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Implications of climate change and variability on rural livelihoods in drought prone areas of central Tanzania

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Abstract

Most of rural people in Tanzania depend on rain-fed agriculture as the source of their livelihood. The antagonistic effects of climate change and variability have swindled their activities hence communities have been adapting various strategies in sustaining their living. The study was conducted in Mpwapwa district in Dodoma region. The objective of the study was to examine the impacts of climate change and variability on rural livelihoods and the standing locally based adaptation strategies. A total of 384 sample households were selected from three study villages. Both primary and secondary data were collected whereas primary data were collected through structured questionnaire, participant observation and focus group discussions (FGD's). Secondary data were collected from the relevant written documents and meteorological stations. A statistical analysis system, statistical package for social science version 20, Chi-square test, and percentage of normal precipitation index were used for data analysis. Accordingly, the results revealed that the area experienced climate change and variability (CCV) as the communities mentioned the perceived indicators of CCV. Such locally based indicators were corroborated with climate data obtained from Tanzania Meteorological Authority (TMA). Furthermore, the Percentage of Normal Precipitation Index (PNPI) was determined to indicate the severity of drought in the study area. The study also revealed that various livelihood assets were adversely affected by CCV. However, in coping with climate stresses and shocks, communities have used different adaptation strategies to minimize the adversative impacts of climate change and variability. Nevertheless, there is a requisite of developing viable adaptation strategies for communities' wellbeing and environmental sustainability.

Keywords: Climate change; Climate Variability; Livelihoods; Adaptation Strategies

1. Introduction

The world faces enormous challenges associated with climate change and variability (CCV). However, flood and drought prone areas are the most affected ones (IPCC, 2007; Crimmins *et al*., 2016; Lusiru and Malekela, 2022, Ntali *et al*., 2023). In most parts of Sub-Saharan Africa, several changes have been witnessed including changes in rainfall trends, melting of glaciers and important rivers are getting smaller (Dahiya, 2023). This has increased the severity of extreme climatic events, including, droughts, floods, sea level rise and storms (NOAA, 2014; Christopherson, 2018). Such changes have brought various impacts to both communities' livelihoods and ecosystems. Such changes have brought various impacts to both communities' livelihoods and ecosystems. Despite of low contribution to global greenhouse gases (3.7%), African continent has been severely affected by the impacts of global warming due to its low adaptive capacity and overdependence on natural resource-based livelihoods (Kogo *et al*., 2021; Nyiwu, 2021). CCV increases tension to the environment and communities; various sectors including agriculture, water, health and infrastructure have been severe threatened by CCV (UNFCCC, 2007; Malekela and Lusiru, 2022). Most of African countries depend on two main sources

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of livelihood namely agriculture and fisheries; about 85% of Africa's population depends on agriculture despite the fact that such activities are under severe pressure from global CCV (Kogo 2021; Pelser and Chimukuche, 2022). Majority of the farmers in sub-Saharan Africa are smallholder farmers and have a low adaptive capacity to climate change due to various dovetailing challenges, including high levels of poverty, poor access to credit for inputs, and poor infrastructure Mubaya 2010; Ringler, 2010). Climate change literatures have reported for incidences of rainfall variability, changes in the minimum and maximum temperature and extreme weather events. Such changes have affected communities' livelihood (Shemsanga *et al*. 2010; Tesso *et al*. 2012; IPCC, 2014). The intensiveness of the impacts of CCV is felt differently among communities depending on their levels of vulnerability. The mostly affected communities are the marginalized groups living in flood and drought prone areas.

Innumerable climate change impacts, both positive and negative, on natural and human system have beenreported (Walsh *et al*., 2014). Most of the positive impacts are experienced in high latitudes and altitudes where increase in temperature results into milder climates, encouraging settlements with less need for energy consumption to warm cold places. Also, increase in temperature and precipitations in high latitudes and altitudes results into increase in crop yields, timber production and a shift of species towards the poles (Christopherson, 2012). However, climate change have adverse impact on different spheres including ice melt, sea level rise, hurricanes, floods, increase of pests and diseases, heat waves, wildfires and droughts to mention but a few (Walsh *et al*., 2014; NOAA, 2014; Zwally *et al*., 2011; Christopherson, 2012). These impacts are closely connected to all livelihood asserts including human capital, social capital, natural capital physical capital as well as financial capital. The study conducted by (IPCC, 2014) in Nepal revealed that usually most people in the rural areas experienced significant climate change impact in food supplies and security, water availability, infrastructure and income. Usually climate change creates risks to the communities which in the final analysis resulted to prolonged poverty as well as pervasive inequality in the society. On the physical assets issues climate change triggers physical asserts such as buildings, roads communication towers, water tank and reservoirs do suffer from disasters such as floods, land slide,and hurricanes (Mope, 2017). The climate change impacts do not only destruct the physical assets rather it disrupts further services from them as it can causes damage in the highways, terminals as well as water routes which in the long analysis could affects food and sanitations.

The studies conducted by (FIAN, 2013 and Moest, 2013) revealed that climate change affects the economic asserts of the communities by affecting two main sectors of the economy namely agriculture and tourism. In agriculture sector climate change triggers the working hours allocated in agriculture activities by reducing farm labour work which in turn results into economic impact to the farm labors. For instance, it was observed that in Nepal by 2050 net agriculture loss will be equivalent to 0.8% of the GDP in a year (Bishowokarma and Sharma 2013). In a similar way, unfavorable weather change causes decline in the flow of recreational tourist in lowlands as it leads to regional and seasonal shift in tourism as it causes cripples to the national economy. In line with the aforementioned studies, Evans, (2009) reported that climate change has a great impact on agricultural land, forest and water which are the basic source of sustaining livelihood and that scarcity of natural resources by climate change increases resources-based conflict.In Tanzania, most parts specifically the central areas of the country are located in drought prone areas and thus become the most vulnerable to the impacts of climate change and variability. Most communities in these areas are highly impacted by climate change and variability due to semi-aridity climatic conditions coupled with low adaptive capacity (Kahimba *et al.,* 2015). Livelihood of these communities have been negatively impacted due to changes in resources utilization and low production resulting into slowness in poverty eradication (Mwendwa *et al*., 2017). Semi-arid areas are characterized by increased droughts with substantial impacts to the communities' livelihoods (IPCC, 2014; Christopherson, 2018).

The study adopted the Sustainable Livelihood Approach (SLA) which stands on the view that communities are termed to be sustainable if they are able to cope with and recover from stresses and shocks and maintain their capabilities. CCV affects livelihood safety and presents a livelihood disturbances (Serrat, 2017). The SLA has proved expedient in explaining the adaption strategies of rural households to the impacts of climate change, thus allowing for a more detailed look at livelihoods on a context-specific level (Mubaya, 2010; Pelser and Chimukuche, 2022). This approach was appropriate in the current study which intendent to examine the impact of climate change on communities' livelihood assets and the coping mechanisms. Various studies on climate change and its associated impacts have rarely focused on the disparities among communities' vulnerability levels, the current study therefore intended to investigate the impact of CCV on communities' livelihoods in drought prone areas using Mpwapwa district in central Tanzania as a study case. Also, the study assessed the locally based climate change adaptation strategies, this was necessary in evaluating communities resilience to climate stresses as the SLA contends that communities becomes sustainable if they can copy with stresses and shocks that comes in their way.

2. Material and methods

2.1. Materials

The study was carried out in three villages of Mpwapwa District including; Mbori, Kimagai and Berege. Mpwapwa District (Figure 1) is one of the seven districts of the Dodoma Region of Tanzania. It is bordered to the north by Kongwa District, to the east by Morogoro Region, to the south by Iringa Region, and to the west by Chamwino District. The selection of this district focused on its climatic characteristics which is semi-arid in nature. The methodological approach in this study based on mixed methods in which a combination of qualitative and quantitative research approaches formed the basis for data collection and analysis. These approaches were essential to ensure the reliability and validity of the data collected. The study used a cross sectional research design. The cross sectional research design allows data to be collected at a single point in time and it is used in a descriptive study in determining the relationships between variables (Babbie, 1990).

In obtaining a sampling frame which was significant in determining the sample size, village executive officers were consulted and provided a list of households in their areas. A total of 384 households formed a study sample at a ratio of 121 respondents from Berege, 154-Mbori and 109 from Kimagai villages.

Source: Mpwapwa District Strategic Plan 2016 – 2021

Figure 1 Mpwapwa District

2.2. Methods

2.2.1. Data Collection Methods

Both primary and secondary data were collected to answer the research objectives. Primary data were collected using survey and participatory rural appraisal (PRA). Techniques for survey method included; household questionnaire survey and in-depth interviews and techniques for PRA method included direct observation and focus group discussion.

The study used secondary data which contributed towards the formation of background information. These data were collected through reading documents such as journals, text books, newspapers, library and web- based materials on the research topic. Research tools used included semi-structured questionnaire, checklist of questions for key informants, checklist for direct observation and checklist of themes for focus group discussions (FGD's). Additionally, climate data were obtained from Tanzania Meteorological Authority (TMA). The data consisted of annual and monthly rainfall as well as minimum and maximum temperatures between the years 1991-2022.

2.2.2. Data analysis

The qualitative data collected through focus group discussions and in-depth interview were analysed basing on their contents. Quantitative data were analysed using IBM SPSS version 20 and Microsoft excel. The data on rainfall and temperature were analysed using Microsoft excel. Moreover, the intensity and frequency of drought were scrutinized using the Percent of Normal Precipitation Index (PNPI). The PNPI was calculated using Microsoft Excel 2013. The corresponding PNPI values were later used to categorize rain and drought severity. The following equation was used to determine the PNPI:

$$\text{PNPI} = \frac{\text{Actual Rainfall} - \text{Normal Rainfall}}{\text{Normal Rainfall}} \times 100$$

Various scholars in the area of climate change have suggested that if PNPI of rainfall deviations ranges from +20% to -20% it is considered to be normal and below -20% is drought (Kuma *et al*., 2009). However, drought can be proclaimed by numerous nations when the rainfall deviation is below -25%. The selection of PNPI in analyzing drought among other indexes based on its effectiveness in making comparison of drought intensities at single location over different years. Also, the index is apparent and suitable for communicating results (Keyantash and Dracup, 2002; Agwata 2014)

3. Results and discussion

3.1. Communities' perceptions on climate change

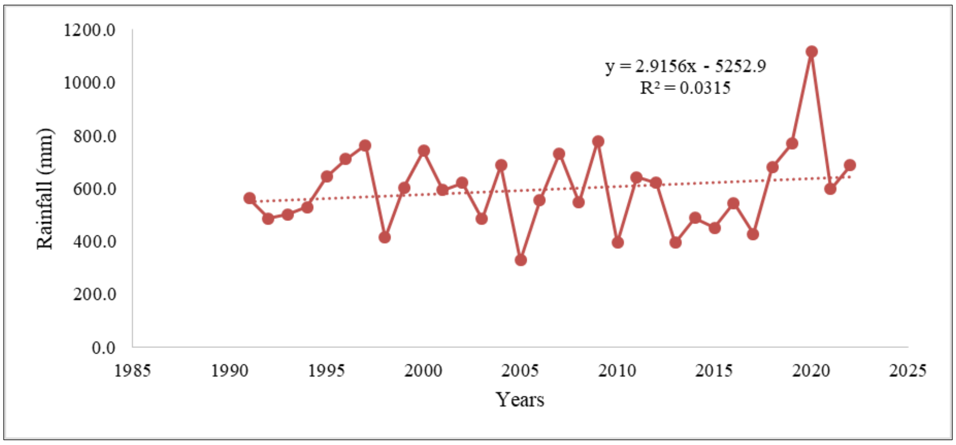
Table 1 Respondents' perceptions on climate change

Perceptions of climate change	**Study villages**				**Pearson's chi-square**
	Berege n=121	**Mbori n=154**	**Kimagai n=109**	**Overall N=384**	**Exact Significance: (2-sided)(1-sided**
Perception:					
Yes	121(100)[1]	154(100)	109(100)	384(100)	- -
No	0(0)	0(0)	0(0)	0(0)	
Indicators of climate change*					
Decrease in rainfall	101(83.5)	133(86.4)	93(85.3)	327(85.2)	(0.635) (0.483)
Increase in temperature	2(1.7)	0(0)	1(0.9)	3(0.8)	
Rainfall variability	18(14.9)	21(13.6)	15(13.8)	54(14.1)	
Droughts	6(5.0)	0(0)	4(3.7)	10(2.6)	(0.027) (0.005)
Shortage of food	2(1.7)	0(0)	1(0.9)	3(0.8)	(0.298) (0.188)

*= Multiple-response answers

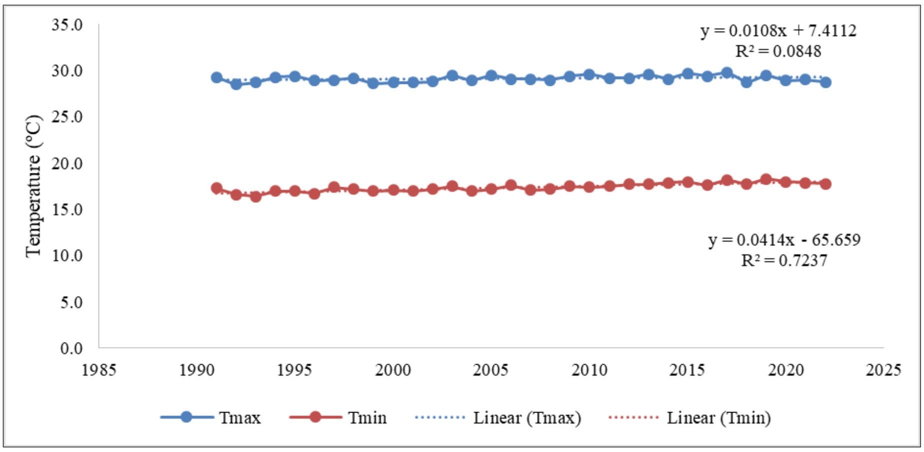
The findings in Table 1 indicates the perceived indicators of climate change in the study area. Majority of the respondents (85.2%) indicated decrease in rainfall totals as the feasible climate change indicator. The decrease in rainfall resulted to decrease in crop production and consequently leading to food insecurity, this has been the case due to overreliance on unpredictable rainfall. Similarly, the decrease in rainfall in the study area has led to droughts and the inferential statistics using chi-square test indicated statistical significance for droughts at $P<0.05$ as an indicator of climate change. These findings are in line with those of (Malekela and Yanda 2021, Mkonda 2022, Malekela and Lusiru 2022).

The perceived climate indicators as shown in Table 1 on the changes in rainfall and temperature formed a considerable basis in corroborating with the meteorological data as indicated in Figures 2 and 3. Figure 2 demonstrate for continual high variability in annual rainfall totals over the past 30 years (1991-2022). There are some years where the area received high rainfall example in the 2020 the total annual rainfall was 1116.6mm but in other years the area received less than 400mm specifically in the year 2005:329.7mm; 2010: 394.6mm; 2013: 394.5mm. The trend line of rainfall patterns in the regression equation indicates the slope b= 2.91 at the rate of R^2= 0.03 as indicated in Figure 2. Rainfall variations affect crop production, particularly maize which is more susceptible to climate stress. Majority of the farmers in the study area indicated to experience persistent droughts in some months thus affecting crop production. Similarly, the area experience variations in temperatures, analysis from the meteorological data revealed a sequential inconsistency of temperatures whereby in 1991 the minimum average temperature was 17.3°C; this had changed to 17.8°C in the year 2022. The maximum average temperatures had also varied between years. The trend line shows the variation in maximum and minimum temperatures at b=0.01, R^2=0.08; b=0.04, R^2=0.72) respectively as indicated in Figure 3.



Source: Authors' computation from Rainfall data obtained from the TMA, 2023

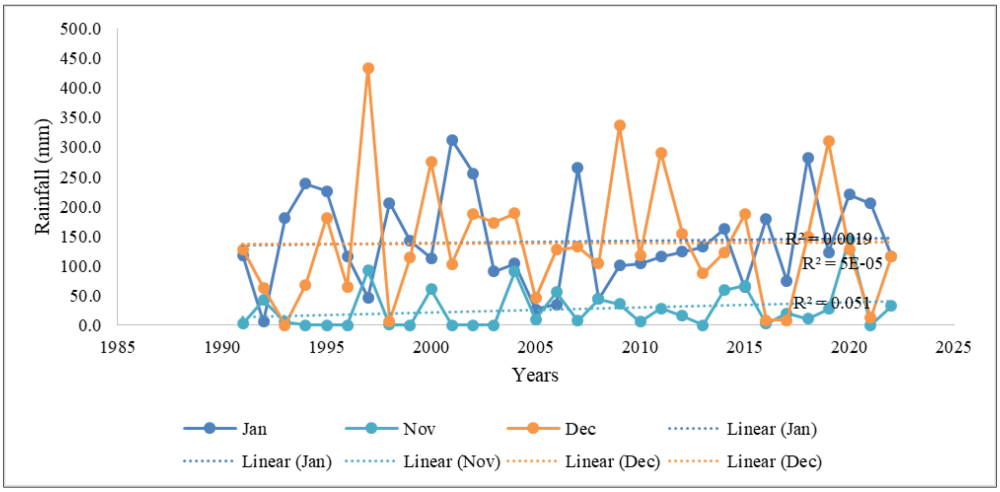
Figure 2 Total Annual rainfall of Mpwapwa District for the period 1991- 2022



Source: Authors' computation from Temperature data obtained from the TMA, 2023

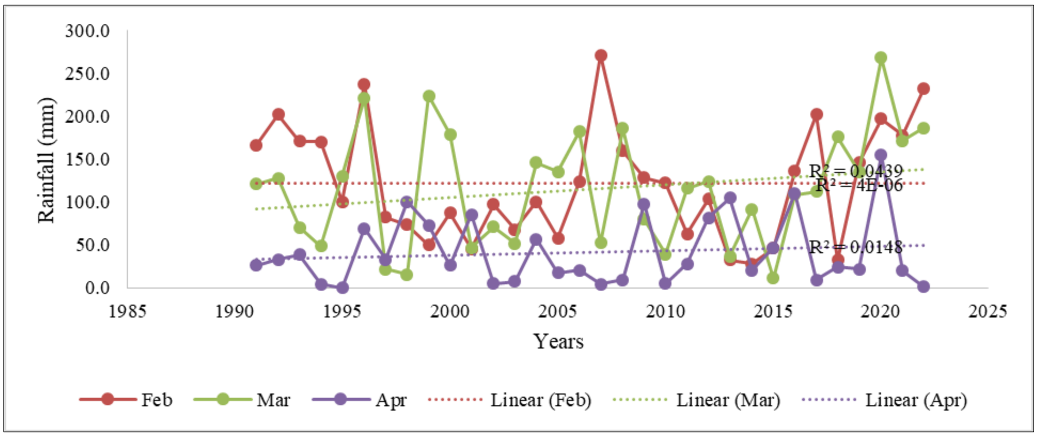
Figure 3 Maximum and Minimum temperatures of Mpwapwa District for the period 1991- 2022

Additionally, the deviation of rainfall was also reported in terms variation in the onset and cessation of rainfall, such information from the respondents was verified using TMA data as indicated in Figure 4 and 5. It was identified that in some years rainfall started early specifically in the mid November while in some years rainfall started on December or early January. Figure 4 indicates that over the past 30 years the area has experienced variations in rainfall during November and December which are essential months for farmers to grow their crops. Subsequently, rainfall cessation in the recent years is early than 30 years back. For instance in the years 1995,1996,1999,2001,2002,2013 and 2021 there was no rainfall during November (0.00mm), whereas, in some years for instance in 2020 the total rainfall amount during November was 114.5mm. In some years even during December which is termed to be the month with high rainfall in different parts of the country characterized by unimodal rainfall pattern, yet the study area recoded low rainfall during the month of December example in 1993:0.00mm; 1998:7mm, 2016:8.5mm; 2017:8.6mm and 2021:12.4mm. Such variation in the onset of rainfall affect crop production as some farmers may sow seeds on their farms with expectation of receiving rainfall and finally end up losing their seeds as they will not germinate. Figure 5 indicates that the study area experienced variations on rainfall cession as in some years the area could receive some amount of rainfall to April thus enhancing crop growth but in some years rainfall could end much earlier leading to crop failure. Many other studies have reported similar observation in different ways depending on the climatic characteristics of the area (Kilembe *et al*., 2012, Malekela and Lusiru 2022; Dahiya 2023; Ntali *et al*., 2023).



Source: Authors' computation from Rainfall data obtained from the TMA, 2023

Figure 4 Total rainfall in the months of November, December and January, 1991-2022



Source: Authors' computation from Rainfall data obtained from the TMA, 2023

Figure 5 Total rainfall in the months of February, March and April, 1991-2022

Furthermore, the study also investigated other aspects of climate that have changed within the period of 30 years using local communities perceptions and TMA data computation as indicated in Table 2a &b and Table 3. Seasonal drought, intra-seasonal dry spells, erratic rainfall (irregular onset/ stop), floods, high temperature, crops insect pests, livestock insect pest, plant disease epidemics, livestock disease, and human diseases are aspects of climate change that were highly reported for at least 90% of respondents in terms of changes, frequency and severity. Moreover, the severity of drought as reported by the local communities was further measured using the Percentage of Normal Precipitation Index (PNPI). It has been advocated that when PNPI ranges from +20% to -20% it is reflected to be normal and when PNPI is below -20% is considered to be drought (Kumar et al., 2009). However the severity of drought may vary depending on the PNPI value, it has been recommended that when the rainfall deviation is below -25% it denote for severe drought and when the PNPI value is between -20.1% and -24.9% entails for moderate drought. In this regard, the study identified years in which the area experienced moderate drought, severe drought and years which had rainfall above normal as indicated in Table 3. All these variations in rainfall had negative impact on community livelihoods. Many other studies have reported the same in various areas though slight differences can be observed due to variations of locations coupled with climatic characteristics of the study area (Lusiru and Malekela 2022, Ntali *et al*., 2023).

Table 2a Aspects of climate that have been changed

Aspects	**Changes**		**Frequency**				
	Yes	**No**	**MF**	**F**	**LF**	**NF**	**DK**
A	384 (100)[1]	0(0)	323(84.1)	58(15.1)	3(0.8)	0(0)	0(0)
B	384 (100)	0(0)	323(84.1)	58(15.1)	8(0.8)	0(0)	0(0)
C	381 (99.2)	3(0.8)	325(84.6)	56(14.6)	3(0.8)	0(0)	0(0)
D	384 (100)	0(0)	50(13)	51(13.3)	47(12.2)	0(0)	27)7)
E	106 (27.6)	278(72.4)	2(0.5)	2(0.5	51(13.3)	51(13.3)	278(72.4)
F	382 (99.5)	2(0.5)	47(12.2)	147(38.3)	188(49.0)	0(0)	2(0.5)
G	159 (41.4)	225(58.6)	29(7.6)	3(0.8)	125(32.6)	2(0.5)	225(58.6)
H	355 (92.4)	29(7.6)	278(72.4)	51(13.3)	3(0.8)	23(6)	29(7.6)
I	311 (81)	73(19)	260(67.7)	48(12.5)	3(0.8)	0(0)	73(19)
J	352 (91.7)	32(8.3)	349(90.9)	3(0.8)	0(0)	0(0)	32(8.4)
K	358 (93.2)	26(6.8)	275(71.6)	54(14.1)	29(7.6)	0(0)	26(6.8)
L	381 (99.2)	3(0.8)	93(24.2)	149(38.8)	59(15.4)	80(20.8)	3(0.8)

A=Seasonal drought, B=Intra-seasonal dry spells, C= Erratic rainfall (irregular onset/ stop), D= Floods, E= Strong wind (hurricane), F= High temperature, G= Extreme cold, H= Crops insect pests, I= Livestock insect pest, J= Plant disease epidemics, K= Livestock disease, and L=Human diseases

MF = More frequent, F= Frequent, LF= Less frequent, NS= Not frequent, DK= Do not know

Table 2b Aspects of climate that have been changed

Aspects	Severity				
	MS	**S**	**LS**	**NS**	**SN**
A	374(97.4)	7(1.8)	3(0.8)	0(0)	0(0)
B	376(97.9)	5(1.3)	3(0.8)	0(0)	0(0)
C	376(97.9)	5(1.3)	3(0.8)	0(0)	0(0)
D	52(13.5)	96(25)	0(0)	27(7)	0(0)
E	2(0.5)	0(0)	53(13.8)	51(13.3)	278(72.4)
F	376(97.9)	5(1.3)	3(0.8)	0(0)	0(0)
G	29(7.6)	5(1.3)	15(32.6)	0(0)	225(58.6)
H	301(78.4)	51(13.3)	3(0.8)	0(0)	29(7.6)
I	260(67.7)	48(12.3)	3(0.8)	3(0.8)	70(18.2)
J	349(90.9)	3(0.8)	0(0)	0(0)	29(7.6)
K	275(71.6)	54(14.1)	29(7.6)	0(0)	26(6.8)
L	93(24.2)	203(52.9)	59(15.4)	3(0.8)	26(6.8)

MS= More severe, S= Severe, LS= Less severe, NS= Not severe, SN= Not sure

Table 3 Values of the percentage of the normal precipitation index (PNPI) in the study area (1991-2022)

Year	Actual rainfall(A)	Normal rainfall (B)	A-B	(A-B)/B	PNPI	Classification
1991	562.8	637.2	-74.4	-0.1	-11.7	Normal
1992	487.1	637.2	-150.1	-0.2	-23.6	Drought
1993	503.2	637.2	-134.0	-0.2	-21.0	Drought
1994	530.8	637.2	-106.4	-0.2	-16.7	Normal
1995	644.5	637.2	7.3	0.0	1.2	Normal
1996	710.4	637.2	73.2	0.1	11.5	Normal
1997	763.1	637.2	125.9	0.2	19.8	Normal
1998	415.4	637.2	-221.8	-0.3	-34.8	Severe drought
1999	603.8	637.2	-33.4	-0.1	-5.2	Normal
2000	742.0	637.2	104.8	0.2	16.5	Normal
2001	593.3	637.2	-43.9	-0.1	-6.9	Normal
2002	620.8	637.2	-16.4	0.0	-2.6	Normal
2003	485.6	637.2	-151.6	-0.2	-23.8	Drought
2004	687.6	637.2	50.4	0.1	7.9	Normal
2005	329.7	637.2	-307.5	-0.5	-48.3	Severe drought
2006	554.7	637.2	-82.5	-0.1	-12.9	Normal
2007	733.5	637.2	96.3	0.2	15.1	Normal
2008	547.1	637.2	-90.1	-0.1	-14.1	Normal
2009	780.1	637.2	142.9	0.2	22.4	Normal
2010	394.6	637.2	-242.6	-0.4	-38.1	Severe drought
2011	643.1	637.2	5.9	0.0	0.9	Normal
2012	620.9	637.2	-16.3	0.0	-2.6	Normal
2013	394.5	637.2	-242.7	-0.4	-38.1	Severe drought
2014	489.7	637.2	-147.5	-0.2	-23.1	Drought
2015	452.2	637.2	-185.0	-0.3	-29.0	Drought
2016	545.2	637.2	-92.0	-0.1	-14.4	Normal
2017	428.0	637.2	-209.2	-0.3	-32.8	Severe drought
2018	679.3	637.2	42.1	0.1	6.6	Normal
2019	770.5	637.2	133.3	0.2	20.9	Normal
2020	1116.6	637.2	479.4	0.8	75.2	Wet
2021	598.1	637.2	-39.1	-0.1	-6.1	Normal
2022	686.9	637.2	49.7	0.1	7.8	Normal

Source: Authors' computation from Rainfall data obtained from the TMA, 2023.

3.2. Communities' livelihood activities affected by climate change and variability

The sustainable livelihood approach (SLA) portrays that communities always engage in various activities despite of the shocks and stresses that may come in their way, such activities may have contribution to livelihood assets including natural, physical, social and human assets. In the study area, majority of the respondents (70.4%) reported to engage in crop faming as a livelihood activity (Table 4). The leading food crops grown by households in study villages are maize (50.8%) and millet (30.3%); and leading cash crops grown are groundnuts (56.3%) and sunflower (13.8%). Majority (94%) of households mentioned crop farming as very an essential source of income and general households' livelihood. Many other scholars have reported that majority of the communities in African countries depend on crop farming (Chimukuche, 2022). This has been the case due to the availability of abundance arable land for farming. In the study area majority of the respondents (94%) reported to have at least three acres. This implies that, land is not a scarce resource in the study villages. The land is largely owned communally (52.6%) and inherited (41.4%). Still, the land can be accessed through borrowed (46.1%) and inheritance (47.1%). Inferential statistics using chi-square test indicated statistical insignificance for respondents' livelihoods' activities at P<0.05. These results indicated that, majority of households in Mpwapwa District engaged in crop production as their main livelihood activity. However, rain-fed crop production is a dominant form of production in the District. Now, climate change and variability brings uncertainties to crop production and necessitate intervention to restrain the situation.

Table 4 Respondents' livelihood activities

Information	**Study villages**				**Pearson's chi-square**
	Berege n=121	**Mbori n=154**	**Kimagai n=109**	**Overall N=384**	Exact Significance: (2-sided) (1-sided)
Livelihood activities [a]:					
Crop farming	114(70.8)	144(69.9)	103(70.6)	361(70.4)	(0.940) (0.124)
Petty business	47(29.2)	62(30.1)	43(29.4)	152(29.6)	(0.971) (0.058)
Food crops grown [a]:					
Maize	66(50.7)	82(50)	60(52.2)	208(50.8)	(0.998) (0.130)
Millet	39(30)	51(31.1)	34(29.6)	124(30.3)	
Beans	23(17.7)	31(18.9)	20(17.3)	74(18.1)	
Paddy	2(1.6)	0(0)	1(0.9)	3(0.8)	(0.298) (0.188)
Cash crops grown:					
Groundnuts	71(58.7)	83(53.9)	62(56.9)	216(56.3)	(0.986) (0.999)
Onions	6(5)	10(6.5)	6(5.5)	22(5.7)	
Sunflower	16(13.2)	21(13.6)	16(14.7)	53(13.8)	
Others	28(23.1)	40(26)	25(22.9)	93(24.2)	
Importance of crop farming as a source of income and general household's livelihoods:					
Very important	114(94.2)	144(93.5)	103(94.5)	361 (94)	(0.940) (0.124)
Important	7(5.8)	10(6.5)	6(5.5)	23(6)	
Cultivation land:					
< 2 acres	7(5.8)	10(6.5)	6(5.5)	23(6)	(0.999) (0.434)
2- 3 acres	32 (26.4)	42(27.3)	29(26.6)	103(26.8)	
4 –5 acres	30(24.8)	41(26.6)	28(25.7)	99(25.8)	
> 5 acres	52(43)	61(39.6)	46(42.2)	159(41.4)	
Type of land ownership:					
Communal	62(51.2)	82(53.3)	58(53.2)	202(52.6)	(0.990) (0.300)
Inherited	52(43)	62(40.2)	45(41.3)	159(41.4)	

Others	7(5.8)	10(6.5)	6(5.5)	23(6)	
Land accessibility:					
Bought the land	2(1.7)	0(0)	1(0.9)	3(0.8)	(0.854) (0.738)
Borrowed the land	54(44.6)	72(46.8)	51(46.8)	177(46.1)	
Inherited the land	58(47.9)	72(46.8)	51(46.8)	181(47.1)	
Others	7(5.8)	10(6.4)	6(5.5)	23(6)	

a=Multiple response answers

Furthermore, majority of the respondents (72.1%) reported for decreasing trend of crop production for the period of ten years 2012 -2022 as indicated in Table 5. Climate uncertainties including drought (56.9%) and unpredictable rainfall (43.1%) were reported to be the main cause for such decrease in production. However, 14.6% of the respondents' mentioned increased production for the past decade due to increase in agricultural inputs and household farm size. Inferential statistics using chi-square test indicated statistical insignificance for respondents' crop production trend for the past decade at $P<0.05$. These results imply that, climate have changed in the study area and that change affect farming activities specifically crop production. This situation leads to malnutrition diseases among household members especially children under five years of age.

Table 5 Respondents' crops production trend for past ten years

Information	**Study villages**				**Pearson's chi-square**
	Berege n=121	**Mbori n=154**	**Kimagai n=109**	**Overall N=384**	**Exact Significance: (2-sided) (1-sided)**
Crops production :					
Decrease	86(71.1)	112(72.7)	79(72.5)	277(72.1)	(0.992) (0.258)
Increase	19(15.7)	21(13.6)	16(14.7)	56(14.6)	
Don't know	16(13.2)	21(13.6)	14(12.8)	51(13.3)	
Reasons for decrease in crop production [a]:					
Drought	95(56.9)	123(56.9)	87(56.9)	305(56.9)	(0.956) (0.091)
Unpredictable rainfall	72(43.1)	93(43.1)	66(43.1)	231(43.1)	(0.983) (0.032)
Reasons for increase in crop production:					
Increase in agricultural inputs	18(14.9)	21(13.6)	15(13.7)	54(14.1)	(0.833) (0.704)
Increased household farm size	1(0.8)	0(0)	1(0.9)	2(0.5)	
Don't know	102(84.3)	133(86.4)	93(85.3)	328(85.4)	

[a] = Multiple response answers

3.3. Communities' food insecurity resulted from climate change and variability

Climate change and variability affect different dimensions of food security including food availability, accessibility, stability and utilization. The results on communities' food insecurity resulted from climate change and variability (CCV) are indicated in Table 6. The study revealed that, 66.4% households in the study area experience food shortage. Some of the households in the study villages appealed occurrences of food shortages to be at least often (41.6%) and others at least rare (48.4%). Drought (79.4%) and on farm pests and disease (20.6%) were found to be the most causes of food shortage in the study area. Chi-square test indicated statistical insignificance for respondents' crop production trend for the past decade at $P<0.05$. These findings imply that, the study area experience food insecurity resulted from CCV and Government and other NGOs need to intervene by providing food aid. Crop failure caused by drought is one among the factors that had led to food insecurity in the study areas. Figure 6 indicates crop failure and drying of river valley due to CCV. The river was reported to be used for irrigation and as a source of water at their households, but with the current rainfall shortage, the river can no longer retain water for different uses.

Table 6 Respondents' food shortage experience

Information	Study villages				Pearson's chi-square
	Berege n=121	**Mbori n=154**	**Kimagai n=109**	**Overall N=384**	**Exact Significance: (2-sided) (1-sided**
Household's food shortage experience**:**					
Yes	80(66.1)[1]	103(66.9)	72(66.1)	255(66.4)	(0.995) (0.217)
No	34(28.1)	41(26.6)	31(28.4)	106(27.6)	
Don't know	7(5.8)	10(6.5)	6(5.5)	23(6)	
Occurrences of household's food shortage:					
Very often	32(26.5)	42(27.3)	29(26.6)	103(26.8)	(0.998) (0.467)
Often	19(15.6)	21(13.6)	17(15.6)	57(14.8)	
Rare	44(36.4)	60(39)	41(37.6)	145(37.8)	
Very rare	26(21.5)	31(20.1}	22(20.2)	79(20.6)	
Causes of household's food shortage:					
Drought	95(78.5)	123(79.9)	87(79.8)	305(79.4)	(0.956) (0.091)
On farm pests and diseases	**26(21.5)**	**31(20.1)**	**22(20.2)**	**79(20.6)**	

Source: Researcher 2022

Figure 6 Crop failure and dryingof river valleys due to CCV in kimagai (a) and Mbori (b) villages

3.4. Impacts of climate change on land uses

Climate change and variability affect the natural assets including agricultural land, forests and water which are the basic sources of community's livelihoods in different parts of the world. In the current study, it was revealed that, climate change brings impacts on land uses as indicated in Table 7. Disappearance of vegetation cover is said to be the leading impact of climate change on land resources by majority (92.7%) of respondents. Chi-square test revealed insignificance variation between impacts of climate change on land uses. The results imply that, climate change parameters like the decrease of rainfall and temperature rise dries vegetation cover resulted to soil infertility. This soil infertility cause inadequate crop production leading to food insecurity. Many other studies in different parts of the world have reported that climate change incidences can lead to forests disappearance due to prolonged drought as well soil infertility due to increased aridity (Thakur and Bajagain 2019, Malekela and Yanda 2021)

Table 7 Respondents' responses on impacts of climate change on land resources

Impacts of climate change on land resources:	Study villages				Pearson's chi-square
	Berege n=121	Mbori n=154	Kimagai n=109	Overall N=384	Exact Significance: (2-sided) (1-sided
Disappearance of vegetation cover	111(91.7)[1]	144(93.5)	101(92.7)	356(92.7)	(0.657) (0.502)
Drying of some forests	8(6.6)	10(6.5)	7(6.4)	25(6.5)	
Loss of soil fertility	2(1.7)	0(0)	1(0.9)	3(0.8)	

3.5. Effects of climate on human assets

Damage of human assets as a result of CCV including food insecurity and chronic hunger due to crop failure affects the poor population in rural areas. The study revealed that, food insecurity is the leading effect of climate change on communities' welfare as indicated in Table 8. The results depicts that in most areas of less developed countries, communities' production rely heavily on food crops; thus climate change may lead to increase in food demands. Also, CCV lead to the spread of diseases associated with hygiene factors. These findings are in line with those of (MoE 2012; FIAN, 2013; Thakur and Bajagain 2019). Their study in climate change and communities' livelihood in NEPAL revealed that CC had affected human wellbeing in terms of diseases and food security.

Table 8 Respondents' responses on effects of climate change on human welfare

Effects of climate change on human welfare:	Study villages				Pearson's chi-square
	Berege n=121	Mbori n=154	Kimagai n=109	Overall N=384	Exact Significance: (2-sided) (1-sided
Food insecurity	112(92.5)[1]	144(93.5)	102(93.6)	358(93.2)	(0.639) (0.487)
Spread of diseases	2(1.7)	0(0)	1(0.9)	3(0.8)	
Destruction of houses and roads	7(5.8)	10(6.5)	6(5.5)	23(6)	

3.6. Locally based adaptation strategies to the impact of CCV

Table 9 Adaptation strategies to the impact of CCV at local level

Variables	Overall N=384	Exact Significance: (2-sided) (1-sided
Practiced adaptation strategies:		
Changing planting dates	2(0.5)	(0.000) (0.000)*
Growing drought resistant crops	200(52.1)	
Growing early maturing crops	6(1.6)	(0.007) (0.002)*
Growing high yield varieties	8(2.1)	(0.114) (0.114)***
Mixed farming	3(0/8)	(0.001) (0.005)*
Food shortage	2(0.5)	
Trees planting	3(0.8)	
Household's most preferred adaptation strategy [a]:		
Growing drought resistant crops	197(51.3)	(0.000) (0.000)*
Growing early maturing crops	6(1.6)	

Adaptation strategies can be termed as adjustments in natural or human systems in response to an authentic or expected climatic effects (IPCC, 2007). As stipulated in the SLA that for a sustainable livelihoods, communities need to cope with stresses and shocks that comes in their ways. For this case, the study assessed the locally based adaptation strategies to the impact of CCV. The study revealed that Communities used various adaptation strategies, one among the dominant strategy was growing drought resistant crops (52.1%), this was the most practiced adaptation strategy and majority (51.3%) of the household's preferred adaptation strategy (Table 9). However, it was identified that most of the strategies used were not sustainable due to the increased incidences of CCV.

4. Conclusion and Recommendations

The current study examined the impact of climate change and variability (CCV) on communities' livelihood. The study focused on the livelihood assets as propounded in the Sustainable Livelihood Approach. The study was conducted in three villages of Mpwapwa district and it was evidenced that the area experiences CCV. The local communities provided the perceived indicators of CCV, among others, drought and rainfall variability were highly reported by majority of the respondents. However, the study corroborated the locally based evidences with the climate data obtained from TMA for the past 30 years; 1991-2022. It was revealed that climate uncertainties in the study area affected adversely the livelihood assets. Most of the farmers in the study area depended on crop farming which is susceptible to CCV due to overreliance on unpredictable rainfall. For this reason, various livelihood assets including, physical, natural and human assets are affected. However, communities reported to have various adaptation strategies in sustaining their living including changing of planting dates, changing of seeds and growing drought tolerant crops. Despite the efforts made at local level, the study recommends for government intervention with regard to sustainable adaptation and mitigation strategies. Also, there is a need for developing a model that will keep communities get informed instantly on climate issues and take the responsible actions. This recommendation base on the fact that in the study area communities have low access to climate information.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have no any conflict of interest for publishing this article.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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