

EVALUATION OF RAINFALL VARIABILITY ON MAIZE PRODUCTION IN HAI DISTRICT KILIMANJARO, TANZANIA

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ABSTRACT: The study aim was to evaluate the rainfall variability on maize production in Hai district Kilimanjaro, Tanzania. The study was guided by three research objectives to establish the state of food security among the community in Hai district, to evaluate the effects of rainfall variability on maize production in Hai District, to evaluate the existing rainfall variability adaptation strategies practiced by farmers in Hai District. The study adopted a mixed research design under which convergent parallel design was used. The study targeted population was farmers, agriculture officers and agriculture executive officers. Questionnaires, interview, and observation was used as data collection instrument, Descriptive analysis involved organizing data in terms of frequency, percentages and means where computer software that is statistical package for social science (SPSS) version 20 was used. Data analysis was done after making some editing to display visual results in terms of tables.

INTRODUCTION

1.1 Background of the Research Problem

Global average precipitation and evapotranspiration are estimated to increase by 3 to 15% and it is predicted that rain fed crop yields in some countries will decrease by 50% (IPCC, 2017). Generally, rainfall changes are likely to reduce yields of

desirable crops and increase the likelihood of crop failures in the short run and a decline in production in the long run. Although there will be gains in some crops in some regions of the world, the overall impacts of rainfall changes on crop production are expected to be negative (Rosenzweig et al., 2018).

In Sub-Saharan Africa (SSA), agriculture plays an important role in providing food and income for the majority of the population. In Tanzania it (agriculture) is a key to economic development as over 70% of the population depend on agriculture, which is almost entirely rain fed, despite that the rainfall is increasingly becoming unpredictable and unreliable due to its variability (Majule et al., 2019). Rainfall variability (RV) is the fluctuations of rainfall occurrence annually or seasonally above or below a long-term normal value. Every year in a specific time period, the rainfall of a location can either be above or below normal value (IPCC, 2017).

The Rainfall variability (RV) is associated with either too much rainfall or a decrease in rainfall amount. This means that RV may be associated with either floods or drought, which is often linked with food insecurity, water shortage, death of people and destruction of animals and properties (Omeny et al., 2018). As reported by Majule and Karonga (2019), RV is rapidly emerging as one of the most serious global problems affecting the agricultural sector and is considered to be one of the most serious threats to sustainable development with adverse impact on agriculture, food security, and economic activities.

In Tanzania, rainfall variability is a major cause of yield variation of most major crops, although other factors such as soil type, shortage of extension services, lack of agricultural inputs, and supervision practice may also play a role in the reduction of crop yield (Hamis, 2018). The climate of Tanzania has precipitation with an average annual rainfall of 600–800 mm in the Eastern part, more than 500mm in the central part, 1200-1600 mm in the Lake Victoria zone and 500-1200 mm in the northern part. Northern regions experience two rainfall seasons which come in March-May (MAM) and October- December (OND). The MAM rains are heavier and last longer, and whose amounts are abundant and have lesser inter annual variability as opposed to the OND rains (Black et al., 2017).

Maize is the major and most preferred staple food and cash crop in Tanzania (Rates, 2003). It accounts for 31 per cent of the total food production and constitutes more than 75 per cent of the cereal consumption in the country (Seth et al., 2011). As reported by Kirway et al. (2020) small-scale farmers produce 85 per cent of maize in Tanzania, which is often consumed at the household level, while commercial production accounts for 15 per cent. Furthermore, maize production constitutes a significant component of agricultural development and livelihood sustainability for rural as well as urban dwellers of Tanzania because of its importance and ability to grow almost everywhere in the country.

Maize yields, food production, an increase of plant pests and diseases, an increase of pastoral livestock that graze on farmland, an increase of food shortages at a household level and changes in the cropping pattern of commercial maize production are all a result of changes in rainfall patterns (FAO, 2018). These effects on crop production have been associated with various adaptation and coping mechanisms including mixed crop and livestock farming systems which are practiced by small holder farmers. Crop livestock mixed farming systems whereby crops and livestock are integrated on the same farm are the backbone of smallholder production in Tanzania as is the case in the rest of developing countries in the tropics (Hererro et al., 2017).

1.2 Statement of the Research Problem

Agricultural activities in the area depend on rainfall whose variability has caused negative effects on the crop production such as increase of plant pests and diseases, increase of food shortages. However, there are coping strategies which have been developed and emphasized by Africa rising project such as mixed crop and livestock farming systems whereby crops and livestock are integrated on the same farm. The project creates opportunities for smallholder farming households to get out of hunger and poverty through sustainably intensified farming systems Lukuyu, (2010).

Maize based schemes are intercropped with various leguminous crops and livestock breeds are widely found in the district. Since there is rainfall variability, which leads to drought and shortage of rain fall, however, relatively insufficient information on

the significance of the technology as an adaptation strategy to rainfall variability among small holder farmers in Hai district.

The study conducted by Lungu, (2020) on mixed crop-livestock production systems by smallholder farmers in sub-humid and semi-arid area in Zambia revealed that crop livestock mixed farming systems help small holder farmers to mitigate uncertainties of rainfall variability. Therefore, the information gathered that would be gathered will be valuable to decision makers in promoting the technology in the entire study area and other areas facing variability in rainfall in Tanzania. The findings would also provide inputs in assisting in poverty alleviation programs among farming households in Hai district.

1.3 Objectives

1.3.1 General Objective

The study was assessing the rainfall variability on maize production in Hai District, Kilimanjaro Tanzania.

1.3.2 Specific Objectives

- i. To analyze the state of food security among the community in Hai district, Tanzania
- ii. To explain the effects of rainfall variability on maize production in Hai District, Tanzania
- iii. To assess the existing rainfall variability adaptation strategies practiced by Small Scale Farmers in Hai District, Tanzania

1.4 Research questions

- i. What is the state of food security among the Small Scale Farmers in Hai district, Tanzania?
- ii. What are the effects of rainfall variability on maize production in Hai district, Tanzania?
- iii. What are the existing rainfall variability adaptation strategies practiced by Small Scale Farmers in Hai District, Tanzania?

1.5 Significance of the study

- i. To the Small-Scale farmers, the study provides useful information regarding rainfall variability impacts on maize yields and by extension and helps them to evaluate their adaptation strategies towards rainfall variability.
- ii. The study may increase an understanding of rainfall variability on food security in Hai district, through formulating mitigation and adaptation practices that have positive outcome in this particular area.
- iii. The study may also inform the Small Scale Farmers of Hai district on effectiveness of the already adopted strategies, inform the stakeholders of the rainfall variability and food security status in the area.

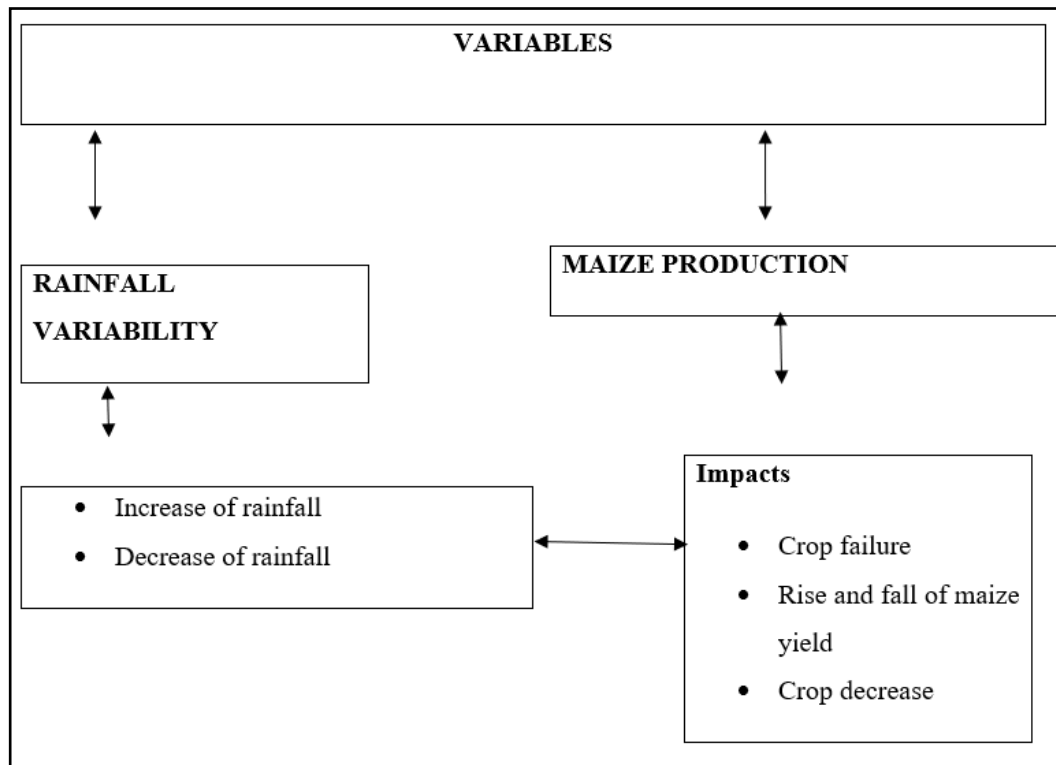
1.6 Scope of the Study

The study focused on evaluating the effect of rainfall variability on maize production in Hai district- Kilimanjaro region. The research study focused on respondents in Hai district especially on rural areas where the farmers depend on rainfall for maize and other food crops. The study was conducted in Hai district because most of farmers depend on maize production. Also, the study was done in Hai district since it is easier to collect the information due to time factor, accessibility and the size of geographical distribution of the population.

1.7 Conceptual Framework

Conceptual framework; this is a chart presentation of the interrelationship between two variables from the research title (Mekonnen, 2015). It shows how variables depend on each other and their results by direction of arrows across one another. The following table below shows the conceptual frame work between rainfall variability's and maize production in the study area. The relationship between the variables on this research is has formed by the conceptual frame work below on the chart, rainfall variability is the degree to which rainfall amounts vary across an area or through time, it is an important characteristic of the climate of an area and has two components i.e. spatial and temporal variability (Banchiamlak and Mekonnen, 2010).

CONCEPTUAL FRAMEWORK



Source: Figure 1: Adopted and Modified from Naab (2017)

LITERATURE REVIEW

2.0 Introduction

This section consists of both theoretical and empirical reviews of previous studies. The reviews of literature were done for the aim of learning what has been done by researchers and other scholars and identifying the knowledge gap which was covered by this study.

2.1 Definitions of Key Terms

Adaptation strategies: This is adjustment to ecological, social or economic system in response to observed or expected changes in climatic stimuli and their effects and impact (Agrawal, 2018)

Climate Variability: Variations in the statistical distribution of weather patterns on a temporal and spatial scale. In this study climate variability has been operationalized to mean rainfall and temperature variability (Nelson, and Palmer, 2017).

Climate Change: Is any change in climate over time that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere in addition to natural climate variability observed over comparable time periods (Blummel et al., 2016).

Food Security: when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (Maghimbi, 2017).

Vulnerability: It refers to the susceptibility of a human society to adapt to the effects of climate change and variability (IPCC, 2017).

2.2 Review of Related Theories

2.2.1 The Greenhouse Theory of Climate Change

According to by J. Fourier (1824) Climate change can dramatically alter the Earth's snow-and ice-covered areas. Unlike other substances found on the Earth, snow and ice exist at temperatures close to their melting point and can thus change between solid and liquid states in response to relatively minor changes in temperature. As a result, prolonged warming or cooling trends can result in significant changes across the landscape as snow and ice masses shrink or grow over time. Countries in sub-Saharan Africa are likely to suffer the most devastating impacts of climate change because of their geographical location, low incomes, low technological and institutional capacity to adapt to rapid changes in the environment, as well as their greater reliance on climate-sensitive renewable natural resources sectors such as water and agriculture.

2.2.2 Strengths of Theory

Global warming is thought to be caused by the greenhouse effect. Energy from the sun reaches the earth's surface and warms it, without the greenhouse effect, most of this energy is then lost as the heat radiates back into space. All the countries of the world that depend on rain for cultivation, their production of crops decrease seriously due to droughts.

2.2.3 Weakness of the Theory

However, the presence of so-called greenhouse gases at high altitude absorbs much of this energy and then radiates a proportion back towards the earth's surface. Causing temperatures to rise, Agriculture activities become low due to increase of high temperature and low rainfall.

2.2.4 The Applicability of the Theory

The theory is related to this study as can affect the production of food production due to increase of temperatures in the country. Thus, the socio-economic activities around the agriculture sector tend to be affected and reduce the crop yield in the farm. If Greenhouses gases like carbon dioxide, fluorocarbon cannot be controlled then the food insecurity occurs since the small-scale farmer depends on much of rainfall in their production activities.

2.4 Empirical Reviews

This part consists of sections which include establishing the state of food security among the community in Hai district, to evaluate the effects of rainfall variability on maize production in Hai District, and to evaluate the existing rainfall variability adaptation strategies practiced by farmers in Hai District.

Table 2: Summary of Empirical Review

S/N	Author	Year	Theme	Weakness	Relevance
01	Mbilinyi et al	2018	The study explains the effect of climate change on maize production and food security in Swaziland	The study talks on general on climate change on maize production and food security in Swaziland	This study is relevant to the objective number two
02	Mkonda	2018	The study explains the climate variability and how it affects crop yields synergies in	The study measuring climate variability on synergies in Tanzania	This study is relevant to the objective number three

			Tanzania's semi-arid agro-ecological zone.		
03	Ajuaye	2019	The study explains the adaptation mechanisms to climate change in Kilimanjaro region	The study shows only short-term adaptation mechanism and not the long-term adaptations	This study is relevant to the objective number three.
04	Mwandosya	2018	The study explains the assessment of vulnerability and adaptation to climate change impacts in Tanzania	The study did not show the current state of food security resulted from rainfall variability.	The study is relevant to the objective number one
05	Katunzi	2019	The study explains the impacts of climate variability on maize crop production in Tanzania	The study did not show the impact of climate variability on Hai district rather show the general situation of climate in Tanzania regions	The study is relevant to the objective number two
06	Morton	2020	The study explains the consequences of rainfall variability in Tanzania and east Africa	The study did not show what are the factors that contributed to rainfall variability	The study is relevant to the objective number two
07	Aggarwal	2017	The study explains the Climate Change Impact, Adaptation and Mitigation in Agriculture	The study did not show the driver of climate change	The study is relevant to the objective number three
08	IPCC	2017	The study explains the	The study did not	The study is

			Impacts, adaptation and vulnerability.	explain the factors contributed to the impacts of rainfall variability	relevant to the objective number two and three
09	Paavola	2017	The study explains the rainfall situation trends in Tanzania	The study did not explain the causes of variability of rainfall.	The study is relevant to the objective number one
10	Lema	2019	The study explains the Vulnerability of Food Availability to Climate Change in Hai District, Kilimanjaro	The study did not explain the causes of climate variability and its effects on maize production	The study is relevant to the objective number two

2.5 Knowledge gap

From the studies on the rainfall variability, it found that the rainfall variability causes a number of effects in agricultural production. According to Ajuaye,(2010), Mkonda, (2018), Lema (2019),Paavola, (2017), IPCC, (2017), Aggarwal, (2017), Mortone al, (2018), Katunzi, (2019) and Mbilinyi et al,(2018), majority of the farming households acknowledged occurrences of rainfall variability in their localities for the past years that climate change and variability have impacted crop farming system in different ways such as, damaging of crops and persistent low yields, reduction of crop varieties and species, decreasing soil fertility, increasing crop pests and diseases and drying of water sources. But they did not deal with the rainfall variability on maize production. Therefore, the purpose of current study was to evaluate the rainfall variability on the maize production in Hai district.

RESEARCH METHODOLOGY

3.0 Introduction

This chapter presented the research design and methodology of the study which comprise of research design, description of the study area, targeted population, description of sample and sampling techniques, description of data collection

instruments, description of data collection procedures and description of data analysis procedure, ethical consideration and rationale for selecting the study area

3.1 Research Design

According to Miller (2006) defines research design as a master plan to specifying the methods and procedure for collecting and analyzing the needed information. The study was adopted a mixed research design under which convergent parallel design was used. Convergent design allows the researcher to collect both qualitative and quantitative data on one visit to the field area. Qualitative research design was used to create meaning and new knowledge, to qualify data. It is highly objective to use statistical tools to analyse and interpreted the result about the data (fisher et al, 2014). Qualitative research design, this is based on the quality (Maxwell, 2012).

3.2 Description of the Study Area

Hai District is one of the seven districts of the Kilimanjaro Region of Tanzania. It is bordered to the south and west by the Arusha Region, to the west by the Siha District, and to the east by the Moshi Urban District and Moshi Rural District and the Rombo District.

MAP SHOW HAI DISTRICT

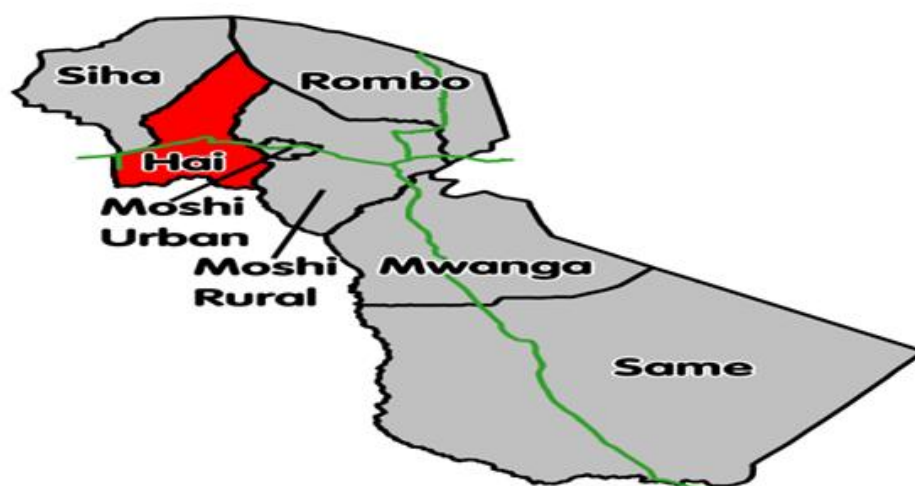


Figure 3.1 Map Show the Location of the Study Area.

Source: Modified and adapted from Google (2025)

3.3 Target Population

According to Kothari, (2014), Define Population as set of people, services, events group of things or households that are being investigated. The target population of the study was Hai district Kilimanjaro Tanzania. The sample involved the respondents in the selected villages including the Agriculture officer, farmers, and village executive officers.

3.4 Description of Sample and Sampling Process

The units of analysis for this study were the farmers, agricultural officers, and individuals, Sample involved the small portion selection from the whole population.

3.4.1 Sample Size

A sample is comprised of a small group drawn from a population, carefully selected to closely reflect the characteristics of the population (Charles and Martler, 2016). A sample is the only group of the population that is studied and the findings are inferred to the entire population.

Sampling is a process or technique of choosing a sub-group from a population to participate in the study; it is the process of selecting a number of individuals for a study in such a way that the individuals selected represent the large group from which they were selected (Ogula, 2005). Simple random sampling used to select farmers to participate in the study; whereby the researcher select farmers from Mbweera, Mboreni and Sonu Villages.

Therefore, the sample number was

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

Where by

n=Sample size

N=Total number of populations

e=Maximum error limit (10%) e=0.1

n=?

Whereby

Population of Mbweera= 23734

Population of Mboreni= 18,976

Population of Sonu= 9,669

Total Population= **52,379**

Standard error= 0.1

From the formula

$$S = \frac{52,379}{1 + 52,379 (0.1)^2}$$

Answer=99.8

=100

Therefore, the researcher used the sample size of 100 respondents.

Table 1: Overall of the Sample Size of the Target Population in the Study Area

S/N	Categories of sample size	Number of sample size	Percentage of sample size	Sampling techniques
1	Farmers	95	95%	Random sampling
2	Agriculture officers	2	2%	Purposive sampling
3	Villages executive officer (VEO)	3	3%	Purposive sampling
4	Total	100	100%	

3.4.2 Description of Sample and Sampling Procedures

A sample of participants was selected through simple random sampling and purposive sampling, the sample included 3 agricultural officers in which one was

selected from the villages, and 3 village executive officer was selected from each ward, and 95 village farmers was selected randomly from each ward and gave the total of 100 respondents.

3.4.3 Ward Sampling

The research used stratified sampling technique in choosing ward. In this study analysis one ward was selected, through the use of random sampling due to the potentiality and reliability of information.

3.4.4 Agricultural Officers Sampling

The study involved agricultural officers responsible for management of farming activities at Hai district; this is due to the fact that because of their administrative position and as the immediate supervisors of the agricultural activities.

3.4.5 Village Leaders Sampling

Two leaders was selected from the ward through random sampling strategy the leaders in the village who was present during the time of collecting data in the study area.

3.5 Description of Data Collection

The study was intended to use interview method, and Questionnaires and as technique to collect data and information from the sample selected and area of the study. The overall aim of the study was to evaluate the rainfall variability on maize production in Hai district. All data collection lies on primary and secondary data, the research focused on the methods above to collect information.

3.5.1 Primary data

Kothari (2014) defined primary data that are those which are collected a fresh and for the first time and thus happen to be original in character. The data was collected by the researcher on the field area and served vital in bringing answer to research objectives and questions. In primary data involved questionnaire and interview

methods. In this primary data the researcher helped to get the reality of the situation in the field as it able to observe different issues pertaining to his/her study.

3.5.2 Secondary data

These are data that always collected from written documents, in this study secondary data was collected through literature review method that is normally found from the organization concern (Kothari, 2015). In secondary data the researcher helped to get the view of other scholars who did the studies on the same issues in other places so as to be able to know what has been done and what should be done.

3.6 Data Collection Method

3.6.1 Questionnaire

3.6.2 Interview Method

3.7 Data Analysis Procedure

Data collected was analyzed both qualitative and quantitatively. Qualitative data was collected and analyzed by using statistical package for social science and Microsoft excel spread sheet. Descriptive and inferential statistics was presented inform of percentage bar graph.

3.8 Ethical Consideration

Ethics is referring as the basic concept and fundamental principles of human conduct. It includes study of universal value such as the essential equality of all men and women, human or natural rights, and obedience to the law of the land, concern for health and safety also for the natural environment. The main ethnic group in Moshi rural district especially Chagga, these ethnical groups especially Chagga are predominantly practice small-scale agriculture and keeping animals as well as trading activities (Danis, 2012). This was helpful in collecting of data of the objective one and objective three in the study.

PRESENTATION OF THE FINDINGS AND DISCUSSIONS

4.0 Introduction

This chapter presents the data analysis, presentation, interpretation of the data collected in the study and discussion of the findings. Findings are presented based on

the research objectives namely to analyze state of food security among the community; to explain the effects of rainfall variability on maize production and to assess the existing rainfall variability adaptation strategies practiced by Small Scale Farmers in Hai District, Tanzania

4.1 Demographic Information of Participants

This section presents information on demographic characteristics of respondents who participated in this study. The information required based on gender, age, education level, economic activities, and living duration. The data of demographic information of respondents were summarized and presented in figure 1. Demographic information of ward executive was not presented since they are interviewed.

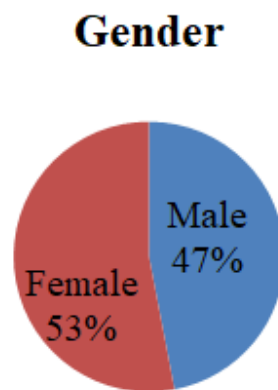


Figure 4.1 Gender of the Respondents

Source: Respondents (2025)

Figure 1 indicates that 53.0% of the respondents were female and 47.0% of the respondents were male. This implies that female were more than male in the study. The reason behind was that during the collection of data, the researcher was able to meet with female more than male since that female were highly motivated to give their views about the evaluation of rainfall variability on maize production that they had enough time compared to male who did not motivated to participate because they had no enough time to participate in the study. According to Kiyingi (2017), Gender issues, as a part of development approach and agriculture development people at the center and ensures their participation in their entire development process.

4.1.1 Marital Status

Marital status; refers to one's situation with regard to whether one is single, married, separated, divorced, or widowed (Alfred, 2018). The intention of the study was to include marital status and to investigate which groups of respondents who were married, single, widowed and divorced that most participate more in economic issues including industrial activities.

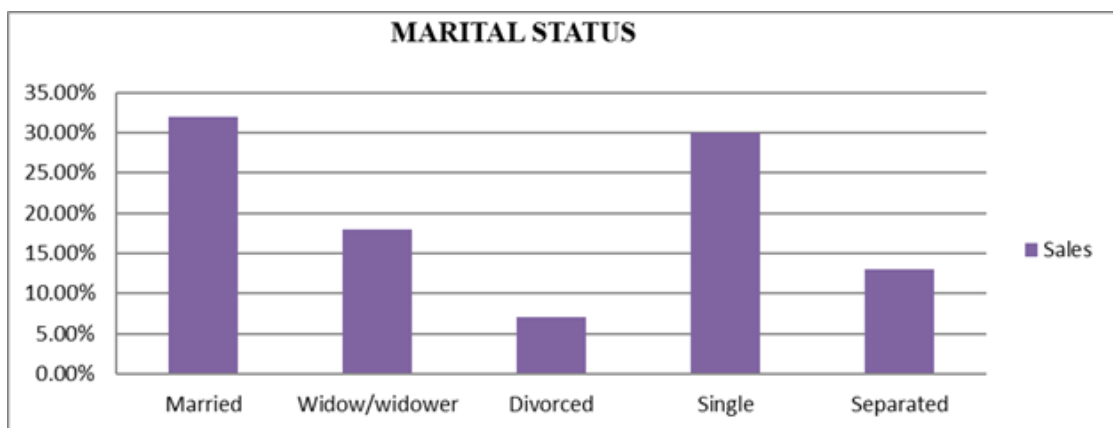


Figure 4.2 Marital Status of the Respondents

Source: Respondents (2025)

The results in figure 2 show the marital status of the respondents 30.0% of the respondents were single, 32.0% of the respondents were married, 18.0% of the respondents are widow, 13.0% of the respondents were separated and 7.0% of the respondents are divorced. The higher percentage of married may suggest that there is high possibility of understanding the extent of the problem since as the ones who are experience rainfall variability on maize production within the household as observed by Mandara (2018). Phillip and Abdillahi (2013) observed that married couples show a high level of experience on the impacts of climate variability since are one who engage in cultivation in rural villages so as to feed their family.

4.1.2 Economic Activities

The findings intended to know the history of the activities conducted by the local community in Hai district where they get income through those activities including farming, farming and livestock, farming and petty trade, formal employment and other activities.

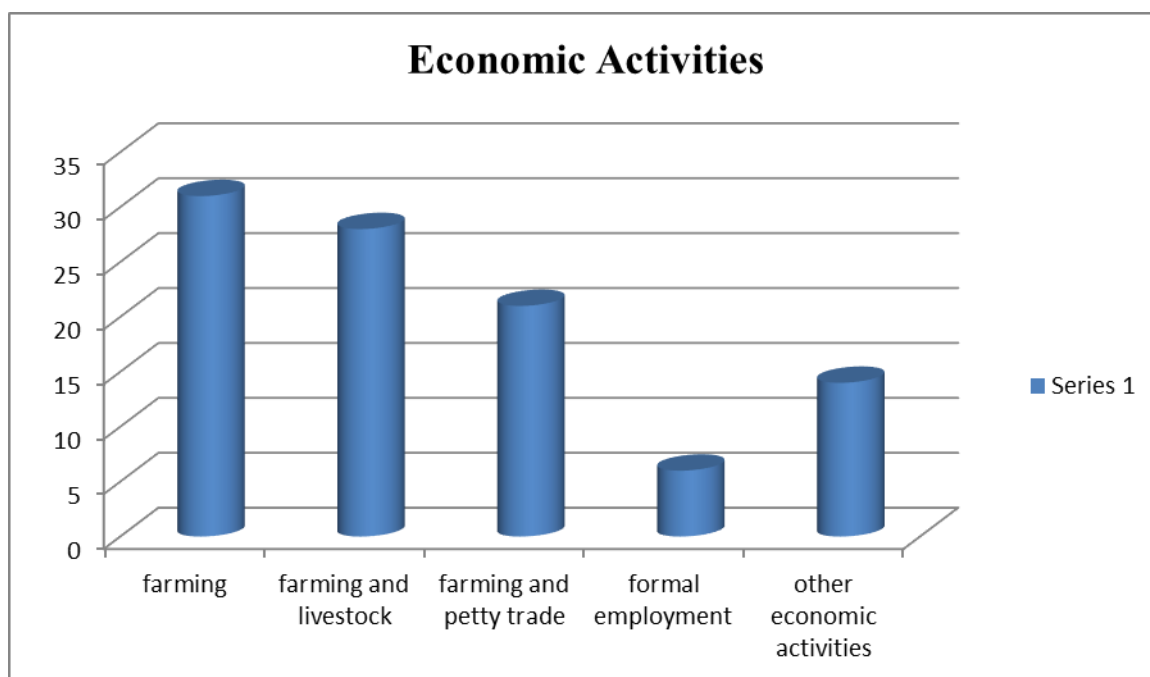


Figure 4. 3 Economic Activities of the Respondents

Source: Respondents (2025)

From the figure 3 the results indicate that 31.0% of the respondents are farmers, 28.0% of the respondents are farming and livestock, 21.0% of the respondents were engaged in farming and petty trade, 6.0% of the respondents were in formal employment and 14.0% of the respondents were engage in other economic activities. The findings revealed that high number of respondents were engaging in farming activities and livestock as the activities related to the use of water such as Irrigation, the farmers seemed to be affected in the cultivation process since the area is semi-arid and water is needed more to enhance irrigation process, moreover the same discussion found by the current study by Sekondo, (2016) who investigated about response of individual's economic activities and found that economic was important to everyone in rising economic status of individuals hence the rainfall variability hinder economic progress of people in study area.

4.1.3 Source of Income

The study viewed that the respondents were different sources of income in the field study. It viewed that there were sale of crops, sales of livestock, pension and business

Table 4.1 Source of Income

Sources Income	Frequency	Percent
Sale of Crops/Vegetables/Fruits	42	42.0
Sale of Livestock/Milk/Eggs	18	18.0
Pension (Old Age Pension)	5	5.0
Business/ Petty Trade	35	35.0
Total	100	100.0

Source: Research Field Data (2025)

The results in table 4.4 show the sources of income of the respondents. The findings show that 42.0% of the respondents sale crops/vegetables/fruits, 18.0% of the respondents earn through sales of livestock/milk/eggs, 5.0% earn their income through pension, while 35.0% of the respondents earn their income through business/petty trade. This implies that majority of the household earn their living through selling livestock and this encourages them to feed their families and accessing their basic needs. According to Ellis (2017), livelihood encompasses income (both cash and kind), as well as social institutions, gender relationships and property rights required to maintain or sustain a given living standard. Moreover, it was observed that some farmers in the villages did not have enough income to support and sustain their livelihoods during extreme weather events. As such, during drought, farmers complained of food shortages due to inadequate production as well as lack of cash to purchase food from the markets.

4.2.4 Education Level

In this case, education level refers to the highest level of school you have completed. The aims of the findings interested to search about education status of respondents this was due to fact that the researcher intended to know knowledge and awareness of people who participated in the study, however the results presented in figure 4.5 below

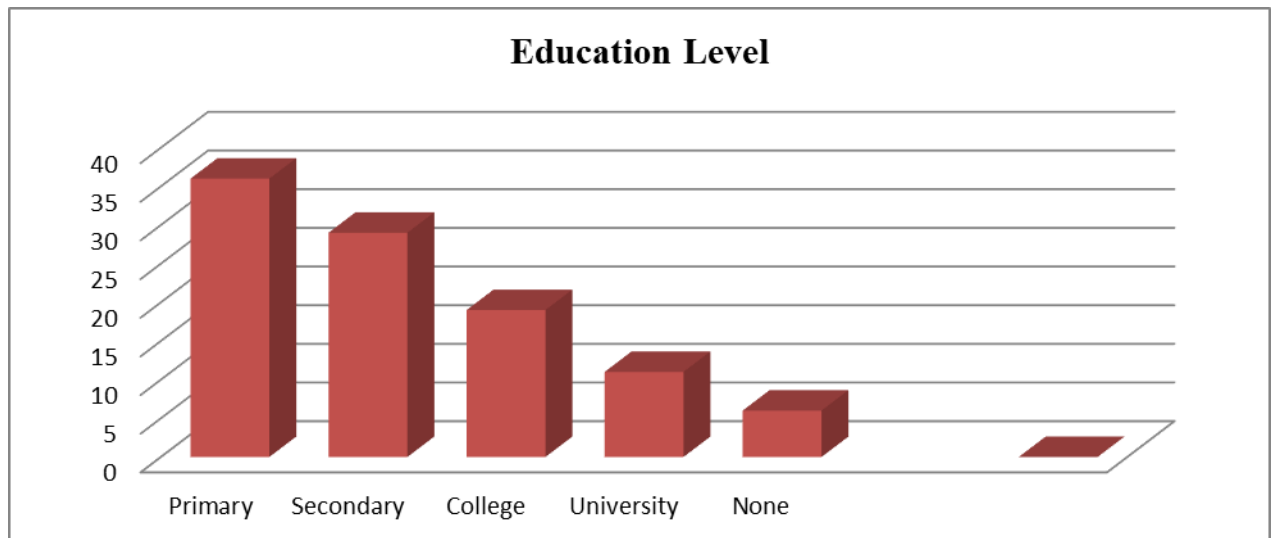


Figure 4.4 Education level of the Respondents

Source: Research Field Data (2025)

Education is always valued as a means of deliverance from ignorance and enables one to perform effectively to any given task within a specified period (Kasanga, 2015). The results in figure 4 shows that 36.0% of the respondents have primary education level, 29.0% of the respondents have secondary education level, 6.0% of the respondents were no formal education and 19.0% of the respondents have attain college education level. From the findings implies that majority of the respondents were attain primary education level the reasons behind for high level of primary education in the study area might be due to measured effort made by the government in 1978 to expand primary education in the country which was made compulsory for all children (URT, 1996) and the Primary Education Development Programme introduced in 2000s increased enrolment for primary school children (URT, 2017). The low number of respondents who had secondary and university education could be explained by the fact the awareness of people about schooling are low

4.2.5 Land Ownership

The researcher wanted to know on the extent on land ownership of the respondents by providing questionnaire to the respondents that shows amount of owning the land in acres and the data were summarized on the figure 4.2 below.

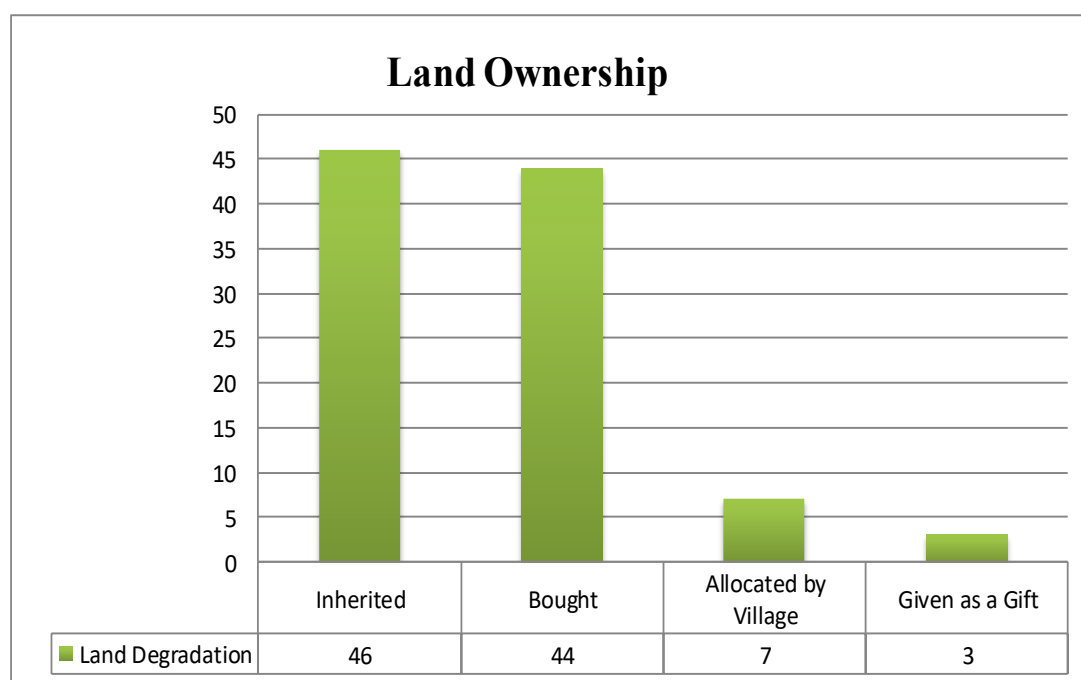


Figure 4.5 Land Ownership of the Respondents

Source: Research Field Data (2025)

The results in figure 5 show the land acquisition by the households. The findings from the table indicate that 46.0% of the respondents acquire land through inheritance, 44.0% of the respondents acquire land through by bought, 7.0% of the respondents acquire land that are located by the village and 3.0% of the respondents acquire the land through as a given gift from their friends and family members. This implies that land acquisition in the Hai district based on social customs as the member of family, friend provide land for their fellow as a gift to construct their settlement. The result is conquered with the Chamberlin (2018). Who conducted the study on inter district variation in farm landholding pattern in Tanzania to determine on how differences in localized farmland structure affect rural household income using nationally representative household panel survey data, Small-scale farmers operate mostly in rural areas, and are the biggest group in the agricultural sector as a whole and the owner land at big area.

4.2.6 Rainfall Variability

The researcher wanted to understand concerning the rainfall variability in Hai district in which the respondents were questioned about the occurrence of rainfall variability in their district through responding by said yes and no.

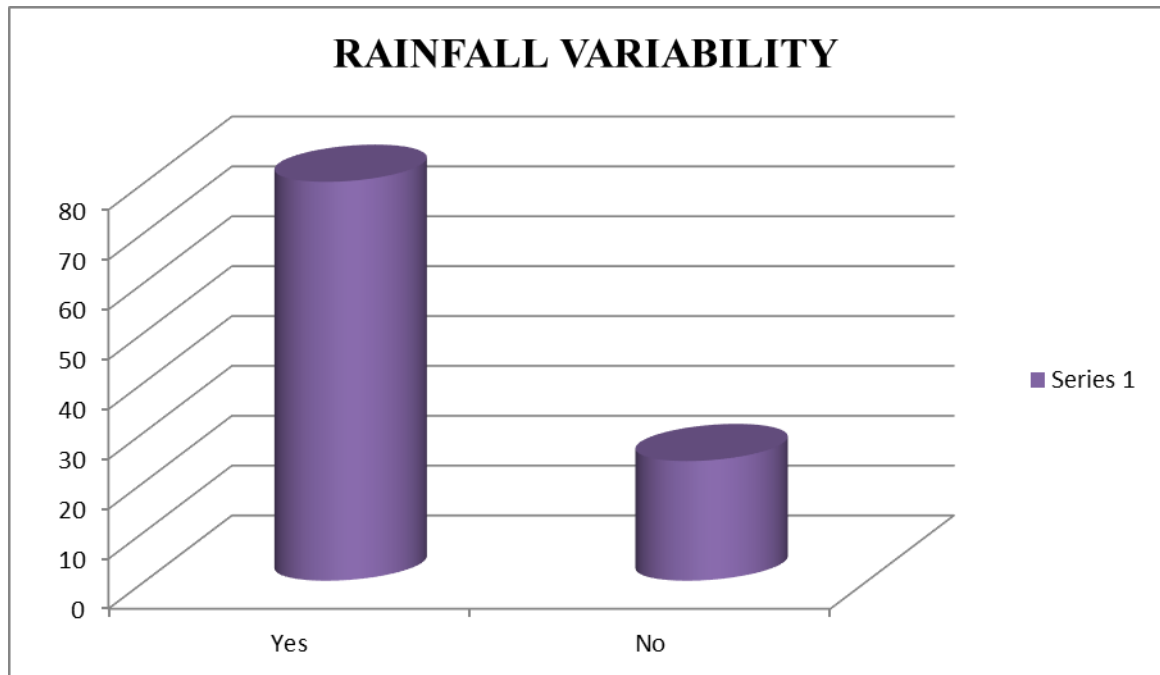


Figure 4.6 Responses on Rainfall Variability
Source: Research Field Data (2025)

The result from figure 6 shows the rainfall variability within Hai district, The finding shows that 80.0% of the respondents declare that there rainfall variability in the village to the extent that affecting the maize production and food security, while only 24.0% of the respondents have never notices the rainfall variability. This implies that the majority of the farmers in Hai were affected by rainfall variability to the extent that they fail to get the good yield of the maize crop compared to the other past ten years. The findings are supported with the study done by Ngana (2013) who argue that the presence of dry spells in critical periods contribute considerably to crop failure and famine. Given the over dependence on rain-fed agriculture by the majority of people living in rural areas, climate change has been one of the major limiting factors in agriculture production, thus resulting in food insecurity and low-income generation.

4.2.7 Extent of Rainfall Variability

The researcher presents the responses of the respondents concerning the extent of rainfall variability in Hai District where the respondents were required to provide

their view on the extent of rainfall variability in Hai district Kilimanjaro, Tanzania whether increase or decrease.

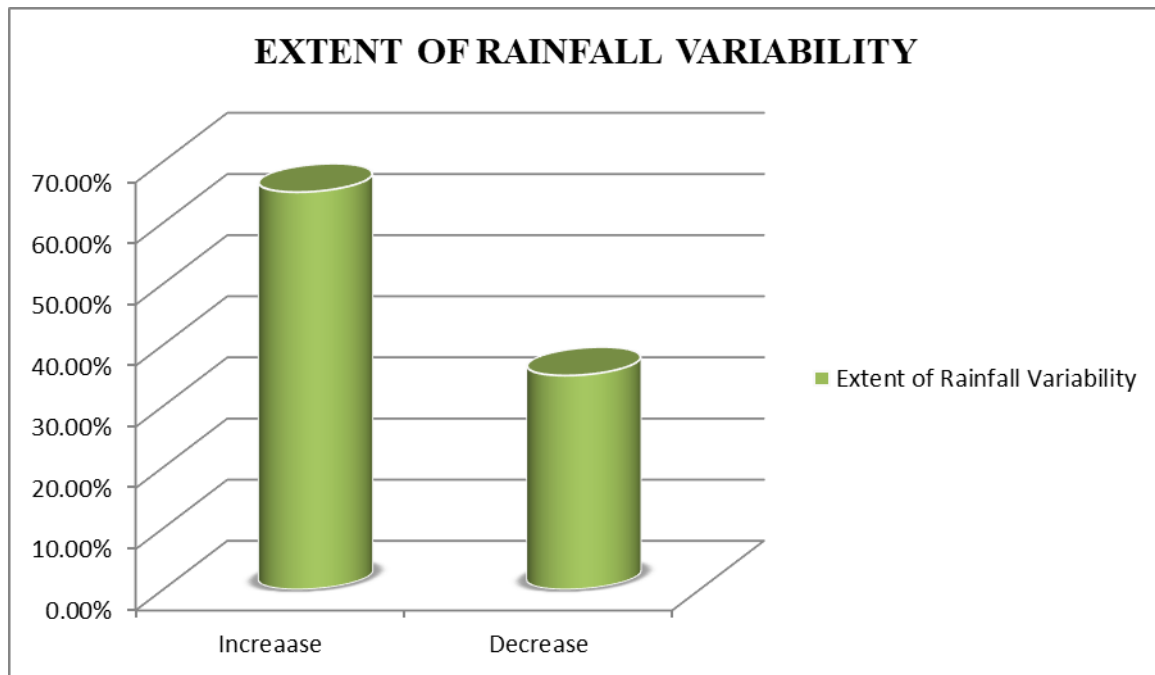


Figure 4.7 Extent of Rainfall Variability

Source: Research Field Data (2025)

The results in figure 7 show the extent of rainfall variability. From the findings show that 65.0% of the respondents accept that rainfall variability is still increasing day by day to the extent that has affected the farmers to cultivate their crops particularly maize production and 35.0% of the respondents were state that the rainfall variability in the study area is still decreased compare to the other years. This imply that the production of maize crops are decreased over time in the Hai district since the changing of the weather patterns such as temperature and precipitation which results affect the maize production and food security in the area. The study findings are in line with study done by Mayaka (2018) who argue that majority of the households adopted drought resistant crops as a result of rainfall variability which decreased production however adaptation was reported to be constrained by lack of finances. Therefore study recommends planned adaptation strategies that will enhance the resilience of small holder farmers to climate variability.

4.2.8 Effects of Rainfall Variation

The researcher here presents the responses of the respondents on the effects of rainfall variation such as drought, floods and other effects.

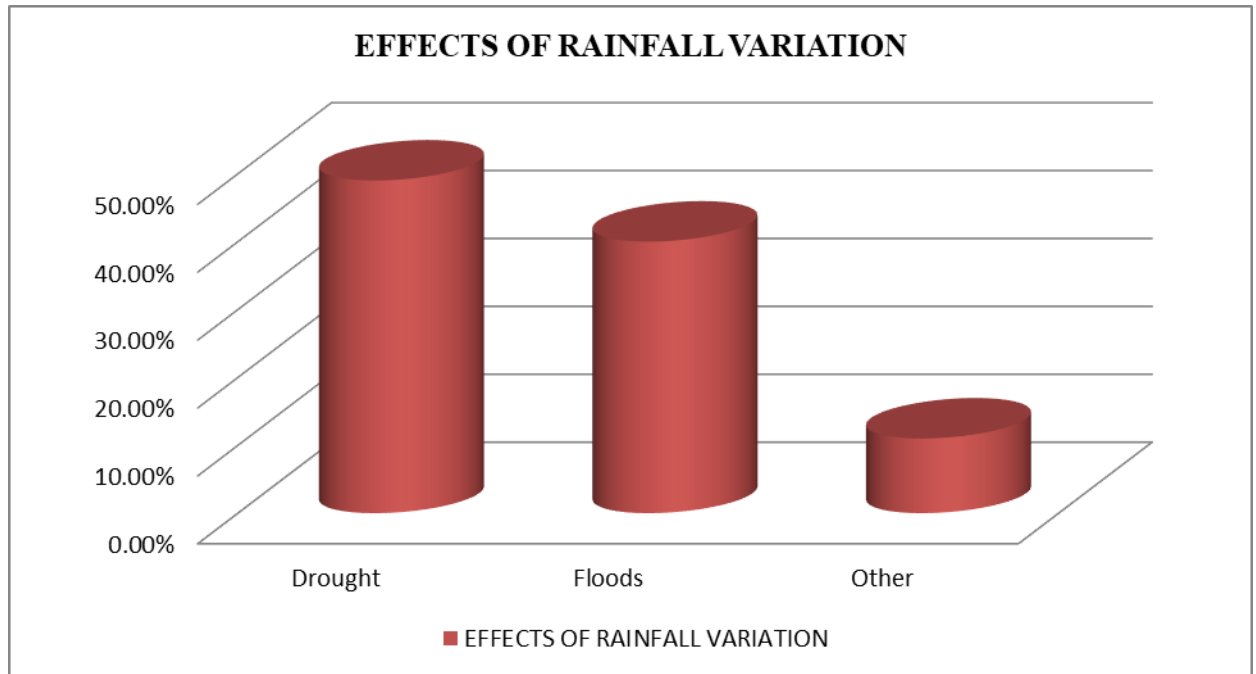


Figure 4.8 Effects of Rainfall Variation

Source: Research Field Data (2025)

The results in figure 8 show the effects of rainfall variations in Hai District. From the findings shows that 49.0% of the respondents accept that there is prevalence of drought in their area, 40.0% of the respondents agreed that there is floods, 11.0% of the respondents accept there is other impacts. These findings imply that in Hai district majority of the respondents witnessed the occurrences of drought prevalence on their farms which has resulted in decline in their maize production which highly cultivated in the area which led to food insecurity. The findings are similar with (Paavola, 2017), who argue that the recent droughts and associated crop failures have led to severe hunger to many places in Tanzania that forced the government to organize food aid to the people. For example, in Dodoma Region there had been an 80% decrease in harvests as a direct result of poor or late arrival of rainfall.

4.2 State of Food Security among the Community

The first research question was required to find out the state of food security among the community. The researcher used questionnaires for households and interview guide for Ward executive officer to obtain information from the field. The responses from the households were summarized in table 4.2 supported by the responses of ward executive officer, which were presented in form of narrations.

Table 4.2 State of Food Security among the Community

	SD		D		U		A		SA	
	f	%	f	%	f	%	f	%	f	%
Presence of School Feeding Programs	0	0.0	12	12.0	7	7.0	46	46.0	0	35.0
Rise of Crops Price	4	4.0	10	10.0	6	6.0	37	37.0	44	44.0
Availability of Food In Household	4	4.0	11	11.0	3	3.0	44	44.0	38	38.0
Access to Sufficient of Food Quality	11	11.0	7	7.0	6	6.0	32	32.0	45	45.0
Increasing Production Cost	4	4.0	13	13.0	7	7.0	20	20.0	56	56.0
Presence of Food Storage Facilities	15	15.0	10	10.0	8	8.0	24	24.0	43	43.0

Source: Field Study (2025)

Key: **SD** = Strongly Disagree, **D** = Disagree, **U**= Undecided, **A**= agree, **SA**= Strongly Agree

The results from table 4.10 show the responses of farmers on state of food security among the community. The findings show that 46.0% of the respondents agreed to the statement that their presence of school feeding program in Hai district, 35.0% of the respondents strongly agreed to the statement, 12.0% of the respondents disagreed to the statement and 7.0% of the respondents were undecided to the statement. This implies that the respondents introduce feeding program to the students so as to encourage them to attend school.

On rise of crops Price 37.0% of the respondents were agreed to the statement, 44.0% of the respondents were strongly agreed to the statement, 10.0% of the respondents were disagreed to the statement, and 4.0% of the respondents were strongly disagreed to the statement while 6.0% of the respondents were undecided to the statement. 44.0% of the respondents were agreed to the statement that there

availability of food in household, 38.0% of the respondents were strongly agreed to the statement, 11.0% of the respondents were disagreed to the statement, and 4.0% of the respondents were strongly disagreed to the statement while 3.0% of the respondents were undecided to the statement.

On access to sufficient of food quality 32.0% of the respondents were agreed to the statement , 45.0% of the respondents were strongly agreed to the statement, 11.0% of the respondents were disagreed to the statement, and 7.0% of the respondents were strongly disagreed to the statement while 6.0% of the respondents were undecided to the statement. 20.0% of the respondents were agreed to the statement that increasing production cost, 56.0% of the respondents were strongly agreed to the statement, 13.0% of the respondents were disagreed to the statement, and 4.0% of the respondents were strongly disagreed to the statement while 7.0% of the respondents were undecided to the statement. Lastly on food storage facilities 24.0% of the respondents were agreed to the statement, 43.0% of the respondents were strongly agreed to the statement, 10.0% of the respondents were disagreed to the statement, and 15.0% of the respondents were strongly disagreed to the statement while 8.0% of the respondents were undecided to the statement.

Based from the findings it implies that in Hai district the state of food security is still insufficient which encourage the family heads and parents in school introduce feeding program for students so as to be able to attend in the school not only that but also the availability of food in household is little compared to the state of food security in previous years. The results finding supported with the study done by Pavoola (2017) who argue that the recent droughts and associated crop failures have led to severe hunger to many places in Tanzania that forced the government to organize food aid to the people. For example, in Dodoma Region there had been an 80% decrease in harvests as a direct result of poor or late arrival of rainfall.

4.3 Effects of Rainfall Variability on Maize Production

The second research question was required to find out the effects of rainfall variability on maize production. The researcher used questionnaires for households and interview guide for Ward executive officer to obtain information from the field.

The responses from the households were summarized in table 4.3 supported by the responses of ward executive officer, which were presented in form of narrations.

Table 4.3 Effects of Rainfall Variability on Maize Production

	SD		D		U		A		SA	
	f	%	f	%	f	%	f	%	f	%
Presence of Prolong Drought	1	1.0	20	20.0	2	2.0	35	35.0	42	42.0
Presence of Crop Diseases	1	1.0	4	4.0	13	13.0	53	53.0	29	29.0
Presence of Floods	3	3.0	22	22.0	5	5.0	42	42.0	28	28.0
Presence of Invasive Species	0	0.0	10	10.0	3	3.0	55	55.0	32	32.0
Decrease in the Level of Maize Yield	3	3.0	3	3.0	2	2.0	53	53.0	39	39.0
Rise of Crop Price	2	2.0	5	5.0	2	2.0	59	59.0	32	32.0

Source: Field Study (2025)

Key: **SD** = Strongly Disagree, **D** = Disagree, **U**= Undecided, **A**= agree, **SA**= Strongly Agree

The results from table 4.11 show the response of the impacts of climate variability on food security. The findings shows that 42.0% of the respondents strongly agreed to the statement that there was the presence of prolong drought, 35.0% of the respondents were agreed to the statement, 20.0% of the respondents were disagreed to the statement, 1.0% of the respondents were strongly disagreed to the statement while 2.0% of the respondents were undecided to the statement. 53.0% of the respondents were agreed to the statement that there was presence of crop diseases, 29.0% of the respondents were strongly agreed to the statement, 4.0% of the respondents were disagreed to the statement, and 1.0% of the respondents were strongly disagreed to the statement while 13.0% of the respondents were undecided to the statement.

On presence of floods 42.0% of the respondents were agreed to the statement, 28.0% of the respondents were strongly agreed to the statement, 22.0% of the respondents were disagreed to the statement, and 3.0% of the respondents were strongly

disagreed to the statement while 5.0% of the respondents were undecided to the statement. Presence of invasive species 55.0% of the respondents were agreed to the statement, 32.0% of the respondents were strongly agreed to the statement, 10.0% of the respondents were disagreed to the statement while 3.0% of the respondents were undecided to the statement.

53.0% of the respondents were agreed to the statement that decreased in the level of food production, 39.0% of the respondents were strongly agreed to the statement, 3.0% of the respondents were strongly disagreed to the statement, 3.0% of the respondents were disagreed to the statement and 2.0% of the respondents were undecided to the statement. Lastly on rise of crop price 59.0% of the respondents were agreed to the statement, 32.05 of the respondents were strongly agreed to the statement, 5.0% of the respondents were disagreed to the statement, 2.0% of the respondents were strongly disagreed to the statement while only 2.0% of the respondents were undecided to the statement.

Based from the findings it implies that majority of the respondent's shows that rainfall variations has greater impacts in their maize production and food production to the extent that has reduced food production and encourages the presence of food shortages in their village. The findings are similar to what was observed by IPCC (2017) which reported that climate change extremes such as drought, floods, heat waves, frosts and cyclones can also impact health as a result of water resources becoming scarcer and competition for water increasing, where polluted water may be used for drinking and bathing, and this spreads infectious diseases such as typhoid, cholera and gastroenteritis and on the other hand decreased availability of water for irrigation and food production heightens the risk of poor nutrition and increased susceptibility to diseases. Hence in order to curb with the negative impacts of rainfall variation the community need to change the way cultivating through the use of irrigation systems, use of resistant crop to climate change, use of artificial insecticides.

Moreover these results findings are similar to Habib *et al.* (2012) who found that majority of respondents (92% of owner-cum-tenant farmers) in northwestern Bangladesh reported that drought conditions occurred more frequently in their areas

than they used to be in the past 30 years. Farmers in northwestern Bangladesh mentioned that nowadays drought occurs once in every year compared to previous decades

During an interview with the key informant in the village it was reveal that despite the fact that there has been reduction in rainfall amounts in Mbweera and Sonu villages, it still rains and can still support crops grown there. What was noticed was more of rainfall variability nature rather than decreasing trends. It was learnt that farmers could experience a few years of decreased rainfall amounts then followed by years of adequate and even more than adequate amounts of rainfall.

Another interview with the village executive officer in the village concerning about the impacts of climate variability on food security state that

“When we were still young, there were clear cut differences in the rainy seasons, but nowadays, things have changed. Rains are no longer predictable - we could prepare our fields but stay for weeks or months before it rains. Even when it rains, it rains just for a short period then it stops”

4.4 Existing Rainfall Variability Adaptation Strategies

The third research question was required to find out the existing rainfall variability adaptation strategies. The researcher used questionnaires for households and interview guide for Ward executive officer to obtain information from the field. The responses from the households were summarized in table 4.4 supported by the responses of ward executive officer, which were presented in form of narrations.

Table 4.4 Existing Rainfall Variability Adaptation Strategies

	SD		D		U		A		SA	
	f	%	f	%	f	%	f	%	f	%
Use of Irrigation System	0	0.0	2	2.0	3	3.0	55	55.0	40	40.0
Water Harvesting	0	0.0	0	0.0	9	9.0	57	57.0	34	34.0
Intercropping	1	1.0	11	11.0	12	12.0	45	45.0	31	31.0
Growing Climate Tolerant Crop Species	1	1.0	7	7.0	2	2.0	49	49.0	41	41.0
Organic Farming	5	5.0	8	8.0	5	5.0	53	53.0	29	29.0
Mixed Farming System	1	1.0	10	10.0	10	10.0	50	50.0	29	29.0

Source: Field Study (2025)

Key: **SD** = Strongly Disagree, **D** = Disagree, **U**= Undecided, **A**= agree, **SA**= Strongly Agree

The results from the table 4.11 show the climate variability coping strategies. The findings shows that 55.0% of the respondents were agreed to the statement that they use irrigation system, 40.0% of the respondents strongly agreed to the statement, 2.0% of the respondents disagreed to the statement while 3.0% of the respondents were undecided to the statement. On water harvesting 57.0% of the respondents were agreed to the statement, 34.0% of the respondents were strongly agreed to the statement while 9.0% of the respondents were undecided to the statement.

Intercropping 45.0% of the respondents were agreed to the statement, 31.0% of the respondents strongly agreed to the statement, 11.0% of the respondents were disagreed to the statement, and 1.0% of the respondents were strongly disagreed to the statement while 12.0% of the respondents were undecided to the statement. 49.0% of the respondents were agreed to the statement that growing climate tolerant crop species, 41.0% of the respondents were strongly agreed to the statement, 7.0% of the respondents were disagreed to the statement, 1.0% of the respondents were strongly disagreed to the statement while 2.0% of the respondents were undecided to the statement.

On mixed farming system 50.0% of the respondents were agreed to the statement, 29.0% of the respondents were strongly agreed to the statement, 10.0% of the respondents were disagreed to the statement, and 1.0% of the respondents were strongly disagreed to statement while 10.0% of the respondents were undecided to statement. 53.0% of the respondents were agreed to the statement that they use organic farming, 29.0% of the respondents were strongly agreed to the statement, 5.0% of the respondents were strongly disagreed to the statement, 8.0% of the respondents disagree to the statement and 5.0% of the respondents were undecided to the statement.

Based from the findings of the responses of the respondents on the strategies coping with climate variability it implies that majority of the community in the study area use different strategies such as use of irrigation system, water harvesting, growing climate tolerant crop species, organic farming and mixed farming system as a means

of fighting with the negative impacts of the climate variability. The findings are similar with the study conducted by Nsemwa (2019) who argue that farmers used various adaptation measures including expanding the area under cultivation, switching to more drought-resistant crops or varieties, changing planting times, growing alternative crops, increasing cultivation in wetlands, and diversification into non-farm activities such as brick and charcoal-making, casual labor, and carpentry.

SUMMARY, CONCLUSION AND RECOMMENDATION

5.0 Introduction

This chapter contains summary of the study, conclusions derived from research objectives and recommendation of the study.

5.1 Summary of the Study

The main objective of this study was to evaluate of rainfall variability on maize production in Hai district Kilimanjaro, Tanzania. The study was guided by three (3) research questions which were;

- i. What is the state of food security among the Small Scale Farmers in Hai district, Tanzania?
- ii. What are the effects of rainfall variability on maize production in Hai district, Tanzania?
- iii. What are the existing rainfall variability adaptation strategies practiced by Small Scale Farmers in Hai District, Tanzania?

The research questions were focused on three issues concerning rainfall variability on maize production which were the condition of food security among small scale farmers, the effects of rainfall variability on maize production in Hai District and existing rainfall variability adaptation strategies practiced by Small Scale Farmers in Hai District. This has been shown by different views of the respondents and different other studies related to the research study which was conducted. The data collected was summarized and coded; thereafter quantitative technique was used to analyze information in terms of means, frequencies and percentages. The computation of data

was helped with computer software called SPSS version 20. Qualitative data were verbally transcribed and analyzed using narration then merging the results. Data analysis was done after making some editing to display visual results in terms of tables.

5.2 Summary of the Findings

5.2.1 State of Food Security among the Small Scale Farmers

The study found that state of food security in Hai district is insufficient to the community since the study witness the increasing the cost of food crops such as rice and maize, also the study found family heads and parents in school introduce feeding program for students so as to be able to attend in the school not only that but also the availability of food in household is little compared to the state of food security in previous years.

5.2.2 The Effects of Rainfall Variability on Maize Production

The study found out that majority of the respondent's reveal that rainfall variations has greater impacts in their maize production and food production to the extent that has reduced food production and encourages the presence of food shortages in their village. Moreover the study found that there has been reduction in rainfall amounts in Mbweera and Sonu villages, but rain still support crops grown there and what was noticed was more of rainfall variability nature rather than decreasing trends. It was expected that farmers could experience a few years of decreased rainfall amounts then followed by years of adequate and even more than adequate amounts of rainfall.

5.2.3 Existing Rainfall Variability Adaptation Strategies Practiced By Small Scale Farmers

The study found out that majority of the community in the study area use different strategies such as use of irrigation system, water harvesting, growing climate tolerant crop species, organic farming and mixed farming system as a means of fighting with the negative impacts of the climate variability. Moreover the community employed various adaptation measures including expanding the area under cultivation, switching to more drought-resistant crops or varieties, changing planting times,

growing alternative crops, increasing cultivation in wetlands, and diversification into non-farm activities such as brick and charcoal-making, casual labor, and carpentry.

5.3 Conclusion

Depending on the research findings which aimed to investigate on the rainfall variability on maize production in Hai district in Moshi District, Tanzania. It has caused decline in food crop production in the study area which in turn has led to shortage of food, reduced income and rise in food prices.

The findings reveal that agriculture sector is a major economic activity that building up the community as well as the country when are developed it can help to improve the standard living of the people but the poor education, inadequate fund, poor technology, traditional equipment, decline in crop production and shortage of food were the main challenges in the study area.

The local community and the government have struggled to adapt to the situation using different strategies but still there are several challenges facing them hence little success has been achieved in terms of adapting to the impacts of rainfall variability towards maize production which has continuously affected food security. These problems are caused by change in climate in the area and this cause low product and food insecurity

5.4 Recommendations

The study has the following recommendations.

To the first objective of this study which said that the state of food security among the small scale farmers in Hai District, Kilimanjaro Tanzania the recommendation of the researcher were as follows.

- i. There is a need to promote community awareness programmers on rainfall and climate variability issues in their areas of jurisdiction.
- ii. There should be emphasizing on making storage of maize rather than selling in the market areas.

- iii. There should be minimization of making local alcohol that are made from the food crops such as Mbege so as to be able to save food for family.

For the second objective of the study which says that the effects of rainfall variability on maize production in Hai district, Kilimanjaro Tanzania the researcher recommendation is as follows;

- i. Government must formulate the policies that favor the farmers on the effect of rainfall variability on maize production such as to provide agriculture extension officers that will provide education to the farmers on the effect of rainfall variability and climate change.
- ii. Another recommendation on this objective is that the government should provide fertilizers for low cost so that the people can afford them and use to improve their land that was distracted by change in rainfall patterns that lead to poor yield of crops.

On the lastly third objective of this study which says that the existing rainfall variability adaptation strategies practiced by small scale farmers in Hai district Kilimanjaro Tanzania the researcher recommended as follow:

- i. First recommendation is that for the people to adapt the rainfall variability would be used alternative ways of farming such as crop rotations and mixed farming that will increase the food security.
- ii. The second recommendation on the same objective is that people should use improved seeds that can tolerate on the rainfall variability that can adapt the change in the climate and using some artificial manure that would help the crops to grow even the climate have changed.
- i. Research on the possible alternative income generating activities for the Hai District.
- ii. Sustainable farming methods in the period of rainfall variability.

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