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THE IMPACTS OF CLIMATE CHANGE AND VARIABILITY ON FOOD PRODUCTION: EVIDENCE FROM MOROGORO, TANZANIA

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ABSTRACT

Adverse effects of climate change and variability continue to be a major threat to rural livelihoods. The aim of this study was to investigate the effects of inconsistencies of micro climates on food production by rural peasants in Morogoro region, Tanzania. Using data from household survey Discourse and descriptive analysis techniques were used. Subsequently, recall data were employed and was improved using associative and sequential probing technique. Findings revealed that fluctuation in climate change in the study area resulted in frequent drought, crop yield reduction, increased food costs, depletion of household assets and increased rural urban migration. Adaptation strategies can be vital in increasing small holder farmers' resilience to climate change and weather variability only if farmers are empowered with appropriate education, adequate information and resources. Thus, locally developed and crop management practices should be promoted while putting more efforts in managing drought through efficient management of agricultural water and or drought resistant crops. Adaptation strategies can be vital in increasing small holder farmers' resilience to climate change and weather variability only if farmers are empowered with appropriate education, adequate information and resources.

Key words: micro-climates, fluctuation, Crop yield, resilience, adaptation, Morogoro

Introduction

Climate is the most important factor in crop production and any change in climate has a profound effect on crops (see Manyeruke*et al.*, 2013; Sikder and Xiaoying, 2014). Due to its impacts, changes in climate is posing global challenges both to sustainable livelihood and economic development (Sudarkodi and Sathyabama, 2011; Munishi *et al.*, 2010). Already there is evidence to date of the effects of climate change on agriculture and other sectors (Sikder and Xiaoying, 2014). Given the fact that global warming is real, and the consequences are potentially disastrous (Hansen, J., 2004; Lindner *et al.*, 2010), the agricultural sector will most likely face significant yield reduction in future due to climate variability (see Islam *et al.*, 2011; Oduniyi, 2014).

For decades now, the globe has been warming and observations have been made on local, regional and global scales (Piao *et al.*, 2010; Qiu *et al.*, 2012; Sikder and Xiaoying, 2014). Understanding the impacts of global warming has become more important because evidence from scientific observations show the increasing concentrations of greenhouse gases will cause the planet to warm (Solomon, 2007).

The relationships between climate change and agriculture involve climatic and environmental aspects whose impacts result into social and economic repercussion (see Rajović and Bulatović,2012; Sikder and Xiaoying, 2014). The economic and environmental impacts of drought may be direct or indirect, and can be expressed in different forms that may include loss of vegetation, rangelands, forests and crop productivity; reduction in water levels; increased livestock and wildlife mortality rates; increase in incidences of fire outbreaks; damage to aquatic and terrestrial habitats hence loss of biodiversity (Shiferaw *et al.*, 2014). As a results of this, the effects may finally manifest in various forms such as reduced income for farmers and agribusiness, increased food prices, reduced tax revenues, malnutrition and famine, unemployment, increased conflict, out migration and displacement, disease epidemics, greater insect infestations and spread of plant diseases among others (Hansen, J. W. *et al.*, 2004; Hellmuth *et al.*, 2007; Shiferaw *et al.*, 2014).

Several countries particularly from the low and middle income countries have been vulnerable to climate change impacts due to their geographical exposure, low income and greater dependence on sectors such as agriculture which is highly sensitive to climate (Sikder and Xiaoying, 2014). In this aspect, Tanzania is no exception as the recent climate trends analysis reveals that climate change poses significant risks in the country (Daninga and Ke, 2014). Most areas are experiencing decline in rainfall while other places are experiencing increase in rainfall trends. However, decreased rainfall, increased dry spell, shortening and shift in the growing season resulting into unpredictable onset and cessation of the rain season all entail possible effects of climate change in Tanzania (Munishi *et al.*, 2010).

Sikder and Xiaoying (2014) show that the effects of global warming results not only from global changes in temperature and sea level but also from increased climate variability and extreme events such as drought leading into reduction in yields. This human induced global warming and subsequent climate change has been widely reported as exacerbating the already existing challenges across major sectors that are sensitive to climate such as agriculture, livestock, energy, water, environment and health. Therefore, the motive behind this study was to find out how smallholder famers in rural Tanzania have been impacted with climate change [changes] and variability in their production systems.

2. Conceptual Framework

The conceptual framework (CF) underlying this study displays a causal relationship of climate change with its associated effects as well as the resulting consequences on crop yield as a result of adapting or failure to adopt to the climate change impacts.

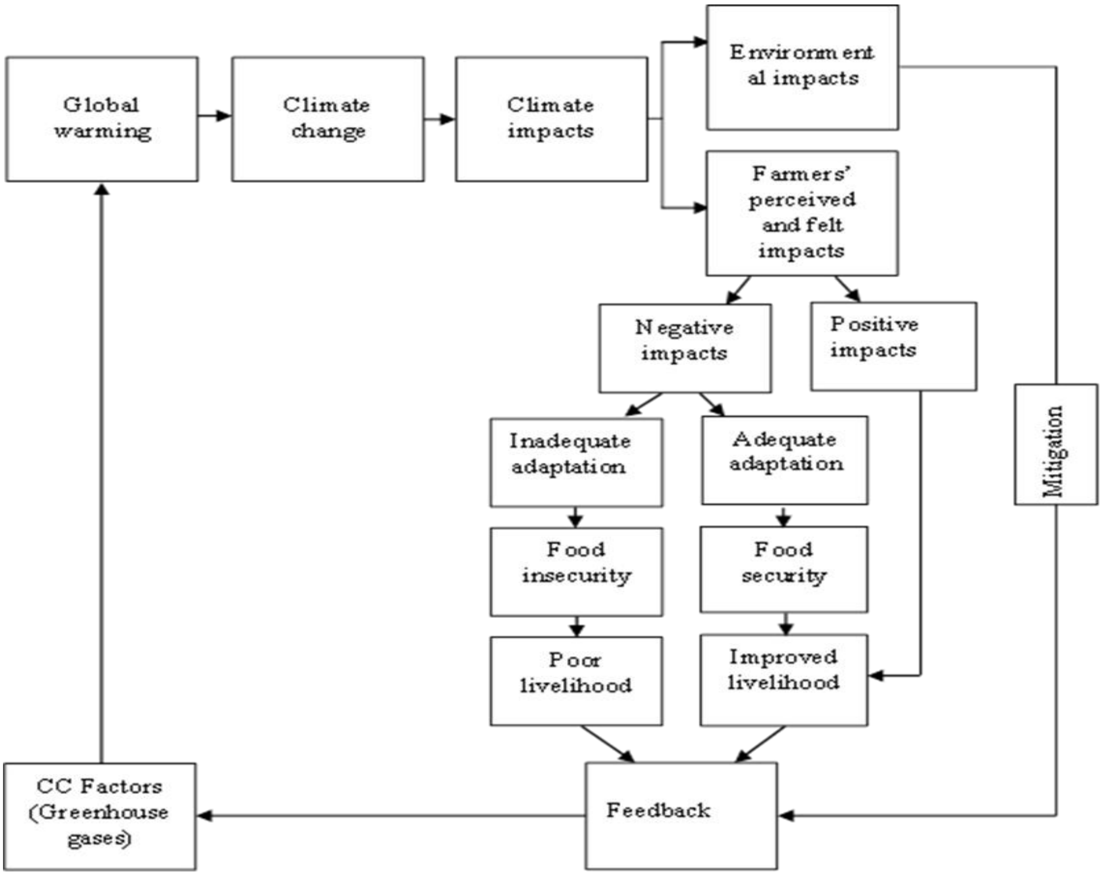

Figure 1: Conceptual Framework showing a causal relationship of climate change with its associated effects on environment and crop yield

Source: Author

The climate change factors responsible with the climate change are the changes in man-made aerosol emissions (Hansen, J., 2004; Ito and Penner, 2005) and other microscopic airborne particles from volcanic eruptions as well as the anthropogenic increase in Green House Gases (GHGs) such Carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), hydro fluorocarbons (HFCs), sulphur dioxide (SO_2) and Chlorofluorocarbons (CFCs) (Seinfeld and Pandis, 2012), which are pumped out into the air through fossil fuel burning and other human activities. The availability of these gases in the atmosphere acts to trap the heat radiation near the earth surface that would otherwise be sent back into space (Koulaidis and Christidou, 1999). This phenomenon results into variations in solar activity which changes the earth's radiation amounts resulting into climate change. The impacts of climate change can be abiotic (changes in precipitation pattern and intensity, occurrence of extreme events like extended drought, flooding, fire outbreak) or biotic (frequency and consequences of pest and disease outbreak) (Lindner *et al.*, 2010).

Farmers are aware of the issue of climate change and will often ascribe changes in farm productivity to changes in rainfall patterns. The nature or extent of climate variation depends on how people perceive about climate change and variability (Figure 1). The impacts felt by farmers can be perceived as negative if climate variations result into low rainfall, occurrence of floods, irregular rain seasons, and persisted aridity or droughts indicated by undesirable outcomes like low crop yields, lack of grazing lands, and eruption of pests and diseases. Inadequate adaptation by farmers will results into poor yields hence food insecurity (Sikder and Xiaoying, 2014).On the other hand, positive climate change impacts will be felt by famers if climate change results onto experiencing optimal temperatures, rainfall increase, increase in river flooding duration which will increase crop yield (Sikder and and Xiaoying, 2014) as well as making pastures for grazing to be adequately available.

These perceived impacts in turn determine what response options or adaptation farmers undertake in an attempt to counteract the effects emanating from climate change and variability. The positive impacts and the better adaptation options lead to sustainable livelihoods. However, actions for reducing carbon emissions and slowing the rate of global warming cannot be substituted by adaptation, no matter how well designed (Munishi *et al.*, 2010). Hence, mitigation programs with focus on climate change, land degradation or desertification and natural resource management must be implemented. Due to the collective effects of adaptation and proper mitigation measures in the long run, the intensity of factors (agents) of climate change in the atmosphere will decrease consequently decreasing the global temperature thus making the climate to stabilize.

Morogoro is one of the regions in Tanzania that is affected by inadequate rains, prolonged droughts, incidences of floods and extreme changes in temperatures, wind and humidity intensities (Daninga*et al.*, 2015). Although various studies on climate change and variability have been done in Tanzanian, there are still inadequate studies done to ascertain the severity of climate change impacts on crop production. As depicted from the conceptual framework (Figure 1), this study therefore sought to assess the micro-level climate change impacts on production systems in rural areas. Understanding the extent to which farmers are impacted with climate change at micro-level will help to prioritize strategies that are aimed at addressing the challenges of climate change impacts that is posing serious risks to poverty reduction and threatening to undo the development efforts in Tanzania.

3. Methods

A multi-stage, simple random and purposive sampling techniques were used to obtain a sample size of 240 respondents in a cross sectional study that was conducted between October 2010 and November 2011 from three districts (Mvomero, Kilosa, and Morogoro rural) in Morogoro region whereby six villages (Mlali, Fulwe, Kiwege, Kigunga, Msowero and Rudewa-Batini) were selected (figure 2). The micro-level climate change impacts in this study were regarded as the consequences of climate variability on farmers' production systems such as changes in net primary productivity, crop infestation, de-vegetation, migration, forest resource etc. Descriptive statistics analysis was used for this purpose. An approach to analysing the qualitative data was sought using discourse analysis technique so as to provide a rich and detailed but complex account of data (Braun and Clarke, 2006). To improve reliability of recall data, farmers in this study were asked to recall events that took place some years preceding the survey. According to Mutabazi (2007), a question about an event that occurred decades ago tends to yield a less reliable response than a query about a similar event which took place last week or last year. To have reliable data, associative and sequential probing was the guiding principle applied to get the major crop yield, and the price of the crop in the past years. The recall process was facilitated through articulation of major events which occurred in a particular year.

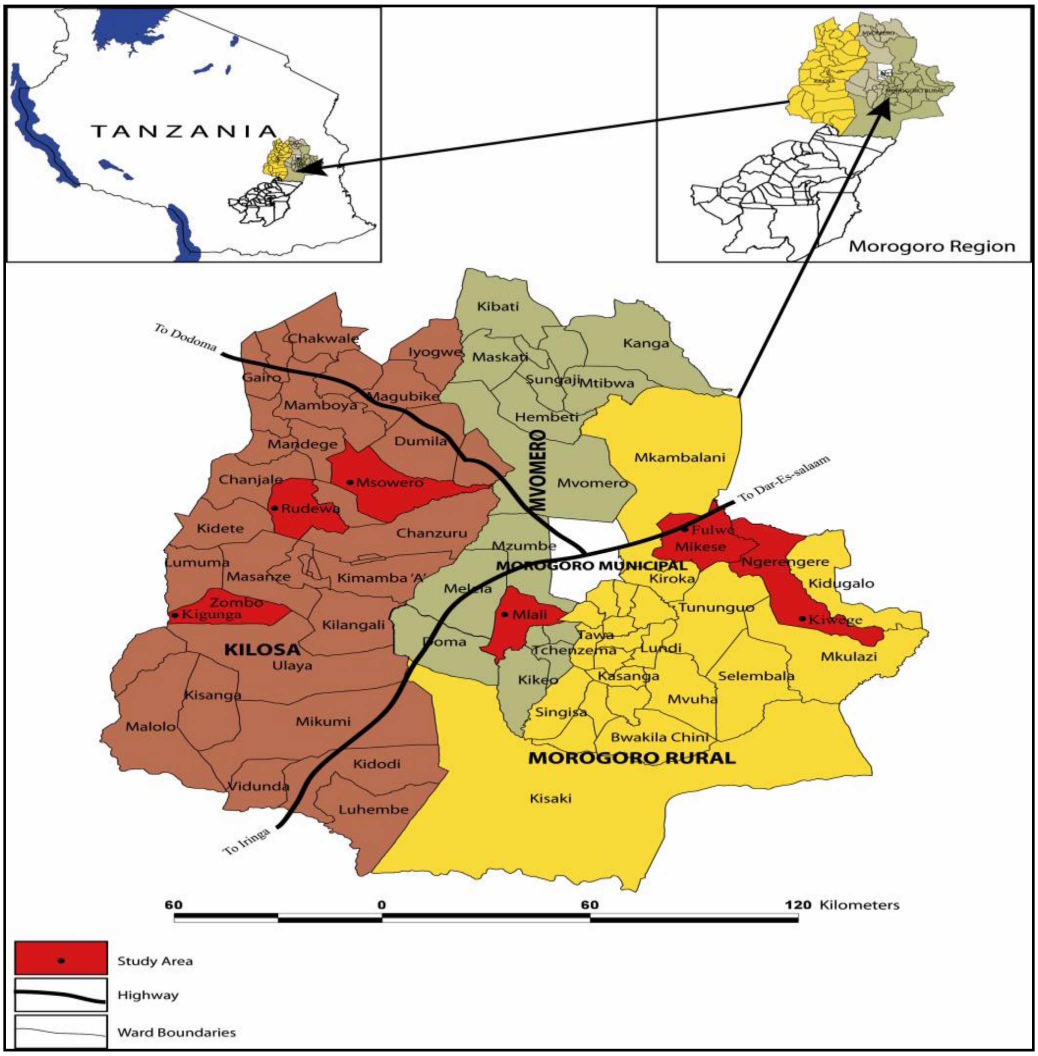

Figure 2: Study area

Source: Author

Among others, a respondent for instance was tactically asked what was his/her harvest, income or prices of major crops in the year prior to this survey and in the year when the country had her third president in power. Recall data were supplemented with maize price trend of morogoro region in various years from the ministry of trade and industry (Maro and Mwaijande, 2013).

4 Analysis and Discussion

Males accounted for 61.3% of respondents while females were 38.7%. Respondents had an average of 46 years with majority (84.3) being above 30 years. Majority (70.4%) had between 1 and 7 years spent in formal education (table 1).

Table 1: Demographic characteristics of respondents

Demographic characteristics of respondents in percentage						
Age(years)				***Sex***		
16 to 35	36 to 45	46 to 65	Above 65	Males	Females	
37.5	22.1	17.1	23.3	61.3	38.7	
Marital Status				***Education***		
Married	Separated	Single	Widow	Non-formal	Primary	Post-primary
82.5	6.3	5.4	5.8	10.8	70.4	3.7

Source: Calculation of data by author

The study found that, farmers in the study area were highly impacted due to climate change and variability. Results revealed that, 62% of respondents perceived to have been highly affected by climate change shocks. About 37% of respondents were neutral and no respondent reported to have been less affected (Fig. 3).

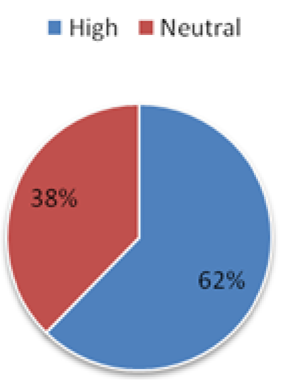

Figure 3: Farmers' perceived climate change impact

These results show a clear picture of how much farmers have been negatively affected by variations in climate in the study area.

Respondents were asked whether they were born in the area or they migrated from elsewhere. The survey found that, 50.8% of indigenous people migrated into the study area whereby only 49.2% were born in the area (Table 2).

Table 2: Indigenous born in the area of study

Response	Frequency	Per cent
Yes	118	49.2
No	122	50.8
Total	**240**	**100**

Source: Field data by Author

However, in the period between 1980 and 2009, the trend shows there had been more people migrating into the study area than in the period before (Fig. 4).

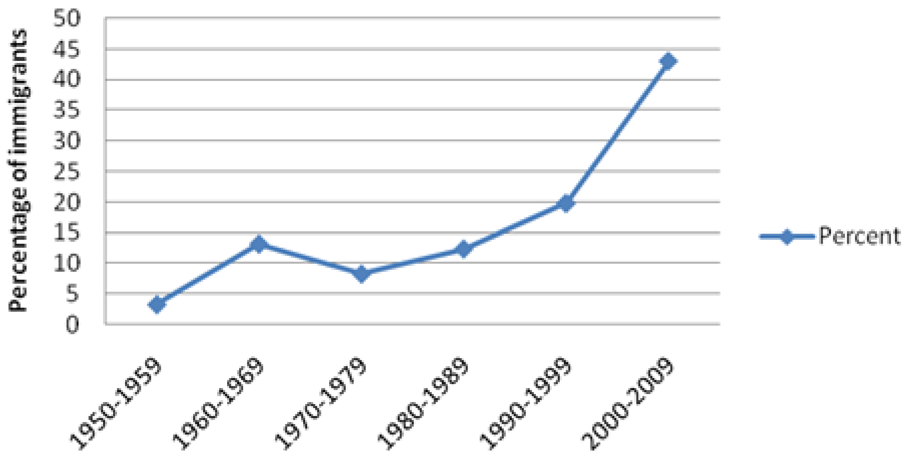

Figure 4: Migration trend from 1950-2009

Source: Authors' Survey data

Results indicated that the majority of the respondents (43%) reported to have migrated into other areas between 2000-2009 in search for favourable climate for growing crops. Fluctuation in climate change resulted in frequent drought, depletion of household assets and increased rural urban migration. However, the rate of migration greatly differed from one year to another depending on climatic conditions experienced in each year of production. As seen from Figure 6, the trend showed from 2000-2009, the number of people migrating in the study area was more than double the number of people who migrated out from the same area in the years 1990-1999. This explained the increasing incidences of drought in areas surrounding the study area, an evidence of impacts caused by climate change and variability.

Internal migration cases were low in 1950-1959 and 1970-1979 with the lowest percentage responses (3.3 %, 8.3%) respectively. This shows that the impacts of climate change and variability at this time were low and that consequences increased as years went by most likely due to increased environmental degradation caused by human activities which increased invasion trend by immigrants like the pastoralists and peasants in search for potential areas for grazing and agriculture. From this aspect, it can therefore be concluded that unfavourable climate changes affect farm production forcing farmers to migrate to areas with favourable climate. This finding complies with Shiferaw *et al.* (2014) who revealed that the economic and environmental impacts of drought as a result of climate change can be manifested in the different forms including out migration and displacement.

Smallholder farmers from the study area were asked to answer the question whether climate change had increased the problem of crop infestation and diseases according to their levels of agreement or disagreement. Table 3 shows respondents' level of agreement responses. Results revealed that, 91.21% of farmers strongly agreed that climatic changes are the major cause of crop yield reduction in the study area.

Table 3: Crop infestation impact due to climate change

	Frequency	**Per cent**
Strongly agree	218	91.21
Somewhat agree	14	5.86
Somewhat disagree	5	2.09
Strongly disagree	2	0.84
Total	**239**	**100**

Source: Field data by Author

A few respondents (5.86%, 2.09%, and 0.84%) reported that to some extent changes in climate contribute to low levels of crop yields due to increased infestation of crop by pests and diseases, decline in soil moisture and nutrients. This is evident as was asserted by one of the Focus Group participant saying:

"...of recent, the land has been invaded with pests that were not seen in the past. These pests

(insects) are destructive to plants and they attack maize and other crops after germination". Since the rains are unreliable and once the insects are seen, then farmers normally end up having less to harvest, causing them to succumb to famines. The findings comply with Lindner *et al.*, (2010) who asserted that climate change will have associated consequences of outbreaks of pest and disease. This suggests that change in climate has been a primary factor responsible for crop infestation in the area of study.

Food costs were reported to have increased due to changes in climate. Results from farmers' recall data indicated that the average price of maize bag (100 Kg) in 2005 was USD 10.2. The cost of food (maize) went on increasing year after year whereby in 2009, the prices shoot to an average price of 13.6 USD per maize bag. This was a reflection that the costs for food had never been constant and the yearly increase was due to decrease in maize yield as a result of prevalence of erratic rains in the area in the period between 2005 and 2009 (Fig.5).

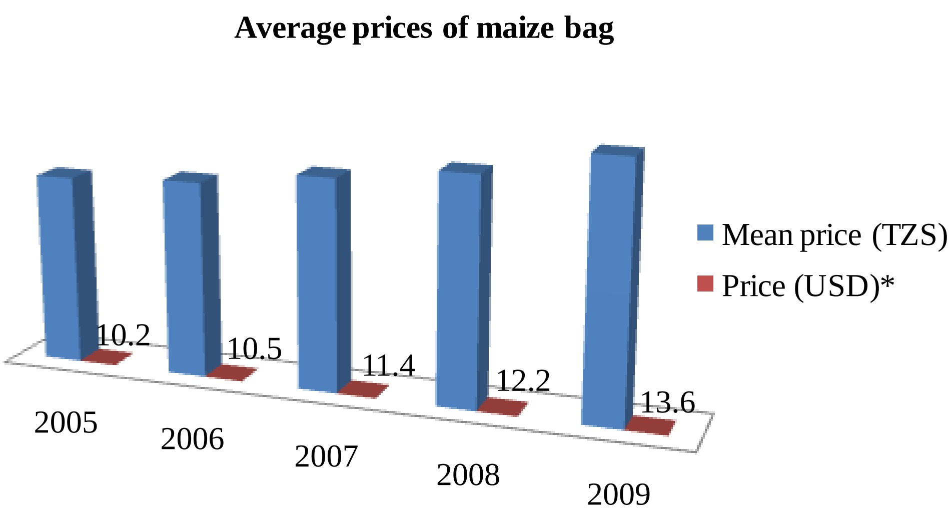

Figure 5: Impact of climatic change on food cost

*According TZS exchange rate as of 2017-06-26

Source: Author's survey data based on farmers' recall records

The increased food costs can be explained by low production output caused by unfavourable climate in the area. Low levels of production have a great impact on price determination. Theoretically, quantity produced of certain product is inversely related to price. Therefore, unfavourable climate in terms of low rainfall, high temperatures and low soil moisture results in low agricultural output. This in turn leads to increased price of food items.

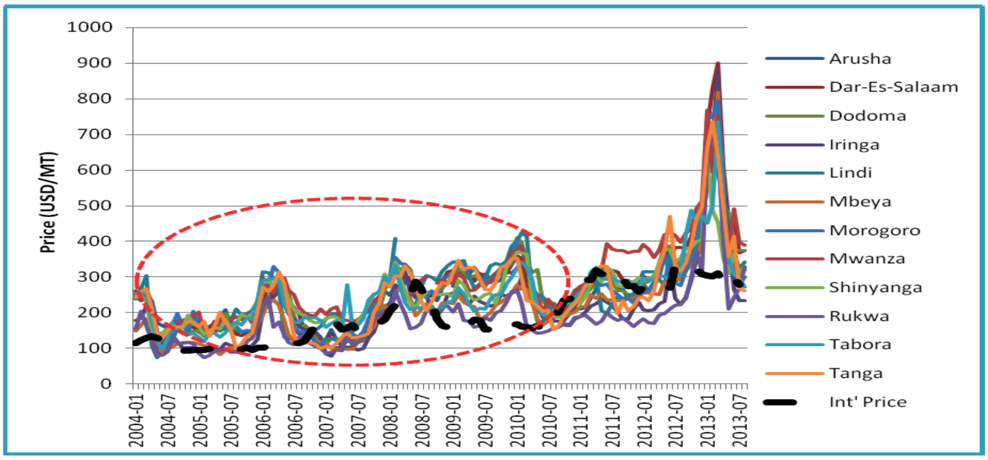

Figure 7: Maize price trend in Morogoro and other selected regions in Tanzania from 2004 to 2013

Source: Ministry of Industry and Trade, Tanzania

When farmers recall data were matched up to that of Morogoro regional Maize price trend (in million tons) there was a similar trend (fig. 6). Prices of maize were observed to fluctuate with the major reason being erratic rains. This is because, maize in Tanzania is rain-fed and depends highly on adequate water and moisture content (ACB, n.d). The findings are also in line with MVIWATA market development programme report (n.d) that showed that the prices of agricultural commodities increased tremendously between 2005 and 2011 because markets had not resolved the problem of risk and uncertainly in farm production as farmers face such risks as drought, floods, price fluctuation, and general crop failure.

Based on their levels of agreement and disagreement, respondents again were asked to state whether the environment had suffered from excessive devegetation or not due to climate change. Results showed that majority of respondents (83.7%) strongly agreed on change of climate as the main cause of de-vegetation. A few of respondents had varying views deviating from climate problem as indicated in Table 4.

Table 4: Impact of climate change on deforestation

Forests have almost disappeared	**Frequency**	**Per cent**
Strongly agree	200	83.7
Somewhat agree	16	6.7

I don't know	2	0.8
Somewhat disagree	13	5.4
Strongly disagree	8	3.4
Total	**239**	**100**

Source: Field data by Author

Respondents reported that in the past, there was thick vegetation that had supported very many living organisms as well as economic activities for people living in the area. For instance, results from the group discussion showed that wild animals like lions, elephants etc. used to roam around the villages. However, today they are hardly seen in the area because forests have been destroyed and cleared by human activities such as searching for fuels, agriculture, housing etc. Variations in climate have negatively impacted on crop production of farmers in the study area. Results indicate that for the past five years, there has been a general decrease in maize production, which is the major food crop in the area (Fig. 7).

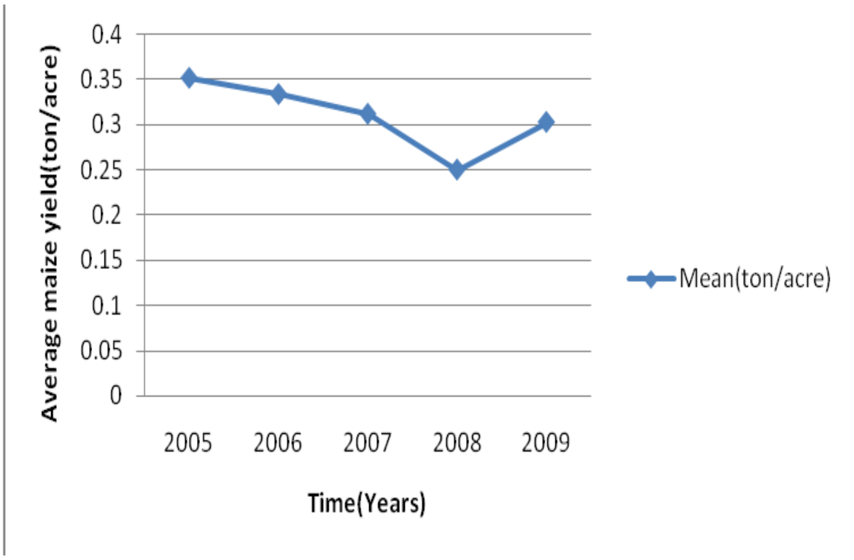

Figure 7: Trend of maize yield for five years in the study area

Source: Author's Survey data

Results show that from 2005 to 2008 there was a gradual decrease of maize yield in tonnes per acres in the study area. In the year 2005, the average maize yield which is the major food crop in the area was 0.352 tonnes per acre. This yield decreased and reached 0.334, 0.312 and 0.250 in 2006, 2007 and 2008 respectively (Fig. 7). In 2009, the yield increased slightly. One reason was obvious that some villages in the study area received some good rains.

However, the general trend is that in the past five years farmers in the area suffered a great loss of crop yield due to poor rains and excessive temperature resulting from climate variability which in turn affected crop production in the area. The gradual decrease in maize production in different years of production could have been caused by the fact that the areas had been receiving low rainfall levels to climate variability. This finding clearly justifies the former scenario in Kiwege village in 2008/09 whereby indigenous settlers in the area were given food relief by the government of Tanzania due to prolonged drought spell. As a result of the 2009 drought which affected more than 1.5 million people in Tanzania, more than 120,000 million tonnes of food aid was required in the country (Munishi *et al.*,2010). Although other factors may have contributed towards decrease in yield, there is, however, sufficient evidence revealing how climate change had impacted on crop yield loss as indicated by Munishi *et al.* (2010) who demonstrated that rainfall characteristics in some parts of Tanzania show a gradual decrease in the length of the growing season, decreasing trend of number of rainy days during the growing season, and decreasing seasonal rainfall amount in areas that are most vulnerable hence poor yield.

Conclusion

A range of strategies are being used by farmers to cope withand adapt to rainfall variability risks. However, more need to be incorporated in the strategies of improving farmers' resilience to climate shocks so as to decrease their vulnerability to food insecurity. Locally developed and crop management practices should be promoted while putting more efforts in managing drought through efficient management of agricultural water and or drought resistant crops. It is further suggested that the governments should make efforts to ensure that extension services and affordable credits reach the resource poor farmers in rural areas so as to increase their ability and flexibility to change production strategies in response to climate change.

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