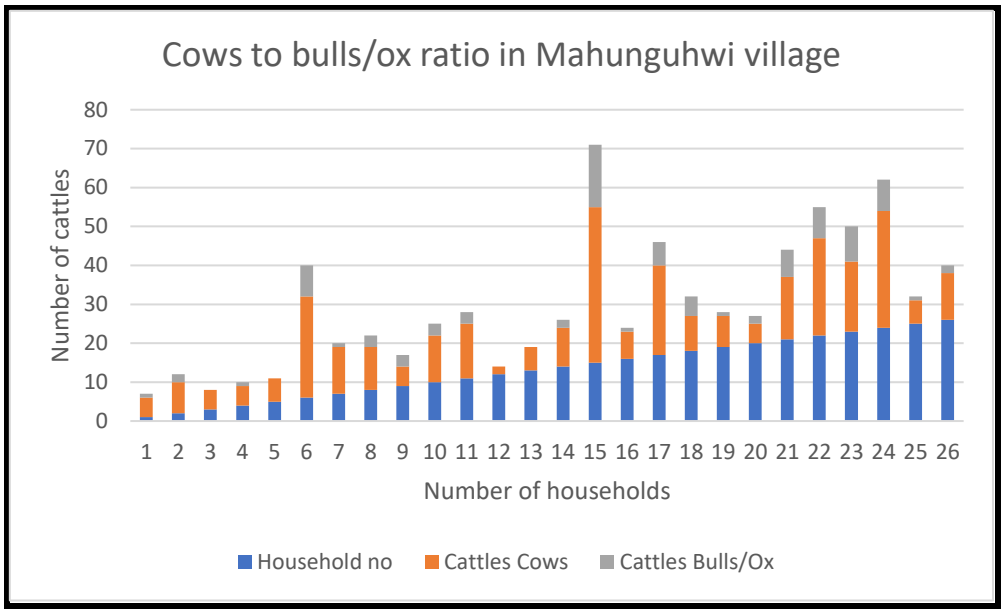

Figure 7. *Cows to bulls/ox ratio in Mahunguhwi village*

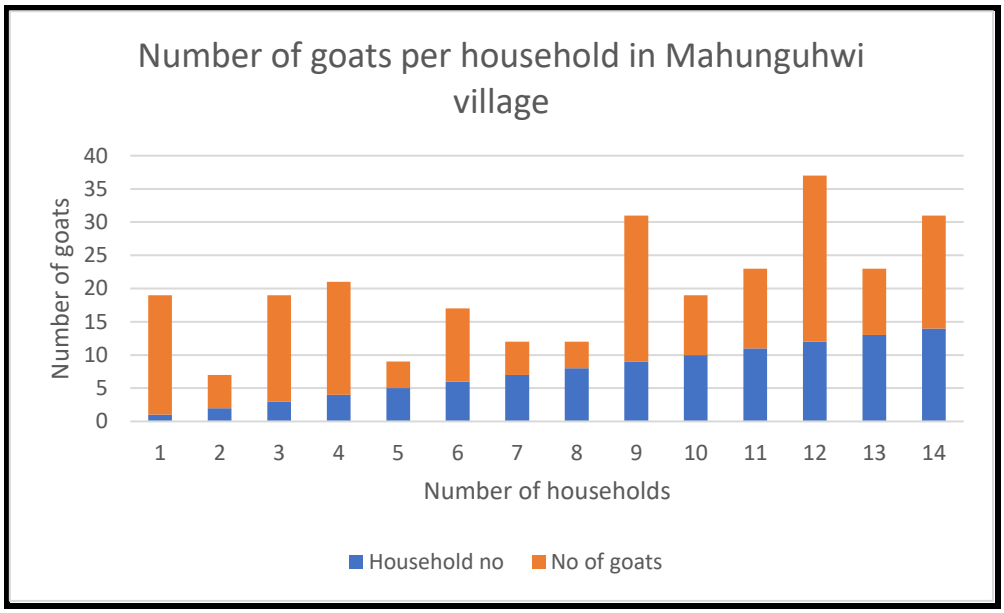

Figure 8. *Number of goats per household in Mahunguhwi village*

Pig farming appeared to attract more women than men. There was 60% of women as opposed to 40% men participating in it. This can be attributed to the fact that the pig requires regular feeding daily. *Figure 9,* shows about 15% of the households partaking in pig farming.

All farming participants were more interested in investment than anything else. Employed people were not taking part in pig farming, this can be attributed to the workload of daily feeding. Accessibility of pigs by the unemployed participants may be attributed to their low prices compared to cattle and goats. There is also low risk of loss in pig farming compared to goats and cattle.

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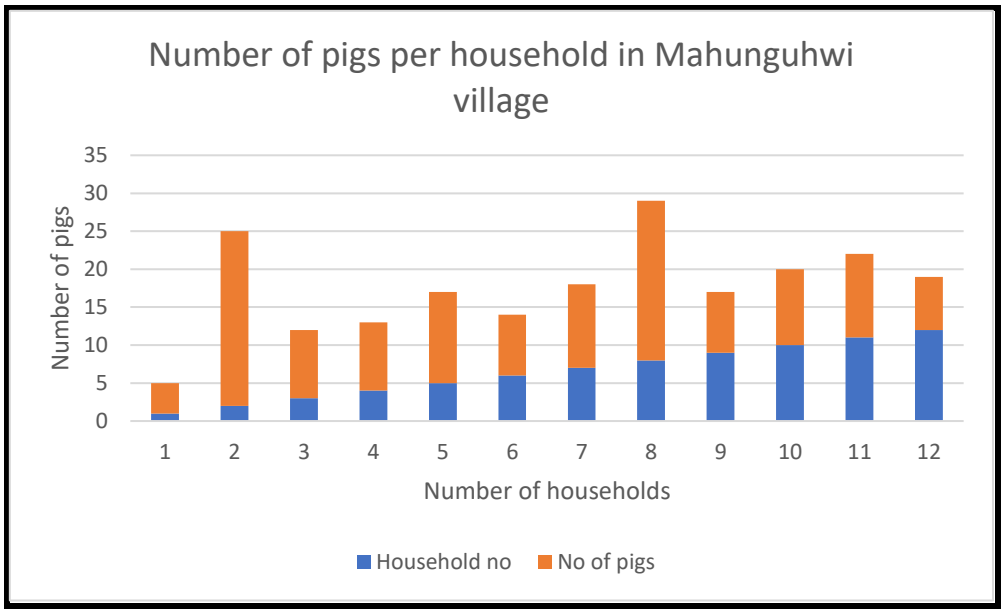

Figure 9. *Number of pigs per household in Mahunguhwi village*

Climate change impacts affecting livestock

Rainfall and temperatures affected the rate at which the rivers retain water, especially the semi-perennial and no-perennial. Goats were easily affected by rainfall, most of them developed foot wounds, and kids can also die because of higher rainfall. Coldness also tends to affect goat more easily compared to cattle. Flooding also caused mortality to livestock.

The dependence of livestock on river water, which is influenced by rainfall and temperatures, underscores the vulnerability of livestock to changing environmental conditions. When rivers run dry, livestock must travel long distances for water, resulting in reduced grazing radius and overgrazing near water sources. Overgrazing has detrimental effects on the quality of available forage, leading to land degradation and reduced food resources for livestock. *Figure 10,* shows animal diseases that are new in the area.

The outbreak of foot and mouth disease (FMD), even though it is associated with wild animals (buffalo), had a severe impact on cattle. The 25% mortality rate was substantial, highlighting the importance of vaccination and biosecurity measures.

Wildlife contacts was a primary contributor to FMD outbreaks in cattle which were located closer to game reserve fences. Acidocis occurrs when rumen pH out of balance causes the animal to produce acid more rapidly than it can absorb or use (Passos et al., 2023). The change in pH is largely influenced by dietary feeds.

Accordning to van den Heever et al. (2022), heartwater is a dangerous tick-borne disease in livestock farming which causes a lot of financial loss in beef cattle farming. In Mahunguhwi village the livestock farmers were able to control it through vaccination and tick sprays.

Climate disasters in Mahunguhwi village

Flooding is the major climate disaster that affects the area. *Figure 11,* shows major road areas that affected by flooding (barriers). Flooding damaged roads and bridges, further hampering access to schools.

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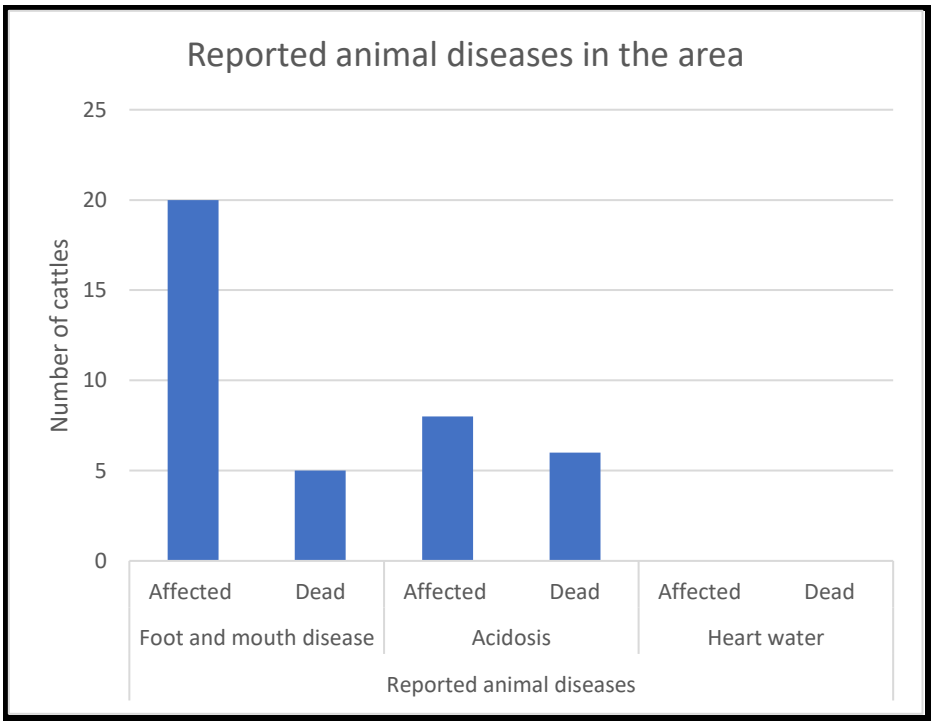

Figure 10. *Animal diseases and their mortality rate in Mahunguhwi village*

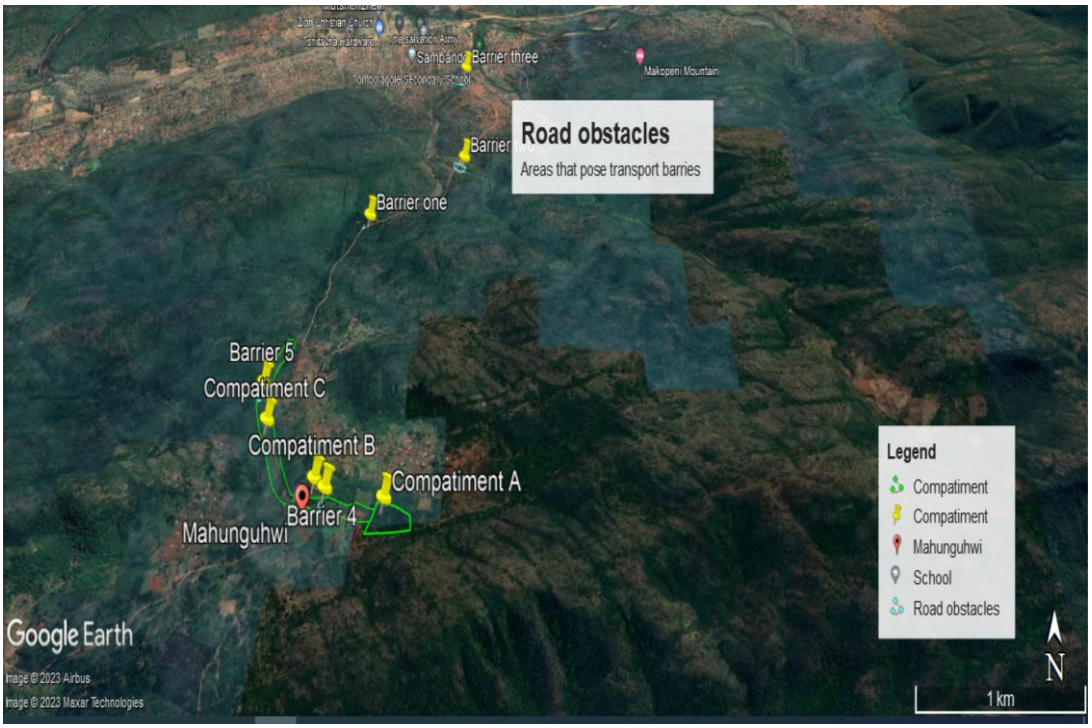

Figure 11. *Major road obstacles that were affected by flooding. Extracted from Google Earth Pro*

Participants in different river compartiments adapt to changing water availability. When water is scarce (drier period) in compartiment A or B, participants moved to

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establish their farms in compartiment C. Environmental concerns were more significant in poor rainfall seasons when space for farming was limited along the riverbed. The number of households involved in farming varies in each river compartiment.

Compartiment C has the highest number of households, indicating greater agricultural activity in this perennial section. There was a risk of agricultural produce being washed away in Compartiment C during flooding seasons. The management of these compartiments helps with ensuring food security to the community. The growing of the crops around streams is consistent with the findings by Chisale et al. (2024). Chisale et al. (2024) further indicated that this strategy is not suitable for long-term since the streams can also dry up.

Veldfires destroyed grazing land and cause mortality to those livestock that cannot escape. Higher temperatures and strong winds increased the strength and severity of veldfires. There was no clear management of veldfires in communal land.

Climate change coping strategies

The diversification of livelihood was also visible in the area. The community was extracting natural resources such as rocks, wood, and firewood for survival. It is important to note that only rock harvesting can be deemed environmentally friendly.

The extraction of firewood and wood required the community to be equipped with general knowledge about protected spies and well as deforestation. There is a need for smart agriculture practices to allow people to cope with variable weather patterns as well as the extreme events. The high gradient slopes above 5 degrees posed great risks for erosion and nutrients depletion in the agricultural soil (*Fig. 12*).

Figure 12. *The profile of the area. Note the average slope is 8%*

The use of contouring ploughing will provide for less erosion and more drainage for soil. The government Agri-parks projects need to be implemented throughout the desired areas.

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For livestock farming, the use of medication and vaccines is recommended to main the health status of the animals. The community need to improve their farming practices to allow for breeding and managing calving seasons. Several studies such as Mnkeni et al. (2019), Ariom et al. (2022) and Zizinga et al. (2022) suggested the combination of kraal manure and or crop residues with fertilizers, is a practice that smallholder participants can implement.

Conclusion and recommendations

The aim of this study was to assess the climate change impact on livelihoods with emphasises on subsidence farming, natural resource extraction and educational livelihoods. The impact of climate change on the livelihood of the people were assessed based on the economic activities which were subsidence farming and natural resource extraction.

Subsistence farming is largely affected by rainfall pattens, lack of pesticides and diseases that affect livestock. The crop farming area is reducing which also lead to reduction in the size of land that people occupy in the village. From the 48-ha available for crop farming, only 59% of the area was cultivated during the time of research. Most households own land with an average size of about 0.3 hectares (ha). People who occupy big areas are unable to plant their entire farm. Climate change is reducing the farming activities in Mahunguhwi village and pushing the participates to seek other alternative source of livelihood.

There was no coping strategies during drier seasons, this was evident by households moving from compartment A to compartment C. Crop farming requires constant supply of water during the early stages of the crops. It is recommended to implement water conservation measures such as rainwater harvesting, efficient irrigation techniques, and the construction of small dams or check dams to ensure a consistent water supply for agriculture. Livestock farming needs to be improved to meet the requirements of the formal markets.

The findings of this study showed that natural extraction of rocks, firewood and wood was conducted for selling purpose. This was carried out as a source of income during dry seasons. Rock extraction was the most viable and sustainable alternative livelihood for long term coping strategy.

The study suggested the following recommendations for the sustainable livelihood in the area. Investigate the effectiveness of engaging the local community in climate change awareness and education programs to build resilience. Explore the impact of promoting climate-smart agricultural practices and sustainable resource management. Examine the outcomes of encouraging diversification of livelihoods to reduce dependence on a single income source, including the assessment of skill development, small-scale businesses, and non-agricultural employment opportunities.

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APPENDIX

Research images

Compartment B farm during low rainfall season

Farm in compartment C

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Livestock water point in compartment B

Livestock water point in compartment B

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Compartment B during dry season

Complement B during dry season

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Compartment B farm in winter

Compartment B farm in winter

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Uncultivated farm

Barrier four during rainy season

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Barrier four bridge washed away

Barrier four bridge washed away

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