Quest Journals
Journal of Research in Environmental and Earth Sciences
Volume 10 ~ Issue 3 (2024) pp: 18-30
ISSN(Online) :2348-2532
www.questjournals.org

Research Paper

The Effect of Climate Change Adaptation Strategies on Economic Wellbeing Among Farmers in Northern Tanzania

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Abstract: *The study provides an analysis of the economic effects of climate change adaptation strategies of farmers in Northern Tanzania. This study was conducted in Moshi Rural District in Kilimanjaro region and covered farming communities around three wards of Kirua Vunjo South, Njia Panda and Makuyuni. Specifically, the study analysed the effects of both on-farm and off-farm climate change adaptation strategies on farmers economic wellbeing. Both qualitative and quantitative research approaches were applied. A total number of 99 respondents comprising of 90 farmers and 9 key informants were involved in this study. Questionnaire, interview, and desk review were used to obtain data. Income of household, housing condition, food security, education and health services were the economic wellbeing indicators which were incorporated in the questionnaire for the respondents to rank. Quantitative data were analysed using SPSS, while content analysis was used in analysing qualitative data. Results indicate that climate change impacts in Moshi district are evident and already compromising livelihoods of farmers by decreasing their crop yields and hence their economic wellbeing. Temperature rise, shortage of rainfall, droughts and decreased crop yields have been observed and severity is likely to increase if no immediate interventions are put forward to arrest the situation. In dealing with climate change impact, farmers use crop diversification, change in planting dates, fertilizer application, drought resistance crops, petty businesses, irrigation, casual labour engagement, livestock keeping and making local brew. However, of these, only fertilizer application, irrigation, change in planting dates, and involving in petty business were having positive effects. The rest are having negative effects except making local brew which was insignificant in determining its effect. There is a need for farmers to depart from relying on rain fed-agriculture instead to be developing heavy utilization of irrigation. Also, the Government needs to ensure that specific information about climate change is easily accessible to farmers.*

Keywords: *Economic wellbeing, Adaptation strategy, Climate change, Northern Tanzania, Agriculture.*

R*eceived 23 Feb., 2024;* ***R****evised 02 Mar., 2024;* ***A****ccepted 04 Mar., 2024 © The author(s) 2024.* ***P****ublished with open access at* ***www.questjournals.org***

I. INTRODUCTION

Climate change refers to a change in the state of the climate that can be identified by changes that persists for an extended period, usually decades or longer (IPCC, 2007). According to the United Nations Framework Convention on Climate Change, UNFCCC (2007), climate change may have a permanent negative impact on the natural resource base upon which agriculture thrives especially considering that it is happening at a time of growing demand for basic human requirements, specifically food. The increased demand for land resources such as arable land, forests, soil materials, water, and so forth, are due to the pressure of the fast rapid population growth and climate change (Hoffmann, 2000). Agriculture is highly dependent on climate and human livelihood, especially the poor is highly dependent on agricultural activities (slater *et al.*, 2007).

1.1 The Problem

Since the Industrial Revolution, human activities have increased the amount of atmospheric CO_2 by 30%, and this has enhanced the greenhouse effect which causes more heat to be trapped in the lower atmosphere and consequently raising the global average temperature which affects the climate system (WMO, 2014). Between 12 and 15 million hectares of forests are lost annually to deforestation and deforestation is responsible for 15% of greenhouse gas emissions (WWF, 2014). Land uses including pulp, palms and soy plantations, roads and other infrastructure constructions are responsible for the observed deforestation rates, which intensify global warming. It is estimated that about 87% of the global deforestation occurs in 10 countries with Brazil and Indonesia accounting for 51% of the total forest loss.

Tanzania losses between 300,000 and 400,000 hectares of forest each year to deforestation from clearing lands, logging and biomass and fossil fuels burning, where forests supply over 90% of energy (IPP Media, 2023; WWF, 2014). Most of these anthropogenic (human) activities increases greenhouse gases into the atmosphere and also interfere with the bio-thermostat (natural balancing of the increased CO_2 by plants as carbon sinks) and therefore increasing CO_2 in the atmosphere a condition which enhances the greenhouse effect, global warming and consequently climate change.

Climate change is one of the major ecological and socio-economic challenges that the World is facing and there is significant scientific evidence that the recent rapid climate changes are driven largely by a range of human activities (NASA, 2014). For more than 50 years, the earth's climate has been changing because of increasing greenhouse emissions of such gases as Water vapour, Methane, Carbon dioxide, Nitrous oxide, and Halocarbons from the burning fossil fuels such as oil, as well as deforestation and other human activities such as mining and agriculture (CAN Tanzania, 2014). Industrial activities that our modern civilization depends upon have raised atmospheric CO_2 levels from 280 to 379 Parts per Million (PPM) in the last 150 years and there is a better than 90% probability that human-produced greenhouse gases have caused much of the observed increase in the earth's temperatures in the past years (NASA, 2014). The United Nations World Tourism Organization estimates that global tourism contributes approximately 26,400 million tons of CO_{2e}/year (metric tons of CO_2 equivalent), a roughly 4.9% of total global emissions - flights and vehicles (driving on Safaris on roads (University of Reading, 2014). Clearing the land for agriculture and industries, agricultural practices that use organic fertilizers, fossil fuels and biomass burning, livestock (ruminant) digestion and manure management have also increased the concentrations of greenhouse gases in the atmosphere (NASA, 2014).

Agriculture accounts for 12.5% of the total global emissions of greenhouse gases, following power stations (21.3%), industrial processes (16.8%) and transportation (14.6%) while followed by fossil fuels retrieval, processing and distribution (11.3%), residential commercial and other sources (10.3%), land use and biomass burning (10%), and waste disposal (3.4%) (Adesoji & Ayinde, 2013). Some indicators of climate change include; rising temperatures (both on land and in oceans), reduced rainfalls, raised sea levels, Ocean acidity and salinity and others like long period droughts and frequent flooding (NASA, 2014).

Global climate change has already had observable effects on the environment where global temperatures have risen by over 0.7^0 C in the last 100 years with the last 12 years as the warmest on the records (University of Reading, 2014), resulting in the global warming, as the greenhouse effect. Global sea level rose about 17 centimetres (6.7 inches) in the last century and the rate in the last decade is nearly double that of the last century, while the area affected by drought has increased since 1970s (NASA, 2014). Unpredictability in the onset and shortening of the rainy seasons is yet another problem that the agricultural sector is facing currently and this leads to some people planting too early while others plant too late and therefore end up losing their investments in agriculture (AGRA, 2014).

In Africa, by 2020, between 75 and 250 million people were projected to be exposed to increased water stress; where by yields from rain-fed agriculture could be reduced by up to 50% in some regions and agricultural production, including access to food may be severely compromised (NASA, 2014).

Agriculture, 95% of which is rain-fed, supports the livelihoods of two thirds of Tanzanians and employs 80% of the rural workforce and it is the main economic activity, accounting for 45% of the GDP and 55% of foreign exchange earnings (AGRA, 2014). The trend of Tanzania's agricultural sector has been of concern as during the period of 2000-2008 agriculture realized a modest average growth rate of 4.4% far below the National Strategy for Growth and Reduction of Poverty (NSGRP) target of 10% by the year 2025 (AGRA, 2014).

Despite all efforts in developing policies and initiatives, climate change adaptation implementation has not progressed far and its coordination needs strengthening. The key problem to climate change adaptation is that the society is not adequately prepared to address the ongoing and future impacts of climate change (UNDP, 2012). In bridging the gap, the country should have the goal to ensure that the environment and climate change are mainstreamed in the most economically important and vulnerable sectors of the economy, including agriculture.

Climate change has already impacted many parts of Tanzania in many ways. According to Intergovernmental Panel for Climate Change (2007), loss of "cloud forests" since 1976 resulted in 25% annual reductions of water sources derived from fog affecting annual drinking water of 1 million people living in Kilimanjaro.

The key issue of concern here is that climate change is expected to increase the severity, duration and frequency of weather related extreme events such as droughts and floods, threatening water availability and food security of millions of people (CAN Tanzania, 2014). Human communities need adequate knowledge, strategies and tools to effectively adapt to impacts of climate change. This study, therefore, aimed to fill the knowledge gap by providing detailed and current information on climate change adaptation strategies, its impacts, knowledge and practicable adaptation strategies. The study fulfilled this by conducting a study in Moshi Rural District, in Northern Tanzania.

1.2 Objective

The objective of this study was to analyse how climate change adaptation strategies has impacted economic wellbeing of farmers in Moshi.

1.3 Research Question

To what extent have climate change adaptation strategies impacts economic wellbeing of farmers in Moshi?

II. LITERATURE REVIEW

2.1 Theory of Adaptation

According to Botha and Atkins (2005), various complementary theories have been propounded to explain the adaptation process; they include the extension theory, theory of reasoned action, consumer behaviour theory and diffusion theory.

The extension theory is based on the premise that communication has the tendency of changing voluntary behaviour hence adaptation rates would increase if information about an innovation is communicated to farmers.

The theory of reasoned action is based on the assumption that farmers' behaviour is strongly related to their attitudes towards that behaviour. Therefore, more farmers would adapt an innovation if more farmers have favourable attitudes towards it.

The consumer behaviour theory suggests that the needs of farmers are the basis for evaluating the merits and demerits of an innovation; more farmers are therefore likely to adapt if they have a need for it.

2.2 Diffusion Theory

According to the diffusion theory, the adaptation process requires a series of decision-making by individuals. Before a climate change is adopted, the individual must first be aware of it. After awareness, the climate change may be rejected immediately or the adaptation process may continue with the individual developing interest in the strategies. If the outcome is favourable, the adapted strategy would be not rejected but tested on the farmers to see if it works for them. The strategy is then adapted if it passes the test. It is possible for a strategy to be discontinued after it has been adapted (Botha & Atkins, 2005). Kopainsky and Derwisch (2009), classify the process above into five stages namely; initial knowledge – where the individual learns of the strategy; persuasion – where the individual forms a perception about the strategy; decision – where the individual evaluates the strategy; implementation – where the individual adapts the strategy and confirmation – where the individual evaluates the performance of the strategy.

For this study, an individual (farmer) is considered to be an adapter if the farmer is using a particular strategy of interest. Studies of the adaptation of climate change in agricultural sector are widely used in assessing impacts of agricultural research as well as identifying and reducing constraints to adaptation through innovative econometric procedures, and analysing the process of learning and social networking (Doss, 2006).

Botha and Atkins (2005) argue that, the adaptation process takes place in a specific setting, for example in a particular social and cultural context, climate, geography, economic condition and policy. These are some of the factors that may influence the adaptation process. Adaptations vary not only with respect to their climatic stimuli but also with respect to other, non-climate conditions, sometimes called intervening conditions, which serve to influence the sensitivity of systems and the nature of their adjustments. For example, a series of droughts may have similar impacts on crop yields in two regions, but differing economic and institutional arrangements in the two regions may well result in quite different impacts on farmers and hence in quite different adaptive responses, both in the short and long terms (Smit *et al.*, 2000).

2.3 Resilience Theory

The theory which guides this study is resilience theory. The concept of resilience most commonly used in the study of ecosystem dynamic (Holling, 1973), can also be applied to social systems (Adger, 2000), social ecological systems (Gunderson & Holling, 2002), and the study of climate change (Holling, 1997). Resilience theory is one of the major conceptual tools to deal with change (Scheffer, 2009) at all levels from local to global (Gunderson & Holling, 2002). Resilience theory deals with system dynamics and envisions ecosystems as continuously changing, sometimes abruptly and unpredictably (Berkes & Ross, 2013).

Adapting to climate change is a process of building resilience of a system. The resilience theory therefore recognizes the role played by the adaptation strategies in building resilience (well-being) of the social system (farmers in this case). However, the theory is inadequate in addressing the power adaptation strategies have in contributing to the resilience of the social system. The proposed study aims at adding to the resilience theory by disaggregating the adaptation strategies and categorizing them based on effectiveness in contributing to building the resilience (economic wellbeing) of the farmers.

2.4 Empirical Literature Review

Nhemachena and Hassan (2007) identified the important determinants of adaptation to climate change in South Africa, Zambia and Zimbabwe to be access to credit and extension, and also farmers' awareness about climate change. As such, that study suggested enhancing access to credit and information about climate and agronomy so as to boost farmers' adaptation to climate change and improve their wellbeing.

Gbetibouo (2009) proposed that the major driver influencing farmers' adaptation to climate change in Limpopo basin, South Africa, is the way that they formulate their expectations of future climate in dealing with the changing weather patterns. According to that study, the major factor restraining farmers' adaptation to climate change is inadequate access to credit. The study argued that among other things, the main factors that promote adaptive capacity are farmers' income, the size of the household, farmers' experience, and engaging in non-farm activities.

While analyzing farmers' perception of climate change governance and adaptation constraints in the Niger Delta region of Nigeria, Nzeadibe *et al.* (2011), pointed out that the factors responsible for hindering adaptation to climate change are inadequate information, narrow awareness and knowledge about adaptation methods, and poor government attention to climate change. Deressa *et al.* (2011), also found that education and gender of the head of the household, size of the household, livestock ownership, availability of credit and environmental temperature significantly influence the presence of farmers' adaptation to climate change. On the same note, Deressa *et al.* (2009), concluded that farmers' education, access to extension and credits, climate information, social capital and agro-ecological settings have great influence in farmers' choice of adaptation methods to climate change while financial constraints and lack of information about adaptation methods hinders the farmers' uptake of other adaptation methods.

These perceived changes could be classified as adaptation strategies for the changing climatic conditions. Adaptation measures have been established to guard farmers against losses due to increasing temperatures and decreasing precipitation (IPCC, 2007). Thus, this study aimed to analyse the effects of climate change adaptation strategies on economic wellbeing of farmers in Northern Tanzania, specifically Moshi Rural District, Kilimanjaro region.

2.5 Conceptual Framework

Figure 1 shows the structure of interrelated variables, both independent, dependent, and controlling variables, which all together shows the relationship between adaptation strategies, demographic characteristics, and economic wellbeing.

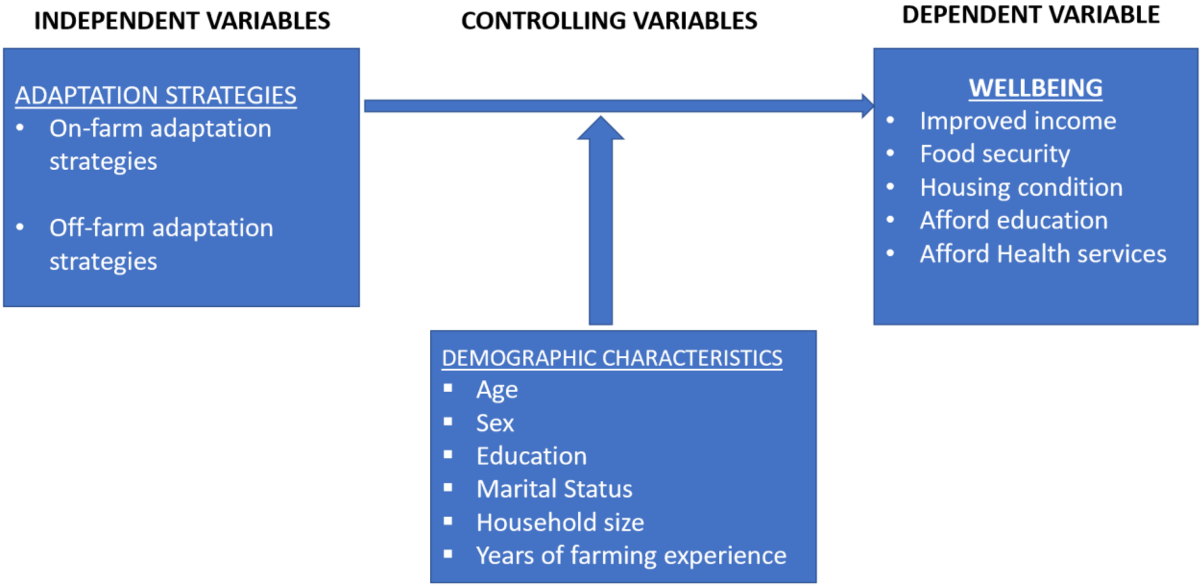

Figure 1: Conceptual Framework of the Study

On-farm climate change adaptation strategies which were included in this study are irrigation, fertilizer application, change in planting dates, crop diversification, and using of crop resistant crops. While off-farm adaptation strategies were petty businesses, casual labour, livestock keeping, and making local brew. Adaptation strategies potentially enhance crop products harvest (Nelson & Stathers, 2009; Shemdoe, 2011), which in turn improved crop harvest contributes to farmers' economic wellbeing in various ways including improving income, food security, housing condition, and affordable education and health services. Improvement of farmers' economic wellbeing implies that adaptation strategies are effective, and this leads to improvement of capacity to adapt which in turn, increases farmers' resilience to climate change.

Demographic characteristics have indirect influence on farmers' economic wellbeing; that is, they directly influence adaptation strategies. For example, age of household head indicates their experience in farming, that is, the older an individual becomes the more experience he/she gains in farming activities hence the more ready power in terms of adaptation strategies against impact of climate change (Hassan & Nhemachena, 2008). Marital status of household head can depict the power at the disposal of a household whether that household may adapt certain strategies or not. For example, households which are headed by married head of household are expected to produce more effectively hence be in a higher wellbeing level due to the fact that couples could be more capable of adapting to impact of climate change than household which were headed by singles. Regarding education, the level of education of household head potentially influences the well-being due to the fact that more formal education help people to be rational in adapting to various adaptation strategies and effectively (Hassan & Nhemachena, 2008). On the other hand, sex of household head for example, is expected to serve as an indicator of wellbeing level of a household and hence a probability of that household to adapt certain strategies such as adapting agricultural technologies and a degree of adapting to climate change impacts (Hassan and Nhemachena, 2008; Deressa *et al.*, 2010; Gatiso, 2015). Household size can potentially influence the adapted strategy to be used as it determines the manpower available in the family.

III. RESEARCH METHODOLOGY

3.1 Research Approach and Design

This study used both qualitative and quantitative research approaches and employed a case study research design to obtain details on adaption strategies to effects of climate change and economic wellbeing amongst farmers in Moshi Rural District, Northern Tanzania.

3.2 Area of the Study

Moshi Rural District is one of the seven districts in Kilimanjaro region occupying an area of 1,300 square kilometres on the Southern Slopes of Mount Kilimanjaro. The most significant physical feature in the district is the snow-capped Mount Kilimanjaro, which is the highest mountain in Africa. It extends from Rombo district in the East and Hai district in the West for about 80 kilometres. The inhabited land in the area consists of three belts; lowland belt (known as farming animals' zone) lengthens up to 900 meters above sea level, middle lands belt (specialized in maize, beans and sunflower) lies between 900 and 1200 meters, and highland belt (specialized in home-garden with coffee and banana) ranges between 1200 and 1800 meters above sea level, (Misana *et al.*, 2012; Regional Commissioner's Office, 2022). Moshi District Council like other districts in Kilimanjaro Region is a land-scarce district. The 2012 census indicated that Moshi District Council land area covers 1,713 Km² and has a human population of 466,737; of which 225,767 are males and 240,970 are females. The population density is high at 360 people per sq.km. The human population growth rate is 1.8 percent. However, the average household size is at 4.2 people. The high human population density has forced youths either to migrate to urban areas or end up doing other commercial activities rather than agricultural activities (http: //www.nbs.go.tz/sensa/popu.php). In 1988 population density was 220 people per sq.km, in 2002 population density was 236 people per sq.km while in current population census in 2022 population density was 273 people per sq.km. This implies that, the population density has increased by 19% from 1988-2022 in a fixed land of 1,713 sq.km. This increases challenges to the land resources available (http://www.nbs.go.tz). The district was chosen due to the following reasons; first, it is one of the major agricultural districts in Kilimanjaro region. However, agricultural production has ever decreased since 1970s due to climate change effects. Secondly, the district experiences recurrent climate conditions including unreliable rainfall, drought and temperature. The unreliable climatic conditions make the district more vulnerable to impact of climate change than other areas in the region. Thirdly, there is inadequate information regarding effectiveness of adaptation strategies against climate change and variability among farmers. However, the study area covered three wards out of 31 wards of the Moshi Rural District which including Kirua South, Njia Panda, and Makuyuni.

3.3 Population and Sample Issues

There are 11574 farming households out of the total of 13376 households in Moshi Rural district (National Sensa, 2022). A multistage sampling design was applied to select wards, villages and then households. This procedure allowed more than one sampling method to be used. Three wards of Kirua South, Njia Panda, and Makuyuni were purposefully selected basing on their climatic condition because the wards were more vulnerable to impact of climate change than other areas in the district. A total of six villages, two from each ward were randomly selected from the three wards. These villages were Uchira and Koresa from Kirua South ward; Mieresini and Kisimani from Makuyuni ward; Kilototoni and Mahoto from Njia Panda. A total of 90 households based on of Yamane's formula were drawn simple random sampling procedure so that each individual household had an equal chance of being selected (Yamane, 1967).

The sampling frame included Ward extension agricultural officers (WEAO), Village chairpersons (VEO), and farming households (Table 1). The category above had given the potential information about effectiveness of adaptation strategies to climate change amongst farmers in Moshi Rural District. WEAO and VEO were Key Informants (KIs) who have knowledge on effectiveness of adaptation strategies to climate change impacts and household farmers were the target study unit having experienced effectiveness of adaptation strategies and climate change impact.

The sample size was calculated as follows (Rwegoshora, 2006) in order to estimate the sample size of the study;

$$n = \frac{N}{1 + N(e)^2}$$

Where; n = sample size, N = total population, which is 11574 in this case, e = standard error, which is 0.1 in this case.

$$n = \frac{11574}{1 + 11574(0.1)^2} \approx 99$$

Therefore, the total sample size was 99 respondents distributed as shown in Table 1.

Table 1: Total Number of Respondents in the Study Area

Category of Respondents	Number
Farming Households	15@6 villages = 90
Village Chairpersons	1@6 villages = 6
Ward Extension Agricultural Officer	1@3 wards = 3
Total	**99**

3.4 Data Collection and Methods

A combination of data collection methods and techniques was used for the purpose of generating qualitative and quantitative data. Both primary data and secondary data were used. Three methods were employed; questionnaire, interview, and desk review. The application of more than one method in data collection is vital for triangulation to provide checks and balances with regard to shortfall characterized by each of the data gathering method. It enhances validity and credibility of the findings.

Quantitative data were collected through household survey method (questionnaire) from household head. Qualitative data were gathered through Key Informant Interview (KII) methods to village chairpersons and ward extension agricultural officer.

3.5 Data Analysis

Quantitative data were presented in term of percentages, frequencies in tabular forms, bar graphs, and pie charts. This made easier to analyse and interpret the results. Qualitative data, on the other hand, were presented thematically according to the themes of this study.

IV. RESULTS AND FINDINGS

4.1 Socioeconomic Characteristics of Household Farmers

These included gender, age, education level, marital status, household size, farming experience, common crop grown, and monthly income. Results showed that the study sample was dominated by men (67.8%). Indeed, female heads of households were most often widows or divorced which is usually a small population. Majority of respondents' age was above 52 years old (48.9%), and 62.2% of them were having primary level of education. Furthermore, the findings revealed that more than half of the total respondents (80%) were married, and most households were having around 4 to 6 family members (53.3%). Moreover, the findings indicate that about 60% have farming experience of more than 30 years, and the common crops grown included maize (45.6%), beans (40%), banana (11.1%), and coffee (3.3%). Lastly, on average, most farmers (55.6%) had monthly income of between 100,000 – 300,000 Tanzania Shillings. These results are presented in Table 2.

Table 2: Socioeconomic Characteristics of Household Farmers

Framers' Socioeconomic Characteristics	Frequency	Percentage
Gender (n=90)		
Male	61	67.8
Female	29	32.2
Age (n=90)		
Below 20	7	7.8
20 – 35	36	40.0
36 – 51	3	3.3
Above 52	44	48.9
Level of Education (n=90)		
Primary	56	62.2
Secondary	27	30.0
Tertiary	7	7.8
Marital Status (n=90)		
Single	18	20.0
Married	72	80.0
Household Size (n=90)		
1 – 3	18	20.0
4 – 6	48	53.3
7 – 9	9	10.0
Above 10	15	16.7
Farming Experience (n=90)		
Below 10 years	3	3.3
10 – 20 years	12	13.4
20 – 30 years	21	23.3
Above 30 years	54	60.0
Common Crop Grown (n=90)		
Maize	41	45.6
Banana	10	11.1
Coffee	10	3.3
Beans	36	40.0
Monthly Income (n=90)		
Below 100,000	5	5.5
100,000 – 300,000	50	55.6
300,000 – 500,000	27	30.0
Above 500,000	8	8.9

4.2 Evidence of the Impact of Climate Change in the Study Area

Different aspects were investigated such as change in temperature, change in rainfall, drought experienced, crop yields., and adaptation strategies.

4.2.1 Change in Temperature

Majority of respondents (90%) claimed that temperature has risen in the study area as indicated in Table 3.

Table 3: Change in Temperature

		How Temperature Changes			
		Rises	**Falls**	**The same**	**Total (%)**
If the respondents think that temperature is changing	Yes (%)	90	1	0	91
	No (%)	0	0	9	9
Total (%)		**90**	**1**	**9**	**100**

Only 1% of respondent said the temperature is falling while 9% of them claimed temperature is not changing. The Tanzania Meteorological Agency (TMA) (2022)'s 1978 – 2021 temperature records show that there was a temperature rise in Moshi district and the trend shows that the rise continues as shown in Figure 2.

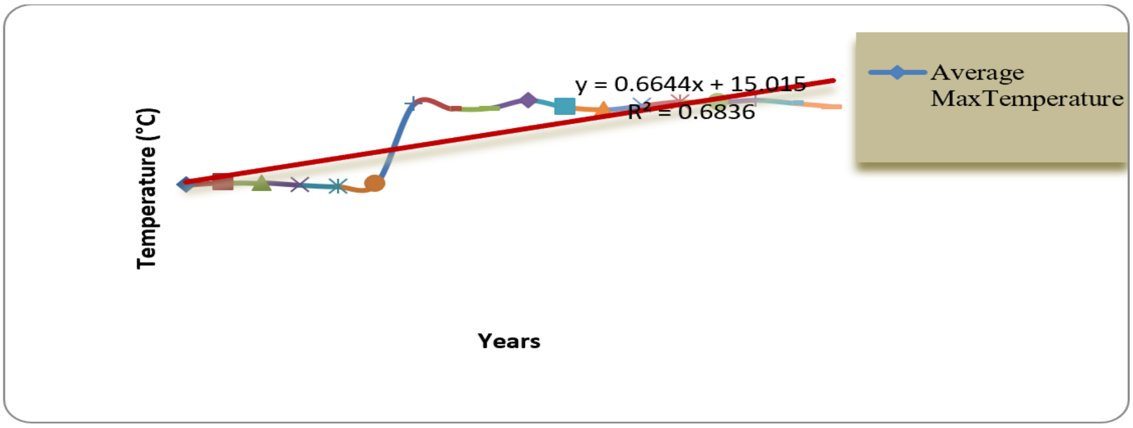

Figure 2: Maximum Average Temperature Trend in Moshi DC (1978 – 2021)
Source: Tanzania Meteorological Agency (2022)

When asked about causes of rise in temperature, majority (42.2%) blamed deforestation as being the cause of temperature rise (as shown in plate 1). 25.6% of the respondents mentioned charcoal making and use to be the cause, while 12.2% of them claimed agricultural activities to be the cause of temperature rise. Furthermore, 7.8% said overpopulation causes temperature change that has been observed in the study area. 6.6% and said burning fossil fuels and industrial activities causes temperature change respectively. The results are displayed in Figure 3.

Plate 1: Bare hills (land) due to deforestation

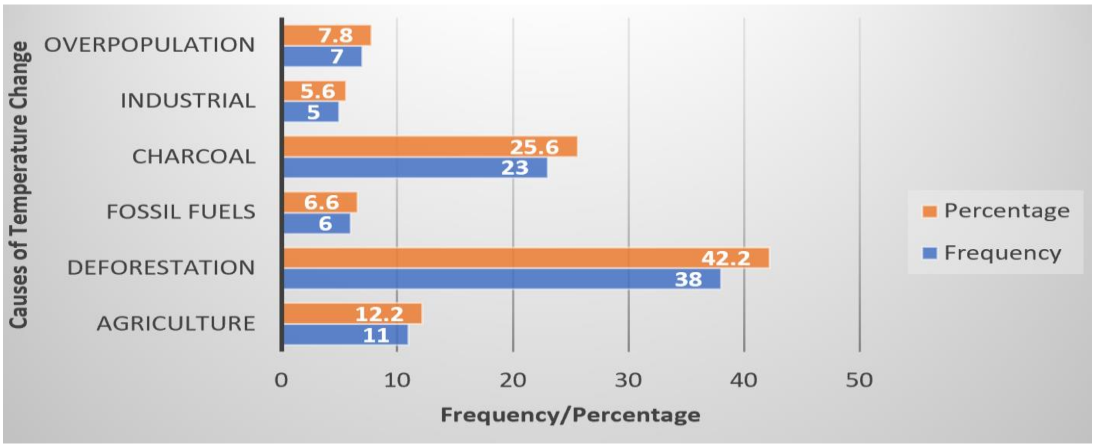

Figure 3: Causes of Rise in Temperature
Source: Survey Results

4.2.2 Amount of Rainfall

Majority of respondents (92.2%) said there is no adequate rainfall while 7.8% said there is adequate rainfall in the study area (Table 4). Average annual rainfall in Moshi district has been decreasing (TMA, 2022) as shown in Figure 4. Many regions of the World are suffering from low rainfall, combined with high temperatures, caused by global warming, a precursor for climate change (Discovery Channel, 2011).

Table 4: Rainfall Adequacy

Adequacy	Frequency	Percent
Adequate	7	7.8
Not adequate	83	92.2
Total	**90**	**100**

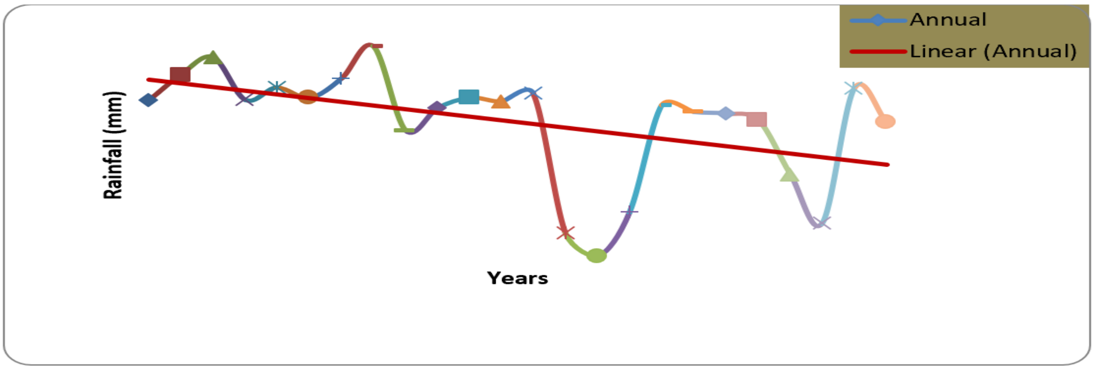

Figure 4: Annual Rainfall (1984 – 2021) in Moshi District
Source: Tanzania Meteorological Agency (2022)

4.2.3 Experienced Drought

90% of respondents said they have experienced drought in the study area while only 10% said they haven't experienced drought (Figure 5). The National Drought Mitigation Center (2014), defines drought as being when there is less rainfall than expected over an extended period of time, usually several months or longer. Scientists believe that drought conditions may increase by nearly 66% as global temperatures rise, and when these droughts get more frequent, less adapted areas can suffer severe water shortages, leading to decreased crop yields and hunger (Discovery Channel, 2011).

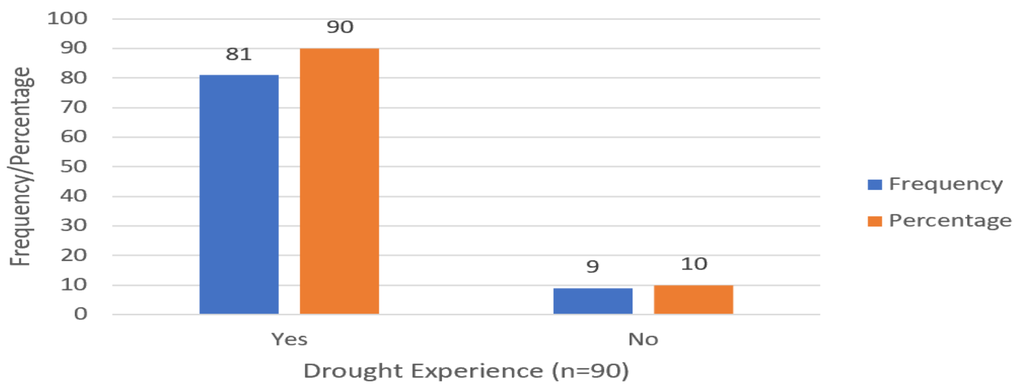

Figure 5: Drought Experience in the Study Area

4.2.4 Crop Yields Status

100% of respondents said that crop yields are generally decreasing as compared to previous years (Table 5).

Table 5: Crop Yield Status in the Study Area

Adequacy	Frequency	Percent
Increased	0	0
Decreased	90	100
Same	0	0
Total	**90**	**100**

Respondents were also asked to reveal their crop yield status ten years ago and now. In this case, maize yields were considered because it was the main crop to majority of farmers. The findings show that 3.3% of respondents were getting less than 500 Kgs of maize in previous years. However, this number has increased to 7.8% currently, implying that yields from maize has decreased significantly. Moreover, those whose were getting around 500 to 750 Kgs of maize previously accounted for 4.4%, while currently the number has also increased to 11.1% meaning that more farmers have entered in this category. Furthermore, it can be seen from the findings that the number of famers who used to get maize yields of more than 750 Kgs previously has fallen significantly as a result of climate change. The number of farmers who used to get more than 1000 Kgs previously has also fallen from 52.2% to 16.6%. This is evidence as the number of those who decreased agriculture activities increased from 2.4% previously to 55.6%. These results are indicated in Table 6.

Table 6: Current and Previous Crop Yields by Respondents

Crop yields (Kgs)	Previous		Current	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Below 500	3	3.3	7	7.8
500 – 750	4	4.4	10	11.1
750 – 1000	14	15.6	8	8.9
Above 1000	47	52.2	15	16.6
Decreased agricultural activities	22	24.4	50	55.6
Total	**90**	**100**	**90**	**100**

According to Table 6, it is true maize yields has decreased significantly. These findings imply that there is a decrease in crop yields which can be linked to the impacts of climate change including rising temperature and rainfall shortage observed in the study area while the type and farming methods remained the same among the interviewed farmers. Extreme events such as droughts can also harm crops and reduce yields as experienced in the study area (EPA, 2013).

According to Tanzania Climate Action Network (2014), duration and frequency of weather-related extreme events such as droughts and unpredictable rainfall threaten water availability and food security for millions of poor people. Despite technological improvements that increase yields of some crops, extreme weather events and low rainfalls have caused significant yield reductions in some years (USGCRP, 2009; as cited by EPA, 2013).

4.3 The Effects of On-farm Climate Change Adaptation Strategies on Farmers Economic Wellbeing

On-farm adaptation strategies that were found to have an effect on farmers' economic wellbeing are crop diversification (97.8%), change in planting dates (87.8), fertilizer application (87.8%), drought resistance crops (84.4%), and irrigation (68.9%) (Table 7). Economic wellbeing was measured in terms of improved income, food security, housing condition, affordable education and health services.

Table 7: On-farm Adaptation Strategy that Led to Farmer's Economic Wellbeing (n=90)

Adaptation Strategy	Frequency	Percent	Effect (Positive/Negative)
Drought resistant crops	76	84.4	Negative
Crop diversification	88	97.8	Negative
Change in planting dates	79	87.8	Positive
Fertilizer application	79	87.8	Positive
Irrigation	62	68.9	Positive

Some of the adaptation strategies were found to have negative influence while others had positive influence to farmers' economic wellbeing. The findings show that crop diversification (planting more than one crop) contributed negatively to farmers' economic wellbeing. Therefore, crop diversification is not an effective adaptation strategy against impact of climate change. This may be due to prolonged drought condition which made the crop harvested to have insignificant contribution to improvement of farmers' economic wellbeing. As Kihupi *et al.* (2015) argued that crop diversification adaptation strategy can become less effective when droughts are more widespread and severe. Drought resistant crop (sorghum) had been performing poorly and the production was very low (Kihupi *et al.*, 2015). Also, planting drought resistant crops seemed to have a negative effect on farmers' economic wellbeing due to the fact that, sorghum cultivation made farmers use more resources in terms of production cost and yet harvest less. This means planting sorghum is not an effective adaptation strategy in the study area and may lead to reduction in farmers' economic wellbeing hence, weakening their resilience to the impact of climate change. These findings are contrary to the findings reported by Nelson and Stathers (2009) which showed that smallholder farmers in Dodoma cultivated drought tolerant crops to overcome food insecurity hence improving their economic wellbeing.

On the other hand, change in planting dates strategy had a positive effect to farmer's economic wellbeing. The interview with key informants revealed that "farmers used to sow seeds in the soil before rains start, and at the onset of rains those seeds germinate. But nowadays if you plant seeds before rains when rain comes it may not be enough to reach the sown seeds resulting into failure of those seeds to germinate". It was also revealed that the start of rains has shifted from November to mid-December and the end of rain season has shifted from May to April. Therefore, farmers wait until it starts raining that is when they plant. Therefore, the likelihood of those who did not change their planting dates to be in a higher economic wellbeing category was less than that of those who changed their planting dates. Those who did not change their planting dates to match with the changes in onset and end of rain season were more likely to harvest less, hence, they were more likely to be in lower economic wellbeing categories. This means change of planting dates is an effective adaptation strategy, because those who changed their planting dates were likely to have good harvest hence improving their economic wellbeing and strengthening their resilience to climate change.

Furthermore, use of fertilizer significantly influenced farmers' economic wellbeing. The key informant interview showed that the possibility of farmers who did not use fertilizers in their fields to be in a higher economic wellbeing category was less than that of those who used fertilizer in their farms. This means application of fertilizer is an effective adaptation strategy against the impact of climate change. This is because application of fertilizer leads to good harvest; thus, ensuring food security and improvement of household income, hence, improvement of farmers' economic wellbeing. Finally, agriculture irrigation was one of the strategies carried out by all respondents in the study area. During interview it was revealed that there was limited access to water for irrigation. However, the findings revealed that irrigation contributes to farmers' economic wellbeing. The interview with key interviewers identified that the likelihood of farmers who did not practise irrigation farming to be in higher economic wellbeing category was less than that of those who practised irrigation farming. Irrigation can be used to supplement water requirements of a plant in case rains stop before crops maturity or during long drought spells. This made farmers who practised irrigation farming to be sure of harvest than those who did not. This means irrigation as an adaptation strategy against impact of climate change is effective and can contribute to the improvement of farmers' economic wellbeing as well as strengthening their resilience to climate change. Tanzania water policy (URT, 2002) states that irrigation provides protection against drought, ensures availability of food reserve and improvement of income. The findings are similar to those of Gbetibouo (2009) in Limpopo Basin South Africa and Deressa *et al.* (2009) in the Nile Basin of Ethiopia which show that irrigation water increases farmers' resilience to climate change.

4.4 The Effects of Off-farm Climate Change Adaptation Strategies on Farmers Economic Wellbeing

Petty businesses (83.3%), livestock keeping (66.7%), and casual labour (56.7%) were found to have an effect on farmers' economic wellbeing. Making local brew (23.3%) was deemed insignificant since its score was below 50% as shown in Table 8.

Table 8: Off-farm Adaptation Strategy that Led to Farmer's Economic Wellbeing (n=90)

Adaptation Strategy	Frequency	Percent	Effect (Positive/Negative)
Petty businesses	75	83.3	Positive
Casual labor	51	56.7	Negative
Making local brew	21	23.3	-
Livestock keeping	61	66.7	Negative

Petty business was off-farm adaptation strategy against the impact of climate change reported by respondents from the study area. Involving in non-farm activities such as petty business helps in reducing the impact of climate change. In a prolonged drought situation, income obtained from petty business can be used to buy food and other necessities. Income obtained from petty business can also be used in improvement of agricultural production through different adaptation strategies against the impact of climate change. Petty business helps farmers to buy agricultural inputs and food supplement in case of food crop failure due to climate change. This means involvement in petty business as an adaptation strategy against the impact of climate change is effective in improvement of farmers' economic wellbeing. These findings are similar to those of Simbarashe (2013) who reported that diversification of livelihood activities such as petty trading activities widened the farmers' source of income and thus enhancing their economic wellbeing.

On the other hand, casual labour was one of the adaptation strategies against the impact of climate change in the study area. However, it was found to have negative effect on famers' economic wellbeing. Findings revealed that farmers who were involved in casual labour were more likely to be in a lower economic wellbeing category than those who were not involved in casual labour. Interview with key interviewers revealed that most of casual labour activities in rural areas are available during rainy season. So, most of farmers who were involved in casual labour spent more time in casual labour activities than in agriculture activities so that they can get money to buy food and other necessities. They thus consequently end up having low harvest leading to food insecurity status in their households (Kihupi *et al.*, 2015). This implies that involvement in casual labour as an adaptation strategy against climate change is not effective as it leads to harvesting little hence, food insecurity, less income and eventually low economic wellbeing.

Making local brew was done by 23.3% of the total respondents (Table 8). However, the findings show that local brew making is insignificant as the percentage of respondents is far less than 50%. This may be due to the fact that local brew making uses maize, so in case of low harvest local brew making may lead to food insecurity and hence this adaptation strategy was found to be ineffective against impact of climate change.

V. CONCLUSION AND RECOMMENDATIONS

Climate change impacts in Moshi district are evident and already compromising livelihoods of farmers by decreasing their crop yields and hence food security, posing a burden of adaptation practices among them. Temperature rise, shortage of rainfall, droughts and decreased crop yields have been observed and severity is likely to increase if no immediate interventions are put forward to arrest the situation. In dealing with climate change impact, farmers use crop diversification, change in planting dates, fertilizer application, drought resistance crops, petty businesses, irrigation, casual labour engagement, planting early maturing crop varieties, agriculture diversification, and livestock keeping. However, of these, only planting early maturing maize varieties, change in planting dates, irrigation, application of fertilizers, and involving in petty business seem to work effectively and improve farmer’s economic wellbeing in the study area. There is a need for farmers to depart from relying on rain fed-agriculture instead to be developing heavy utilization of irrigation. This will be achieved through government support by construction of infrastructures which could be regarded as crucial for climate change adaptation. Also, the Government needs to ensure that specific information about climate change is easily accessible to farmers. Without solid scientific information public and private sector decision makers cannot design logically.

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