Climate Variability and Sustainable Food Security in Tanzania: An Over View of Coast Region

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Abstract—**The consequences of climate change for agriculture and food security in developing countries are of serious concern. Due to their reliance on rain-fed agriculture, both as a source of income and consumption, many low-income countries are considered to be the most vulnerable to climate change. This paper estimates the impacts of climate variability as an indicator of climate change on food security in the coastal region of Tanzania. In this study, rainfall and temperature and maize production data for 16 years at Bagamoyo district were used for analysis. Representative climate projections and regression models were used to predict crop yield changes for Bagamoyo district in the country.**

Keywords— **agriculture, climate change, climate variability, food security**

I. Introduction

This case study provides a practical example of how to use climate information to support adaptation planning and policy-making. The focus was on Bagamoyo district in coastal Tanzania, north of Dar es Salaam. The study builds on work done through by the PhD Project, Climate Change and Food Security in Tanzania: The Case of Western Bagamoyo. Climate change is any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2007). Food security is the state achieved when food systems operate such that all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996).

Agriculture is an international question, in terms of trade, food security, climate variability and the management of natural resources. It is recommended to increase the availability of food, emphasizing enhancing crop and animal production while supporting smallholder farmers, reducing food waste, developing markets, and working with producers and consumers to achieve sustainability goals.

National food insecurity is a major economic and health problem in Tanzania. The country currently ranks 62 out of 78 countries on the 2013 Global Hunger Index (GHI) with a score of 20.6% categorized as 'alarming' (IFPRI, 2013). Although the prevalence of undernourishment has improved since its peak in 2002-2003 (above 37.4%), the food security situation in Tanzania has actually slightly deteriorated since the 1990s, from an undernourishment rate of 24.2% in 1992 to 35.7% in 2012 (http://faostat3.fao.org/faostat-gateway/go/to/browse/D/*/E). Although there seems to be stability in the prevalence of hunger since 2000, the number of people undernourished keep increasing due to rapid population growth. This currently leaves some 15.7 million people undernourished due to inadequate consumption of calories and energy-proteins (FAOSTAT, 2014). The environment can be viewed as an interlinked network of systems with very complex relationships. For example, increased use of wood fuel or the expansion of land area for cultivation or for grazing often times results in deforestation and land degradation. The climatic shifts and possible desertification which may result adversely impacts on food security. Thus in order for the environment to be sustained, the systems of which it is comprised must be in balance with one another, otherwise serious consequences for survival of the entire networks may be jeopardized. Most of the major factors affecting food production and thus availability like land use, soil fertility and climate form part of the environmental systems which affect food security. They determine the agricultural production and consumption systems and often times disease patterns.

Tanzania has one of the largest agricultural potentials of all East and Southern African countries (Beir et al 1990). Mainland Tanzania has a land area of 88.6 million hectares of which 39.5 million (44.6 percent) can be cultivated under rain fed conditions. Of this only 17.6 percent or 7.0 million hectares were cultivated in 1988/89 when the population was estimated at about 23.0 million. The area under irrigation is 144,000 ha of which 26,000 ha are "modern" and the remainder is traditional mainly for paddy production and some vegetables. Woods and forests cover about half the country. Much of these are infested with tsetse flies making them inhospitable for the habitation of both humans and domestic animals. Tanzania's agricultural potential is also reflected in the role of agriculture as the single most important sector in the economy. In 1989 the agricultural sector contributed on average 51 percent of the GDP; and accounted for over 72 percent of export earnings. For the majority of Tanzanians, agriculture is the main source of livelihood: some 85-90 percent of the labour force is engaged in agricultural activities including about 20 percent of the urban population (Beir et al 1990). Most of the agricultural production is done on small scale, labour intensive farms, with archaic low productivity technology. Subsistence farming comprises of about 70-75 percent of total food production. Agriculture provides raw materials for over 85 percent of the country's industrial production. Nearly 80 percent of the sector's output is generated by these smallholder, with an average farm size of 2.0 ha. The majority of the remaining 20 percent is derived from large scale, until recently, public commercial “estates” which are mainly confined to the production of sisal, sugar, tea, wheat, irrigated paddy, with some dairy, poultry and beef enterprises. A third important segment of the agricultural sector is dominated by extensive beef cattle production mostly as an integral component of mixed crop and livestock farms or as a single pastoral activity in the semi-arid range-lands.

There are enormous land resources and small scale irrigation potentials to sustain a much higher level of crop production and diversification than exists at present. The population arable land ratio in Tanzania is still so favorable that principally Tanzania is said to be able to potentially provide all the food its neighbors may need (Beir et al, 1990). However, there is a large discrepancy between Tanzania’s agricultural potential and its realization and for many years Tanzania has been importing huge amounts of grain every year sometimes from its less potentially endowed neighbors.

TABLE I. TANZANIA AGRICULTURAL POLICIES

Policy	**Time frame**	**Key linkages**	**Focus**
Agricultural Sector Development Program (ASDP)	Phase 1:2006-2013	Five agricultural ministries & donor projects	Small holder production & irrigation
KILIMO KWANZA	Began in 2009, open ended	Commercial farmers &SAGCOT	Commercial agriculture
Tanzania Agriculture and Food Security Implementation Plan (TAFSID)	2012-2017	ASDP	Small holder production and food security

Source: modified from Cooksey, 2013

This paper presents the findings on the extent to which climate variability affects food security in the rural household of Tanzania. The expected outcome was to develop and implement agricultural adaptation and mitigation strategies in the face of climate change as an integral part of agricultural development. In this analysis, secondary date of climate variability (rainfall and temperature) and maize yield of 16 years (1985, 1986, 1987, 1989,2003, 2004,2005, 2006, 2007, 2008, 2009, 2010, 201, 2012, 2013 and 2014) at district level were used to run multiple linear regression model. Understanding the biophysical processes of CO_2 and climate variability effects on crops remains an important research area.

1.1. Objectives of the study:

The objective of the study was to examine the extent of relationship between rainfall and temperature variability with maize production.

II. Materials and Methods

2.1 Study area

Bagamoyo district is located in the Coast region of Tanzania north of the commercial city, Dar es Salaam. It is one of six districts of the Coast (“Pwani”) region of Tanzania. Its geographical coordinates are 6° 26' 0" south, 38° 54' 0" east. It is bordered to the north by the Tanga region, to the west by the Morogoro region, to the east by the Indian Ocean and to the South by the Kibaha District. Bagamoyo Town is roughly 70 km from Dar es Salaam City Centre. Bagamoyo District as a whole had a total population of approximately 311,740 according to census in 2012. The district covers an area of 9,842 km^2 where 855 km^2 is covered by water (Ocean and river) while the remaining part, which is 8,987 km^2 is occupied by dry lands (Bagamoyo District,2009). The District has two parliamentary constituencies that are Bagamoyo and Chalinze. It is divided into six administrative divisions and sixteen wards (Bagamoyo District, 2006).

1.1.1. Climate

There is a fluctuation throughout the year in the maximum and the minimum monthly air temperatures. Minimum mean temperature varies from 18ºC in July/August to 24ºC in January/February; the maximum mean temperature ranges from 29C in July to 32ºC in February. Annual precipitation in the area is approximately 1000 mm. The annual rainfall distribution is bi-modal with the first wet period (long rains) occurring in April and May, and the second wet period occurring from November to January (short rains). The driest months are June to September when monthly rainfall is generally less than 50 mm per month (Lyimo et al., 2013).

1.1.2. Agriculture

The percentage distributions of the population who engage in agriculture are 76% and the cultivated area per district is 9%. Food crops produced are cassava, rice, millet, legumes, maize and sweet potatoes. The status of the areas suitable for irrigation (Ha) is 16850, the area which is under cultivation (Ha) is 720 and the percentage of utilization is 4.2%. Kiwangwa –Bagamoyo is an area which is the most popular for production of pineapples. Bagamoyo district ranks second in production of honey and bees wax. Livestock kept are sheep, chicken and pigs (Bagamoyo, 2014).

2.2 Data collection

The mean of annual time series data from Tanzania Meteorological Agency (TMA) for Bagamoyo district that include the following; temperature and rainfall for sixteen years (1985, 1986, 1987, 1989,2003, 2004,2005, 2006, 2007, 2008, 2009, 2010, 201, 2012, 2013 and 2014) were collected for the study. Maize yields of the same period were collected from Bagamoyo District Agriculture Extension Office. The data were subjected to multiple regression model analysis through Statistical Package for Social Sciences (version 20).

III. Results and Discussion

In an attempt to answer the question of this research, multiple linear regression model was used for the purpose of analysis. Regression analysis was used to run to see whether amount of rainfall and temperature had any significant influence in maize production. The analysis was based on 16 years’ climate (rainfall and temperature) as independent variables and maize (dependent variable) of corresponding years. The analysis was used to determine how rainfall and temperature had influence on maize production at district level. Regression analysis studies the causal relationship between one economic variable to be explained (the dependent variable) and one or more independent variables. It helps to see the trend and make predictions outside or within a given data. Regression gives the cause and effect of one variable on the other (Mendenhall & Sincich, 1989; Oakshott, 2006). Due to the linear relationship between rainfall and temperature and maize production, the model specification was stated of the form;

Multiple linear regressions

$Y=a + b_1X_1 + b_2X_2$

Y is the value of the dependent variable (Y), what is being predicted or explained

a (Alpha) is the Constant or intercept

b_1 is the Slope (Beta coefficient) for X_1

X_1 First independent variable that is explaining the variance in Y

b_2 is the Slope (Beta coefficient) for X_2

X_2 Second independent variable that is explaining the variance in Y

The values of the DW and R^2 in table II are 1.121 and 0.079 respectively. The value of the Durbin-Watson is greater than the value of the R^2. That is 1.121>0.079. This means that the regression results are sensible and the model can be accepted. The R statistics indicate a lower correlation and this is being accounted for by 7% of the variability of climate. The R^2 given from the regression analysis is 0.079 which is approximately 7%. Economically, it means that about 7% of climate variability has influence on maize production. That is 7% in the production is attributed to or explained by climate variability (rainfall and temperature). The unexplained variation is 93%. This means that climate variability cannot better explain maize production in Western Bagamoyo. Other factors must be considered.

TABLE II: MODEL SUMMARY

Model	R	R^2	Adjusted R^2	Standard error of estimate	Durbin Watson
1	.281	.079	-.063	26447.47616	1.121

The ANOVA table III statistics from regression analysis shows a statistically no significant difference between climate variability (rainfall and temperature) on maize production in 16 years. This is indicated by (p=0.587, p>0.05). This shows clearly that rainfall and temperature has no difference in terms of their impact on maize production.

TABLE III: ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	7.770E8	2	3.885E8	.555	.587
	Residual	9.093E9	13	6.995E8		
	Total	9.870E9	15			

The coefficients table IV establishes the extent of the impact of climate variability on maize production. From the standardized coefficients and its correspondence beta values, both temperature and rainfall indicate a positive impact on milk production; however, this difference is not statistically significant. This is indicated as rainfall (B= .384, t=.015, p>0.05) and temperature (B=226.694, t=1.034, p>0.05). This clearly shows no differences in terms of variability of climate i.e. rainfall and temperature on maize production. It can also be stated that with low positive impact by rainfall and moderate positive impact by temperature as indicated in the coefficients table, then this is not statistically significant.

TABLE IV. COEFFICIENTS

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	-49855.849	69544.855		-.717	.486
	Rainfall	.384	25.562	.004	.015	.988
	Temperature	226.694	226.694	.280	1.034	.320

IV. LIMITATIONS OF REGRESSION ANALYSIS

When before and after is impossible or too costly, regression analysis can be a good substitute. But regression analysis can't obtain all the information needed to know about the factors influencing food security in a given society. For example, regression analysis just tells us the association between climate variables and yields, it can't tell us whether the production time saving caused by climate variability (if any) on the people could offset food production. Consequently, regression analysis can be a simple and effective research method for testing the macroscopic association or trend between climate change management and agriculture performance; however, to obtain an overall evaluation of each of the food security systems in climate change contexts, additional research is still necessary

V. CONCLUSION AND RECOMMENDATION

Regression analysis revealed that temperature had more impact on maize production than rainfall; but this difference was not statistically significant. Rainfall was revealed to be the most influencing factor than temperature. Since agriculture remain to be the most important for source of livelihood to the rural communities in the study area, however, the trend showed diminishing agriculture dependence among rural people. This is a reason that food security needs to be considered with other non-climatic factors due to diversification of economy. People are engaged on other sources of labour, and this is caused by number of factors affecting agriculture such as importation of food, poor production, population increase that led to pressure on land and diversification of economy as well as climate variability.

Based on the result findings presented, it is obvious that this research project achieved the intended objectives. Though these communities are situated very close to valuable land resources, their economic status is still poor. The fact that even previous studies indicated decline in agriculture can possibly be associated with climate variability impact as global warming can increase surface temperature. Crops are very sensitive to temperature change hence when the earth surface temperature increase the crops can easily access is getting warmer first and it affects evapotranspiration as well. This will bring biodiversity loss for future agriculture. This finding is also in line with Ozsabuncuoglu (1998) who established a functional relation between wheat production and climate variables in South eastern Turkey, and revealed that increments of rainfall during the growing period generates higher productivity and economic return. There is, however, need for caution. Given the revealed non-linear relationship between farm income and rainfall, increasing rainfall may, therefore, to a certain extent be 'bad' for farms, especially if it is accompanied by the already reported erosivity of rains. The findings show that, food security in Tanzania appears likely to deteriorate as a consequence of climate variability. Noteworthy differences in impacts across households may also be present both by district and by income category. Also food security cannot be explained by climate as the only influencing factor. A combination of economic, political and socio-cultural context of the community are crucial.

This assessment has yielded observations of climate variability signals in Bagamoyo district. The district has evidence of shoreline changes, beach erosion, unreliable rainfall and increasing temperatures in dry seasons. These have seriously affected Bagamoyo community coastal agriculture, fisheries and partly booming tourism industry. Unless there are serious efforts to adaptation, the district is vulnerability to the impacts of climate variability will increase in a few decades. Increased district vulnerability will also have a multiplier effect to the country's Gross Domestic Product (GDP). Recommended actions to minimize climate variability impacts from a district wide perspective fall into the food security system as a holistic approach. Admittedly, many factors will determine Tanzania's ability to feed her people now and in the future. There is plenty of land available. Though not all of it is appropriate for cultivation only a small fraction of that which is arable is under cultivation. Because of low agricultural productivity for both food and cash crops and population pressure in a few areas; farmers are now moving onto more marginal lands to increase the area under cultivation, and in the process are clearing forests and sometimes threatening wildlife. Thus there is an urgent need to improve agricultural productivity if sustained productive agriculture and food security is to be developed and sustained. Improved agriculture will also strengthen the economic base and thus improve economic accessibility to food. Until this is achieved, even in the presence of enough arable land to go around, the rapidly growing population will continue to place added pressure on the ability of Tanzanians to stay well fed.

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