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Coping Strategies to Climate-related Events Across the Gradient of Three Agro-ecological Zones of Same District, Tanzania

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Abstract

This study assessed coping strategies used to climate-related events across the gradient of three agro-ecological zones of Same District, Tanzania. The data was collected through household survey, key informant interviews, focus group discussions, and a review of documents. The quantitative data was analysed using SPSS and XLSTAT, while the qualitative data was analysed using content analysis. A forty-year climatic trend analysis depicts changes in both temperature and precipitation, and there is a significant difference in drought occurrence (p=0.0000) among the study villages; with high frequencies of occurrence recorded in Bangalala and Jiungeni compared to Malindi. The year 1974 was affirmed as the most difficult year ever experienced in the study area, characterized by a prolonged drought. Jiungeni frequently experienced floods, while Bangalala and Malindi never experienced floods. Climate stress events affected the livelihood of the people by damaging crops, reducing crop yields, reducing pastures for livestock, increasing livestock diseases, diminishing water sources, increasing crop pests and diseases, and decreasing crop varieties. The extent of the impact of the local climate change was significantly felt in the lowland areas because floods and droughts were predominant in these areas. To cope with the climatic stress, different coping strategies were employed by the local communities such as by eating neglected and underutilized plant species like red amaranth and spiderwisp, moving livestock to Tanga and Kiteto, eating fewer meals per day, looking for food relief aid, and selling forest products.

Keywords: *climate, agro-ecological, coping strategies, drought, Tanzania*

1. Introduction

The changing of the global climate system is now undeniable, and it is human-induced as it has been proved by scientists during the past decade (IPCC, 2007). For the rest of this century, the global climate will most likely be affected by the ongoing increase in concentrations of atmospheric greenhouse gas (ibid.), which has caused a tremendous increase in average temperature, changes in rainfall quantity, as well as seasonality (IRA, 2016). Climate change is affecting every form of life on the planet, and recent reports by the World Meteorological Association (WMO) (2020) show that the average temperatures for the five years (2015–2019) and ten years (2010–2019) periods were the highest on record. Since the 1980s, each

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decade has been warmer than the previous one. This trend is expected to continue because of record levels of heat-trapping greenhouse gases in the atmosphere. The annual global temperature in 2019 was 1.1^{0}C warmer than the average of 1850–1900 (WMO, 2020), making these gradual changes in climate globally stressful and threatening to livelihood security, especially in Africa (Nelson et al., 2009).

Africa has been experiencing an increase in the frequency and intensity of extreme weather events; notably floods, droughts and tropical storms (IPCC, 2007). The average temperature rise in Africa is faster than the global average, which caused semi-arid conditions for most African countries; and absolutely harmed livelihoods (Boko et al., 2007; Kandiji et al., 2006) and the natural environment (Pauline, 2015). It is expected that by the end of the 21st century, Africa's temperature will rise to between 30°C and 40°C; roughly 1.5 times the global average (Schlenker & Lobell, 2010; Mohamed et al., 2002). This is likely to affect agriculture and increase food insecurity (Kihupi et al., 2015), especially due to low capacity to adapt the impacts of climate change and variability (Boko et al., 2007; Niang, et al., 2014); and higher reliance on natural resources—such as agricultural land, forests and water—which are very sensitive to changes affecting the environment (Adger et al., 2003); Boko et al., 2007). Consequently, the continent is likely to be most susceptible to the negative impacts of climate change and variability (IPCC, 2007, 2013; Niang et al., 2014).

Most regions in Tanzania have been seriously impacted by climate change and variability. The Same District is one of the most susceptible areas to climate stress, whereby there have been an increased frequency of droughts and floods, changes in the timing of rainfall—rains arriving later than expected—followed by severe droughts and famine (Liwenga et al., 2013; Tatu et al., 2015; Bakari, 2019). The situation causes even changes to the natural environment (Shabani, 2018), leading to significant and often negative social, cultural and economic consequences (Ndaki, 2014; Bakari, 2019). However, the magnitude of the stress differs according to the agro-ecological zones of the district (Liwenga et al., 2013, Bakari, 2019). Communities find it necessary to apply different strategies to cope with such climatic stress.

This study aimed at assessing the coping strategies towards climate-related events across the gradient of three agro-ecological zones of Same District in Tanzania. The resilience theory, which emphasizes the capacity of systems to adjust and recover from disturbances, provided the foundation for this study. By exploring various coping strategies, the study highlights how communities can proactively anticipate the impacts of climate change and mitigate them.

2. Methodology

This study was conducted in three agro-ecological zone of Same District. One village from each agro-ecological zone was selected. The selected villages were Malindi (upland plateaus), Bangalala (midland plateaus), and Ruvu Jiungeni (lowland plateaus). Figure 1 shows the location of the selected villages.

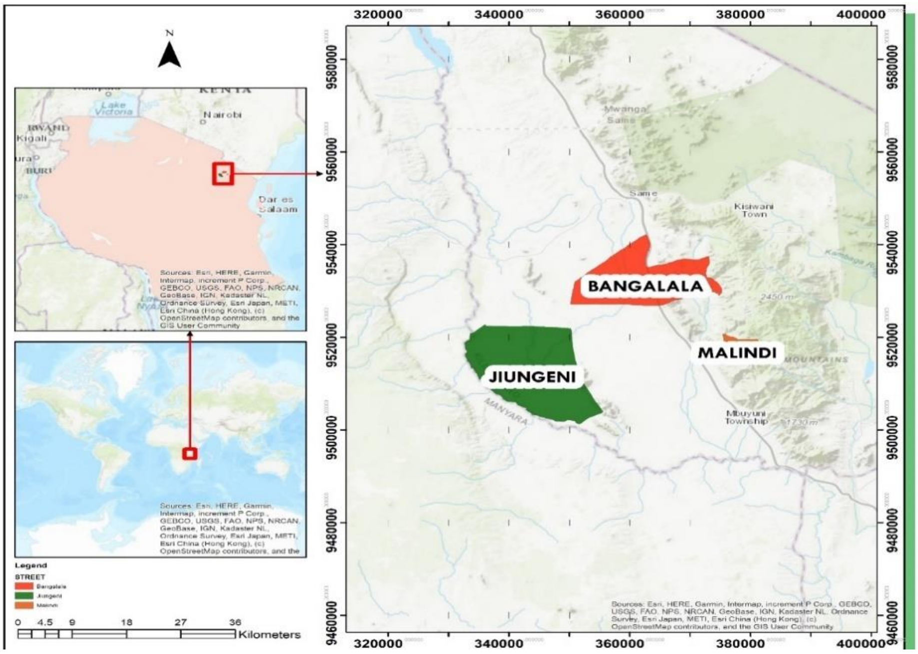

Figure 1: Location of the Study Area

The selection of the study villages was conducted randomly through the fishbowl draw method. After sampling the study villages, the village government offices were consulted to provide lists of the household heads. The three selected villages had the following number of households: 515 in Malindi village, 698 in Bangalala village, and 1,075 in Ruvu Jiungeni village. Hence, for comparison purposes, an equal number of households were taken from each village. A total of 60 households from each of the study villages were selected for the questionnaire survey, making a total of 180 surveys.

Data was collected using a combination of methods, including household survey, key informant interviews (KIIs), focus group discussions (FGDs), and field observation. These were used to collect primary data, while document review was used to collect secondary data. The KIIs (n = 15) were administered at district and village levels, whereby one (1) district agricultural officer, one (1) extension officer, three (3) village officers, one (1) forest officer, and nine (9) elder farmers were recruited for interviews. These were people with experience and outstanding knowledge about the theme of the study. Three (3) FGDs (n = 24) were conducted; one in each study village. A group of eight (8) farmers in each sampled village participated in the discussions. Knowledgeable people within the villages were recruited to participate in the FGDs, taking on board the question of gender. Discussions mainly focused on climate change trends and the occurrence of climate-related events for the past four decades, and the coping strategies used.

Secondary data was obtained through a review of books, journals and government documents; as well as from archives of meteorological and maize crop-yield data. Qualitative data was analysed through content analysis, while quantitative data was analysed using SPSS, version 20; together with XLSTAT, version 4.

3. Results and Discussion

3.1 Socio-economic Characteristics of the Respondents

The findings in Table 1 depict that female respondents were dominant in Bangalala and Malindi villages, represented by 65% and 72%, respectively; while male respondents were dominant for Jiungeni village, with 75% of the respondents.

Table 1: Socio-demographic Characteristics of Respondents

	Village			
Sex	*Bangalala (n=60)*	*Jiungeni (n=60)*	*Malindi (n=60)*	*Total (n=180)*
Male	35	75	28.3	46.1
Female	65	25	71.7	53.9
Age (Years)				
18–29	0.0	0.0	3.3	1.1
30–39	15	10	10	11.7
40–49	30	40	31.7	33.9
50–59	45	45	38.3	42.8
60+	10	5	16.7	10.6
Marital status				
Married	85	100	78.3	87.8
Divorced	5	0.0	1.7	2.2
Widow/er	10	0.0	20	10
Household size				
1–3	15	0.0	20	11.7
4–5	60	75	71.7	68.9
6+	25	25	8.3	19.4
Education level				
Informal education	5	10	1.67	5.6
Primary education	35	30	25	30
Secondary education	40	60	53.3	51.1
College	15	0	16.7	10.6
University	5	0	3.3	2.8
Land size (Acres)				
<1	15	0.0	38.3	17.8
1–2	50	10	60	40
3–5	35	50	1.67	28.9
6–10	0.0	35	0.0	11.7
10+	0.0	5	0.0	1.7
Land acquisition				
Inherited	90	20	48.3	52.8
Bought	10	20	51.7	27.2
Rent	0.0	60	0.0	20

The age structure varied between respondents in the study villages, where respondents aged 40 years and above were reliably considered to provide relevant information regarding climate change and the associated extremes. For example, 87% of the respondents across all study villages were over 40 years old, with 85% in Bangalala, 90% in Jiungeni, and 87% in Malindi. Married respondents were 85%, 100% and 78% for Bangalala, Jiungeni and Malindi villages, respectively.

Moreover, household size varied in the surveyed households, ranging from 1–3, 4–5, and above 6 members. For instance, the household size for Jiungeni ranged from 4–5 and above 6 members. Having a larger number of members in a households means being more vulnerable when encountering climate stress. The level of education was examined among the respondents as it was critical for respondents to understand and explain various climate events and the related impacts on individual livelihood. The results show that secondary school education was the highest education level attained by 40%, 60% and 53% respondents in Bangalala, Jiungeni and Malindi villages, respectively. Education plays a critical role in shaping individuals' ability to anticipate the impacts of climate change; and in fostering greater awareness, understanding, and proactive engagement to improve wellbeing and livelihoods.

3.2 Climate Extreme Event Occurrence

3.2.1 Monthly Rainfall from the year 1980 to 2020

Analysing monthly data from 1980 to 2020 shows that the positive Mann-Kendall Z value and Sen's slope estimate suggest an increasing trend in rainfall in January. However, the p-value is greater than 0.05, indicating that this trend is not statistically significant. In January and February, the positive Z value and Sen's slope estimate suggest an increasing trend, but the high p-value indicates that this trend is not statistically significant (Table 2).

Table 2: Mann-Kendall Trend of Rainfall

Time Series	**Mann-Kendall Trend**	**Sen's slope estimate**	*p-value*
	Test Z	*Q*	
January	1.090	0.558	0.276
February	0.427	0.176	0.669
March	2.291	1.583	0.022
April	-0.101	-0.147	0.919
May	-1.168	-0.648	0.243
June	-0.192	0.000	0.848
July	-1.550	-0.028	0.121
August	-0.938	-0.016	0.348
September	-0.397	0.000	0.692
October	-0.135	-0.033	0.892
November	-0.640	-0.285	0.522
December	-0.708	-0.385	0.479
Annual temp	**0.494**	**0.283**	**0.621**

The negative Z value and Sen's slope estimates suggest decreasing trends in rainfall from April to December. However, the p-values for all these months are greater than 0.05, indicating that these trends are not statistically significant. The results show that the only month with a statistically significant trend (at the 0.05% level) is March, which shows a significant increasing trend in rainfall. The other months do not show statistically significant trends. On the other hand, annual rainfall indicated an insignificant increasing trend.

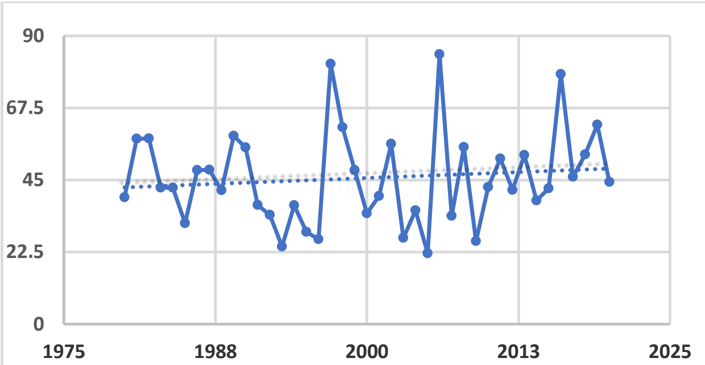

Figure 2: Average Annual Rainfall of Same Meteorological Station for 40 Years

3.2.2 Maximum Temperatures between 1980 and 2020

Most months showed a statistically significant upward trend in maximum temperatures from 1980 to 2020, with February being the exception with a significant decreasing trend. These trends provide valuable insights into climate patterns and changes over the past four decades (40 years) (see Table 3).

Table 3: Mann-Kendall Trend of Maximum Temperature

Time Series	Mann-Kendall Trend *Test Z*	Sen's Estimator *Q*	Signific
January	0.742	0.014	***
February	-1.181	-0.016	***
March	1.091	0.018	**
April	0.495	0.009	**
May	1.474	0.022	*
June	2.959	0.034	**
July	3.318	0.043	**
August	2.149	0.031	***
September	1.968	0.025	*
October	-0.067	0.000	**
November	1.250	0.013	***
December	1.732	0.033	***
Annual temp	**0.183**	**0.062**	**

3.2.3 Minimum Temperatures between 1980 and 2020

Minimum temperature data suggests that several months—particularly January, February, March, April, May, August, October, November, and December—show significant increasing trends in minimum temperatures over the period 1980 to 2020, as shown in Table 4.

Table 4: Mann-Kendall Trend of Minimum Temperature

Time series	Mann-Kendall Test Z	Sen's Estimate Q	*Signific*
January	4.456	0.047	***
February	3.321	0.042	***
March	2.816	0.025	**
April	2.936	0.050	**
May	2.104	0.032	*
June	0.934	0.018	
July	0.844	0.013	
August	2.161	0.022	*
September	1.519	0.020	
October	2.757	0.038	**
November	4.343	0.044	***
December	4.018	0.033	***
Annual temp	**2.823**	**0.471**	***

The data in Table 4 indicates an increasing trend for both minimum and maximum temperatures. These findings comply with the results of various studies conducted in semi-arid areas of Tanzania, which show increases of both maximum and minimum temperatures (Mongi et al., 2010; Zacharia, 2011; Lusiru, 2018; Gosbert et al., 2023; Shabani & Noah, 2022; Bakari, 2019).

3.3 Occurrence of Climate-related Events as Perceived by Respondents

3.3.1 Drought Occurrences

The occurrence of climate-related variable events differed significantly among the study villages (Table 5). For example, the findings indicated a significant difference in the frequency of drought occurrence (p=0.0000), with high frequencies of occurrence recorded in Bangalala and Jiungeni, each scoring 100%; and Malindi scoring 98% (Table 5). However, occurrences of drought to farmers in Jiungeni are severely disastrous as they also depend on irrigation from the Pangani River, while it is pure disaster to agro-pastoralists and livestock keepers. This was revealed by a respondent during an FGD in Jiungeni, who gave the following account:

> *"When drought occurs, we thank God for having given us the Pangani River on which we depend so much for irrigation to sustain our livelihoods. Livestock keepers are the ones who suffer most as they have to go about in search of pasture; and this sometimes causes conflict between farmers and livestock keepers."*

3.3.2 Flood Occurrences

Similarly, the frequency of flood occurrence differed significantly (p=0.0000) among the study villages (Table 5). All surveyed respondents in Bangalala and Malindi admitted that they had never experienced flood incidences. For Jiungeni, flood occurrences were ranked 'very frequent' (80%), and 'frequent' (20%)

Table 5: Frequency of Occurrence of Climate-Related Events in the Study Villages

Climate Variables	Frequency	Village				χ^2	p-value
		Malindi (n=60)	*Bangalala (n=60)*	*Jiungeni (n=60)*	*Overall (180)*		
Droughts	Very frequent	0.0	85	75	53.3	104.4	0.0000
	Frequent	98.3	15	25	46.1		
	Less frequent	1.7	0.0	0.0	0.6		
Floods	Very frequent	0.0	0.0	80	26.7	180	0.0000
	Frequent	0.0	0.0	20	6.7		
	Never	100	100	0.0	66.7		
Late rains	Very frequent	3.3	30	85	39.4	87.1	0.0000
	Frequent	96.7	70	15	60.6		
Early cessation of rains	Very frequent	98.3	100	85	94.4	15.5	0.0004
	Frequent	1.7	0.0	15	5.6		
Out of rain season	Very frequent	0.0	0.0	70	23.3	284.6	0.0000
	Frequent	0.0	5	30	11.7		
	Less frequent	0.0	75	0.0	25		
	Never	100	20	0.0	40		
Increase cold temperature	Very frequent	1.7	0.0	0.0	0.6	82.3	0.0000
	Frequent	30	0.0	0.0	10		
	Less frequent	66.7	100	65	77.2		
	Never	1.7	0.0	35	12.2		
Increase hot temperature	Very frequent	0.0	70	75	48.3	88.8	0.0000
	Frequent	88.3	30	25	47.8		
	Less frequent	11.7	0.0	0.0	3.9		

Source: Survey data (2021).

During one FGD in Jiungeni, a respondent gave the following narration:

"Floods are disasters in our area; and sometimes even when it is not raining, we get floods as water gets collected from Arusha and Moshi, and flows to the Nyumba ya Mungu Dam. When the dam is full, we start experiencing floods which seriously impact our livelihood activities, and forces us to migrate temporary to Makanya for safety."

3.3.3 Late Rains Occurrences

Incidences of late rains were significantly (p=0.0000) associated with geographical location of the study villages (Table 5). For example, all respondents in the study villages reported that incidences of late rains were occurring 'very frequently' (39%) and 'frequently' (61%) (Table 5). These results corroborate those of earlier studies by Shabani and Noah (2022), Pauline (2015), and Bakari (2019): all of which revealed that the occurrence of late rains had negative impacts on farming activities.

3.3.4 Early Cessation of Rains

Incidences of early cessation of rain was reported by 94% of the respondents across the study villages: by 98% of the respondents in Malindi, 100% in Bangalala, and 85% in Jiungeni (Table 5). Early cessation of rains was significantly (p=0.0004) associated with village localities. The perception of respondents of incidences related to out-of-rain seasons differed significantly among the study villages; with this 'frequently' occurring in Jiungeni village (100%), 'less frequently' and 'never' in Bangalala and Malindi villages, respectively (Table 5).

3.3.5 Increase in Temperatures

Changes in temperature were perceived differently among the respondents in the study villages. For example, there was a significant association (p=0.0000) in the perceptions of increased cold temperatures between respondents in the study village, whereby about 67%, 100% and 77% of the respondents perceived that cold periods occurred less frequently (Table 5). Similarly, hot incidences were significantly (p=0.0000) associated with the villages under study. This is indicated by a strong statistical relationship between the occurrence of hot incidences and the villages, with 88% of the respondents reporting that hot events were occurring more frequently (Table 5). However, participants agreed during FGDs that floods and droughts were common climate-related extreme events, frequently occurring for the past 30 years in the study villages. These events were reported to cause significant hunger due to the loss of farm crops; and also due to disease outbreaks, as these environmental conditions were conducive for pests and parasites.

Extreme climate-related events were reported to occur differently in the study villages (Figure 3). For example, all the respondents in Jiungeni reported to have been experiencing these extremes in the years 1998, 1999, 2006 and 2020 (Figure 3). However, 98% and 66% of the respondents reported extreme climate events for the years 1998 and 2006, respectively. This is supported by the Same meteorological data, whereby 2006 was an exceptional year with a high recorded annual rainfall of about 1011.3 mm. The year 1998 recorded 272.1 mm of rainfall in January, which is the highest monthly record in the Same meteorological station. On the other hand, in Bangalala, extreme climate events were reported to occur in the years 1995, 1996, and 1997; as confirmed by 60%, 80% and 92% of the respondents, respectively (Figure 3). Across the study villages, in the period of 30 years, extreme climate events were felt the most in 1998, 2006, and 2020; as reported by 66%, 64% and 77% of the respondents (Figure 4).

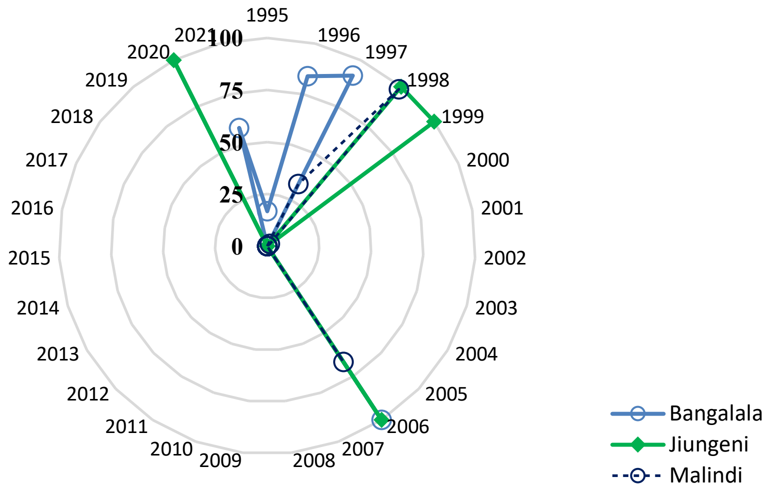

Figure 3: Respondents' Perception on Years of Extreme Climate-related Events
Source: Survey data (2021)

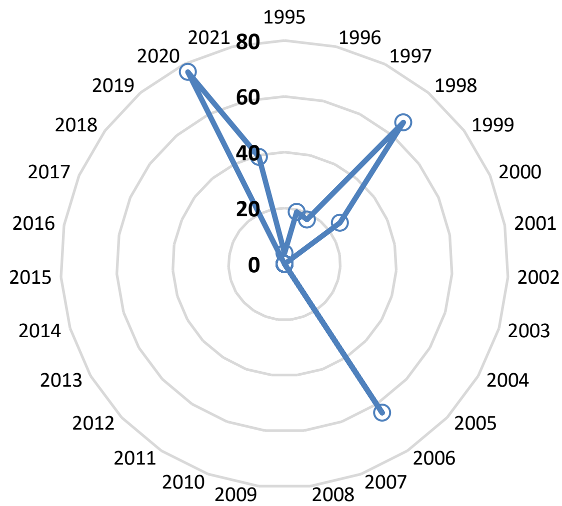

Figure 4: Respondents' Perception on Years of Extreme Climate-related Events
Source: Survey data (2021)

However, during FGDs in all the three villages, discussants affirmed that 1974 was the most difficult year as drought had a severe impact on people's livelihoods; with all necessities like food being provided by the Regional Trading Corporation (RTC). Access to enough food was very difficult, with the staple corn flour being rationed.

3.4 Coping Strategies

3.4.1 Use of Neglected and Underutilized Vegetables

Some coping strategies to the impacts of climate change and variability varied significantly between the study villages (Table 6). For example, the use of neglected and underutilized species of plants differed significantly (p=0.0000), and was affirmed by all respondents (100%) in Bangalala and Jiungeni villages, but only by 90% in Malindi village.

Table 6: Respondents' Coping Strategies to the Impacts of Climate Change Related Stress

Coping Strategy	Responses	Village				χ^2	p-value
		Bangalala (n=60)	*Jiungeni (n=60)*	*Malindi (n=60)*	*Overall (n=180)*		
Use of neglected and underutilized species	Yes	100	100	90	97	12.41	0.0020
	No	0	0	10	3		
Sell forest product (charcoal and timber)	Yes	10	20	20	17	2.88	0.2369
	No	90	80	80	83		
Selling livestock	Yes	25	45	5	25	25.6	0.0000
	No	75	55	95	75		
Eat food normally not eaten	Yes	100	100	90	97	12.41	0.0020
	No	0	0	10	3		
Livestock movement	Yes	100	30	0	43	128.69	0.0000
	No	0	70	100	57		
Eating fewer meal per day	Yes	85	65	0	50	94.8	0.0000
	No	15	35	100	50		
Look for food relief aids	Yes	80	70	0	50	91.2	0.0000
	No	20	30	100	50		

The neglected and underutilized species of plants that were commonly eaten in the study village during the drought periods include red amaranth (botanically named *Amaranthus cruentus,* and locally known as *mburuja*), and spiderwisp (botanically named *Gynandropsis gynadra,* and locally known as *mgagani*). This is similar to what studies conducted by OXFAM (2018) in Myanmar, Peru, Vietnam and Zimbabwe found: that neglected and underutilized plant species play an important role in diversifying people's diet in times of hunger. These neglected and underutilized species contain a wide range of nutrients and fibres.

3.4.2 Selling Forest Products

Selling forest products—such as charcoal and timber—as one of the coping mechanisms was neither significantly associated with the village's geographical location, nor was it particularly considered by respondents as a coping option. However, a study by Ndaki (2014) showed that making and selling charcoal, as well as firewood, were the most common sources of income, and coping strategies in Mkundi village.

3.4.3 Selling of Livestock
Selling of livestock was less reported (<50%) as a coping option across the villages, but it differed significantly (p=0.0000) between respondents in the study villages. Few farmers responded by selling livestock (particularly goats, sheep and poultry) during times of food shortage (Pauline, 2015). A study by Eakin (2005) in Central Mexico found that farmers coped with food shortages by selling livestock to acquire sufficient funds to purchase maize. Likewise, Mertz et al. (2010) reported that selling livestock—particularly small livestock—is a common coping strategy that may be used to solve short-term problems.

3.4.4 Livestock Movement
The adoption of the strategy of moving livestock to villages with adequate water and pastures as a coping mechanism appeared to differ significantly between villages, and among all respondents in Bangalala village; although this was not the case for respondents in Jiungeni and Malindi villages. Related findings are also noted in other studies: that temporary or permanent migration is one of the key coping strategies adopted to reduce risks associated with spatial and temporal resource variability (water and pasture) (Liwenga et al., 2013; Ndesanjo, 2017; Goldman & Riosmena, 2013; Silvestri et al., 2012).

3.4.5 Eating Fewer Meals
About 85% and 65% of the respondents in Bangalala and Jiungeni villages reported eating fewer meals per day as a coping strategy to climate change impacts; although this differed significantly (p=0.0000) among respondents in Malindi village. Maliki (2019) also found out that households in Hanan'g ate fewer meals per day as an incremental response strategy to deal with food shortages caused by climate stress.

3.4.6 Seeking Food Relief/Aid
Seeking aid (food and shelter) was also reported as an important coping strategy, and it was significantly (p=0.0000) associated with village location. This was reported by about 80% and 70% of the respondents from Bangalala and Jiungeni, respectively. Similar studies conducted by Maliki in Hanang (2019), and Shabani in Isimani (2018), confirm that seeking aid and relief from neighbours, together with offering manual labour, were response strategies to climate variability and change. Seeking food and shelter were vital coping strategies during drought and flood occurrences. During floods, Jiungeni villagers always looked for shelter in nearby villages such as Makanya.

4. Conclusion and Recommendation
It is evidenced from the study that there are occurrences of prolonged droughts and extreme precipitations in the study areas resulting from environmental

change, which put into jeopardy the livelihoods of local communities in the study area. This study has revealed significant variations in the occurrence of climate-related events and impacts across the three agro-ecological zones of Same District, Tanzania. Droughts are prevalent in Bangalala and Malindi, while Jiungeni faces both frequent droughts and floods; with notable impacts on crop yields, livestock, water availability, and food security. The year 1974 stands out as a particularly challenging period, alongside 1998, 2006, and 2020, due to extreme drought and flooding events. Local communities have employed diverse coping strategies, including the use of crop drought resistant species, livestock movement, reduced meal frequency, and reliance on food relief. Hence, it is recommended that collective efforts—involving both the government and other stakeholders—are needed to improve and enhance the coping and adaptive capacity of local communities that face extreme climate stress events resulting from climate change and variability.

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