CLIMATE CHANGE IMPACTS ON AGRICULTURE AND HOUSEHOLD FOOD SECURITY IN KAZUNGULA DISTRICT

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Abstract: The study assesses the nature and impacts of climate change induced hazards on agriculture and food security as well as the coping strategies of vulnerable households to climate change. The study shows that climate change is a major problem to agriculture, household food security and rural livelihoods for majority of the households in Kazungula district. Survey findings suggests that climate change is real and parameters such as temperature and rainfall have changed in the last 30 years (1963-1993) affecting crop production negatively. Temperature has increased by 2° C while rainfall has decreased by 130mm. Climate change has impacted negatively on agriculture and the four pillars of food security (access, utilization, availability and stability). Survey findings indicate that 64 percent of the households were exposed to climate change, youth headed households (44 percent) were less vulnerable to the impacts of climate change compared to the elderly (56 percent) headed households. Majority of the households were highly dependent on emergency and crisis coping strategies. The study strongly recommends promotion and adoption of long-term adaption strategies to build the adaptive capacity of local communities

Keywords: Climate change, Climate variability, Agriculture, Food security, Households, Kazungula

1. Introduction

Southern Africa like any other region in Africa experiences more severe droughts and floods due to climate change, and this is projected to intensify in the future. Therefore, Zambia due to its geographical location, high poverty levels, lack of adaptive capacity, inadequate investments in the agriculture sector and early warning systems makes it vulnerable to the adverse impacts of climate change (Vincent and Cull). The impacts of climate change will affect all sectors of the economy such as agriculture and food security, water and energy, health, tourism and natural resources as well as infrastructure. Thus, any abrupt change in the earth's climate system has potential to significantly affect agricultural production and household food security among others. Increased frequency and severity of climate related hazards pose a great risk on the majority of people living in Kazungula. Most of the households in Kazungula district lack risk knowledge and long term planning to adapt to various climate change risks threatening their rural livelihoods and food security.

The expected impacts of climate change at global level include an increase in the mean annual temperature of about 1.2 to 3.4°C by 2060, a decrease in rainfall during the months of September to November period and an increase during December to April (Thurlow et al: 2009). These changes are projected to result into seasonal droughts, dry periods within the rainy season, intense rainfall, heat waves, increased temperatures, flash floods and changes in growing season as a result of delayed onset of rainy season or shortened growing periods. Since the majority of Zambia's population live in rural areas and are highly dependent on rain-fed agriculture for food and income, therefore, climate change presents a challenge to the country's attempts to increase agricultural production and productivity as well as poverty alleviation which stands at 80 percent (CSO, 2010). According to the Survey conducted by Thurlow et al., 2009 indicates that there is a 75 to 80 percent chance in any given year that there will be either a drought or too much rain in the three zones, droughts affected Agro-ecological region I, four

in region IIa1, and one in Zone IIb. An increase in the frequency and severity of El Niño events has been observed from the 1980s for example strong El Niños occurred every 10 to 15 years. Further, between 1988 and 1992, more than 15 El Niño drought events were reported at regional and national level (Kandji etal: 2006). The main objective of the survey was to examine the impacts of climate change on household food security in Kazungula districts, Zambia.

Climate change is possibly the most significant environmental challenge of our time and poses serious threats to sustainable development in the world and particularly in Zambia. The challenges for climate change are substantial, particularly in the developing countries where there is high dependence on climate sensitive natural resource sectors for food security, livelihoods and incomes. The Fourth Assessment Report further observed that during the coming years, global climate change will impact on food and water security in a significant but highly uncertain manner (IPCC: 2014: 5).The means and capacity to adapt to climate change are scarce due to low levels of human and economic development and high rates of poverty. These conditions combine to create a state of high vulnerability to climate change in many developing countries.

Due to global warming, the climate in Africa is projected to become more variable and extreme weather events are expected to be more frequent and severe. There is over whelming evidence that developing countries will bear the consequences of climate change in Africa particularly Sub-Saharan Africa (CGIAR: 2011). Agriculture which is the economic main stay of rural households, household food security and rural livelihoods is particularly vulnerable to the adverse impacts of climate change and the adaptive capacity of rural households is extremely low. Although the global demand for food will increase in the coming years, without seriously adaptation measures, climate change is likely to be one of the major causes for low food production due to crop failure, collapse of fisheries and livestock deaths. These impacts are already causing economic problems and undermining food security and these are likely to become more severe as global warming continues (CGIAR: 2011).

Some of the climate change induced hazards affecting the rural communities include droughts, floods, epidemics, pests and environmental degradation (Disaster Management Mitigation Unit: 2005). Although Zambia's economy is predominantly dependent on the exploitation of natural resources such as mining, the agricultural sector continues to plays a significant role in the country's economy. It is the largest and most important source of livelihood and food security in terms of providing food, income and employment in Zambia. Apart from mining the agricultural sector is also the major sources of economic development. Thus productivity and efficiency of this sector is the central phenomenon to any economic planning of the country. It is imperative to however note that this sector has come under serious threats from the adverse effects of climate change thus impacting household food security negatively. The adverse effects of climate change on agriculture and household food security is significantly affecting the economic, social and environment dimensions of our national sustainable development (Mudenda: 2010).

Agriculture and food security are highly vulnerable to changing climatic conditions due to the sensitivity of crops to timing, amount, and intensity of rainfall and temperature fluctuations (IPCC: 2014). In this regard, agriculture production has multiple impacts on other sectors of the economy such as health because sufficient nutrition determines productivity to some extent. Agriculture failure results into food insecurity. Increase in temperature and decrease in rainfall over the next ten years may limit the potential for growth in the Agriculture sector. It must be argued that low productivity and high levels of poverty, poor soils, poor market systems and prices coupled with the effects of climate change will adversely affect household food security and rural livelihoods on which the majority of the people depend on for income generation. Livestock will also be affected by drought and floods and will result into livestock deaths because droughts will affect vegetation growth.

2. Methodology of Research

The methodology for determining the impacts of climate change on agriculture and food security included conducting a temporal analysis of climate related risks by looking at the last 30 years and projecting future trends using Coordinated Regional Climate Downscaling CORDEX data. The Survey involved the analysis of agricultural production figure from crop forecast surveys, analysis of climate information from meteorological services, hydrological data and analysis of CORDEX climate global models(Jones etal: 2011). The Survey also looked at an ensemble of different Regional Climate Models (RCMs) from CORDEX models.

2.1 Methods

2.1.1 Study Area and Sampling

Kazungula district is geographically located between -17.6 South and 25.08 and 26.4 East of the equator. Kazungula district lies within the valley of the Zambezi escarpment in Southern Province. According to the 2010 Census Report, Kazungula district has 11 wards with a total number of 10,132 households. The target ward which is Sekute has 656 households. This research used non- probability sampling in selecting the wards to be visited, institutions and focus group discussions. The research further used probability sampling (Krejcie and Morgan sampling method) to select population and keep the sampling error low. Krejcie and Morgan: 1970 used the following formula to determine sampling size:

S= required sample size

$$S = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2 P(1-P)}$$

X^2= the table value of chi-square for one degree of freedom at the desired confidence level
N = the population size
P = the population proportion (assumed to be .50 since this would provide the maximum sample size)
d = the degree of accuracy expressed as a proportion (.05)

Therefore, the total sample size for this research using Krejcie and Morgan (1970) for Sekute ward was 242 households which were interviewed during the research period. However, the selection of Sekute ward was done using random probability sampling while the sampling of institutions utilized non-probability sampling methods. Therefore, this research utilized both probability and non- probability sampling methods. The household sample size for this research was derived as illustrated below:

$$S = \frac{3.841 * 656 * 0.50(1-0.50)}{0.05^2(656-1) + 3.841 * 0.50(1-0.50)}$$

$$S = \frac{3.841 * 656 * 0.50(1-0.50)}{0.05^2(656-1) + 3.841 * 0.50(1-0.50)}$$

$$S = \frac{3.841 * 656 * 0.50(0.5)}{0.0025(655) + 3.841 * 0.50(0.5)}$$

$$S = \frac{629.92}{1.6375 + 0.96025}$$

$$S = \frac{629.92}{2.59775}$$

S= 242.486

Sample Size= 242

After the sampling interval (K or I) had been calculated then the Random Start Number (RS) was picked from the Random Start Table randomly and the sampling was cyclic. Therefore, the formula and sampling was done as follows:
RS+ K or I
Where RS= Random Start
K or I = Sampling Interval
Therefore,
RS or First Respondent
RS+ K or I
RS+ K or I+ K or I
RS+ K or I K or +I K or +I

RS= 662
662+ 3= 665
662 +3 +3 = 668
662 + 3+ 3+3 = 671

The data was collected using three sets of questionnaires and these were administered to individual respondents (household questionnaires), key informants at the district level (district questionnaire), key institutions and key informants at community level (community questionnaires for focus group discussions).

3. Results and discussion

3.1 Results

A quantitative assessment of climate change effects was based on agricultural production which was partially determined by crop yields over a period of time. This research therefore analyzed both temperature and precipitation as key variables of climate change in determining agriculture production and food security. Historical agricultural data and climate data was collected from the Ministry of Agriculture and Zambia Meteorological Department as well as the Swedish Meteorological and Hydrological Institute respectively. Food security was determined by the data that was generated through the field survey in Kazungula district.

3.1.1 Agricultural Production

According to the Survey findings the main crops grown for both sale and consumption in Kazungula district were local maize, hybrid maize, groundnuts, sweet potatoes, vegetables mixed beans and sorghum. The Survey findings further showed that the main livestock kept by the households were chickens (92 percent), cattle (48 percent), goats (33 percent) and pigs (12 percent). The main staple consumed by the in this Survey included households in Kazungula district were maize (99 percent) and cassava (1 percent). The Survey further established that 27 percent of the consumed food was from own production and 73 percent was from purchases outside the district.

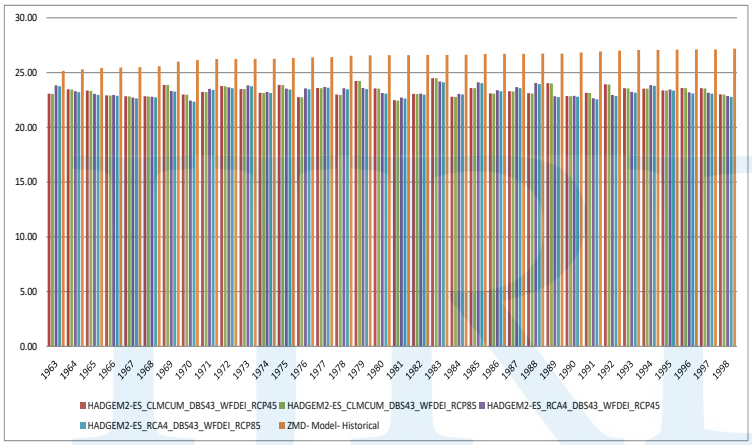
3.1.2 Risk Knowledge

The Survey indicated that 58 percent of the households interviewed were of the perception that the local climate had changed over the last 30 years. For instance 58 percent of the households interviewed indicated that they were experiencing climate change while 42 percent were of the view that the Kazungula district was not experiencing any climate change. Further, the majority of the households (58 percent) explained that Kazungula was experiencing increased occurrence of floods and increased

temperatures every year. The data shows that Kazungula district has been experiencing frequent occurrence of extreme weather events such as droughts and floods resulting into water stress for livestock and crop cultivation. According to the climate information obtained from the Zambia Meteorological Station in Livingstone for Kazungula, temperature has increased by 2.0° C while rainfall has decreased over a long period of time (1963- 1998). Figure 2 below on historical climate trends shows that Kazungula has been experiencing both climate change and climate variability during the period under review (1963-1998).

From CORDEX data, the model HADGEM2_ES_CLMCUM_DBS43_WFDEI_RCP45 shows that temperature decreased by 1.4° C under 85 RCP for the same model under business as usual increased by 1.47 ° C. All the scenarios show similar trends. The different climate scenarios below shows that climate change is projected to increase by 2.0° C under business as usual while under mitigation climate change is projected to increase by 1.71° C as indicated below. The annual minimum mean temperature recorded between 1963 and 1998 was 22.47° C while the annual maximum mean temperature was 23.64° C for the selected models.

Figure 1: Long Term Analysis of Climate Change from 1963- 1998

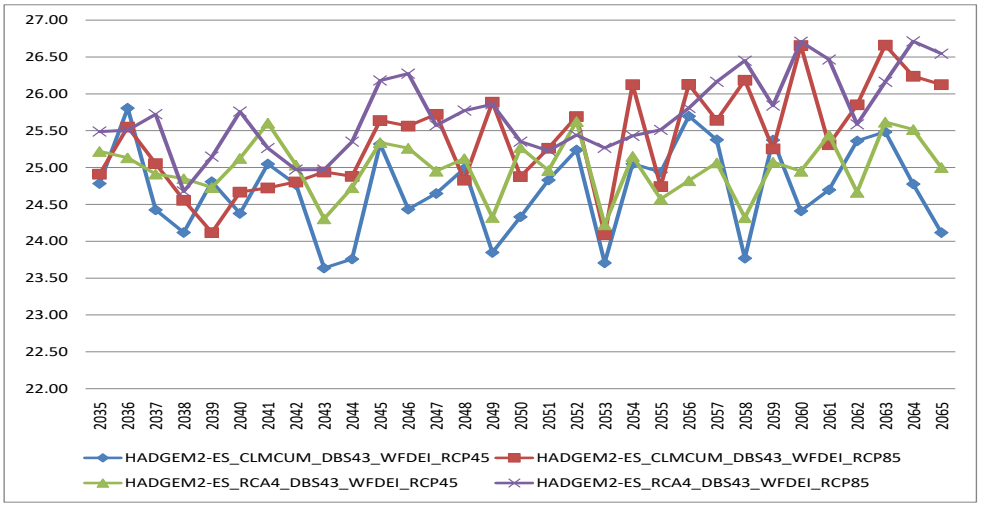


Source: CORDEX and Zambia Meteorological Department

3.1.3 Climate change projections under different Scenarios from 2035- 2065

Figure 2 reveals that Kazungula district is projected to experience high temperatures under different climate scenarios and temperatures will slightly decrease if mitigation measures are employed. For example the model HADGEM2_ES_RCAL_DBS43_WFDEI_RCP85 shows that temperature is expected to decrease as low as 25° C by 2065 and RCP 45 shows that temperature will rise as high as 26.71° C between 2035- 2065. The scenarios further projects that if mitigation measures are put in place, temperature will decrease and under business as usual temperature is projected to increase by 2065 as shown in figure 2 below.

Figure 2: Climate Change Projections and Scenarios from 2035 - 2065



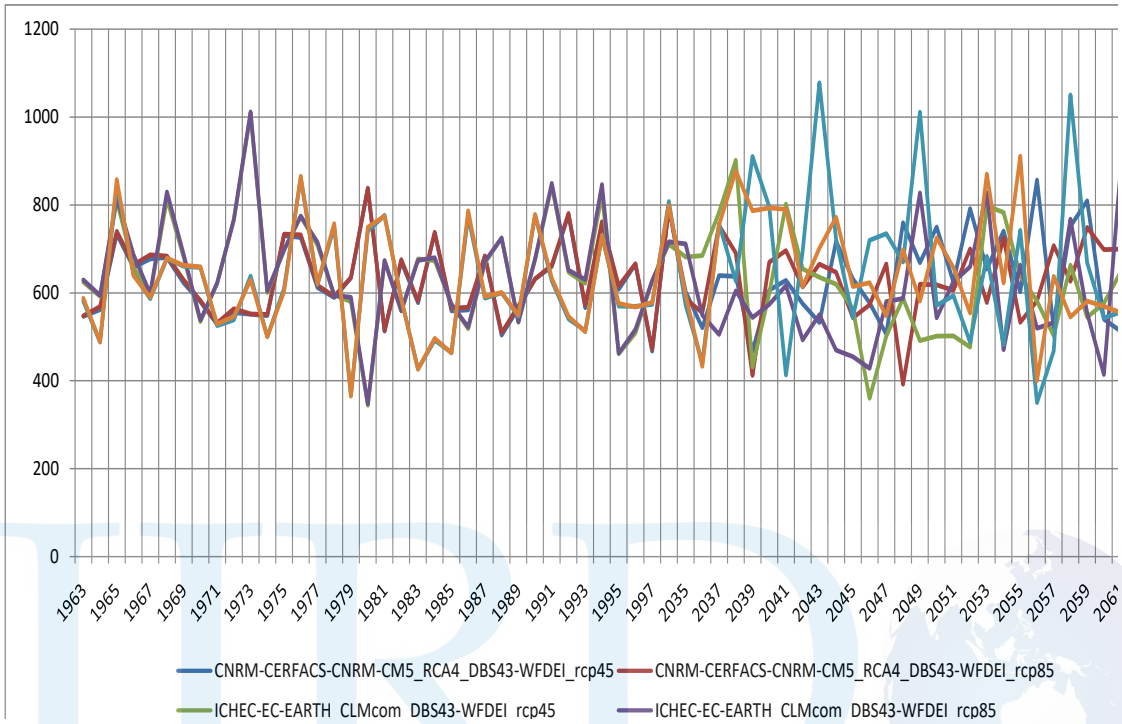
Source: CORDEX: 2016

3.1.4 Rainfall Performance over a Long Period of Time

The figure below indicates that there are both climate induced hazards and non- climatic hazards affecting agriculture and household food security in the district. The Survey showed that majority of the households were affected by increased disease burden with malaria accounting for 58 percent. The Survey further showed that 38 percent of the households were affected by floods while 35 percent were affected by droughts. The Survey also shows that high food prices (27 percent), pest infection (21 percent) and wild animals (18 percent) were other underlining causes of food insecurity and decreased agricultural production in Kazungula. Though HIV/ AIDS is a social problem it has a bearing on food security because unhealthy people cannot manage to do hard work. On the other hand human/ animal conflict is worsened with increased dry spells as animals move closer to households in search of water.

Figure 3 shows that in 1972 Kazungula recorded high rainfall and 1980 recoded low rainfall below 400 mm. In terms of rainfall projections, all the models predict a decrease in rainfall under business as usual and an increase under mitigation measures.

Figure 3: Time Series Analysis of Rainfall Under Different Climate Scenarios



Source: Cordex Data

3.1.5 Vulnerability of Household to Climate Change induced Hazards

The results indicated that the youth headed households aged between 20 and 34 years (40 percent) were less vulnerable to the impacts of climate change compared to the elderly aged between 45 and above (56 percent). This was attributed to lack of ability by the elderly to cope with the adverse impacts of climate change.

3.2 Impacts of Climate Change on Household Food Security

3.2.1 Access to Food by Households

Using the Food consumption score as a proxy for access to food and dietary need, the research showed that only 43 percent of the households were better- off and had access to quality food, 33 percent were on borderline while the rest of the households had poor or no access to quality food to meet their daily dietary needs. In other words, 57 percent of the households had poor access to food.

Table 2 below shows that food access was likely to be impacted by climate change over a period of time. Table 2 shows that majority of the households were marginally food insecure (29 percent) and severely food insecure (35 percent) giving a total of 64 percent of hgouseholds with poor access to food.

Table 1: Composite of Food Security Indicators

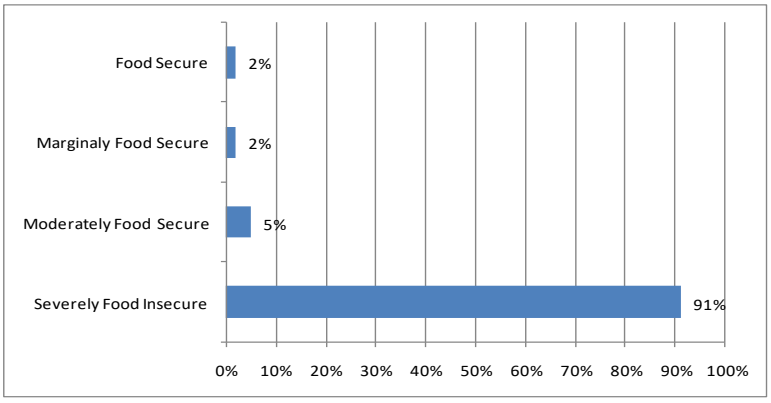
Food Security Indicators	**Food**	**Moderately secure**	**Marginally Food Insecure**	**Severely insecure**
Food Consumption Score	27%	0	30%	43%
Asset Wealth Index	19%	0	42%	39%
Food Expenditure Share	19%	17%	19%	45%
Coping Strategies	42%	21%	25%	13%
Average Food Security Indicator	27%	0.095%	29%	35%

Source: Field Survey, 2016

3.2.2 Food Availability

The research showed that 91 percent of the households had very low food stocks because they produced below 100 by 50 Kg bags of maize while 5 percent of the households had moderate stocks of maize translating into 100 to 200 by 50 Kg bags of maize compared to the marginally food secure (2 percent) and the food secure (2 percent).

Figure 4: Food Stocks Availability or Production



Source: Field Survey, 2016

In terms of food utilization and dietary food diversity which is an indicator for measuring household food utilization, 96 percent of the households did not consume leguminous foods compared to 9 percent who indicated of consuming leguminous food groups 24 hours before the field survey. The research futher revealed that majority of the households consumed cereal food

groups (27 percent), vegetables (4 percent), Sugar (7 percent), meat (27 percent) oils foods (72 percent) and fish food groups (5 percent) and most of these foods were from purchases from other districts like Lusaka, Choma, Sesheke, Chipata and Ndola.

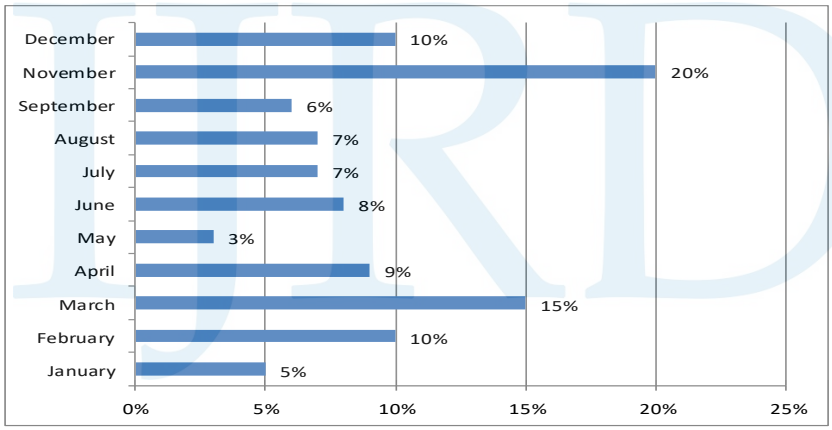
3.2.3 Food Nutrition: Prevalence of Oedema in Under- Five Children

Oedema which is a form of severe acute malnutrition, characterized by swelling of both feet and face of the child is of public health concern due to its consequences. The research revealed that majority of children (98 percent) who were suffering from oedemaare were female. The research further showed that Stunting, underweight and wasting was highest in children aged between 12-23 months though it affects all children within the age group of 12 to 49 months.

3.2.4 Food Stability and Purchase Over Time

The pie chart below in Figure 25 shows that 39 percent of the households were more likely to purchase more maize compared to the previous seasons due to less carryover stocks and low crop yield. Majority of the households (84 percent) indicated that they had no carryover stocks resulting into food instability. In other words, about 15 percent were likely to purchase less food because they have stable food stocks. Figure 26 below shows that though households started running out of food as early as May (3 percent) majority of the households run out of food stocks by November (20 percent), February (15 percent) and March (15 percent).

Figure 5: Impacts of Climate change on Food Stability

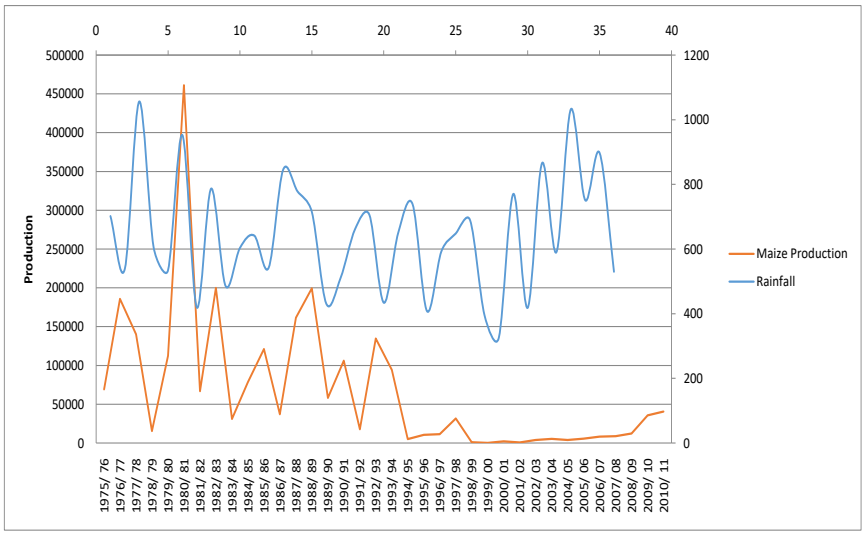


Source: Field Survey, 2016

3.2.5 Impacts of Climate Change on Agricultural Production

The long - term analysis of meteorological data from the Zambia Meteorological Department shows that the rainfall pattern in Kazungula has changed over time. The highest rainfall recorded was in 1974 and the lowest rainfall ever recorded was in 1986. The long- term rainfall accumulation from 1962 to 2010 shows that that rainfall has decreased over time. The analysis of meteorological data shows both a change in the climate system over a long period of time resulting in frequent occurrence of extreme events. The reduction in rainfall and increase in temperature as shown in figure 5 makes agricultural production to be vulnerable to climate change effects resulting into decreased crop yield or crop production, pest infestation on crops and crop failure.

Figure 6: Impacts of Climate Change Agricultural Production from 1975 - 2010



Source: Zambia Meteorological Department and Ministry of Agriculture, 2016

3.2.6 Coping Strategies

The coping strategies employed by households during the occurrence of a hazard is a proxy indicator for adaptive capacity among the affected households. The research shows that majority of households (41 percent) did not employee any coping strategies, while 25 percent used crisis coping strategies, 21 percent adopted stresses coping strategies and 13 percent engaged in emergency coping strategies. Crisis coping strategies include selling productive asserts like holes, cattle and holes while stresses coping strategies include reducing the number of meals taken per day by adults, sending children to eat from relatives and skipping meals.

4. Discussion

This chapter discusses and analyses the Survey results in chapter five above on the impacts of climate change on agriculture and household food security in Kazungula district. This chapter will therefore discuss the demographic characteristic of the population, household vulnerability to household vulnerability to the impacts of climate change and climate variability. This chapter will further discuss and analyze the impacts of climate change household food security and the coping strategies of affected households by climate change.

The Results shows that most of the households are affected by mainly two climate induced hazards and these are floods and droughts with the former being the most predominant hazard. The survey showed that most households in Kazungula district were experiencing climate change in the last 30 years hence affecting agriculture their main source of income, food and rural livelihoods. The increased occurrence of floods and dry spells was having negative effects on agricultural production and food security.

The perceptions were in line with the long term changes from the Zambia Meteorological Department which shows that temperature has increased by 2.0° C while rainfall has decreased in the last 35 years (1963- 1998). An ensemble of all global, regional and local models show that temperature has increased by 25° C and projects that temperatures will rise 26.71° C by if no mitigation measures are adopted by 2065 give a total rise of 1.71° C which will have a negative impact on agriculture and food security.

The research results from all climate ensembles further shows that Kazungula experienced extreme rainfall (above 800 mm) in 1968, 1974 and 1978 and is further projected to experience similar events in 2042, 2048 and 2058. The climate models further shows that the district experienced drought conditions in 1981, 1991and 1996 and project to experienced similar occurrences in 2045 and 2065 if no mitigation measures are adopted hence the need to develop adaption measures to safeguard agricultural production and enhance food security. Agricultural production has already been affected by 40 percent due to climate change due to unstable rain seasons leading to shorter growing seasons and unpredictable weather conditions.

The main livestock kept by households were chickens, cattle and goats. Most of the better- off households own cattle, goats, pigs and chickens well the poor own limited number of goats and chickens. The poor households mainly grow maize and cannot afford to buy inputs and use recycled seed while the better- off households grow maize, cotton and cow peas. Further, the better- off households use fertilizer and animal power to increase agricultural production. Therefore, when climate change induced hazards interacts with high poverty levels, poor farming practices, human- animal conflict, pest infestation and high disease incidence due to extreme temperatures it exacerbates the impacts of climate change on agricultural production and household food security.

The Survey revealed that 58 percent of the households were exposed to climate change. Apart from people, agricultural systems, water sources and livestock were equally exposed to the adverse effects of climate change. The Survey established that households were affected differently depending on gender, assert ownership, age and household size. For example 70 percent of the females were severely impacted by climate change compared to 40 percent males.

The survey further showed that the youthful households (25-44) were more vulnerable compared to the aged and young because the elderly had more productive asserts to cope with the effects of climate change. On the other hand, the survey showed that most of the households with medium household size of 3 to 8 were more vulnerable to the impacts of climate change and climate variability compare to larger and smaller households. This may be attributed to the fact that larger households are able to cope with the effects of climate change and climate variability because they have enough labor for farming.

The Survey further showed that 58 percent of the households were assert poor while 42 percent of the households were assert rich. Majority of the households had poor access to food due to limited access to food. Though food was readily available on the market, it was quite expensive because people were unable to purchase the food stocks due to high prices and high poverty levels at household level.

The Survey revealed that in terms of the impacts of climate change on food stability, it was equally under stress. For example the interviewed households (84 percent) indicated that they had no carryover stocks. In a normal situation food stocks are expected to reach the next harvest season. However, 96 percent of the households were food insecure in relation to food availability due to low crop yields, lack of incomes to purchase food and inadequate carryover stocks.

In terms of food utilization, large populations had no access to a balanced diet but were mainly dependent on cereals like maize and cassava as well as food oils and wild fruits affecting food utilization and household nutrition.

A linear regression model showed that coeffient for rainfall was 188.04, hence for every unit increase in rainfall , a 188 unit increase in maize production was predicted holding all other variables were constant. For every unit in increase in temperature, a -93590.896 decrease in maize production was expected holding all other variables were constant. This shows that climate change parameters such as temperature and rainfall have a negative bearing on agriculture and household food security.

Majority of the households were engaged in emergency and crisis coping strategies such as reducing number of meals taken per day by both children and adults, sending children to eat from friends and relatives, reduced expenditure on food and eating less preferred foods as opposed to adaption strategies.

5. Conclusion

Droughts and floods were the main climate induced hazards affecting the people of Kazangula district and it effected their livelihoods differently depending on their adaptive capacity. 58 percent of the people were already exposed to the adverse impacts of climate change. The major crops grown in Kazungula were maize, groundnuts, mixed beans, sweet potatoes and vegetables which are very sensitive to any abrupt change to the climate system.

Rural households are highly vulnerable to the impacts of climate change depending on age, gender, sex, assert wealth, disability and household size. The assert rich were less vulnerable to impacts of climate change and climate variability compared to the assert poor due to high adaptive capacity.

There is 95 percent confidence that temperature has increased in the last 30 years (1963- 1998) by 2.0^{o} C and rainfall has decreased by 129 mm. The increased occurrence of floods and dry spells was having negative effects on agricultural production and food security.

Climate change was significantly affecting the four pillar of food security (availability, access, utilization and stability). About 50 percent of households have been negatively impacted by the effects of climate change and climate variability on agricultural production and household food security. More than 50 percent of the population are food insecure due to the impacts of climate change and climate variability on food security.

6. The way forward

These results will be disseminated to the relevant stakeholders and decision makers through emails and bulletins for them to make informed decisions regarding the future climate outlook of Zambia. Most of the relevant sectors that may find this report beneficial include the Pilot Programme for Climate Resilience, Ministry of Agriculture, Zambia Meteorological Department Water Resources Management Authority and the Disaster Management and Mitigation Unit. This report important for understanding risk and for adaptation planning. Risk planning is an important component for disaster preparedness and mitigation.

In moving forward, there is need to focus on more training on climate change modelling, climate change projections, international climate change protocols and global climate change models as well as regional climate change models. These trainings should be organized for in country training as well at international level to share best practices. Arising from the above conclusions and discussion, the survey recommends the following:

- Government should invest in long term adaption programmes to help the communities become more resilient to the adverse impacts of climate change and climate variability,

- The local communities should consider growing draught tolerant crops like cassava, sorghum and millet,

- The survey recommends for further research on long term adaptation strategies under different climate change scenarios.

- The Government in collaboration with stakeholders and the involvement of the local communities should invest small dams, water harvesting technologies to promote irrigation agriculture and move away from rain- fed agriculture,

- Local communities should adopt conservation farming methods like pot holing and the use of manure to promote soil fertility,

- Government in partnership with local communities especially women to adopt adaptation measures that are women friendly and should encourage people to replant trees, protect wetlands and discourage the indiscriminate cutting of trees because of its effects on the rain cycle, and

- Promote alternative livelihoods for the well being of the local communities and promotion of nutrition and poverty reduction.

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