Socio-demographic Determinants of Smallholder Farmers' Adaptive Capacity to Climate Variability in Bukombe District, Tanzania.

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Abstract

This paper examines the socio-demographic determinants of smallholder farmers' adaptive capacity to climate variability in Bukombe district. It employed a mixed approach, utilizing both quantitative and qualitative methods. A simple random sampling selected 175 farmers for the study. The data collection methods included household surveys, observations, focus group discussions (FGDs), in-depth interviews, and document reviews. We conducted both descriptive and inferential statistical analyses using SPSS and Excel software. Ordinal logistic regression was adopted to determine the influences of socio-demographic determinants on farmers' adaptive capacity. Qualitative data were subjected to content analysis. Rainfall and temperature data were analysed by using Microsoft Excel. The results indicated most of the smallholder farmers have low adaptive capacity to climate change. Furthermore, the findings reveal that socio-demographic factors of households—including age, gender, education, income, household size, and marital status—significantly influence smallholder farmers' ability to adapt to climate variability; whereas land size and tenure do not significantly influence this capacity. Therefore, we recommend improving farmers' adaptive capacity through sensitization and strengthening of household farming subsidies. We also recommend improving adaptive capacity by creating a more conducive environment, such as access to information, finance, seeds, and fertilizers. However, all initiatives should consider the demographic characteristics of farmers, as their adaptive capacity is dependent on the level and status of their household's demographic characteristics.

Key terms: *socio-demographic, determinants, climate variability, smallholder farmer, adaptive capacity.*

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Introduction

Global climate variability is currently challenging and threatening humanity's future (Shikuku et al., 2017; IPCC, 2018). Climate variability, as an environmental issue, disturbs all aspects of human life, as indicated by Varela et al. (2018). These human life aspects are the environment and social communities. The agricultural sector is particularly vulnerable to fluctuations in climatic conditions, which significantly impact agricultural production and the livelihoods of farming

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communities (Menike & Arachchi, 2016). It is also clear that smallholder farmers are one of the most vulnerable social groups to climate variability (Lindoso et al., 2012), especially in developing countries.

Climate variability is expected to alter pest and disease outbreaks, increase the frequency and severity of droughts and floods; and increase the likelihood of poor yields, crop failure, and livestock mortality (Morton, 2007; Harvey et al., 2014). Considering the close relationship between crop production and the income of smallholder farmers, the negative impact of climate variability on crop yield increases the vulnerability of farmers, especially those living in arid and semi-arid areas. Therefore, climate change not only has an impact on the agricultural production of farmers, but it also puts their household well-being and food security at risk (Alam et al., 2017).

Most rural communities in sub-Saharan Africa (SSA) rely on agriculture as their primary source of livelihood. For decades, rainfall variability, drought, and extreme weather events have affected agricultural performance in rural (SSA) (Mollua, 2012; Agrawala et al., 2016). The most vulnerable areas in the region include arid and semi-arid countries such as Sudan, Somalia, and Ethiopia. Climate-variation-induced food shortages and famines have frequently exposed these areas (Deressa et al., 2018). According to Hellmuth et al. (2007), climate variability and extremes have exacerbated poverty in many rural communities of SSA. The most critical consequences of climate variability for rural communities are food shortages and declines in rural income.

Morlai et al. (2011) contend that the low adaptive capacity of Africa's growing population exposes these countries to high negative impacts of climate variability. Nyong (2015) asserts that farmers in Sub-Saharan African countries—Tanzania being one of them—are vulnerable to climate change and variability because they lack the capacity to adapt. According to Yanda and Mubaya (2011), the impacts of climate change and variability severely damage the social and economic systems of most developing countries. The inherent climate and weather sensitivity of agricultural livelihoods, the over-reliance on rain for farming sustenance, and low adaptive capacity make smallholder farming vulnerable to climate change and variability.

According to IPCC (2018), adaptive capacity is the ability of farmers to adjust to climate change, lessen potential damages, and take advantage of opportunities or cope with consequences. A system's adaptive capacity is the culmination of its tangible and intangible assets, including financial, natural, and human resources; as well as the variety of livelihoods it possesses. Assessing the adaptive capacity of smallholder farming systems, therefore, goes beyond an appraisal of their physical asset base.

According to Jones et al. (2010), a system's climate change adaptation capabilities, actions, and methods: all determine local adaptive capacity. Researchers have demonstrated that many of the impacts of climate variability, as well as the determinants of people's ability to adapt, are the outcomes of social processes (Jones & Boyd, 2017). Other studies—for example, Cooper et al. (2018)—measured adaptive capacities of farmers by considering the types of livelihood assets; namely social, human, physical, and financial capital. They found that the more varied the asset base, the greater the people's adaptive capacity and the level of security and sustainability of their future livelihoods. Along that line, Adger et al. (2012) and Ziervogel et al. (2006) assert that local-level adaptive capacity is context-specific; and that it is also highly heterogeneous within a society or a locality.

Numerous studies have explored Tanzania's adaptive capacity to climate change and variability. Goldman and Riosmena (2013) conducted an assessment of adaptive capacity in Tanzanian Maasai-land, with a focus on livestock keeping, and discovered disparities in adaptive capacity within communities. Ricci (2011) assessed peri-urban livelihood and adaptive capacity in Dar es Salaam, and found that the majority of households surveyed implemented water management practices—including rainwater harvesting—and depended on a diverse range of water sources. Other studies, including those by Kangalawe and Lyimo (2010) and Mary and Majule (2009), have evaluated the impacts, vulnerability, and adaptation strategies of climate change. However, none of these have focused on the determinants of smallholder farmers' adaptive capacity.

Therefore, this study aimed to determine the levels of smallholder farmers' adaptive capacity, and the impact of socio-demographic factors on this capacity in the context of climate variability. Understanding this knowledge may greatly help in developing adaptation and mitigation measures to climate variability based on their social-demographic characteristics. This paper is based on a research conducted between January and April 2020 to explore the impact of socio-demographic factors on smallholder farmers' adaptive capacity to climate variability in the Bukombe district.

Materials and Methods

This study was conducted in two villages of the Bukombe District in the Geita region (Figure 1). Bukombe was one of the nine rural districts established by the government of Tanzania in July 1995, with a total of 13 wards: Uyovu, Ushirombo, Lulembela, Ilolangulu, Mbogwe, Ushirika, Nyasato, Lugunga, Masumbwe, Bukandwe, Iponya, Iyogelo, and Bukombe (NBS, 2023). The district was separated from the Kahama district after it had experienced a number of administrative and development challenges, such as the vast area of Kahama district in the Shinyanga region, which had an area of 19.943 km², inaccessible topography, population increase, and the thinly dispersed distribution patterns of human settlements with its area of jurisdiction.

Bukombe district occupies an area of about 8,055km², of which 5,803km² (about 76.32%), is suitable for farming. Geographically, the district lies at the western apex of the Geita region. It is located between latitude 3° 31' 0" S and longitude 32° 2' 59" E (NBS, 2020). The district had 224,542 people; with 110,857 being female and

113,685 being male (Bukombe District Council, 2020). The population growth rate is 5.9% per annum, and the factors for population growth are births and migration. The district's population exhibits an uneven distribution, with a household size of 5.9; and a population density of 27 people per km^2 (NBS, 2020).

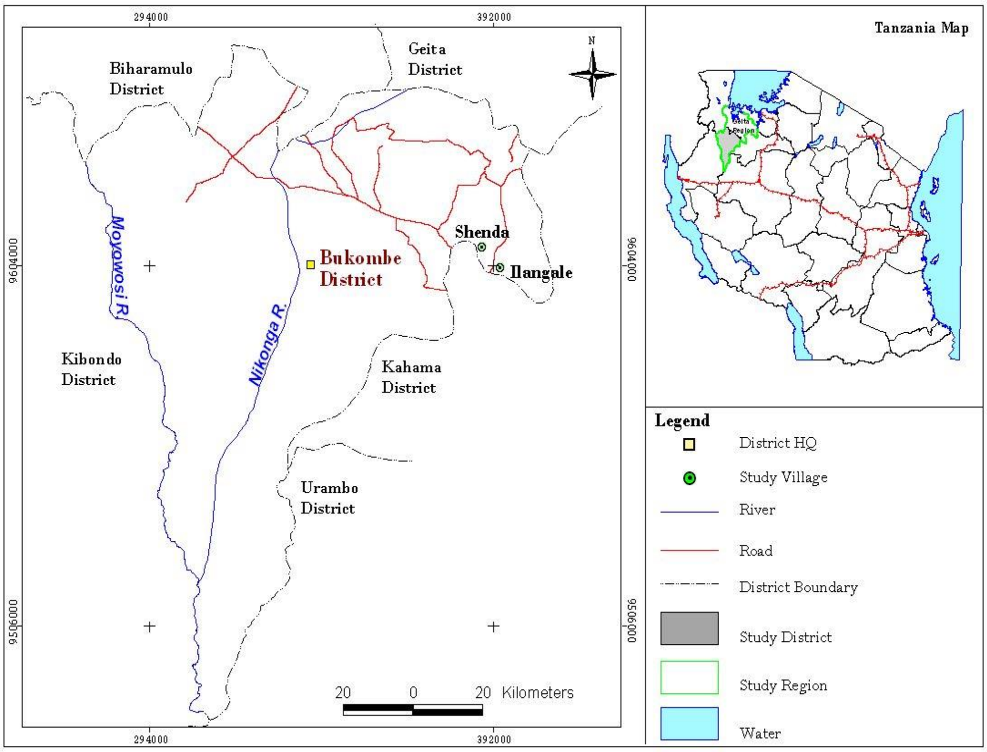

Figure 1: Map of Bukombe District Showing the Study Villages

The district experiences a tropical type of climate, with an average of 22^{0}C annual range of temperature. The annual range of rainfall varies between 900mm and 1200mm. The major economic activities in the district are crop farming and livestock keeping. The food crops grown include maize, millet, paddy, cassava, sweet potatoes, and vegetables; while the cash crops range from cotton, sunflower, and tobacco (Sawe, 2018).

Bukombe District was selected as the study area because it is located in the Geita region, where more than 70% of its farmers rely on crop production as their primary economic activity (Bukombe District Council, 2023). This percentage of farmers is very high compared to the other four districts in the region. This implies that a large number of households depend on agriculture, which is the most vulnerable sector to climate variability. Moreover, an estimated 55% of its population lives below the food poverty line, with an average per capita earning of US$170. This is very low compared to other crop-producing regions such as Shinyanga and Morogoro, which have an average per capita earning of more than US$350 (URT, 2022). The study area was also selected based on the available information from previous studies on the effects of climatic stresses on agriculture (Swai et al., 2020).

Study Design

This study utilized a mixed research design, incorporating both quantitative and qualitative research methods. This enabled the researchers to collect both quantitative and qualitative data to meet the objective of the study. It also applied a mixed-method research approach for triangulation and complementary purposes (Creswell, 2013). The research found this approach useful in comprehending complex climate variability issues that neither quantitative nor qualitative methods could alone fully grasp.

Sampling Procedures and Sample Size

Both purposive and simple random sampling techniques were employed. Purposive sampling was used in the selection of the study area and key informants. This method involves the use of personal judgment and a deliberate attempt to obtain a representative sample by including presumed typical areas or groups in the sample. A simple random sampling technique was employed to identify heads of households for the administration of questionnaires.

To get a sample size for quantitative data to fill the questionnaires, village officers were consulted for a list of households. This list was used as the village sampling frame, while a household was used as the sample unit. The heads of households were chosen for the study because they are the decision-makers at the household level. From Shenda village, which had 850 households, 85 heads of households were chosen; while from Ilangale village, which had 900 households, 90 heads of households were chosen: making an overall total sample size of 175 from both villages (Table 1). This accords with Kothari (2004), who argued that a sample size of 10% is adequate and recommendable to represent a study population.

Table 1: The Distribution of Sample Size from Each Village

Village Name	Total Households	Number of Respondents from Each Village	Respondents Selected Based on Sex	
			Male	***Female***
Shenda	850	85	54	31
Ilangale	900	90	62	28
Total	1750	175	116	59

Source: Field data (2020).

Data Collection Methods

In this study, both primary and secondary data were used. The primary data were collected through household questionnaires, focus group discussions (FGDs), observations, and key informant interviews. Both open- and closed-ended household questionnaires were administered to 175 household heads or household representatives involved in small-scale crop production. This data collection method was used to gather information on smallholder farmers' perception of climate variability, household demographic characteristics, the level of adaptive capacity, and how socio-demographic factors influence adaptive capacity.

Eight participants from each study village participated in FGDs, sharing views and opinions on a checklist of open-ended questions related to perceptions of climate variability, levels of farmers' adaptive capacity, and the impact of socio-demographic factors on farmers' adaptive capacity. Moreover, key informant interviews (KIIs) were conducted using open-ended questions to gather first-hand information on the adaptive capacity levels of smallholder farmers, as well as to examine the impact of demographic characteristics on this capacity. Key informants, such as agricultural extension officers, village leaders and elders: all were purposively selected due to their knowledge, skills, and experience with regard to the study objective. A total of 9 participants were interviewed, including 1 ward extension officer, 2 village elders from each village, and 2 village leaders from each village.

Furthermore, we conducted a non-participant field observation to observe the impacts of climate variability on smallholder farmers' livelihoods and assets. We also used this observation to determine smallholder farmers' adaptation strategies and the impact of households' socio-demographic factors on their adaptive capacity. Lastly, the field observation enabled the determination of the levels of farmers' adaptive capacity by considering their socio-demographic characteristics. In general, the field observation helped ensure the validity and reliability of data collected through other methods, such as household surveys, interviews, document reviews, and FGDs. We also carried out a triangulation of data as this not only ensures validity, but also ensures that the data collected are error-free and are a true reflection of the existing situation in the study area (Creswell, 2013).

A review of documents was done to obtain secondary data. This was done through reviewing journal articles, books, research reports, and other sources relevant to the study. The Tanzania Meteorological Agency (TMA) headquarters in Dar es Salaam provided the data for the average annual rainfall and temperature recorded at the Bukombe meteorological station over the past 20 years (2000–2019). These data were used to establish the trends of rainfall and temperature of the Geita region where the study villages are located.

Data Analysis and Presentation

Data analysis involved both quantitative and qualitative analysis techniques. Data obtained through household surveys were coded and analysed by using the SPSS and Microsoft Excel software to generate descriptive and inferential statistics. Moreover, the ordinal logistic regression was adopted to assess the impact of households' socio-demographic factors on smallholder farmers' adaptive capacity. Based on individual scores of adaptive capacities, we categorized the dependent variable (*Y*) into three levels: low, moderate, and high. The independent variables included the eight socio-demographic variables (age, gender, education, farm size, household size, marital status, and land tenure). The odds ratio in this model was calculated at a 95% confidence interval as an estimate of determinants of adaptive capacity levels, and a p-value of 0.05 was considered statistically significant. The ordinal logistic regression model was appropriate for this study since the dependent variable had ordered categories: namely low, moderate, and high. It was also the appropriate model because it estimates the effects of a set of explanatory variables on the dependent variable. Qualitative data collected through interviews and FGDs were coded and arranged according to the research themes, and analysed through content analysis. Moreover, quantitative data were presented through tables and figures; while qualitative data were presented through descriptive statements and direct quotations.

Results and Discussion

Demographic Characteristics of the Participants

Understanding demographic characteristics of smallholder farmers was necessary to describe smallholder farmers' adaptive capacity to climate variability. This is due to the fact that the impact of climate variability is not uniformly felt by all smallholder farmers, as their adaptive capacity varies based on their socio-demographic characteristics. The results in Table 2 indicated that the majority of the respondents were males (60.3%), while females were 39.7%. This implies that males are decision-makers and responsible for all family matters. The study took into account the perspectives of both genders to understand the respondents' perceptions of climate variability and adaptive capacity. The study was also interested in getting to know the education levels of the smallholding farmers in Bukombe District. The results shown in Table 2 reveal that about 77% of the respondents attended primary education, 23.3% had no formal education, 6.9% had ordinary level education, and none had advanced level education. Generally, the findings indicate that most respondents had primary education. The fact that most respondents were from farming communities, where education was not a priority, may have influenced this. The study's findings align with those of Derresa et al. (2008), who identified low levels of education in Ethiopia as a sign of a reduced ability to adapt to the impacts of climate variability on income levels.

Furthermore, the study was interested in getting to know the age groups of smallholding farmers. The findings show that most of the smallholder farmers (65.5%) were in the age range between 26 and 45. In most cases we expect these groups to have engaged in crop farming activities. Therefore, it suggests that the youth constituted a significant portion of the labour force in the study area. This age group is important because it determines a community's adaptive capacity level, technological diffusion, and participation in the farming decision process (Frank, 2012). Additionally, the results show that about 72% of the respondents were married, while 18% were single. However, about 7.3% of the respondents comprised people who were once married, but for various reasons were now separated. Families in the study area—including fathers, mothers, children, and relatives—engage in farming. Lowa (2005) rightly argues that marital status has implications not only for social organization and decision-making, but also for the assessment of adaptive capacity and strategies employed in response to the impacts of climate variability.

Table 2: Demographic Characteristics of Respondents

Respondents Characteristics	Percentages (%) Respondents in the Surveyed Villages		Overall Total
	Ilangale	*Shenda*	
Sex			
Male	69.2%	51.4%	60.3%
Female	30.8%	48.6%	39.7%
Education level			
No formal education	21.0%	25.6%	23.3%
Primary	79.0%	75.%	77%
Ordinary secondary	5.3%	8.2%	6.9%
Advanced secondary	0%	16.3%	9.2%
Vocation training	0%	12.2%	6.9%
Age category			
26–35	23.7%	36.7%	31%
36–45	34.2%	34.7%	34.5%
46–55	18.4%	18.4%	18.4%
55+	23.7%	10.2%	16.1%
Marital status			
Single	16.4%	19.6%	18.0%
Married	75.6%	68.4%	72.0%
Separated	6.0%	8.3%	7.3%
Household size			
1–4	50.0%	51.6%	50.8%
5–9	42.2%	46.0%	44.2%
10+	6.0%	4.0%	5.0.0%
Occupations			
Crop farming	100%	69.4%	82.8%
Business	5.3%	34.7%	21.8%
Livestock keeping	0.00%	28.6%	16.1%
Self-employment	0.00%	18.4%	10.3%
Formal employment	0.00%	8.2%	4.6%

Source: Field data (2020).

It is also perceived that farmers' adaptive capacity is associated with their household size. Thus, the paper similarly aimed to establish the current status of household sizes in the study area. The results revealed a range of household sizes, spanning from two (2) to fifteen (15) individuals per household. Also, it is shown that 50.8% of the respondents had family sizes between 1–4 people, about 44.2% of respondents had family sizes between 5–9 people, while 5% of respondents had sizes of 10 and above members. The study's findings are in line with those of Sawe et al. (2018) in Bukombe district, Tanzania.

Perceived and Empirical Evidences of Climate Variability
The study evaluated both perceived evidence of climate change from smallholder farmers and empirical evidence from rainfall and temperature data as detailed below.

Perceived Evidence of Climate Change
Before assessing the impact of demographic characteristics on smallholder farmers, the paper examined smallholder farmers' perceptions of climate variability to understand their level of awareness of this concept. The Tanzania Meteorological Agency provided temperature and rainfall data for the analysis of empirical evidence. The results from the analysis of rainfall and temperature data were compared with those from farmers' perceptions of climate change to determine if they were similar. Lyimo and Kangalawe (2013) argue that farmers' awareness of climate variability enhances their understanding of what and how to adapt to climate variability. This argument highlights the importance of understanding smallholder farmers' perceptions of climate variability through various indicators.

The results in Table 3 indicate that rainfall decline was a major indicator of climate variability, as perceived by 89.8% of the respondents. The respondents perceived the decrease in rainfall to manifest in occurrences such as rainfall duration, intensity, and intervals. During the interviews, smallholder farmers reported on a decrease in rainfall amount and an increase in temperature as compared to the past 20 years. A key informant reported the link between temperature increase and rainfall decline, and the frequency of crop failure as follows:

> *Dear researcher, when we compare the current temperature and rainfall amount to those of the past 15 years, we absolutely agree that the temperature has increased while the rainfall has decreased. Additionally, we have observed an increase in drought incidences and frequent crop failures in our community, which have had significant impacts on our livelihoods* (Interview with a Male Elder, 67 years old, from Ilangale Village, 2020).

Table 3: Perceived Climate Change Evidences

Perceived Climate Change	Responses	
	Frequency (N)	*Percent*
Decrease in rainfall	80	89.8
Decrease in crop yield	76	85.3
Increase temperature	65	73.0
Drying of water sources	70	78.6
New plant and crop disease	27	28.0
Decrease temperature	07	7.8
Unpredictable rainfall	62	69.6
Change of season	45	50.5
Increase drought incidence	60	67.4

Note: Analysis based on multiple responses hence column tallies exceed 100%.
Source: Field data (2020).

These results align with the findings of other Tanzanian scholars, such as Myeya (2022), Swai et al. (2020), Westengen and Brysting (2014), and Lyimo and Kangalawe (2013): all of whom also reported on the perceived decrease in rainfall in various agroecological zones of Tanzania. Moreover, 85.3% of the respondents identified reduced crop yields as the second indicator of climate variability. Respondents linked reduced rainfall to having a greater effect on cereal crop yields. Smallholder farmers have reported that, compared to the past 20 years, the current amount of rainfall is insufficient for crops to thrive. Reports indicate that crop failures are occurring more frequently now than in previous years. Kangalawe and Lyimo (2013), and Sawe (2018), who linked erratic rainfall and recurrent droughts with reduced cereal crop yields in Geita and Singida regions, respectively, support these observations.

Furthermore, about 78.6% of the respondents identified the drying up of water sources as an indicator of climate variability. They reported the drying up of seasonal rivers, wells, and dams used as water sources for domestic and irrigation purposes. Respondents further argued that, in the past 20 years, these sources retained water for 4–5 months, and some were useful until the next rainfall season. However, it was reported that these water sources now tend to dry up within 1–2 months after the cessation of rainfall. This finding aligns with those of Swai et al. (2020) and Miyeya (2022) in semi-arid areas of Tanzania. Respondents further reported that unpredictable rainfall was another indicator of climate variability, as pointed out by 69.6% of them. They reported that, presently, the onset and cessation of rainfall are unpredictable. Sawe et al. (2018) had similar results in Manyoni district, Tanzania.

Analysis of the Trend of Temperature

The results of temperature analysis over the past 20 years (2000–2019) presented in Figures 2 and 3 indicate increased values for both the average annual minimum and maximum temperatures by a correlation coefficient of $R^2 = 0.6534$ ($y = 0.0661x - 109.54$) for the annual average minimum temperature, and $R^2 = 0.6684$ ($y = 0.0862x + 29.4330$) for the annual average maximum temperature.

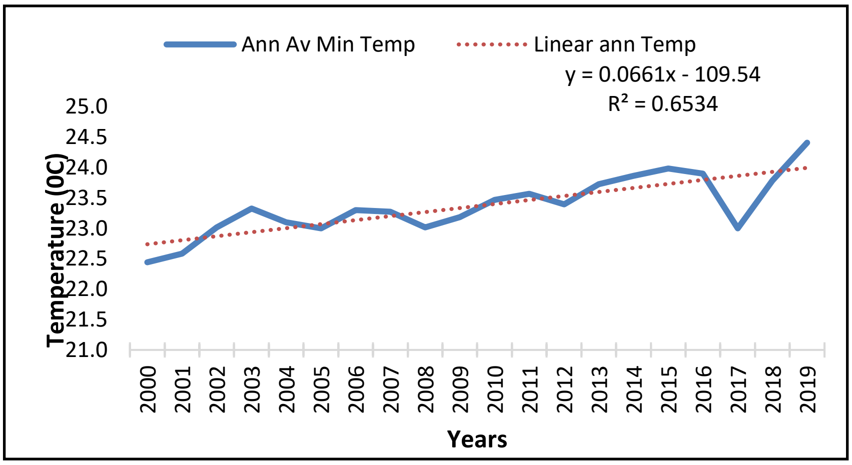

Figure 2: Annual Average Minimum Temperature Trend in Bukombe District (2000–2019)

Source: TMA (2020)

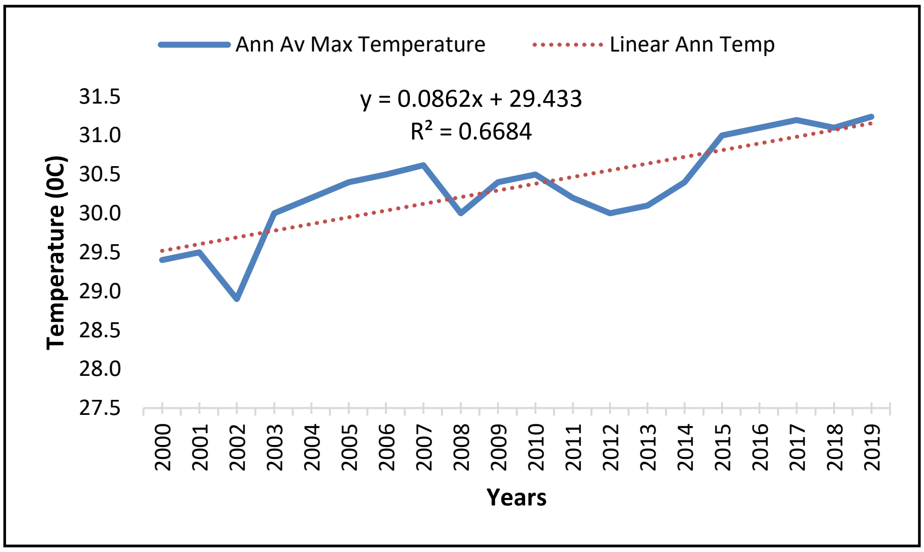

Figure 3: Annual Average Maximum Temperature Trend in Bukombe District (2000–2019)
Source: TMA (2020)

Moreover, the results indicate that the average minimum temperature increased by 6.5%, while the average maximum temperature increased by 6.6% for the last twenty years. Based on the results, we note that the average maximum temperature in Bukombe district increased more than the average minimum temperature over the last 20 years (2000–2019). These findings correspond with the findings by Sarr (2012) in Nigeria, and Latha et al. (2016) in India; who observed an increase in temperature in their study areas. Generally, these findings imply that the perceptions of smallholder farmers on the trend of temperature are in line with empirical evidence from the meteorological data collected for Bukombe district.

Analysis of the Trend of Rainfall

The analysis of rainfall patterns and trends was based on Bukombe meteorological data collected from the Tanzania meteorological station (TMA) covering the years 2000 to 2019 (Figure 4). The aim was to assess rainfall variability in Bukombe district. The rainfall analysis results showed insignificant decreasing trends, with a significance level of 5%. The results also indicate that there was a year-to-year rainfall variability. This is due to the fact that rainfall tends to increase in some years, while in others it tends to decrease. For example, rainfall decreased in the years 2003, 2007, 2008, 2009, 2016, 2017, and 2018. The fluctuations in rainfall levels align with the respondents' perceptions of rainfall trends. This finding is in line with Mkonda and He (2018) in Tanzania; and Abaje and Oladipo (2019) in Nigeria: all of whom similarly noted declining and increasing rainfall trends in their study areas; thus aligning with these research findings on rainfall decrease and slight increase in the study area.

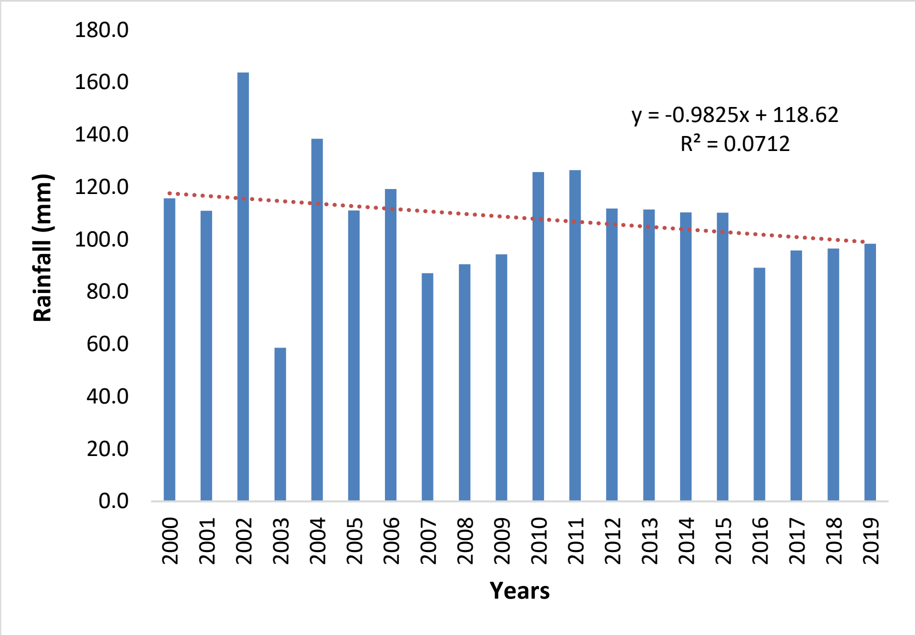

Figure 4: Average Annual Rainfall (2000 to 2019)
Source: Tanzania Metrological Agency (2020).

Levels of Adaptive Capacity among Smallholder Farmers
The study sought to determine the levels of adaptive capacity among smallholder farmers in the study area. Since there is no general rule for classifying adaptive capacity levels (Defiesta & Rapera, 2014), cut-off points were based on previous studies such as Eakin et al. (2018), and Gbetibouo (2016). It was also based on the median that was used as a moderate level. The cut-off point for each level was determined by setting three intervals based on the median, which represented the dispersion of the data. These were low, moderate, and high adaptive capacity levels.

The results in Table 4 indicate that 60.5% of the farmers interviewed belonged to the low adaptive capacity category, while 34.3% belonged to the moderate adaptive capacity category; and only 5.2% of the respondents interviewed belonged to the high adaptive capacity level. Similar results were obtained during interviews with key informants and FGDs. For instance, one key informant had the following opinion:

> *We have been experiencing the impact of climate variability in our area for a long period of time. Our crops are drying because of increased temperature since our adaptive capacity is low. We have sufficient money to perform other economic activities; therefore, we don't know what will happen in the future if this situation continues. The government ought to assist us in enhancing our ability to adapt by offering subsidies for farming implements; and providing guidance on what and when to cultivate in light of the current climate variability* (In-depth Interview with a Village Executive Officer in Ilangale village, 2020)

Table 4: Levels of Adaptive Capacity for Smallholder Farmers

Levels	Scores	Percent
Low adaptive capacity	4–6	60.5%
Moderate Adaptive Capacity	8	34.3%
High adaptive capacity	9–12	5.2%
Total		**100**

Source: Field data (2020).

These results are in line with the results of Bello et al. (2018), who reported low adaptive capacity among smallholder farmers in semi-arid areas. The findings suggest that the majority of smallholder farmers in Manyoni district had a limited ability to implement interventions related to climate change effects due to their low adaptive capacity. This made them more vulnerable to climate variability, preventing them from adapting successfully. In line with this result, Eriksen et al. (2015), and Paavola (2014), remark that local farmers with low adaptive capacity are more vulnerable to adverse effects of climate variability, which lead to the loss of their natural resources. This is because smallholder farmers with low adaptive capacity, typically associated with low resource endowment, rely solely on the natural resources available to them. This, in turn, leads to the depletion of these resources, making these smallholder farmers more vulnerable.

Association between Socio-demographic Factors and Farmers' Adaptive Capacity

The main objective of this paper was to examine the impacts of smallholder farmers' social-demographic characteristics on adaptive capacity to climate change. Household social-characteristics—such as age, gender, level of education, marital status, household size, land size, land ownership, and household income—were used to determine the impacts of demographic factors on farmers' adaptive capacity. To determine the impacts of socio-demographic factors on smallholder farmers' levels of adaptive capacity, ordinal logistic regression was applied, whereby β-coefficients (positive or negative) were computed to obtain the directions of the predictor variables' impacts as indicated in Table 5.

Table 5: Chi-square Test Between Socio-economic Factors and Farmers' Adaptive Capacity

Variable	X^2	Df	P Status
Age	51.457a	1	0.014 -
Gender	62.124a	1	0.042 -
Education level	63.355a	1	0.012 +
Household size	56.355a	1	0.010 +
Marital status	20.304a	1	0.032 +
Household income	87.001a	1	0.015 +
Land ownership	0.012a	1	0.081 +
Land size	48.001	1	0.169

Note: Valid cases = 175, Goodness of fit: Pearson's Chi-square = 458.137 p= (0.025), Nagelkerke R^2 = 0.170, x^2 = Chi-square, $P < 0.05$ = significant, $P > 0.05$ not significant.

The results in Table 1 show that six (6) socio-demographic variables out of the eight (8) were found to be statistically significant, signifying that the variables strongly contributed to the chances of the households attaining high adaptive capacities. The overall model fit containing all the demographic characteristics was statistically significant ($p = 0.025$), indicating that the model was able to predict adaptive capacity as low, moderate, and high. The Nagelkerke R^2 was 0.170, implying that the independent variables entered in the model explained 17% of the variance in the respondents' adaptive capacity.

It was hypothesized that household size has an impact on smallholder farmers' adaptive capacity to climate variability. The results in Table 5 show that household size ($p = 0.010$) was the strongest demographic variable influencing farmers' adaptive capacity. This is partly caused by rural household labour setups that rely on household members for production. These results are in line with those of other studies such as that by Kayunze (2020), which show that household size is an important asset in terms of working together in household economic activities. Under this situation, it implies that farming labour becomes sufficient depending on the number of household members. This finding is corroborated with that of Apata et al. (2015), whose study in southwestern Ghana found that household size had a significant influence on smallholder farmers' adaptive capacity to the impacts of climate variability, as large-sized families had more labour force and multiple livelihoods sources than small-sized families.

Furthermore, the results in Table 5 show that the age of a household head significantly and negatively impacts the adaptive capacity of smallholder farmers ($p = 0.014$), suggesting that this variable negatively affects the likelihood of the surveyed households having adaptive capacities. This is because, as household heads age, their access to resources decreases, limiting their ability to implement other livelihood strategies that could enhance their livelihood outcomes. In other cases, as household heads age, they become dependent on others; and are only able to make decisions based on the land and assets they own.

This implies that elderly household heads have a reduced ability to adapt; relying solely on the number of other household heads to determine livelihood outcomes and, in this case, the adaptive capacities of families. These results align with Sawe's (2018) findings, which suggest that young people have a higher adaptive capacity to climate variability than elders due to their high energy levels and ability to engage in various economic activities to secure income; unlike the elderly who, due to their relatively weaker physical status, are less able to adapt. Moreover, most of the time the elderly relies on external support, such as remittances. Agyei et al. (2013) stated that about 55% of elder farmers in northeastern Ghana depended on remittances from their children as an off-farm adaptation strategy to climate variability. Chandni et al. (2018) and Dang et al. (2019) showed that young farmers are more energetic, and are the earlier adopters of new technology compared to old ones who are typically conservative, and hence late or laggards in adoption.

Moreover, the results in Table 5 indicate that the gender of household heads significantly and negatively impacts the adaptive capacity of smallholder farmers. In other words, gender influences the adaptive capacity of smallholder farmers. Climate variability does not affect males and females equally. Moreover, it is considered that males have a higher adaptive capacity than females. This is due to the fact that males typically make decisions at the household level. Hence, for instance, during periods of severe climate stress, males have the ability to sell household assets to generate income to enable them adapt. Additionally, due to their greater mobility compared to their females counterparts, males are better able to secure alternative sources of livelihood, thereby enhancing their ability to adapt to climate change.

These results align with the findings of Hampson et al. (2017), who found that men in rural areas tend to possess more resources and assets—such as radios and mobile phones—than women, who mostly dedicate their time to family affairs—such as raising children, cooking, and housekeeping—when compared to males who have more time to engage in income-earning activities (Hampson et al., 2014). Moreover, this study's findings align with the findings of Cohen and Garrett (2010), whose study in Southern Africa found that males, due to their high adaptive capacity from farming and non-farming activities, were more likely to adapt to the impacts of climate variability than women who were typically at home. This enabled men to earn more income and select appropriate adaptation practices to respond to the impacts of climate variability.

The level of education was also used to determine the impact of demographic characteristics on smallholder farmers' adaptive capacity to climate variability. It was hypothesized that education level influences smallholder farmers' adaptive capacity. The results in Table 5 indicate that education has a significant impact on smallholder farmers' adaptive capacity ($p = 0.012$). This result suggests that it is assumed that more educated farmers have a higher adaptive capacity compared to those with less education. The impact of education level on a farmer's adaptive capacity may stem from their increased receptivity to new ideas and their expanded scope, suggesting that a higher level of education enhances one's adaptability to various adaptation strategies. These results are in line with Kinuthia et al. (2018) in Kenya, who observed that education levels had a significant influence on the adaptive capacity among smallholder farmers. Likewise, Glewwe and Hall (2007) stated that households with better-educated heads have a higher adaptive capacity to climatic shocks than those relying on informal education.

This study further examined the impacts of farmers' marital status on adaptive capacity to climate variability. The results in Table 5 reveal a statistically significant association between marital status and farmers' adaptive capacity ($p = 0.032$). The results imply that marital status has a significant influence on a farmer's adaptive capacity. The observed results could be explained by several factors. One is that most farmers in developing countries like Tanzania practice communal farming, where members of the family are involved. Hence, the composition and size of a family tend to influence farming and productivity (Igben, 2020). Also, married couples may have more contacts from the husband, wife, and children; thereby increasing the chance of accessing more information and livelihood sources, and ultimately increasing their adaptive capacity. In other words, the social networking of married farmers positions them to meet more contacts who can influence information and knowledge acquisition. Thus, married farmers can have wider access to climate change information sources compared to those unmarried. Moreover, married couples have shared gender roles and responsibilities, which is essential in enhancing their adaptive capacity compared to unmarried ones (Kabote, 2018). The marital status also shapes the farming and adaptive behaviour of farmers since married farmers tend to be more committed (Singh et al., 2016) and highly engaged in farming, and expanding networks than those who are not.

Moreover, the paper examined the impacts of income on the adaptive capacity of smallholder farmers (Table 5). Similarly, the results show a significant positive correlation (p = 0.015) between the level of income and the adaptive capacity of smallholder farmers. These results imply that farmers' income influences their adaptive capacity. These results align with the findings of Mtega (2012), and Elia (2013), which suggest that farmers with higher incomes can enhance their ability to adapt to climate change by implementing effective and user-friendly coping and adaptation strategies. Such measures can include user-friendly farming technologies, diversifying economic activities, developing irrigation schemes, and cultivating high-yield varieties. Thus, income facilitates better access to climate information, enabling farmers to proactively plan for adaptation measures against the adverse effects of climate variability (Muema et al., 2018).

As stated earlier, the results did not find any statistical impacts of two demographic characteristics—namely land ownership and land size—on smallholder farmers' adaptive capacity (p = 0.081 and 0.169, respectively) (Table 5). This implies that farm size, whether small- or large-scale, does not have any impact on a farmer's adaptive capacity. Similarly, the status of land ownership does not affect farmers' adaptive capacity. These quantitative insights align with qualitative findings from FGD participants who highlighting that while land ownership and size are important assets, they may not directly impact adaptive capacity without accompanying resources and support systems.

> *Owning land does not necessarily mean we can adapt to climate changes. Even those of us with large plots of land still struggle because the soil is no longer fertile, and we don't have resources like fertilizers or irrigation to make the land productive. What matters more is whether we have access to knowledge and support, like training on better farming techniques or access to improved seeds. Without that, land ownership alone does not help us cope with climate variability* (FGD Participant, Ilangale village, 2020).

Conclusion and Recommendation

This study concludes that climate variability has been occurring in the study area. This manifests through increases in temperature, and decreases in rainfall amount.

The study discovered that most smallholder farmers have low adaptive capacity to climate change. By highlighting key determinants such as education level, household income, farm size, and access to extension services, the paper provides insights into how socio-economic disparities shape farmers' abilities to respond to climate challenges. The study findings enhance existing knowledge by emphasizing the critical role of localized socio-demographic characteristics in shaping adaptive strategies, which can inform the design of context-specific policies and interventions to improve resilience among smallholder farmers.

Based on the findings, it is recommended that efforts be made to enhance farmers' adaptive capacity by promoting awareness and strengthening household farming subsidies. Additionally, the adaptive capacity of smallholder farmers should be improved by creating a more supportive environment, which includes access to information, finances, seeds, and fertilizers. However, all initiatives should take into account farmers' socio-demographic factors as their adaptive capacity is largely dependent on the level and status of their households' socio-demographic factors. Similarly, there is a need for the government and non-governmental organizations to support smallholder farmers in all agricultural activities to improve their adaptive capacity. In this regard, it is crucial to educate smallholder farmers about the significance of diversifying their livelihoods, and to motivate them to engage in alternative livelihood activities instead of solely relying on crop production. This will help improve their household's income, adaptive capacity, and standard of living. Again, to reiterate, all these initiatives should be set and implemented by considering the socio-demographic factors of smallholder farmers.

Despite its contributions, the study has several limitations. First, it relied on cross-sectional data, which captures conditions at a single point in time, potentially missing seasonal or year-to-year variations in adaptive behaviour. Additionally, the self-reported nature of the data may have introduced recall bias, as respondents might not have accurately remembered or disclosed all relevant information. However, this limitation was addressed by the triangulation of data during data collection and analysis.

Moreover, this paper identified several gaps that warrant further research. For instance, the study primarily focused on socio-demographic determinants, potentially overlooking biophysical and institutional factors that could also influence adaptive capacity. Therefore, further studies can be conducted to assess how biophysical and institutional factors affects smallholder farmers' adaptive capacity to climate variability. Incorporating biophysical and institutional factors—such as soil quality, water availability, and local governance structures—could offer a more comprehensive view of the determinants of adaptive capacity. Exploring the interaction between socio-demographic factors and these variables would deepen the understanding of the complex dynamics at play. Another area for further research is the role of social capital and networks in enhancing farmers' adaptive capacity. Similarly, examining gender dynamics in adaptive capacity, particularly the role of women in household decision-making and resource allocation, could likewise provide actionable insights for designing gender-sensitive adaptation interventions.

Overall, this study underscores the importance of addressing socio-demographic disparities to enhance smallholder farmers' resilience to climate variability. The study provided useful information for policy and decision makers on the importance of considering socio-economic factors during policy formulation and decision-making concerning farmers' adaptation to climate change. Moreover, by addressing the identified limitations and building on the identified gaps, future research can further enrich our understanding of adaptive capacity, and further inform policies and programs aimed at fostering sustainable agricultural livelihoods in the face of climate change.

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