ADAPTATION TO RAINFALL VARIABILITY, SOCIOECONOMIC FACTORS INFLUENCING MAIZE PRODUCTION IN CROP LIVESTOCK MIXED FARMING SYSTEMS IN BABATI DISTRICT, TANZANIA

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ABSTRACT

Agriculture is an important source of food and economic survival of rural populations in Tanzania however farming activities are highly affected by rainfall variability which cause loss in crops and livestock yield. This study explored adaptation strategies to rainfall variability, socioeconomic factors influencing maize production in mixed farming systems. Specifically, assessed the trends in rainfall and maize production, determined the relationship between trends, identified farmers' adaptation strategies to rainfall variability and ascertained the influence of socioeconomic factors on maize yields in the mixed farming systems. The study employed questionnaire survey method to collect household data. Focus group discussions, key informant interviews, documentary review were also conducted to complement the information. Descriptive and inferential statistical analyses were employed using MS excel and Statistical Package for Social Sciences (SPSS) programs. Annual rainfall and maize yield data for the past ten years were used to study the trends and trend relationship in rainfall and maize production. Results showed increasing trends in rainfall with high inter annual variability and decreasing trends in maize production. The relationship between rainfall trend and maize production was found to be insignificant (p value = 0.927). On the adaptive capacity of the farming system to produce maize, the mixed farming system found to be efficient in adapting to rainfall variability effects with the average maize yields of 2.57 tonha^{-1} compared to 1.36 tonha^{-1} in non-mixed. Household size, farm size, the costs of pesticide, and farmers' access to credits had a significant influence on maize production in the study area. The study recommends that education on environmental management should be done to reduce vulnerability to inter annual rainfall variability, up scaling of the crop livestock mixed farming system to other areas of Tanzania and formation of farmer managed co-operatives to assist in the provision of soft loans with affordable interest rates for meeting the costs of inputs.

DECLARATION

I, Zuhura Peter Msigwa, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

Zuhura Peter Msigwa Date
(MSc. Candidate)

The above declaration is confirmed by;

Dr. Felister Mombo Date
(Supervisor)

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This work is dedicated to my beloved parents, Ms. Alatukemela Vahaye and the late father Mr. Peter Msigwa who laid the foundation of my education.

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LIST OF ABREVIATIONS AND ACRONYMS

FAO	Food and Agriculture Organization of the United Nations
FDG	Focus group discussion
GHG	Greenhouse gases
IFPRI	International Food Policy Research Institute
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence zone
RV	Rainfall variability
SPSS	Statistical Package for Social Science
SSA	Sub Saharan Africa
TMA	Tanzania Meteorological Agency
URT	United Republic of Tanzania
VIF	Variance Inflation Factor

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

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.,* 2008). 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, 2007).

The 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.,* 2008). As reported by Majule and Karonga (2009), 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, 2013).

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.*, 2003).

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 75per cent of the cereal consumption in the country (Seth *et al.,* 2011). As reported by Kirway *et al.* (2000) 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, 2010). 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.*, 2010). The systems produce a bulk of livestock and crop products where 90% of the milk, 80% of the meat, and 86% of maize are produced and employ millions of people in long value chains. The systems are practiced in nearly all agro-ecological zones of the country under widely disparate climatic and soil conditions (Thornton and Herrero, 2015).

Livestock in the system makes farmers more adaptive to changes in rainfall and variability through efficient use of natural resources. This practice provides a buffer against crop losses (Thornton and Herrero, 2010; Mombo and Bigirwa, 2017; Blache, 2018). Legumes in the system functions as a key integrating factor in intensifying crop-livestock farming systems through the supply of healthy plant proteins in the human diet, fodder for livestock, adds nitrogen into the farming system through nitrogen fixation, improves soil structure, replenishes soil nutrients, and reduces soil erosion (De Haan *et al.,* 1997; Sanginga *et al.,* 2003; Mkonda, 2014).

1.2 Problem Statement and Justification of the Study

In Northern Zone of Tanzania particularly Babati District maize is a staple food and largely grown as cash crop. More than 90% of the population in the district comprises small scale farmers who depend on crop and livestock for their livelihood (Ngunga and Lukuyu, 2016). Agricultural activities in the area depend on rainfall whose variability has caused negative effects on the crop production. However, there are coping strategies which have been developed and emphasized by Africa Rising (Africa research in sustainable intensification for the next generation) project. The project aims at creating opportunities for smallholder farming households to get out of hunger and poverty through sustainably intensified farming systems (Crop livestock mixed farming system) that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base (Ngunga and Lukuyu, 2016).

Maize based systems, which are intercropped with various leguminous crops and livestock breeds are widely found in the district. Since there is rainfall variability, which leads to drought or shortage of rainfall, mixed farming systems help farmers to overcome the adverse effects of drought through the beneficial characteristics inherent in the systems. There is however, relatively insufficient information on the significance of the technology as an adaptation strategy to rainfall variability among smallholder farmers in Babati District. In other areas however, the option has had significant impact on people's livelihood. For example a study by Lungu, (2002) 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 by allowing diversification of risks, improving soil water holding capacity, preventing nutrient loss, adding value to crops and crop products and providing cash for purchasing food and farm inputs in cases of crop loss.

Similarly, Thornton and Herrero's (2015) study on the adapting climate change in mixed crop livestock farming systems in sub-Saharan Africa reported that the synergies between cropping and livestock husbandry offer various opportunities for raising productivity and increasing efficiency of resource use. These synergies, as a result increase household income, availability and secure access to food. Therefore, to the current study was set to assess the adaptation strategies to rainfall variability in crop livestock mixed farming system with the aim of improving productivity of maize as a principal crop in the crop livestock mixed farming system in Babati District.

Specifically, the study intended to identify and assess the adaptation strategies to rainfall variability in mixed farming system in comparison to non-mixed farming systems. The study also assessed the influence of socioeconomic and farm factors on maize production in a mixed crop livestock farming system. The study findings are envisaged to inform policy makers on the advantages of the farming system in improving maize yields during rainfall variability. On socioeconomic factors, the findings are envisaged to help in developing specific strategies of improving productivity of that crop. The information gathered would also 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 for advocacy and scaling up of development among farming households in Babati.

1.3 Objectives of the Study

1.3.1 Overall objective

The overall objective of the study was to assess adaptation strategies to rainfall variability and ascertain socioeconomic and farm factors influencing maize production in the crop-livestock mixed farming systems in Babati District, Manyara Region in Tanzania.

1.3.2 Specific objectives

The specific objectives of the study were to:

i. Assess the trends in rainfall and maize production for the last ten years in the study area.

ii. Determine the relationship between maize production trend and rainfall trend for the last ten years.

iii. Identify adaptation strategies to rainfall variability which are available in crop livestock mixed farming system in the study area.

iv. Ascertain the influence of socio-economic and farm factors on maize production in crop livestock mixed farming system.

1.4 Research Questions

The research strove to answer the following questions:

i. What is the rainfall trend for the past ten years in the study area?
ii. What has been the trend of maize production for the last ten years?
iii. How has maize production been affected by rainfall variability for the past ten years?
iv. How does maize legume livestock integration adapt to rainfall variability?
v. What are socioeconomic and farm factors influencing maize production in the study area.

1.5 Conceptual Framework

Figure 1 shows the conceptual framework of the study indicating the relationship between the effects of rainfall variability and maize production; however, mixed farming system plays a role in mitigating the effects of rainfall variability in order to increase maize production. The framework also illustrates the influence of socioeconomic and farming factors on maize production. The conceptual framework is defined as a visual or written product that explains either graphically or in a narrative form, the key factors, concepts or variables and the presumed relationships among them, which need to be studied (Miles and Huberman, 1994). From Figure 1, the annual average rainfall is an important independent variable in assessing its variability; and maize production is the dependent variable. Rainfall variability causes stress that affects maize production. Such stress requires coping and adaptation strategies which may help farmers to adjust to the adverse effects and realize optimum maize production. The effect of rainfall variability is felt by farmers mainly in the timing, frequency, and intensity of rainfall events and in the distribution of these events within the season of crop growth (Blignaut *et al.*, 2009). The study assumes that rainfall fluctuations will have considerable effects on maize production which lead to low maize yields, shortage of food and poor household income however mixed crop livestock farming system can shield against the adverse effects caused by rainfall variability and lead to increased maize yields, food security among households, increased household income, improved well-being of people and sustainable resource use. Socioeconomic factors such as age, education level, family size, gender, farm size, farmers’ access to extension services, farmers’ access to credits and cost of agricultural inputs may also influence productivity of maize in the system. Figure 1 illustrates the relationship between the variables.

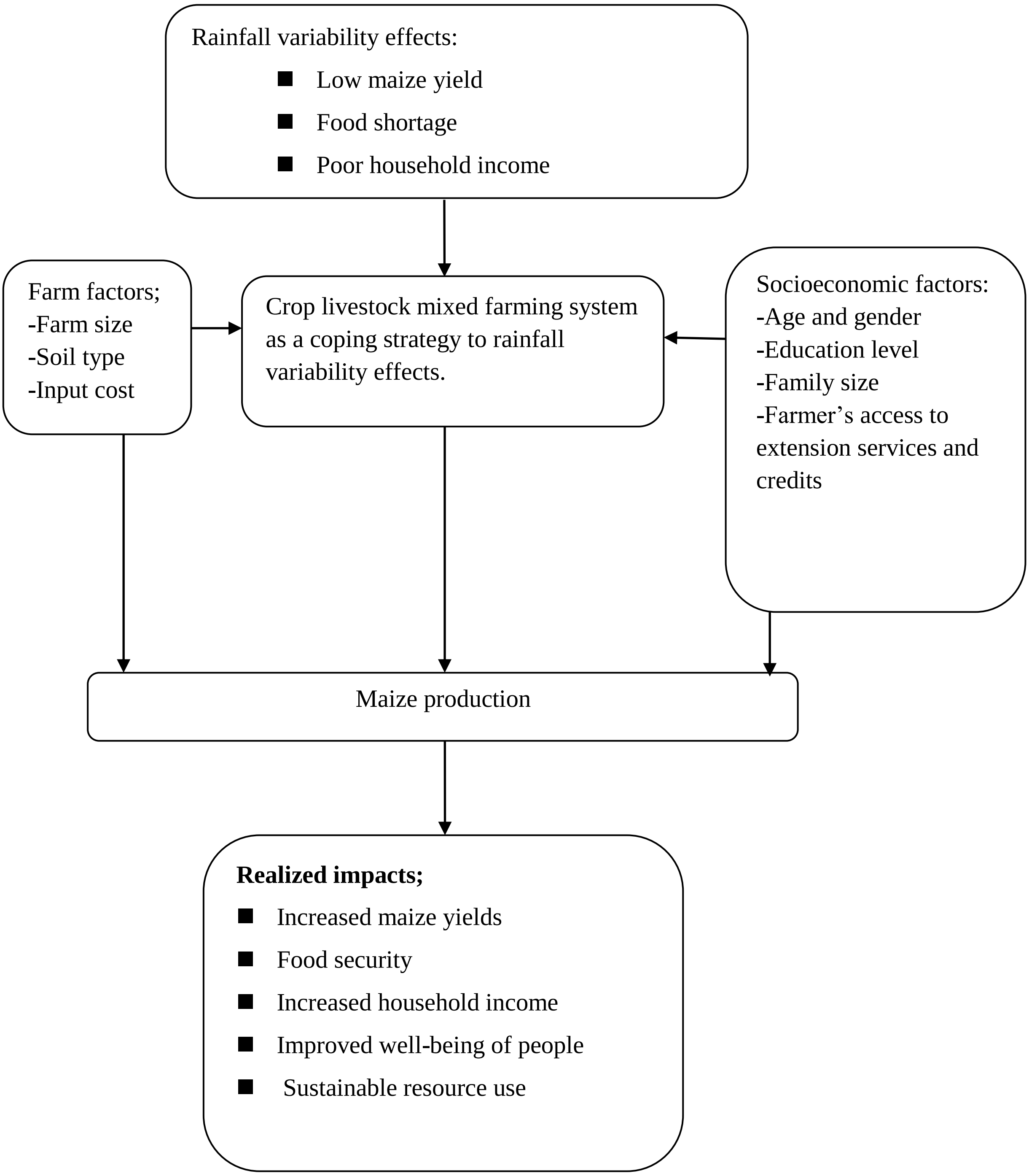

Figure 1: Conceptual framework for crop livestock adaptation strategies to rainfall variability as modified from Mehta and Movik (2014).

CHAPTER TWO

2.0 LITERATURE REVIEW

This chapter describes relevant literature to this study in which various concepts regarding rainfall variability and adaptation strategies in mixed crop livestock farming system are described. Further socioeconomic factors influencing maize production have also been described by various scholars in various studies.

2.1 Definition of Concepts

2.1.1 Rainfall variability

Banchiamlak and Mekonnen,(2010) defines rainfall variability as the degree to which rainfall amounts vary across an area or over time; it (rainfall variability) is an important characteristic of a climate of an area and has two components: namely spatial and temporal variability. IPCC, (2007) defined rainfall variability as the fluctuation 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.

2.1.2 Farming systems

Several definitions of farming systems have been provided by different authors. Some of the notable definitions of farming systems are as follows. Fresco, (1986) defined farming systems as decision making and land use units consisting of farming households, cropping and livestock systems that produce crop and animal products for consumption and sale. Dixon, (2001) defines farming system as populations of individual farming systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate. Beets, (1990) defined farming systems as units consisting of human groups (usually households) and resources they manage in their environments, involving the direct production of plant and/or animal products.

2.1.3 Coping

Coping is the use of the existing resources to achieve various desired goals during and immediately after unusual, abnormal, and adverse conditions of a hazardous event or process. The strengthening of coping capacities, together with preventive measures, is an important aspect of adaptation and usually builds resilience among households of withstanding the effects of natural and other hazards (Agrawal, 2008).

2.1.4 Adaptation

Adaptation is described as adjustments made to the changed environmental circumstance that occur naturally within biological systems and with some deliberations or intents in social systems (Nelson, and Palmer, 2007). IPCC, (2001) defined the term as changes in processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate. It involves adjustments to reduce the vulnerability of communities and activities to climatic change and variability.

2.1.5 Drought

A drought is a period of below-average precipitation in a given region which results in prolonged shortages of water supply, whether atmospheric, surface or ground water. It is the result of acute shortage of water causing severe and sometimes catastrophic economic and social consequences (Blaikie *et al.*, 1994).

2.2 Theoretical Framework of the Study

Sen’s theory of hunger

The current study is guided by Sen’s theory of hunger which attempts to explain the causes of famine at a household unit of analysis. Famine occurs when a large number of people in a region lose their means (or entitlements) to access commodities (Devereux, 2002). Entitlements are defined as a set of alternative commodity bundles that a person can command in a society using the totality of rights and opportunities that he or she possesses. A set of person’s entitlement is a full range of goods and services that he or she can acquire by converting his or her endowments (assets and resources, including labour power) (Sen, 1987). The entitlement approach aims comprehensively at describing all legal sources of food, which Sen (Ibid) reduces into four categories: production-based entitlement (growing food); trade-based entitlement (buying food); own-labour entitlement (working for food); and inheritance and transfer entitlement (to be given food by others).

Sen (1987) argues further that when millions of people suddenly die in a famine, it is hard to avoid the thought that there must have been a major decline in the output and availability of food in the economy. Whereas this is sometimes the case, there have frequently been famines whereby food output and availability have remained high and undiminished. Therefore, the major concern is not primarily the overall availability of food, but the acquirement of food by individuals and families. However, when a person is lacking the means of acquiring food, then the presence of food in the market is not much a comfort. Therefore in order to understand hunger, people's entitlements, that is, the commodity bundles, including food which they can make their own, should be asserted. According to Sen (1987), entitlement of a person stands for a set of different alternative commodity bundles that the person can acquire through various legal channels of acquirement which are open to that person. Starvation will occur if the set of entitlement does not include any commodity bundle with adequate amounts of food.

Moreover if some changes either in the person’s endowment (e.g., alienation of land, or loss of labour power due to ill health), or in his/her exchange entitlement mapping (e.g., a fall in wages, the rise in food prices, the loss of employment, the drop in the price of the goods he/she produces and sells), makes it no longer possible for him/her to acquire any commodity bundle with enough food (Sen, 1987). Since the majority of the poor are dependent on agriculture for their livelihood (FAO, 2009), achieving nutrition and food security is a prerequisite to achievement all of the Millennium Development Goals (MDGs). Therefore, food security at both macro and micro levels enhances the prospects for rapid economic growth, poverty reduction and broad-based participation of citizens in higher living standards (Timmer, 2004).

2.3 Causes and Consequences of Rainfall Variability

Rainfall Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forces (external variability or human induced variability. The current global rainfall variability is mainly resulting from human activities such as burning of fossil fuels such as oil, coal, natural gas and through land use activities such as burning for agriculture which adds CO2 to the atmosphere and increases the concentrations of anthropogenic greenhouse gas, change of the natural atmospheric greenhouse includes warming of the earth whereby some regions may experience warmer temperatures, while others may not. Warmer conditions will probably lead to more evaporation and overall precipitation, but conditions will vary in individual regions, some will become wetter while others will become dryer (Lean, 2010)

A change in rainfall patterns will affect crop yields, will lead to shifts in agro biodiversity, food production, an increase of plant and animal pests and diseases, an increase of pastoral livestock crossing on farmlands, an increase of food shortages and poverty, a decrease of quality and quantity of forage, unpredictable rainfall, uncertainty in cropping patterns, and prolonged dry spells beyond normal patterns. Other effects include an increased competition of weeds against crops over moisture, ecological changes for pests and diseases, and a decline of yields of maize which is the national food crop (Majule *et al,*. 2008). As Thornton and Herrero (2014) report, changes in rainfall regime may have considerable impacts on agricultural productivity and on the ecosystem provisioning services which are provided by forests and agroforestry systems on which many people depend.

2.4 Global and National Level Rainfall Variability

2.4.1 Global rainfall variability

Global average surface temperature has increased by around 0.6 ^{0}C in the 20th century (Barber, 2004). During this period of an increase in global temperatures, there has been a decrease of snow and ice cover, a rise in the average sea level and many changes in the weather patterns which can also be associated directly or indirectly with the rising temperatures and the reduction of rainfall intensity (Majule *et al.*, 2010).

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, 2014). 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.*, 2002).

In developing countries, rainfall variability will cause yield declines for the most important crops resulting to the rise of prices to such crops as maize, common beans, soybeans, rice, and wheat (IPCC, 2014). The quantity and quality of crop residues which are a key dry-season feed resource for ruminants in mixed crop-livestock systems will negatively be affected. The residues comprise 45-60 percent of the diets of ruminants in mixed farming systems (Blummel *et al.*, 2006).

2.4.2 Rainfall in Tanzania

Rainfall is influenced by Inter-tropical convergence zone (ITCZ), jet streams, pressure gradient, regional and local effects (Tilya, 2008). It (rainfall) is also affected by Monsoon winds and Congo air mass (Chang'a *et al.*, 2008). The performance of a given rainy season does not only depend on the total amount, but also on adequate distribution of the rains throughout the year. In some areas of Tanzania, agriculture is limited by the length of the rain season while in others it is limited by the amount. Thus, intra seasonal rainfall forecasts can assist farmers in making decisions regarding planting, fertilizing, pesticide application, and irrigation requirements (Tilya, 2008). Rainfall failure ranges from late onset, pre-mature end of rainfall, to short but intense rainfall events separated by long dry spells (Camberlin and Okoola, 2003). Therefore, rainfall information is important in reducing the impacts associated with extreme rainfall events. However, rainfall performance is highly affected by intra seasonal variability (Okoola and Ambenje, 2003).

According to URT report (2011), Tanzania has a total land area of about 945,087 Sq. km. About 88.8 million hectares of these are suitable for agriculture. About eight million hectares of the estimated land is used annually for rain fed crops. Small-scale farmers who are dependent on low input and low output and on rain fed mixed farming with traditional technologies dominate the agricultural sector. The dependence on rainfall and its erratic pattern has largely contributed to food shortages and crop crises that constantly confront farmers (URT, 2011).

Rainfall variability contributes to poverty both directly - through actual crop losses from rainfall shocks and indirectly -through responses to threats of crisis. The direct impacts particularly occur when a drought destroys all the crops. Under such circumstances, not only will the farmers and their families go hungry, but also they will be forced to sell or consume their plough animals in order to survive. This has significantly made the situation worse off than it was before because farmers can no longer farm effectively when the rains return (Barrett *et al*., 2007).

2.4.3 Maize production in Tanzania

In Tanzania, maize is the major and most preferred staple crop; it has been identified as a key crop in enhancing food production, income, poverty alleviation and food security, around 45 % of the land, which is allocated for cereal production, is used for maize (Pauw and Thurlow, 2011). Overall, maize production has grown at an annual rate of 4.6 % over the last 25 years. Production is carried out in two rainfall seasons (*Masika* and *Vuli);* this allows for constant domestic production of maize throughout the year and the crop is grown in nearly all agro-ecological zones in the country (Verheye, 2010).

Over two million hectares of maize are planted per year with average yields of 1.2– 2.5 tons per hectare. However, the yields remain very low against 12 ton/ha, in the US or 4 ton/ha, in South Africa (Cairns *et al*., 2013). The main causes of low yields and sporadic production include drought stress (shortage of rainfall); infestation by insects, moulds, and other pests; weeds and diseases; low agricultural inputs such as fertilizer and crop protection chemicals; low levels of technology; and poor infrastructure and storage facilities (Cairns *et al*., 2013). Other constraints to good yields and production include poor agricultural practices, farm size, shortage of improved seeds, and inadequate access to information and extension services. Also, inadequate institutional support (credit) including shortage of funds for purchasing inputs and reliance on unpredictable and irregular weather conditions (Chauvin *et al.*, 2012) is an additional restraint.

2.5 Farmers' Adaptation Strategies to Rainfall Variability in Mixed Crop Livestock Farming System

Farmers are often the repository of traditional and indigenous knowledge, expertise, skills and practices related to crop and animal production. These systems provide an invaluable resource for ensuring agricultural diversity, livelihood, and food security (FAO, 2009). Adaptation has become an important agenda in international and domestic discussions on rainfall variability and change due to its adverse effects on crop productivity. Farmers must therefore employ adaptation strategies to cope with these changes to ensure that production is not only maintained but is also increased to support people whose economy depends on agriculture (Smith, 1997). Over time, farmers have been developing coping strategies in mitigating uncertainties induced by year to year variation in rainfall amounts (Cooper *et al.*, 2008). The strategies may be of different types; they may be technological, such as the use of more drought-tolerant crops; behavioural, such as changes in dietary choices, managerial, such as implementing different farm management practices; and policy-related, such as market and infrastructure development (IPCC, 2014). The choices of animal types and breeds (e.g. goats instead of cattle, African breeds instead of more productive cross breeds) that are better adapted to heat stress and dry conditions improve the management of ecosystem and biodiversity leading to more resilient, productive, and sustainable systems (FAO, 2010). Appropriate soil and nutrient management, through composting manure and crop residues, more precise matching of nutrients with plant needs, controlled release and deep placement technologies, and the use of legumes for natural nitrogen fixation can increase the yields of maize crop while reducing the need for synthetic fertilizers. The reduction in the use of synthetic fertilizers has an advantage of reducing emissions of greenhouse-gases (GHG) which are associated with their manufacture and use, water harvesting and retention, through the use of pools, dams, pits, retaining ridges; and increasing soil organic matter to raise the water retention capacity of soils are some of the strategies that enhance farmers' resilience to rainfall Variability (FAO, 2010).

Genetic variability in domestic crops and livestock characteristics such as the ability to withstand drought, flooding and pests and diseases are often at least partially genetically controlled. The utilization of different crops and livestock breeds and their wild relatives is fundamental in adapting to rainfall shocks (Thornton and Hererro, 2010). Transformational shifts in livestock production from grassland-based systems to more productive mixed crop-livestock systems could substantially increase production efficiencies and decrease market prices as opposed to baseline scenarios with no system transitions (Havlik *et al.*, 2014). Local integration of cropping with livestock systems which reduce depletion of resource and environmental fluxes to the atmosphere and hydrosphere, offer more diversified landscapes that favour biodiversity and an increase of the system's flexibility of coping with rainfall variability (Thornton *et al.*, 2010).

2.5.1 Crop diversification

Crop diversification is a practice of cultivating more than one variety of crops belonging to the same or different species in a given area in the form of rotations and or intercropping (Makate, 2016). Crop diversification is one of the most ecologically feasible, cost effective ways of reducing uncertainties in agriculture especially among smallholder farmers (Joshi, 2005). It can improve productivity through its ability of suppressing pest outbreaks and dampen pathogen transmission which may worsen and reduce yields. It also buffers crop production against the effects of greater rainfall variability and extreme events (Mc Cord, 2014).

As Makate *et al*. (2016) reported, diversified cropping systems including cereal and legume intercrops can improve productivity of the principal crop which is usually maize. Generally, diversified cropping systems tend to be agronomical stable and resilient. This resilience is mainly associated with reduced weed and insect pressures, reduced needs for nitrogen fertilizers, reduced erosion, increased soil fertility and increased yield per unit area (Lin, 2011). Moreover, diversified cropping systems can also provide habitats with beneficial insects, and this can help reduce the number of pests by rendering host crops less suitable for colonization by parasites. Crop mixtures increase natural enemies of insect pests, break the disease cycles, suppress weeds and volunteer crop plants thereby creating a dilution effect by reducing resource concentration and modification of the microenvironment within the crop canopy making penetration of pests and diseases pathogen more difficult (Makate *et al.,* 2016).

2.5.2 Crop intensification

Households may increase financial or physical productivity of the existing production patterns. This can be done through for example application of external inputs such as irrigation and the adoption of water-conserving land management practices such as Conservation Agriculture (CA). CA is a system of agronomy based on minimum soil disturbance through ploughing, residue retention and crop rotations. It is a farming practice which increases storage of soil water by improving water infiltration, reducing evapotranspiration and water runoff (Verhulst *et al.,* 2010; Thierfelder, 2012). Conservation agriculture techniques are associated with increased soil moisture content (Ussiri and Lal, 2009). An experimental study by Verhulst *et al.,(*2010) showed that under mild drought, yields of maize grain under conservation agriculture were 1.8 to 2.7 times higher than under the conventional management practices. Higher soil water content under conservation agriculture may be an important mechanism through which maize production can be buffered against short drought periods during the growing season (Fischer *et al.,* 2002).

2.5.3 Expansion

Expansion is an increase of farmers’ income or resources through their land or their herd size. Expansion may come about through a distribution of new lands via land reforms, the accumulation in fewer hands of land abandoned by migrating farmers, or through a clearing of previously unused land (Jill *et al.,* 2013).

2.5.4 Weed dynamics

A Mixed farming system affects weed composition and its occurrence by changing the pool of management practices applied to the area. This changes the nature and amount of resources available for weeds, and excludes from the system those weed species which are highly specialized in exploring a single or a few environmental resources, leaving behind less specialized and more flexible plant species which are usually not troublesome weeds (Gurevitch *et al.,* 2009). There is some evidence that legumes may help to reduce the number of viable *Striga hermonthica* seeds in the soil through stimulating suicidal germination of the seed. *S. hermothica* is parasite on cereal plants which causes huge crop losses (Berner *et al.,* 1996).

2.5.5 Animal production

The linkage of mixed crop-livestock production systems through feed resources particularly legumes, which fix nitrogen and provide high quality feed, can enhance both the level and rate of nutrient cycling in the system, leading to increased soil fertility, improve animal nutrition, and an increase of the overall production and protect the environment (Kabede *et al.,* 2016). Legumes in a crop livestock mixed farming exploit symbiotic microbes to fix nitrogen, which is harvested in the crop and partly transferred to subsequent crops increasing their yields. In forage legume/grass mixtures, nitrogen is also transferred from legume to grass, and increases pasture production, provides proteins and amino acid lysine which is deficient in cereals. Legumes complement cereals in human diets and can compensate for the lack of animal proteins. Thus, further inclusion of legumes in livestock feed can increase food conversion ratio and decrease methane emissions from ruminants, thus increasing efficiency and at the same time reducing GHG emissions (Matuso *et al.*, 2014).

In an integrated system, livestock and crops are produced within a coordinated framework. The waste products of one component serve as a resource for another. For example, manure is used to enhance crop production; crop residues and by-products feed the animals, supplementing often inadequate feed supplies, thus contributing to improved animal nutrition and productivity (FAO, 2010). Animals play key and multiple roles in the functioning of a farm, not only because they provide livestock products (meat, milk, eggs, wool, and hides) or because they can be converted into prompt cash in times of need but also because animals transform plant energy into useful work. Animal power is used for ploughing, transportation and other activities such as milling, logging, road construction, marketing, and water lifting for irrigation. They also provide manure and other types of animal waste which can be applied to the farm for healthy growth of associated crops in the system (FAO, 2010).

Table 1: Positive and negative aspects of mixed crop–livestock farming systems

Factor	Positive aspect	Negative aspect
Trade and price fluctuations	Act as buffer	Need high levels of management skill (Fewer economies of scale)
Weather fluctuations	Buffer against weather fluctuation	May increase risk of disease and crop damage
Erosion	Control erosion by planting forages	Cause erosion through soil compaction and overgrazing
Nutrients	Improved nutrient cycling because of direct soil–crop–manure relations	Increased nutrient losses through intensive recycling
Draught power	Allow larger areas to be cultivated and more flexible residue management	Extra labour (often women) required for weeding increased area
Labour	Allow more rapid planting	Continuous labour requirement
Income	Diversified income sources More regular income streams	
Investment	Provides alternatives for investment	Requires capital
Crop residues	Provides alternative use for low-quality roughage if mulched, controls weeds and conserves water	Feeding competes with other uses of crop residues (for example mulching, construction, nutrient cycling
Security and savings	Provides security and a means of saving	Requires investment
Social function	Confers prestige	Cause conflict

Source: Thornton and Herero, (2015).

2.6 Socioeconomic Factors Influencing Maize Production in Mixed Crop Livestock Farming System

Study by Altarawneh, (2012) show that a relative contribution of socioeconomic factors depends on the type of the enterprise and its associated innovations. The socio-economic and farm factors of farmers include age, gender, level of education, household size, farm size, cost of maize seed, cost of pesticide, farmer’s access to credits and extension services.

2.6.1 Household size

Household size is among the important socio economic characteristics which influence crop productivity because a fairly large family size implies availability of more family labour for the household farm activities (Ozor and Cynthia, 2010; Ogundari, 2008). Igben (1988) reports that household size is an obvious possible advantage in terms of farm labour supply when it is relatively large.

2.6.2 Education level of household head

Education level determines one’s ability to comprehend and analyse issues before taking any action. Thus, education level is very useful for improved crop productivity. Ozor and Cynthia (2010) found that, an increase in educational level of farmers positively influence the adoption of improved technologies and practices. Farmers with basic education are better equipped for making more informed decision for lives and for their communities as well as becoming active participants in economic, social, and cultural dimensions of development (Ozor and Cynthia, 2010).

2.6.3 Farmers’ access to credits

According to Anyiro and Oriaku (2011), access to credit is regarded as one of the key elements in raising agricultural productivity. Micro credit is the name given to extremely small loans given to poor borrowers. The role of this money is to enhance the production capacity of the poor resource farmers through financial investment in their human and physical capital (Okurut *et al*., 2004). Households with access to credit may help farmers obtain the capital which is required for adopting the higher profit production technologies and therefore increase productivity (Wachira, 2012). According to Oladeebo (2008), availability of adequate and timely credit help farmers in expanding the scope of operation as well as in enhancing the purchase and use of some improved inputs which are not available on the farm.

2.6.4 Farmers’ access to extension services

Extension services which are reflected by the number of extension contacts either through farm visits made or training sessions received prior to and during production season can influence crop productivity (Anyiro and Oriaku, 2011).

2.6.5 Farm size

Some causes of poor crop production are a decline of farm sizes due to population growth, land degradation resulting from inappropriate land use practices such as cultivation on steep slopes; over cultivation and overgrazing. However if it is well managed, small farm size can produce high maize yields.

The literature reviewed inform how crop livestock mixed farming systems adapt to rainfall variability effects through its beneficial characteristics the system possess, further it informs how socioeconomic factors influence maize production in different areas. The current study aims at investigating how the mixed farming system adapt to rainfall variability to improve maize production as when compared to non-mixed systems in Babati district. Further the study aimed at investigating socioeconomic factors that influence maize production apart from rainfall variability in the district.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

3.1.1 Geographical location of the study area

Babati is one of the districts in Manyara Region Tanzania, and which is located at latitudes 4°S and longitude 35°E and consists of 21 wards and 96 villages. Its altitude ranges from 950 to 2450 m above sea level in the northern part of Tanzania. The District share borders by Arusha Region to the north, Simanjiro District to the southeast, Dodoma Region to the south, Hanang District to the southwest and Mbulu District to the northwest (Ngunga and Lukuyu, 2016).

3.1.2 Description of the study area

Babati District covers a total area of 6069 km^2 with a large proportion (640 km^2) being covered by the water bodies of Lake Babati, Lake Burunge and Lake_Manyara The district land potential for agriculture is about 134 187 hectares (ha) whereby 132 000 ha is under the cultivation of various food crops, cash crops and rearing of animals (URT, 2016). The main types of crops grown are cereals, legumes and oil crops, where among the produced crops are termed as food and cash crops. Livestock kept is mainly indigenous cattle, sheep, goats, and chickens. Livestock are mainly kept for beef, milk, draught power, production of farmyard manure, source of income and cultural functions. The rural population consists mainly of small-scale farmers and agro-pastoralists that practice semi traditional farming system which is characterized by low use of farm inputs (Ngunga and Lukuyu, 2016). The study district was selected because it is one of the major producers of maize in the Northern part of Tanzania and had been implementing crop livestock mixed farming systems to cope with rainfall variability.

The plate below shows one of the household farms containing Maize, pigeon pea livestock mixed farming systems at Ayamango village in Babati District.

Plate 1: Maize- legume livestock mixed farming system in Babati District

The study was conducted in three wards namely, Mamire, Galapo, and Riroda. Mamire, Ayamango and Riroda villages were selected to participate in the study. Figure 2 shows the map of study villages.

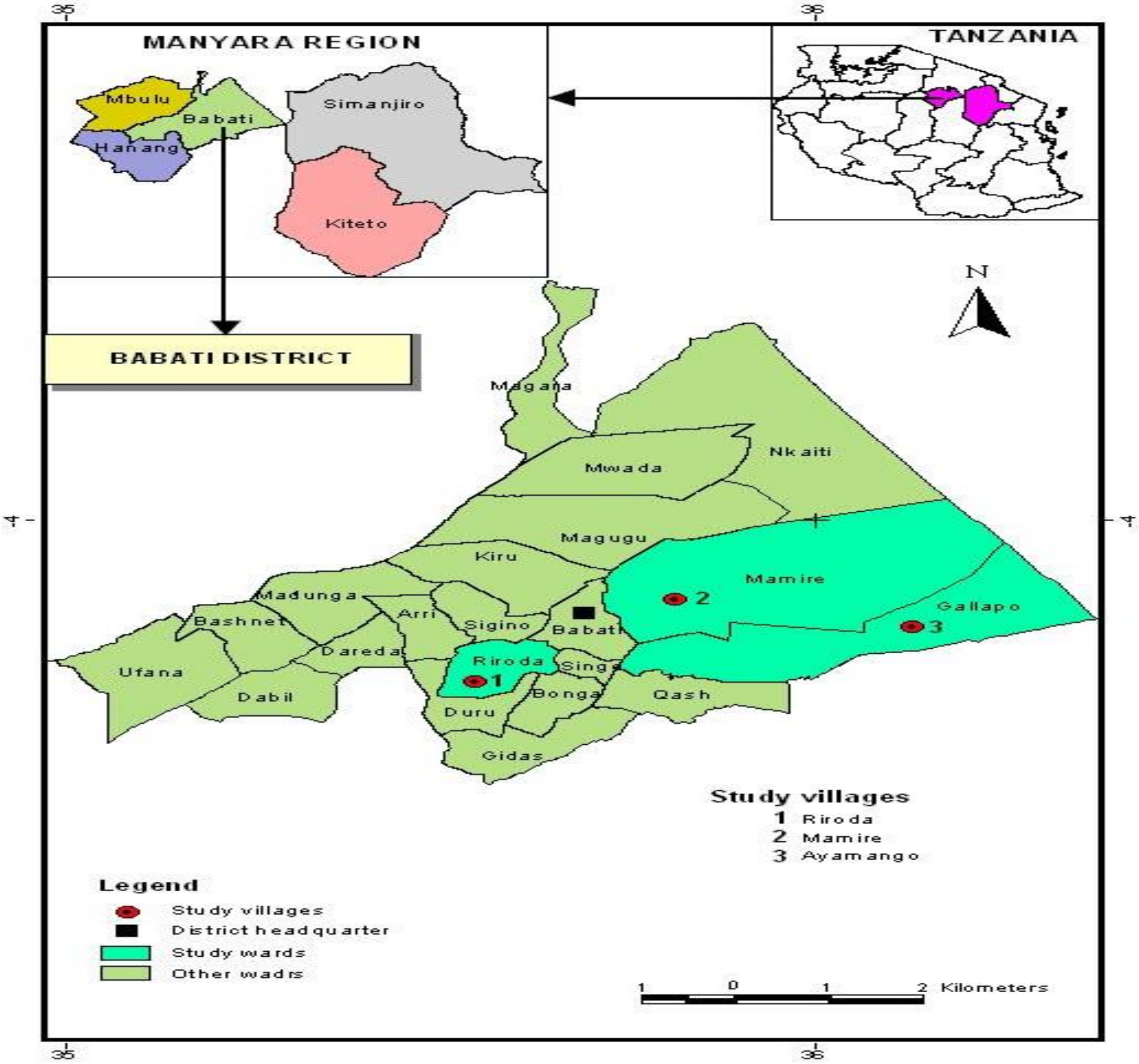

Figure 2: Map of Babati District showing study area

Source: SUA GIS Department (2017)

3.1.2.1 Climate and agro- ecological zones

Babati District is characterized by many undulating hills and mountains as part of the East African Rift Valley Highlands. These provide diverse climatic and agro-ecological conditions due to a wide range of altitudes from 950 to 2450 m above sea level. The average rainfall ranges from 500mm to l200 mm per year. However, the range varies basing on agro ecological zones as shown in Table 2. The average annual temperature is 20.2°C. Most of the soils are volcanic and range from sandy loam to clay alluvial soils (District profile, 2016).

Table 2: Agro ecological zones of Babati District

No.	Agro ecological zone	Altitude (m a.s.l.)	Rainfall (mm)
I	Humid Highlands	2150 -2450	1200
II	Sub humid Highlands	1850 -2150	1100 -1200
III	Semi Humid Up lands	1500 -1850	900 -1100
IV	Semi Humid Arid Midlands	1200 -1500	750 -900
V	Semi-Arid Low lands	950 -1200	500 -750

Source: URT (2016)

3.1.2.2 Population

According to the National Population and Housing Census (2012) the district had 312, 392 people with 158 804 males and 153 588 females. The major ethnic groups in the area are the Iraqw, the Gorowa, and the Mbugwe. However, there are other minor ethnic groups including the Rangi, the Masaai, and the Nyaturu. The main economic activities for the population in the district are crop and livestock production (URT, 2013).

3.2 Methods

3.2.1 Research design

A cross-sectional research design was used in this study due to its advantage of allowing data to be collected at a single point in time and to its cost effectiveness. A cross-sectional research design is suitable for a descriptive study as well as for the determination of relationship between variables (Bailey, 1998). In this design, different methods and techniques were used to collect qualitative and quantitative data.

3.2.2 Sampling procedure and sample size determination

Purposive sampling was employed to select the study district (a district that had a project on grain legume livestock integration and that has high maize production); while simple random sampling was used to select the villages; and three villages were selected in three wards. The subjects/unit of analysis for this survey was farming household where three village registers were used to select the households within each village. The households were randomly selected.

On sample size determination Saunders *et al.* (2007) reported that the larger the sample the more representative it is likely to be. The sample size of 240 was considered adequate for the current study, because, according to Hair *et al.* (2006), any sample size usually suffices for descriptive statistics. However, a sample size of between 200 and 500 units is better for most analyses. The samples was considered big enough based on Bailey's (1998) argument that 30 cases is the bare minimum for a study in which statistical data analysis is to be done. Therefore, the sample size for each village and the total for all the three villages were obtained as shown in Table 3.

Table 3: Respondent profile (n=240)

District	Ward	Villages	Households	Sampled
Babati	Mamire	Mamire	232	93
	Galapo	Ayamango	201	80
	Riroda	Riroda	167	67
Total			**600**	**240**

Since, all the farmers in the villages face similar socio-economic, environmental and climate conditions in their farming activities, they mostly make up a homogeneous group which validates the use of a small sample size to represent the whole population (Blaikie, 2010). The sample size was justified for precision by the general formula for sample size developed by Yamane, (1967) as shown hereunder:

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

Where,

n = Sample size

N = Population size

e = Level of precision (α=0.05)

The population was assumed to be homogeneous in most aspects with respect to farming practices as the level of technology used, the type of crops grown, and weather conditions are more less the same. At the end, 93 respondents, 80 respondents and 67 respondents of the village households were sampled in Mamire, Riroda and Ayamango villages respectively making a total of 240 people participating for the survey.

3.2.3 Data collection

In collecting the primary data for this study, household survey and interview methods were used. The study collected both quantitative and qualitative data where by quantitative data were collected from households using a questionnaire with both closed and open ended questions. Individual interviews were carried out to get information from the farmers within the targeted households. Questions that capture the trends in maize production and rainfall were used to identify changes over time. On the other hand, secondary data on maize production and rainfall amounts for the period of 10 years (2008-2017) were collected from Babati District Agricultural Office and the meteorological stations respectively through documentary review method.

3.2.3.1 Preliminary visits

Reconnaissance survey was conducted so as to explain the objectives of the study to various administrative levels in the study area, to familiarize with the research site, to gather general information and to ascertain sampling process. Furthermore, the pre survey was done to get a general picture of the study area; and the questionnaire was pre-tested in order to check for its validity and reliability. The pre-test also helped in the identification of relevant partners from whom the data were to be obtained in the villages (Appendix 1).

3.2.3.2 Research observation

The transect walk was conducted in the household farms to identify farming practices, the crop species grown within the farming systems, and the livestock the households were rearing. Different crop types and livestock were identified under different farming systems. The crops include maize, pigeon peas, beans, lablab, cassava, sweet potatoes and sunflower. Livestock include cattle, goat, sheep, poultry and donkeys. The main farming systems found in the area include mixed maize legume and livestock; maize legume integration and pure crop stand (maize, sunflower, cassava and sweet potatoes).

3.2.3.3 Focus group discussion (FGD)

This is a structured discussion which is used to acquire in-depth information from a group of people about a particular topic. In this study, two focus group discussions were conducted each consisted of eight members in Ayamango and Riroda villages where information on rainfall variability and maize production was obtained. The information obtained helped in studying the trends in rainfall and maize production for ten years period.

3.2.3.4 Documentary review

This method was employed to gather secondary information which could otherwise not be gathered using other methods. The information obtained included maize production for the past ten years (2008-2017) from the District Agricultural Office and rainfall trends from Babati Meteorological station for ten years period (2008-2017).

3.2.3.5 Key informant interview

The informants were selected based on their training and personal knowledge/experience with the rainfall, farming systems, and maize production in the study area. Among the informants was the Extension Officer who had worked in the study area for more than ten years and maize farmer practicing mixed crop livestock farming system for the last 10 years. Each interview took about thirty minutes. Notes were made after each interview from which key themes were identified.

3.3 Data Processing and Analysis

Quantitative data were summarized, coded and analyzed using Statistical Package for Social Sciences (SPSS) computer software whereby both descriptive and inferential statistical data analysis methods were used. Socio-economic characteristics of the households were analyzed descriptively, findings were then presented using frequency tables and graphs. On the other hand rainfall amount and maize production data were analysed using Ms excel computer program.

3.3.1 Descriptive statistics

Descriptive statistics including frequency distribution and percentages were computed. Rainfall and maize production data for the past 10 years (2008–2017) were analysed for trends and trend relationship.

3.3.2 Linear regression analysis

Linear regression analysis was employed in order to explore the relationship between maize production (tonha^{-1}) and rainfall amounts (mm) for estimating the potential impact of rainfall variability on maize production using time series on the data which were collected. Maize production provided by annual maize yield (tonha-$^{1)}$ was regressed with the rainfall amounts in order to estimate their effects on the yield. Using Ms-excel as a program of analysis, the following simple regression model was performed:

$Yi = \alpha + \beta 1\ (RAINt) + \varepsilon i$ ………………………………….................................... (2)

Where:

Y_i = Yield for maize crop (ton)

$\beta 1$ = Regression coefficient for the predictor

α = Y intercept

Total *RAIN t* = Total rainfall (mm) in a year

εt = error term in the observed value

t = time (i.e. year).

3.3.3 Adaptation strategies to rainfall variability in mixed farming systems

3.3.3.1 Response frequencies

The adaptation strategies to rainfall variability were determined in terms of their frequencies, percentages of responses, percentages of respondents (cases) and response earmarked by most of the people were determined.

3.3.3.2 T test

Independent t-test was used to test significant difference on the mean maize yields from mixed and non-mixed farming systems. The Independent-Samples t-test compares the means for two groups of cases (Hair *et al*., 2006). It involves a test of the two randomly chosen groups so that any differences in the response is due to the treatment (or lack of treatment) and not to other factors. In this study, the two groups included the respondents who were performing mixed framing and those who were performing non-mixed farming.

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3.3.3.3 Yield data

Maize was harvested in 25m^2 plots from six household farms in both mixed and non-mixed farming systems and its weight measured using a spring balance. The average weight was obtained and was computed in tonha^{-1} so as to compare its yield among the two farming systems.

3.3.4 Multiple regression model

Statistical Package for Social Sciences (SPSS) program was used to identify and ascertain the influence of socioeconomic and farm factors on maize yield. Multiple regression Model was employed to estimate the influence of each socioeconomic and farm factor to the yields of maize in the mixed farming system. Multiple regression estimates the coefficients of linear equation, involving two or more independent variables that best predict the value of the dependent variable (Hair *et al*., 2014). It is used to model the value of a dependent scale variable (interval or ratio) based on its linear relationship to one or more predictors. In this study, the dependent variable was maize yield from farmer which is a scale variable.

Prior to the estimation of the model parameters, it was crucial to look into the problem of multicollinearity among the explanatory variables (Hair *et al*., 2006). Variance inflation factor (VIF) was used to detect multicollinearity among the independent variables. Coefficient of determination (R^2) was used to measure the goodness-of-fit of the model. This index explains the proportion of the variation in the dependent variable to that of the independent variable in the model (Chaudhuri and Loh, 2002).

Multicollinearity is a statistical phenomenon in which two or more predictor variables in a multiple regression model are highly correlated (Hollar, 2010). In this situation, the coefficient estimates may change erratically in response to small changes in the model or the data. The variance inflation factor (VIF) test is regarded as one of the most rigorous diagnostic tests for multicollinearity in the regression model (Wooldridge, 2001). In addition, the Durbin-Watson's tests were used to test for auto-correlations. At the end, the following model was estimated:

$$Y_i = \beta_0 + \beta_1 \text{ AGE} + \beta_2 \text{ GENDER} + \beta_3 \text{ EDU} + \beta_4 \text{ HS} + \beta_5\text{SC} + \beta_6 PC + \beta_7 \, F\text{AES} \quad \beta_8 F\text{AC} + \text{FS}_9 + Ci \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (3)}$$

Where:

Yi =Yield of maize (ton/ha)

β_0 =Intercept

$\beta_1 \, \beta_2 \, \beta_3 \ldots\ldots \beta_9$ = Regression coefficient to be estimated

AGE = Age of household head (years)

GENDER = Gender (dummy variable: male=1, female=0)

ED = Education level (1=illiterate, 2=primary, 3=secondary, 4=college

HHS = Household size (0=1-5), 1=above 5

SC = Seed Cost (Tsh/kg) 0=High, 1=low

PC = Pesticide cost (Tshs) 0=high, 1=low

FAES = Farmer's Access to extension services (dummy variable; enough=1, Not =0)

FS = Farm size (ha)

FAC = Farmer's Access to credits (dummy variable: Yes=1, No=0)

Ci = *Error* term.

Variables and expected sign from the model

It was hypothesized that household head age is positively or negatively related to maize yields. It can be positive because farmer's old age is likely to enhance good decision making through accumulated farming experiences. On the other hand, it can be negatively related to age since young farmers are used to be more willing and likely to adapt to new and improved technologies compared to old farmers. Gender of the household was included in the model as a dummy variable (1 if the farmer was a male and 0 if the farmer was a female). It was hypothesized that the sex of a farmer does not impact the yields. Education was measured as the number of years a farmer spent in school and was positively related to maize yields. It was assumed that the higher the level of education of a farmer, the higher the yields. According to report by Msuya *et al., (*2008), education level was an important factor in enhancing agricultural production.

It was important also to include the costs of inputs (seeds and pesticides) in the model because inputs may affect yields. It was hypothesized that the cost of inputs affects maize yield negatively. The higher the cost of inputs the lower the crop yields. This is because smallholder farmers with low capital in most cases cannot afford to pay for higher input prices.

Household size (the number of adults aged 20-55 years) was included in the model to establish how this variable influenced maize yield in the study area. It was hypothesized that as the household size increases, the yields also increase. In smallholder farming, the household is the major source of labour; thus, household size is a measure of labour availability (Mendola, 2007). Makingi and Urassa, (2017), reported that large sized (6 – 10 members) households relatively improved paddy production compared to small sized ones (1 – 5 members). Farmers' access to credits was included in the model to show how the variable influences maize yield. It was hypothesized that farmers' access to credits is positively related to maize yields, in that the higher the access to credits farmers have the higher the maize yields. It was envisaged that the fund obtained from credits would be used for by farmers to buy improved seeds and pesticides, which would in turn increase maize yields.

It was assumed that if the farmer attends more training sessions provided by extension officers on maize production practices then it is possible that the farmer will use the skills obtained to increase yields, this means access to extension services is positively related to maize yields. The coefficient of land size of the farmer is expected to have either positive or negative sign. In the mixed farming systems, farming is highly demanding in terms of labour, financial resources, time, and management skills. Therefore, a farmer can use a large land area but produces minimally due to poor management and the sign will be negative. On the other hand, land size can be positive if the farmer uses small land area which he/she can manage well to produce higher yields. Table 4 illustrates summary of variables included in the regression model.

Table 4: Summary of variables included in the regression model

Variable	Unit	Category	Expected significance
Yield	Tonha^{-1}	Dependent	
Age of household head	Years;1= 20-55 Above 55 = 0	Independent	Positive
Gender of the household	1 = male 0 = female	Independent	Positive
Farm size	1 =3-5 0 below 5 acres	Independent	Positive
Seed cost	T.shkg^{-1}	Independent	Negative
Pesticide Cost	Tsh	Independent	Negative
Farmer’s access to credits	Tsh	Independent	Positive
Farmers access to extension services	Training visits	Independent	Positive
House hold size	1= above 3 acres 0= below 3 acres	Independent	Positive

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter presents and discusses the major findings of the study. The first part presents the findings on socio- economic characteristics of the sampled population with respect to farming system and rainfall variability. The second part presents the trends in rainfall and maize production. The third part describes the relationship between rainfall and maize production trends; the fourth part presents information on farmers' coping and adaptation strategies to rainfall variability in mixed farming systems. Lastly, while the fifth part provides information on the influence of socioeconomic and farm factors on maize yields in crop livestock mixed farming systems.

4.1 Socio-economic Characteristics of Respondents in the Study Area

The socioeconomic characteristics of the population including age, gender, marital status, education level, family size, farm size, farming experience and land ownership are critical to farm decisions and performance in relation to crop production. For example, gender determines responsibilities for male and female farmers in crop and livestock production; and family size determines labour force in production. Studying these characteristics is important in understanding the contribution of each attribute in maize production under maize legume- livestock mixed farming systems in the study area.

4.1.1 Age of respondents

The respondents involved in the study were of different ages as shown in Table 4. The average age was 43.5 years with a minimum of 20 years and a maximum of 77 years. Most (92.07%) of the household heads were individuals in the age class of 18-60 whereby 46.66% were involved in mixed farming system and 45.41% practiced non-mixed farming system. About 7.9% are in the 56 to 77 age class with 2.7% in the mixed farming and 5% in the non-mixed farming system. When the percentages of age were tested using Chi square the results showed insignificant difference among the two farming systems (mixed and non-mixed).

4.1.2 Gender and marital status

During the study, male and female respondents were involved and the household heads were the targeted group. Based on gender, 38.3% and 11.25 % of the respondents were males and females practicing mixed farming system. On the other hand, 38.75% of the males and 11.67% of the females were under non-mixed farming system. However, the percentage differences were statistically not significant among the farming systems. The study also found out that the study area had more married individuals in both farming systems than the unmarried ones. Couples were actively engaged in farming activities than unmarried individuals thus making it the target population because the study targeted active farmers. The difference in marital status among the farming systems was statistically significant (p value 0.024).

4.1.3 Level of education of the household head

47.1% and 49.6% of the respondents engaged in the mixed and non-mixed farming systems respectively had primary education, 0.8% had not gone to school and 2.5% attained secondary and college education, the differences in the education level were insignificance between the two farming systems.

4.1.4 Family size, farm size and land ownership

Households in the sample population had the average of 5.7 and 5.4 family members per household in mixed and non-mixed farming systems respectively. This was higher the average of 5.2 members per household which was reported in the National statistics of 2012 on household size in the study area. The results show that mixed farming system has large average family size than non-mixed farming system (p value = 0.02).

Households with farm area ranging from 1 to 5 acres were 36.67% and 31.25 % for mixed and non-mixed farming systems respectively; and those with farm area ranging from 6-12 acres were12.92% and19.17% for mixed and non-mixed systems respectively. The differences among the two farming systems were significant (p = 0.027). Land ownership between the two farming systems showed that 29.17% and 47.92 of farmers under mixed and non-mixed farming systems owned the farming land and 20.42% and 2.5% under the mixed and non-mixed farming systems did not own the farming land. These households farmed on rented or on borrowed land. Generally, most (77%) of the respondents in the study area are farming on their own land and had enough of time for staying in the villages far farming activities. Land ownership among the two farming systems showed significant difference (p value = 0.00). More households under non-mixed farming owned farming land than did households under mixed systems. Table 5 provide results from descriptive analysis of socioeconomic characteristics of respondents in Babati district.

Table 5: Socio economic characteristics of the respondents (n= 240) in Babati District, Tanzania

Variable	**Type of farming system**				**X^2Value**
	Mixed		**Non mixed**		
	Frequency	**%age**	**Frequency**	**%age**	
Age class					
18-35	30	12.5	35	14.58	0.123
36-60	82	34.16	74	30.83	
Above 60	7	2.9	12	5	
Gender					0.9345
Male	92	38.3	93	38.75	
Female	27	11.25	28	11.67	
Marital status					0.024
Married	100	41.67	105	43.75	
Un married	19	7.92	16	6.67	
Education level					
Illiterate	2	0.8	0	0	0.06
Primary	113	47.1	119	49.6	
Secondary	3	1.3	0	0	
Post-secondary	1	0.4	2	0.8	
Family size					0.013
3-5	54	22.5	66	27.5	
Above 5	65	27.1	55	22.92	
Farming experience					0.03
Over 10 years	82	34.2	69	28.8	
Less than 10	37	15.4	52	21.67	
Farm size					0.027
1-5	88	36.67	75	31.25	
6-10	31	12.92	46	19.17	
Land ownership					0.00
Owned	70	29.17	115	47.92	
Non owned	49	20.42	6	2.5	

4.2 Trends in Rainfall and Maize Production in the Study Area

4.2.1 Trends in rainfall

Rainfall results from meteorological station during the rainy season showed an increasing trend for the past 10 years from 2008 to 2017. The lowest rainfall recorded in the area occurred in 2012 which had the total annual rainfall of 542.4 mm. The highest rainfall recorded was 1054.1mm in 2013, with the average rainfall of 852.36mm for ten years period. Figure 3 depicts rainfall trend for ten years period.

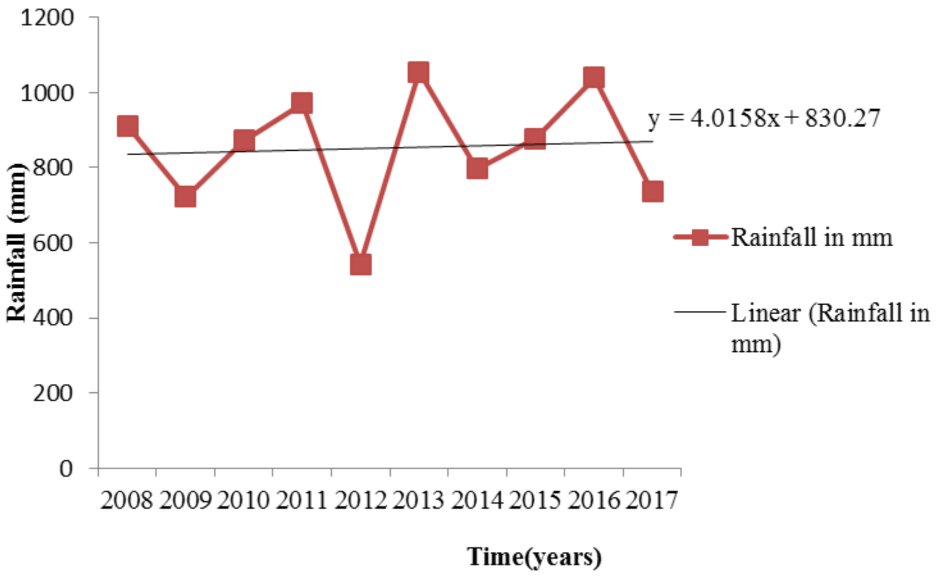

Figure 3: Annual rainfall trend in Babati district from 2008-2017

Source: TMA-Babati (2017).

Fig. 3 shows that on average, there was 4.0mm increase in rainfall per season for the ten years period implied by a positive slope. However, there was high inter-seasonal variability in rainfall. For example, there was a sharp decrease in rainfall in 2012. The results are inconsistent with the findings reported in a study by Munishi *et al.* (2006) which indicate that areas with a bimodal rainfall pattern in Tanzania will experience decreased rainfall of 5% to 45% and those with unimodal rainfall pattern will experience decreased rainfall of 5% to 15%.

4.2.2 Rainfall during the growing season

The Figures 4 (a-c) shows the monthly rainfall for Babati meteorological station for 2008 to 2016 growing seasons. The district has two growing seasons which are October-December and March-May with Bimodal rainfall. The figures 4a to 4c below depict rainfall variability within seasons.

From the figures it shows that there was rainfall variability within seasons. In the years 2008, 2012, 2013, and 2016, there were noticeable changes in the onset of rains which delayed the season as the rains started on November instead of October. This implies that rainfall in the area is unpredictable. During focus group discussions, at Ayamango village, farmers showed awareness on rainfall variability; in their local language they call the situation as Qaymanda or Tiita and others Answi. In old days, farmers believed that drought or flood occurred because gods were angry of something; therefore they had to give sacrifice to their gods for the situation to become normal. They would usually slaughter livestock such as sheep, cattle, or goats and ask for apology to their gods and the situation would then change to normal, one old farmer claimed further that drought could simply be solved by a rain makers.

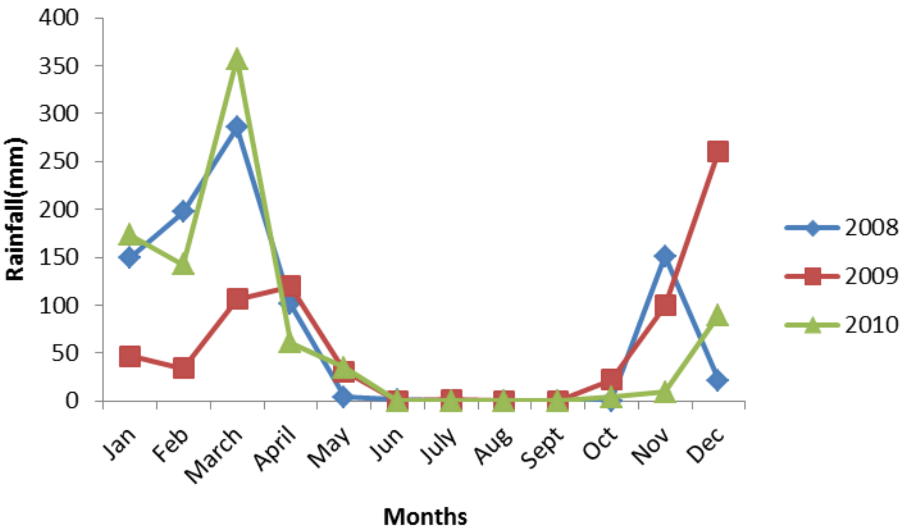

Figure 4 (a): Monthly rainfall for 2008, 2009 and 2010 growing seasons

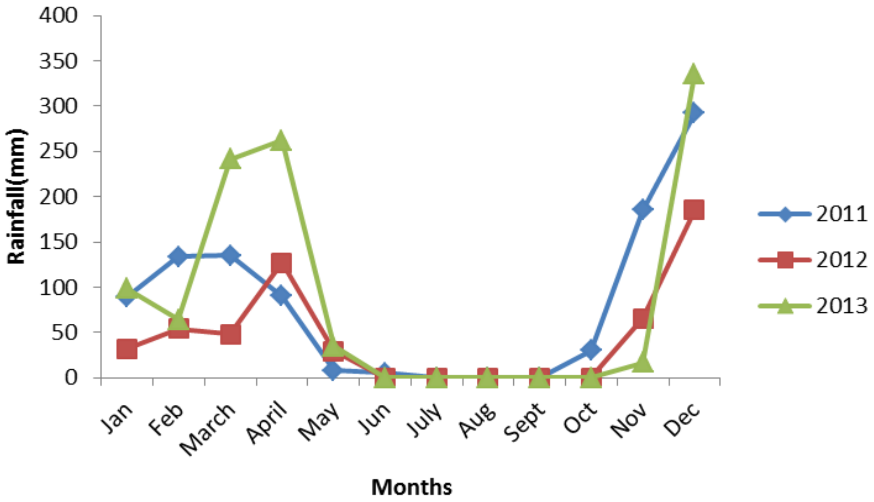

Figure 4(b): Monthly rainfall for 2011, 2012 and 2013 growing seasons

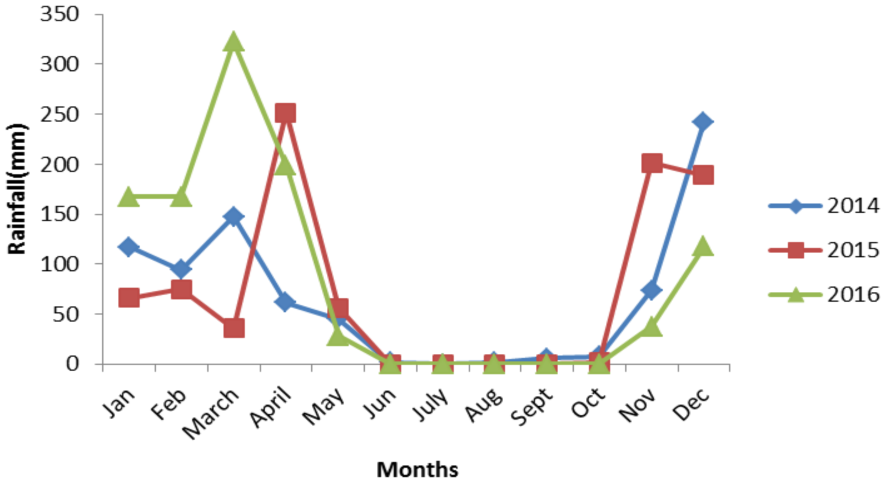

Figure 4(c): Monthly rainfall for 2014, 2015 and 2016 growing seasons

When farmers were asked for their views on rainfall trend during these current years; the response varied among farmers, about 99.6% said rainfall is unpredictable, 87.5% delay the planting season and 76.3% said it is unevenly distributed over the area.

4.2.3 Trends in maize production

Based on documents from the District Agricultural Office, maize production has shown a decreasing trend over the ten years period (2008-2017) implied by negative slope in the fig.5. On average, maize production was decreasing by 0.046 tonha^{-1}. The maximum annual maize production in the area was 3.0 tonha^{-1} and minimum production was 1.25 tonha^{-1} as shown in the Fig. 5.

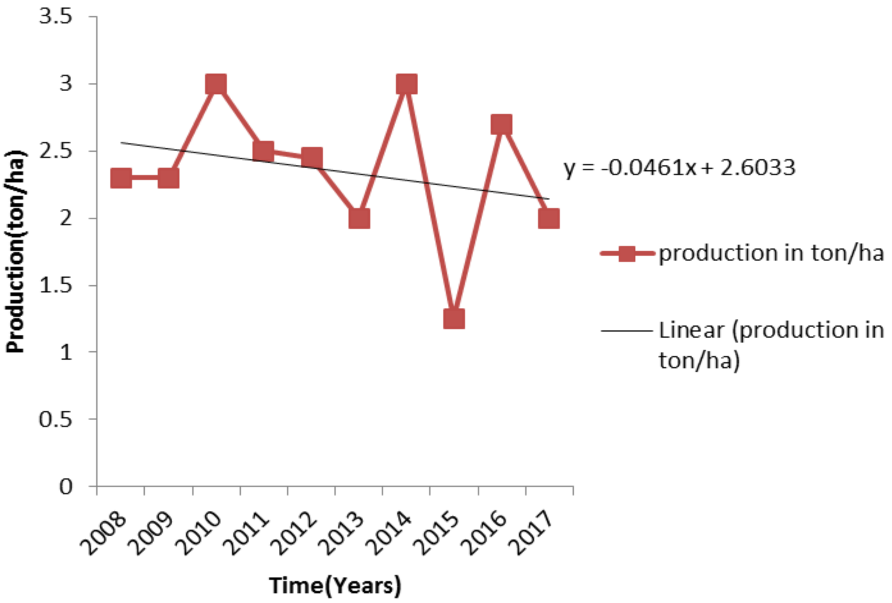

Figure 5: Maize production trend in Babati District (2008-2017).

Findings in Fig. 5 show that maize production fluctuates from one year to the other. The extent of fluctuation depends on the onset and distribution of rainfall within the season that may trigger incidence of shortage of moisture that constitutes a major threat to tonnage of maize yield. For example in the year 2015, maize yield was the lowest over ten years period amounting to 1.25 tonha^{-1} In that year, the rainfall recorded was 877.1 mm which was not enough to produce higher maize yields. In order to obtain optimum maize production, the area should receive 1 000 mm rainfall per season. However, for the average maize production, rainfall should range from 875 mm to 900 mm per season for most maize varieties (Wilson and Lewis, 2015). Therefore low maize production was contributed by poor seasonal distribution of rainfall.

In the ten years period, the study area received enough rainfall in only two years 2013 and 2016; the average rainfall was received in four years (2008, 2010, 2011 and 2015). The years 2009, 2012, 2014, and 2017 received rainfall below the average requirement for maize production. Therefore, low maize yields have been contributed by shortage in rainfall amounts because most of the seasons in the period received less rainfall.

4.3 Relationship between Rainfall Trend and Maize Production Trend In Babati District

Simple linear regression analysis was performed in Ms-Excel Program to determine the relationship between rainfall and maize production trends. Linear regression model produced results which are shown in Table 6.

Table 6: Relationship between rainfall trend and maize production in Babati district

	Coefficients	Standard Error	t Stat	P-value
Intercept	2.444329609	1.014272674	2.409933415	0.04251262
	-0.000110669	0.001172059	-0.094422506	0.92709567

Results in Table 6 indicate that a unit millimetre increase in rainfall leads to a decrease of maize production by 0.00011tonha$^{-1.}$ The regression coefficient has insignificant effect on the amount of maize produced with p-value 0.927. This means that though an increase in rainfall leads to a decrease in maize production this decrease in maize is at non-significant rate. This implies that maize production is not affected only by rainfall variability but also by other factors.

During household survey most of the respondents (99.6%) agreed that a decrease of maize production from one year to another was influenced not only by rainfall variability but also by non-rainfall factors although rainfall is playing part but at a small rate. The factors may include poor farming practices, temperature amounts, soil types, and high costs of agricultural inputs. For example changes in temperature affect maize production whereby dramatically increase in temperature is responsible for increased evapo-transpiration in the soil hence making maize fail to reach mature due to lack of enough moisture in the soil eventually reduce maize production while encouraging weed and pests proliferation. From household survey, respondents said that when there was high temperature there were high incidences of crop pests and diseases and the situation occurred mainly during dry spells of the season. The responses observations are consistent with what is reported by Mkonda, (2014) that an increase in dry spells was connected to increased incidences of crop pests and diseases.

Global Information and Early Warning System (GIEWS), (2018) reported that, in north-eastern regions of Tanzania Arusha, Kilimanjaro, Manyara and Tanga, cumulative seasonal rainfall was up to 70 percent below the average, with a negative impact on crop production. As a result, a reduced maize production is expected, thus leading to a fourth consecutive season with below-average cereal output (URT, 2018). Another study, which was conducted in the district by Ngurumwa, 2016 on the contribution of smallholder maize production towards household food security, revealed that on average the area produces 509.72kg/acre which is lower than the national average yield of 641.64 kgacre^{-1}. This low maize production was due to low rainfall especially in critical times of plant growth. Fig.6 shows the relationship between rainfall and maize production in Babati District.

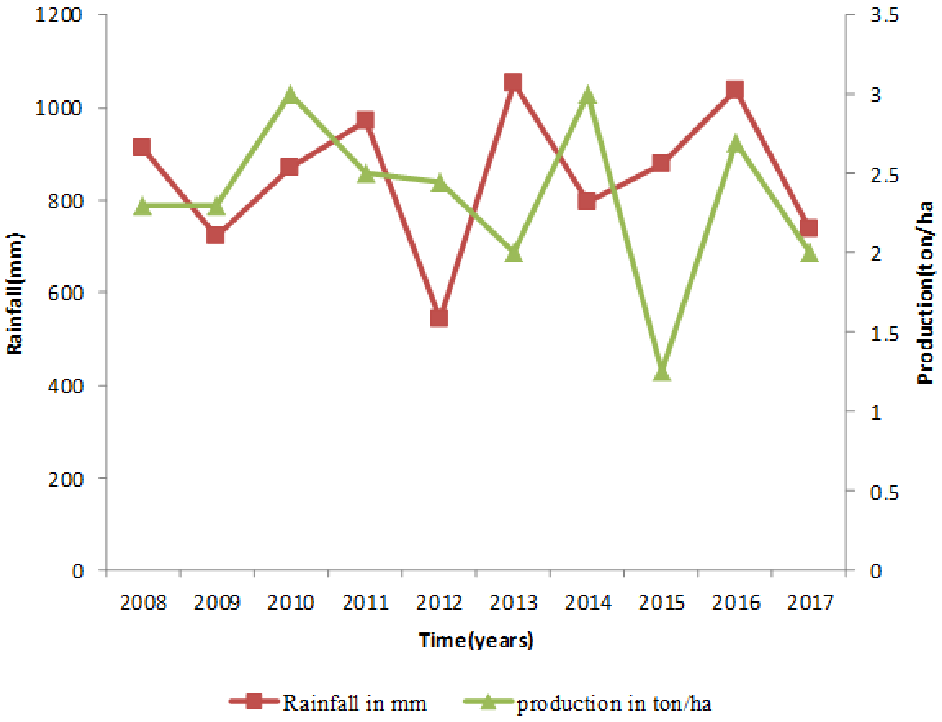

Figure 6: Relationship between rainfall and maize production trends in Babati (2008 –2017).

The correlation of rainfall variability and maize production indicated that, as rainfall continues to increase, the additional gain in maize production begins to diminish. This might be due to the fact that, if the amount of rainfall is above normal it causes water logging and therefore it affects maize production. Further, change in the seasonal precipitation patterns may result in late planting and consequently affecting the total maize yields despite of the high total annual rainfall.

4.4 Adaptation Strategies in Mixed Crop Livestock Farming System to Rainfall Variability in Babati District

4.4.1 Household response frequencies

This study identified several coping strategies to rainfall variability in mixed crop livestock farming system which enhance maize yields on the face of rainfall variability as shown in Table 7. The strategies include the ability of legume plant roots to break the hard pan of the soil and thereby allowing proper growth of plant roots of the associating maize, legume plants covering the soil and reducing the surface temperature and water loss through evaporation, legumes adding natural nitrogen to the soil, livestock being sold when there are crop loss due to rainfall variability, livestock producing manure and being used for ploughing the land, adopting the mixed farming system allows diversification, intensification and reduction of crop weed competition. Table 7 shows the results from the analysis of multiple responses of adaptation strategies in terms of their efficiency in adapting to rainfall variability.

Table 7: Adaptation strategies to rainfall variability in mixed farming systems

Variable	**Response**		**Per cent of cases**
	Frequency	**Percent**	
Tap root of legumes grow down the soil and break the hard pan for other roots to grow well	198	9.5	82.5
Legume plants reduce surface temperature and water loss	213	10.2	88.8
The roots of legumes fix nitrogen for crop nourishment	200	9.6	83.3
Livestock produce manure	209	10.1	87.1
Livestock are sold to get cash income in case of crop loss	207	9.9	86.2
Manure improve water holding capacity of the soil	173	8.3	72.1
Livestock used for ploughing the land	226	10.8	94.2
Manure release nutrients to the soil	220	10.6	91.7
Crop and livestock diversification	214	10.3	89.2
Less crop -weed competition	224	10.7	93.3

From the table it can be noticed that all the responses contribute to the increase in maize production; however a response which has been mostly pinpointed is livestock being used for ploughing the land (10.8%), and which is also has been earmarked by most people (94.2%).

The results revealed that mixed farming system is efficient in adapting to rainfall variability in varying percentages. Root system of leguminous plants have the ability to grow down to the subsoil where it draw moisture for its growth and the intercropped maize uses the moisture on the upper soil thus there are no moisture competition among the associating plants. About 82.5% of the respondents agreed with the statement. About 88.8% of the respondents said that legumes have the characteristic of covering the soil during its growth course, crop cover reduces soil water loss through evaporation and soil erosion by reducing the speed of water runoff thus all the moisture are up taken by the plants for its growth.

Leguminous plants fix nitrogen through nodules in its roots which are released to the soil for nourishing the plants and replace the use of inorganic nitrogen which is associated with environmental pollution during its manufacture and use. Similar findings are reported by Mariki (2003) who reveal that legumes are grown primarily to prevent soil erosion, reduce soil surface temperature and water losses, add organic matter to the soil, stimulate soil life, suppress weeds, and fix nitrogen.

In another study, Thornton and Herrero (2014) revealed that using legumes for natural nitrogen fixation can increase the yields and resilience of crops to rainfall variation. Similarly, other researchers (e.g. Kremen and Miles, 2012; Bryan *et al.,* 2013) reported that legumes on mixed crop-livestock farms can increase the resilience of farming systems by increasing species richness and abundance while providing substantial mitigation benefits to rainfall shocks.

Livestock in the system have basic functions in coping with changing rainfall situations especially when the rainfall is below or above the required amounts to supports maize growth. About 86.2% of the respondents said that livestock are sold for buying food when there is crop loss due to insufficient rainfall or too much rainfall. For example, cattle can be sold to obtain cash for buying maize and other household requirements which would have been bought after selling maize. Eighty seven percent (87%) of the respondents agreed with the statement that livestock produce farm yard manure which is added to the soil for nutritional purposes, though it can also improve soil water holding capacity and retention. These results are consistent with the findings in a report by FAO (2010), which indicate that composting farmyard manure and crop residues, more precise matching of nutrients with plant needs, deep placement technologies and using legumes for natural nitrogen fixation can increase maize yields while reducing the need for synthetic fertilizers with the benefit of reducing the greenhouse-gas (GHG) emissions associated with their use.

About 94.2% of the respondents said that livestock are used for ploughing the land. For better maize growth, land should be ploughed to a depth of 15 to 20cm and seed sown at 5cm deep for better water uptake by the roots of the plant. Thus, ox plough can dig the land at better depth of the soil for better growth of the plant roots of maize as opposed to the hand hoeing. Crop and livestock diversification was another adaptation strategy for coping to rainfall variability in the mixed farming system where 89.2% of the respondents said that diversification provides food security at a household level. This is because several products are grown in the system, thus when one crop fails due to drought or flood there are some which can tolerate the situation and provide yields at the harvest period.

Mixed farming systems help to reduce crop-weed competition during its growth since growing different crops on the same land changes the nature and the amount of resources available for weeds. Weeds are crop specific thus weed species which affect grass crop for example may not affect legumes. Therefore, mixing maize with legumes on the same land may affect continuous growth of weeds specific to legumes or maize, 93.3% of the farmers agreed with this statement. This finding is consistent with the finding in a study by Gurevitch *et al.* (2009) who revealed that mixed crop livestock farming systems exclude species which are highly specialized in exploring a single or few environmental resources, leaving room for less specialized and more flexible plant species which are usually not troublesome weeds.

Generally, it has been reported that local integration of cropping with livestock systems can reduce resource depletion and environmental fluxes to the atmosphere and hydrosphere, can provide more diversified landscapes that favour biodiversity and increase system flexibility to cope with climate variability (Thornton and Herero, 2015).

Thornton and Herrero (2015) observed further that the synergies between cropping and livestock husbandry offer various opportunities for raising productivity and increasing efficiency of resource use. This ultimately leads to increasing household incomes, security and access to food, crop residues, manure, power, and financial resources.

4.4.2 T test

Mean maize yields per hectare in the mixed and non-mixed farming systems were compared for the last five growing seasons in SPSS program as shown in Table 8.

Table 8: Maize Mean Yields (tonha^{-1}) in mixed and non-mixed farming system in Babati District

Variable	Non Mixed (n=121)	Mixed (n=119)	t test	df	p-value
Maize mean yield (tonha^{-1})	1.36	2.57	11.67	238	0.00

From the Table 8 results, the mean maize yield per hectare was 2.57tonha^{-1} in mixed farming system and 1.36tonha-^{1} in non-mixed farming system. The increase in the mean maize yield in mixed farming system was due to the adaptation characteristics of mixed farming systems which enhance growth and yield of maize crop. As Thornton (2015) reports, the justification for integrating crop and livestock activities is that crop livestock production can produce resources that can be used to benefit livestock and crop production, leading to greater farm efficiency, productivity, and sustainability.

The mean of maize yields were tested using independent t-test for its significance and the results showed a significant difference in the mean yields between the two farming systems. From household survey responses, about 86% of the respondents said that maize yields under mixed farming system were higher than that in the non-mixed system. Figure.7 illustrates the maize mean yields under mixed and non-mixed farming systems. The results show that the yields were higher in the mixed farming system, than in the non-mixed farming system.

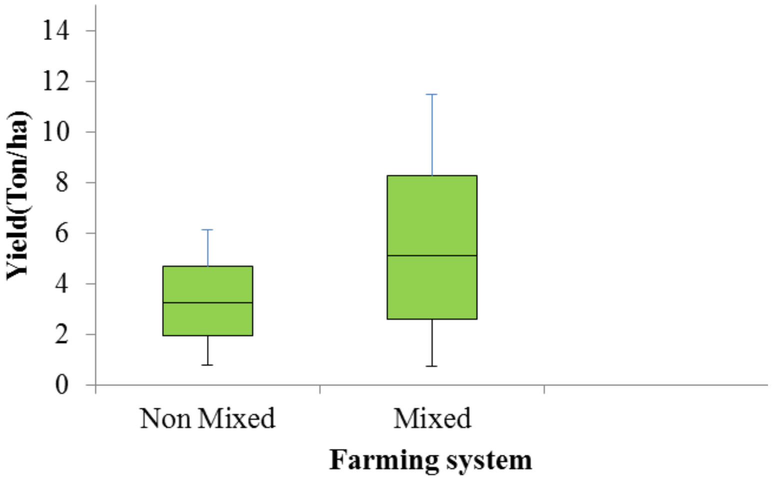

Figure 7: Maize mean yields for mixed and non-mixed farming systems in Babati District

4.4.3 Yield data

During transect walk around the household farms, maize cobs and crop cuts were harvested in six plots each with 25m^2 quadrant land threshed and maize grains measured separately in terms of its weight in both mixed and non-mixed farming systems in 2018 growing season, the results are as shown in Table 9.

Table 9: Maize yield data in mixed and non-mixed farming system 2018 season

Observations	Mixed farming systems			Non mixed farming systems		
	Mean	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**
Farmer's area estimated (acres)	2.0	0.5	12	2.0	0.5	12
Plant stand in a 25m^2 quadrat	67	15	211	62	11	168
Total cob dry weight in 25m^2 quadrat (kg)	8.66	2.4	57.46	5.2	1.35	43
Grain yield in a 25m^{2}quadrat(kg)	6.65	4.85	7.49	4.21	2.2	5.8
Total grain yield tonha^{-1}	2.66	1.94	2.99	1.6	0.88	2.32

Table 9 results show that average grain yield in a 25 m^{2}quadrant land was 6.65 kilogram in mixed farming and 4.21 kilograms in non-mixed. These yields were converted into tonnes per hectare and the results were 2.66 tonha^{-1} under mixed system and 1.6tonha^{-1} under non-mixed farming system, thus mixed farming system yielded more maize than non-mixed system. This is because under the mixed system, maize plants are well nourished with farmyard manure and natural nitrogen fixed by leguminous plants. Nutrients are also well replenished through the recycling of wastes and thus minimizing soil erosion making maize plants grow healthy and fill the grains with heavier weights that increase tonnage per hectare. This finding is supported by 89.6% of the respondents who agreed that under the mixed farming systems maize plants grow vigorously and produce higher yields per unit area.

4.5 Socioeconomic Factors That Influence Maize Production among Mixed Crop Livestock Farmers in Babati District

The identified socioeconomic factors that influence maize productivity amongst maize farmers in the crop livestock mixed farming system include age, level of education, gender, household family size, average land under farming, farmer's access to extension services, and credits. The study used multiple regression analysis tools to examine the influence of each factor on farm yields. Maize yields were regressed against the factors to determine its influence on the yields in the mixed farming system. The results show that the Variance Inflation Factor (VIF) for all variables in the model ranged from 1.069 to 1.242 which meets the VIF as stipulated by Pallant (2011). This implies that there was no problem of multicolinearity. Durbin-Watson's was 1.781, falls within the values of $1.5 < d < 2.5$ implying that there was no auto-correlation (Kutner *et al.*, 2005). Hence, there was no auto-correlation in the multiple linear regression data (Table 10).

The cost of seed had a beta coefficient of -0.095; this meant that as the cost of seeds increase, maize yields decreases by 0.095 units. This implies that when the seed becomes more costly, only fewer farmers are able to afford the costs involved in growing maize to the optimum production thus decreasing the overall maize production. However, the variable in the model was statistically insignificant but influence maize yields negatively. These findings support the study's hypothesis related to the cost of seed. In another study, Mangasini *et al.* (2014) who studied on Socio-economic factors limiting smallholder groundnut production reported that high costs of seeds generally reduce the number of farmers which in turn, reduce the yields of groundnuts. The costs of pesticide had a negative impact on maize production with beta coefficients of -0.190; p value = 0.007 and was statistically significant. This means that an increase in the cost of pesticide leads to a decrease in maize yields by 0.19 units. Similar findings are also reported by Mangasini *et al.* (2014) who revealed that pesticides may stop the destruction of crops by pests and diseases, which might lead to improved yield, the costs of pesticides may affect farm size, assuming that farmers will cultivate a farm size which they can manage with little or no pesticides, this will likely reduce the quantity of crop harvested.

Table 10: Influence of socioeconomic and farm factors on maize production in Babati District

Variable	Unstandardized Coefficients		t	p value	Collinearity Statistics	
	B	Std. Error			Tolerance	VIF
(Constant)	7.325	0.292	25.061	0.000		
Education level of the household head	0.368	0.134	2.752	0.062	0.852	1.174
Gender of respondent	0.020	0.118	0.166	0.868	0.935	1.069
Respondent's age	0.003	0.005	0.609	0.544	0.891	1.122
Family size	0.280	0.024	11.698	.000*	0.870	1.149
Cost of seed per kilogram	-0.095*	0.107	-0.886	0.377	0.909	1.100
Cost of pesticides	-0.190	0.101	-1.885	0.007*	0.918	1.090
Farmer's access to extension services	0.192	0.105	1.835	0.069	0.876	1.142
Farmer's access to credits	0.255	0.107	2.379	0.019*	0.805	1.242
Farm size	0.282	0.108	3.066	0.003*	0.883	1.132

Multiple R = 0.824; R^2 = 0.679; Adjusted R Square = 0.652; p = 0.000, Std. Error of the Estimate = 5.95; Durbin-Watson =1.781

House hold size was another factor that significantly influence maize yields (p = 0.00) in the study area; households with five people or above who can participate in farming activities accounted for 57.92% of the farmers. This size has a possibility of increasing maize yields by 0.280 units as opposed to family size with less than five members. This entails that there is enough man power to work in farming activities since most of the households use family labour for farming activities in the study area.

Farm size variable had a beta coefficient of 0.282 and was statistically significant ($p = 0.003$). This means that as the land for farming increases, maize yields are increased by 0.282 units. This implies that households with large land area (3 to 5 acres) for farming have the potential of having high maize yields than those with small area(less than 3acres). However in the mixed farming systems, farming activities are highly demanding in terms of labour, financial resources, time, and management skills. Therefore, a farmer can have a large land area but produces low due to poor management. On the other hand, a farmer can have small land area that he/she can manage well and produce more farm products. Farmers with access to credit facilities are more likely to increase maize production compared to those without access. Beta coefficient of 0.255 implies that farmers with access to credit are 0.255 times more likely to produce maize than those with no access to credit. According to Wachira (2012), households with access to credit may be of help to farmers in obtaining the capital required for adopting higher profit production technologies and therefore increase productivity.

Generally results from the chapter shows that rainfall trend is increasing with inter annual variability and maize production is decreasing. Crop livestock mixed farming system yield more maize than non-mixed system and socioeconomic factors found to influence maize production in the study area include family size, farm size, costs of seed and pesticides and farmers’ access to credits.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The findings of the study show that rainfall variability influence maize production as annual rainfall was increasing maize production was decreasing the decrease of maize yield is influenced by inter annual rainfall variability. On the relationship between rainfall and maize production trends, an increase in rainfall led to a decrease in maize production; however, maize decreased at non-significant rate (p-value 0.927).

Based on the results from the adaptation analysis of farming systems, the study concludes that the mixed farming system yields more maize than the non-mixed farming system with average maize yields of 2.57 $tonha^{-1}$ and 1.36 $tonha^{-1}$ respectively. Socio-economic and farm factors which influence maize yields in the study area were house hold size, farm size, farmer's access to credits, and the cost of agricultural inputs.

5.2 Policy Implication and Recommendations

Tanzania's agriculture is the driving force of the country's economy and therefore its development is of importance. In order to achieve this, the sector has to grow at, at least 6 per cent. However, the rate of growth has over the past decade averaged about 4.4 per cent indicating a stagnant growth. In order to address the stagnating growth, a number of reforms such as KILIMO KWANZA Resolve, the Tanzania Food Security Investment Plan (TAFSIP), Feed the Future Programme and Bread Basket Initiative have been initiated to complement speedy implementation of Agriculture. The reforms aim at creating the enabling environment for ensuring household food security, improving agricultural productivity, profitability, farm incomes and alleviating rural poverty.

In order to boost production and contribute to improved income and livelihoods for small holder maize farmers, this study recommends the following policy responses:

i) Appropriate strategies for reducing vulnerability to inter seasonal rainfall variability should be adopted; the strategies may include deliberate efforts for protecting the environment through providing environmental management education to farmers. These may include for example, the conservation of natural forests, proper farming practices, tree planting and sustainable farming (Crop livestock mixed farming systems).

ii) Up scaling of crop-livestock mixed farming systems since mixed systems were found to be capable of adapting to rainfall variability effects.

iii) Agricultural production input costs should be affordable to farmers therefore private companies and government institutions responsible for farming inputs should find a way of supplying inputs (seed and pesticides) at a cost that many farmers will afford and use it to increase crop production.

iv) The formation of farmer managed co-operatives among smallholder farmers should be encouraged. These may be in the form of co-operative banks, agricultural marketing co-operatives (AMCos), or savings and credit co-operative societies (SACCOS) that would assist in providing soft loans which are purposively aimed at meeting the costs of inputs with affordable interest rates.

5.3 Area for Further Studies

Based on the findings from this study most of the smallholder farmers were aware that mixed farming system can help to shield against crop loss on the face of rainfall variability. However only few have adopted the technology; therefore further studies can be conducted to find out the reasons as to why only few farmers have adopted the technology.

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APPENDICES

Appendix 1: Household Questionnaire

Dear household head,

As one of farmers in the village, your house hold has been selected so as to provide information that could be used to assess the effect of rainfall variability in maize production. I assure you that, all the information provided are special for academic purpose and not otherwise. Therefore, you are friendly requested to respond truthfully to the following questions. I thank you in advance.

A: GENERAL INFORMATION

1. Name of interviewer……………………………..Date……………………………
3. Ward …………….. Village: ………………………..
4. Name of the head of household……………………………………………………
   Gender ii) Male ( ) ii) Female ( )
5. Marital status: i) Married ( ) ii) Single ( ) iii) Divorced ( )
   iv)Widowed ( ) v) Separated ( )
6 How old are you? (Head of household)……………………………………. years
7. What is level of your education?
   i) Illiterate ( ) ii) Primary school ( ) iii) Secondary school ( )
   iv) Adult Education ( ) v) College ( ) vi) University ( )
8. How long have you been living in the village? ....years
9. What is your main occupation?
   i) Farmer ( ) ii) Employee ( ) iii) Business person ( )
   iv) Other (Mention)………………………………..

10 (a) Total family size of the household…………………..

Total……….Male…….Female………….Adult…………Young…………..

(b) Make sure the total number is the same as the family size in 10 (a)

(i) Below 12years Old …………… (ii) 13-17 years old……….. (iii) 18-35 years old………… iv) above 35 years old……………

11(a) Does your household own farming land? Yes ( ) No ( )

How many acres? ....

11(b) If yes how did you acquire the land? (i) Buying…………

(ii) Borrowing………….. (iii) Hiring…………..

(iv)Inheriting …………….

12 (a) In which ways has the income in your household has changed over the last 5 years

(i) Has improved ( ) ii) has stayed the same ( ) iii) Getting worse ( )

12 (b) Give the reason to way the response of 12(a)………...

…………………………………………………………………………………………

…………………………………………………………………………………………

B: RAINFALL VARIABILITY AND ITS IMPACTS ON CROP PRODUCTION

13. How do you perceive rainfall variability?

....

14. Have you ever noticed any rainfall variability in your village?

i) =Yes ( )

ii) = No ( )

15. If yes, how do you notice that the weather/ rainfall is changing?

i) Decrease ii) Increase

16. What were the impacts/ effects of rainfall variation?

i) = Drought ( )

ii) = Floods ( )

iii) = Other; mention……………………………………………….

17. Does the rainfall variation have an effect in the crop productivity?

i) =Yes ( )

ii) = No ( )

18. If yes what are the effects of rainfall variation to the crop productivity?

i. ……………………………………………………………………….

ii. ………………………………………………………………………..

iii. ………………………………………………………………………..

iv. ………………………………………………………………………

19. Have you experienced any crops loss in the past five years?

i) =Yes ( )

ii) = No ( )

20. If yes what was the major cause of loss?

1 = Drought ( )

2 = Floods ( )

3 = Heavy rainfall ( )

4 = others specify……………………………………..

C: MAIZE PRODUCTION

21. a) Do you grow maize? Tick the most correct

i) Yes ………………. ii) No……………

b) If yes, what type of farming system do you practice?

i) Mixed farming system ( )

ii) Non mixed farming system ( )

22. How much maize was harvested in the last five years?

Year	**Land size cultivated (Acre)**	**Total harvested (Kgs)**
2017		
2016		
2015		
2014		
2013		

Note: Debe = 18kgs bag= 6 or 7debes = 108 or 120 kgs

23. What is the price of maize sold in each year?

Year	Price/unit (TZS)
2017	
2016	
2015	
2014	
2013	

24. What amount is normally consumed by the household? ....

25. What amount is sold to get cash income? ……………………………………

26. Total income generated from maize produced for the past consecutive five years

Year	Total harvested	Price(Tsh)	Amount consumed	Amount Sold	Total income
2017					
2016					
2015					
2014					
2013					

27. What farm inputs are used for maize production other than land?

i. ………………………………….

ii. ………………………………….

iii. …………………………………

28. What are the prices for each farm input mentioned above?

Input	Units (Kg/tons/ debe/ bags/ crates/ horse cart	price (TZS)

29. What are the sources of labour in the farming activities?

Family labour	Hired labour	Both family and hired	others

30. For how long have you been in farming activities? ………………………… years.

D: MAIZE PRODUCTION AND RAINFALL VARIABILIRITY ADAPTATION STRATEGIES IN CROP LIVESTOCK MIXED FARMING SYSTEMS

31. a) Are there any beneficial characteristics of crop livestock mixed farming system to adapt to rainfall variability? Yes ( ) No ( )

b) If yes mention them;

i. ……………………………………………………………………

ii. ……………………………………………………………………..

iii. ……………………………………………………………………

iv. ……………………………………………………………………….

v. …………………………………………………………………………

vi. ………………………………………………………………………..

32. Do you plant a diversity of crops and crop varieties as a means of coping to maize crop loss?

1=Yes ( )

2= No ( )

33. If yes indicate the type of crops planted for coping to crop losses

S/No	Type of crop	Season

34. What food is eaten during the period of maize crop loss?

1 ……………………………………

2 …………………………………….

35. Do you plant improved varieties of crops and keep livestock in order to cope with changes in rainfall patterns?

1=Yes ( )

2= No ( )

36. If yes indicate the type of crop varieties planted for coping to losses for both crops

Crops:

S/No.	Type of crop	Variety name	Maturity time
1.	Maize		
2.	Pigeon peas		
3.	sunflower		

Livestock:

S/No	Livestock	Type of breed
1.	Cattle	
2.	Goat	
3.	Poultry	
4.		

37. What kinds of maize intercrop? (Tick the most correct)

i. Beans
ii. Pigeon pea
iii. Cowpea
iv. Lablab

38. How do leguminous plants help to overcome rainfall variability in improving maize crop in the intercrop?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

39. How do livestock in the mixed farming system help to improve maize production under rainfall variability situations?

1 ……………………………………………..

2 …………………………………………….

40. How does manure help to conserve moisture in the soil?

i. ………………………………………………………………….

ii. …………………………………………………………………

iii. …………………………………………………………………

41. How much manure is obtained per season? …………………………… tons.

42. Are there differences in maize yields under maize legume livestock integration and non-maize legume livestock integration? 1=Yes ( ) 2= No ( )

If yes describe the difference;

………………………………………………………………………………………

………………………………………………………………………………………

43. What other methods do you use to cope with rainfall variability apart from crop-livestock mixed farming?

1 ……………………………………..

2 …………………………………….

1. ……………………………………..

44. Do you think there is a need of any special initiatives for community to cope with rainfall variation?

1=Yes ( )

2= No ( )

45. If yes, describe the coping options?

1…………………………………………….

2……………………………………………..

3……………………………………………….

46. What are the limitations to your existing coping mechanism? (Maize legume livestock mixed farming system)

47. What new activities do you suggest in order to overcome those limitations?

48. How do you respond to rescue the situation of crop loss?

1 = reduce number of meals per day ( )

2 = eat less preferred food ( )

3 = sale of family labour ( )

4 = buying after sale of livestock ( )

5 = buying from off-farm money ( )

6 = borrowing ( )

49. Have you decided to change your calendar for caring out farm activities?

1=Yes ( )

2= No ( )

50. If yes, why did you decide to change your calendar for taking out farm activities?

i. Rainfall is delaying

ii. Rainfall is coming early

iii. No reason.

E: SOCIO-ECONOMIC AND FARM FACTORS INFLUENCING MAIZE PRODUCTION.

51. Are there socio-economic factors that contribute to low maize production in mixed farming systems? Yes ( ) No ( )

52. If yes mention the factors

a. ………………………………………………………………

b. ………………………………………………………………….

c. …………………………………………………………………..

d. ……………………………………………………………..

e. ………………………………………………………………

53. How do the factors influence maize production in your community?

i. …………………………………………………………………..

ii. …………………………………………………………………..

iii. ………………………………………………………………….

iv. ………………………………………………………………….

v. ………………………………………………………………….

Appendix 2: A checklist for focus group discussion

Focus group discussion guide for elders in the village

Division……………………………………………Ward……………………………….

Name of the community/village..

Date of discussion..

FGD No..................................

1. How do you understand rainfall variability?
2. What is the local language associated with rainfall variability?
3. Are there any variations in rainfall in this area?

   Yes…………….No………………
4. What is your view on how it rains these days, 5 years back, and 10years back?
5. How have the above changes affected maize production activities in this community?
6. Which year can you recall the occurrence of drought or floods and related impacts to maize production in the district?
7. How did you cope with the events of crop loss due to rainfall variability?
8. Is mixed crop livestock farming system helpful in coping against rainfall variability in your area?
9. Are there other factors influencing maize yields in your community apart from rainfall variability.
10. Explain how those factor influence maize yields
11. What planning and policy documents do you think should incorporate rainfall variability measures in their implementation?

Appendix 3: A checklist for key informant interview

A: Understanding of the rainfall variability

1. What do you know about the rainfall variability?
2. Are there any changes in rainfall patterns in this area?
3. How many rain seasons do you have in the area?

B: Trend rainfall variability and maize production over 10 years

1. What are the actual mean rainfall trends for 10 years in the district?
2. What has happened over the year concerning rainfall variability?
3. How serious was the problem?
4. What were the responses of the people, government and local institutions?
5. What is the maize production trend for 10 years in the district?

C: Coping strategies to rainfall variability

6. What has been the practices used by the community to cope with rainfall variability
7. What draw backs that farmers face in practicing crop livestock mixed farming system?
8. What initiatives have you taken in order to help farmers to overcome the rainfall variability challenges they face.

Appendix 4: Total monthly rainfall for ten years from 2008 to 2017

Month/Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
JAN	150.1	47.1	173.5	89.8	32.3	98.5	116.8	66.1	167.4	49.8
FEB	197.1	34.4	142.6	134.1	54.1	64.5	94.5	75.1	167.3	136.6
MAR	285.6	106.4	357.2	134.9	48.3	241.2	147.3	36	322.4	181
APR	101	120	60.6	90.4	127.2	262	61.3	251.8	199.2	50.8
MAY	3.9	30.6	34.9	8.3	29.3	35.1	45	56	28	73
JUN	1.3	0	0	5.2	0	0	1.7	TR	0	TR
JULY	0	1.2	0	0	0	0	0	TR	0	0.7
AUG	0	0	0	0	0	0	1.6	0	0	0
SEPT	0	0	0	0	0	0	5.7	TR	0	0
OCT		22	3.8	30.4	0	0	7.9	1.9	TR	14.2
NOV	151.1	99.5	9.5	185.3	65.7	17.1	73.5	201.4	37.3	160.8
DEC	21.7	261.1	89.6	292.3	185.5	335.7	242.1	188.8	117.8	69.8

Source: Babati Meteorological station (January, 2018)

Appendix 5: Maize production and Rainfall in Babati district from 2008 to 2017

Year	**Rainfall(mm)**	**Production area(Ha)**	**Production(Tons)**	**Productivity(T/Ha)**
2008	911.8	42 925	98 728	2.3
2009	722.3	42 925	98 728	2.3
2010	871.7	40 000	120 000	3.0
2011	970.7	35 925	89 813	2.5
2012	542.4	22 820	55 909	2.45
2013	1054.1	41 600	83 200	2.0
2014	797.4	46 375	139 125	3.0
2015	877.1	32 844	41 055	1.25
2016	1039.4	43 649	117 825	2.7
2017	736.7	43 167	92 902	3.5

Source: Babati District agricultural Office and Babati Meteorological station (January, 2018)