

Smallholder Farmers' Perception of Climate Change Versus Meteorological Data in Semi-arid Areas of Iringa District, Tanzania

¹Mary L.Kihupi, ²Emmanuel E. Chingonikaya and ³Chritopher Mahonge,

¹The Mwalimu Nyerere Memorial Academy, P. O. Box 9193 Dar es Salaam, Tanzania.

²Development Studies Institute, Sokoine University of Agriculture, P. O. Box 3024 Morogoro, Tanzania.

³SUA Centre for Sustainable Rural Development, P. O. Box 3035 Morogoro, Tanzania.

*E-mail of the corresponding author: marykihupi@yahoo.co.uk

Abstract

The ongoing changes in global climate threaten the sources of livelihood, especially among smallholder farmers in poor parts of the world. Smallholder farmers need to recognize the changes in climate already taking place in their areas and undertake appropriate investments towards adaptation. The coping and adaptation strategies of the farmers are linked to a very large extent with their perception on climate change and its impacts. The main objective of this study is to examine smallholder farmers' perception of climate change vis-à-vis meteorological data. Specifically this paper answers the following research questions: how smallholder farmers perceive climate change, what are the meteorological data of the study area, and how meteorological data link with smallholder farmers' perception to climate change. The study was carried out in semi-arid areas of Iringa District. The research design was cross sectional. A multistage sampling procedure was applied to select divisions, wards, villages and households. Ismani and Pawaga Divisions of Iringa District were purposefully selected based on their climatic conditions. A total of 240 respondents were drawn randomly from eight villages. Data were collected through household survey, key informant interviews, observation and focus group discussions methods. Meteorological data were collected from Tanzania Meteorological Agency. Quantitative data were analyzed through SPSS and qualitative data through content analysis. Instant Statistical Packages for Agro-climatological data was used in analyzing the 54 years meteorological data of Nduli meteorological station in Iringa District. The findings revealed that smallholder farmers perceived climate change in terms of change in temperature, changes in rainfall, increase in drought condition and increase in malaria and crop pests and diseases. Change in rainfall pattern, temperature pattern and occurrence of pests and diseases had significant impact on smallholder farmers' households whose livelihood depends on rain fed farming. Therefore smallholder farmers need to adapt to the changing climate. It is recommended that there is need for development of appropriate adaptation strategies to climate change of which smallholder farmers in semi-arid areas of Iringa District perceived. This can be achieved by helping smallholder farmers use their local knowledge in combination with introduced innovations to enhance adaptation to the impact of climate change.

Key words: perception; climate change; temperature and rainfall; semi arid; Iringa; smallholder farmers; Tanzania

1.0 Introduction

The earth's average surface temperature has increased by almost 0.74°C over the past century (IPCC, 2007a). The consequences of this alteration are now becoming more visible as climatic conditions and ecosystems change (IPCC, 2007b). Climate refers to the characteristic conditions of the earth's lower surface atmosphere at a specific location over long period of time; weather refers to the day-to-day fluctuations in these conditions at the same location (FAO, 2008). Air temperature, precipitation, atmospheric pressure and humidity, wind, and sunshine and cloud cover are variables that are commonly used by meteorologists to measure daily weather phenomena. Climate change refers to changes for at least 30 years in all the essential climate variables (FAO, 2008). Climate variability refers only to the year-to-year variations of atmospheric conditions around a mean state (WMO, 1992). The change in climate is a natural phenomenon as it has been changing since the origin of earth (FAO, 2008). The natural rate of climate change is so slow that species would have time to adapt the changes (Darwin, 1959 cited in Lamichhane, 2010). However, change accelerated by anthropogenic activities takes place at a high rate not allowing species to adapt to that change. This finally creates adverse impacts on lives, people's livelihood and development of the society.

Developing countries are more vulnerable to impact of climate change due to the fact that they have low income

and high dependence on natural resource sectors for their livelihoods and incomes (Leary and Kulkarni, 2007; Shemsanga *et al.*, 2010; Yanda and Mubaya, 2011). The impacts of climate change are likely to severely damage social and economic systems of most developing countries (Yanda and Mubaya, 2011). The ongoing changes in global climate threaten the sources of livelihood, especially in poor parts of the world (Hisali *et al.*, 2011). Agriculture is negatively affected by climate change (Desanker and Magadza, 2001). It has been said that climate change is set to hit the agricultural sector the most in Sub-Saharan Africa (Tanzania being one of them) and cause much suffering, particularly to smallholder farmers (Komba and Muchapondwa, 2012).

Smallholder farmers need to recognize the climatic changes already taking place in their areas and undertake appropriate investments towards adaptation (Komba and Muchapondwa, 2012). Farmers' ability to perceive climate change is a key pre-requisite for their choice to adapt (Maddison, 2007; Gbetiouo, 2009; Acquah and Onumah, 2011; Mengistu, 2011; Moyo *et al.*, 2012; Kitinya *et al.*, 2012). The coping and adaptation strategies of the smallholder farmers depend, to a very large extent on their perception knowledge level and sources of information about climate change available to them (Bello *et al.*, 2013). However, perceptions are influenced not only by actual conditions and changes, but also by other factors (Acquah and Onumah, 2011). Weber (2010) believes that most farmers' knowledge and exposure to climate change have been influenced indirectly by the media reporting various events on climate change occurring elsewhere. Having fertile soil and access to water for irrigation decreases the likelihood that farmers will perceive climate change (Gbetibouo, 2009) due to the fact that perception of climate is based on economic and social impact it has on personal lives (Slegers, 2008).

Several studies have been done in Tanzania on climate change impacts, vulnerability, and adaptation strategies. Only few of them partly focused on perception of local communities on climate change (Lyimo and Kangalawe, 2010; Mongi *et al.*, 2010; Swai and Majule, 2009). However, those studies were done in semi-arid areas of central and western parts of Tanzania. The knowledge of climatic perception is a key entry points for farmers to respond to impact of climate change, also for decision makers and policy makers to learn how and where to enhance adaptive capacity of smallholder farmers. But there is limited knowledge on how smallholder farmers perceive climate change in semi arid areas of Iringa District. It is important to note that local perception cannot be estimated by models (Okonya *et al.*, 2013) and adaptation is place based and needs the use of place specific strategies (Hassan and Nhemachena, 2008; Kurukulasuriya and Mendelsohn, 2008; Lobell *et al.*, 2008; Seo *et al.*, 2008; Deressa *et al.*, 2011). Therefore, this study examined how smallholder farmers in Iringa District semi arid areas perceive climate change and implication of these changes in agriculture production.

This study is in line with the National Climate Change Strategy (URT, 2012) of which, one of its specific objectives aims at building the capacity of Tanzania to adapt to climate change impacts. First first step towards building this capacity is to underline the perception knowledge level of smallholder farmers (Tanzanians) about climate change. Also, the study is in line with the National Adaptation Programme of Action (NAPA) (URT, 2007), which calls for identification of immediate and urgent climate change adaptation actions that are geared toward long-term sustainable development. These efforts are intended to shield both the Tanzania Development Vision 2025 and Millennium Development Goals from failure due to the climate change impacts. As such, perception is a necessary precondition for adaptation. Therefore, smallholder farmers' perceptions of climate change and variability are important in adaptation as they determine decisions in agricultural planning and management.

2.0 Methodology

The study was conducted in Iringa District in Iringa Region Tanzania. The district is one of the four districts of Iringa Region. Iringa District has six administrative divisions. Two divisions namely Ismani and Pawaga out of six were selected for the study basing on their climatic conditions. The area (Ismani and Pawaga) is semi-arid with low mean rainfall ranging from 500 to 600 mm. The temperature in Pawaga Division is over 25 °C while that in Ismani Division is 20 – 25 °C.

The rationale for choosing Iringa District for the study was twofold. First, Iringa District was one of the major maize producing districts in Iringa Region until the early 1970s, but now agricultural production is low due to unreliable rainfalls. Secondly, Iringa District especially in Ismani and Pawaga Divisions experiences recurrent drought conditions, therefore, is more vulnerable to impact of climate change than other areas in the region.

The study used a cross-sectional research design. A multistage sampling procedure was applied to select divisions, wards, villages and then households. This procedure allows more than one sampling method to be used. Ismani and Pawaga Divisions were purposively selected basing on their climatic condition. Four wards in Ismani and Pawaga Divisions were selected randomly. In each selected ward; two villages were randomly selected making a total of eight villages. A total of 240 respondents were drawn randomly.

Both quantitative and qualitative data were collected. Quantitative data were collected through household survey method. A tool for this method was a questionnaire. The questionnaire was pre-tested to ten households in Lwang'a village, Ismani Division and accordingly revised to produce the final questionnaire that was administered to heads of household smallholder farmers through in-depth personal interview approach. Information on smallholders' perception on climate change was gathered through this method. Qualitative data were gathered through focus group discussion, key informant interview and field observation methods. Secondary data were collected from Tanzania Meteorological Agency whereby temperature and rainfall year to year data from 1961 – 2013 from Nduli meteorological station in Iringa district were gathered. Meteorological data were collected so as to establish the extent to which climate has changed (through rainfall and temperature).

Quantitative data collected through household survey method were analyzed using Statistical Package for Social Sciences (SPSS). The perception of smallholder farmers was organized into three levels. The highest perception had a score of 30; the neutral had a score of 20; the lowest perception had a score of 10. Therefore the lowest perception was represented by 10-19 while the highest perception was represented by 21-30. A score of 20 meant neutral. Descriptive statistics was applied whereby frequency and percentage were calculated. Qualitative data were analyzed using content analysis. Instant Statistical Packages for Agro-climatological data was used in analyzing the 54 years meteorological data of Nduli meteorological station. Daily mean rainfall was computed and cumulative mean daily rainfall curve was used to estimate possible late start and early end of growing season. Maximum and minimum mean temperatures, annual mean temperature were computed. Total rainfalls, number of wet days and a 7-day or more dry spell within 30-day periods in each season were computed for each year and hence simple linear trend analysis for each characteristic was carried out. The dry spells were grouped into three temporal periods of seventeen years each for early, mid and late years i.e. 1961-1977, 1978-1994 and 1995-2011 respectively.

3. Results and Discussion

The main objective of this study was to examine on how smallholder farmers perceive climate change. The level of perception on climate change is very high as shown in Table1. About 99% of respondents perceived changes in climate. The minimum perception was 11 while the maximum perception was 30. The results imply that smallholder farmers had very high perception on climate change. The results were complemented by climatological data from Nduli station, Ismani Division in Iringa District which showed the climate was changing (Figure 1-7).

Table1. Level of Perception on Climate change

| | Frequency | Percentage |
|-----------------|-----------|------------|
| Low perception | 2 | 0.8 |
| Neutral | 1 | 0.4 |
| High perception | 237 | 98.8 |
| Total | 240 | 100.0 |

3.1 Smallholder Farmers' Perception of Temperature Change

The study revealed that significant numbers of smallholder farmers perceived that there was an increase in temperature. About 61% of respondents (Table 2) remarked that the temperature has increased today comparing to twenty or more years back. However, 35% did not notice temperature increase. About 59% of respondents claimed that there was extremely high temperature during summer, while 34% opposed that claim. Also respondents were asked whether they agreed that there was an extreme cold weather during winter. About 64% of respondents agreed that there was extreme cold during winter. However, perception of smallholder farmers on increase of temperature was confirmed by the trend of mean annual temperature (Fig. 1) which showed increase in temperature.

The trend of mean annual temperature for Iringa District was increasing and statistically highly significant ($P < 0.01$) (Fig. 1). Both the mean maximum and mean minimum temperature were significantly increasing. But the mean maximum temperature appeared to rise at a higher rate than the mean minimum temperature. These trends

were similar with those of Manyoni District (Mary and Majule, 2009) where mean maximum temperature increased rapidly and mean minimum temperature increased slowly. The results differ from those of Tabora (Mongi *et al.*, 2010) where the minimum temperature increased faster while the maximum temperature increased gradually. Also the results differ from those of Shinyanga Rural District (Lyimo and Kangalawe, 2010) who reported that both minimum and maximum temperature showed significantly increasing trends but the minimum temperature increased sharply while the maximum temperature increased gradually. This implies that different areas experiencing similar climatic conditions can experience changes in climate differently.

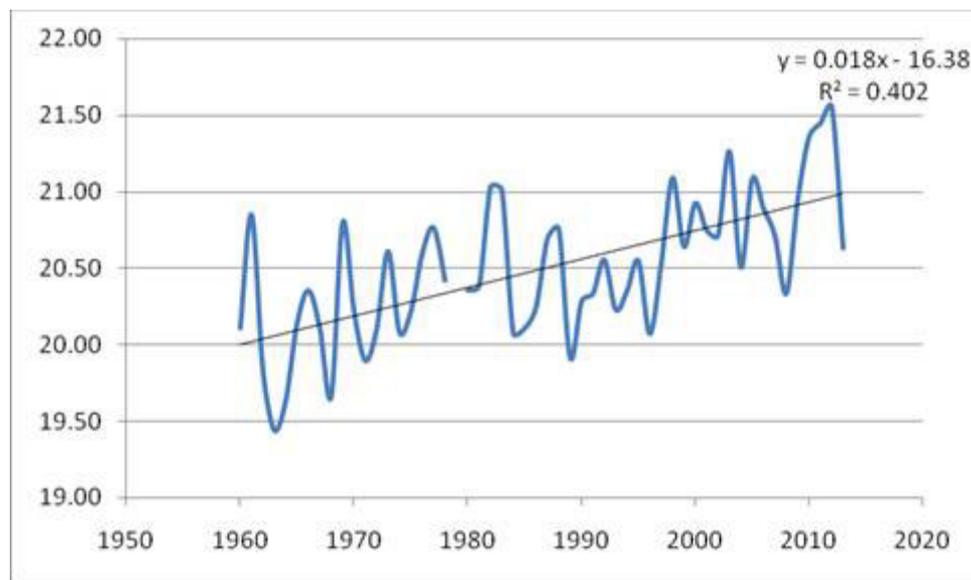


Figure 1: Iringa Mean Annual Temperature 1960-2013

According to IPCC (2007b), increase in average temperature will adversely affect crops, especially in semi arid areas where heat has become a limiting factor for crop production. Increase in temperature also increases evapo-transpiration rate of plants, and increases chances for severe drought. This means farming activities in semi-arid areas of Iringa District were affected by the increased temperature. This has impact on food security and smallholder farmers' wellbeing in general.

Table 2: Perception of Climate Change among Smallholder Farmers

| Variables | Disagree | Undecided | Agree |
|--|----------|-----------|-------|
| There is increase in temperature | 35.4 | 3.3 | 61.3 |
| There is extremely high temperature during summer | 34.1 | 6.3 | 59.6 |
| There is extreme cold temperature during winter | 27.9 | 6.7 | 65.4 |
| Precipitation has decreased | 1.2 | 0.0 | 98.7 |
| There is change in timings of rains | 1.2 | 0.0 | 98.8 |
| Frequencies of drought have increased | 1.2 | 0.0 | 98.8 |
| It rains in patches within the same village | 0.8 | 0.0 | 99.2 |
| It rains much in short time periods leaving other months dry | 2.5 | 1.3 | 96.2 |
| There is increase in malaria | 28.3 | 5.8 | 65.8 |
| There is increase in pests and crop diseases | 10.5 | 5.4 | 84.2 |

3.2 Smallholder Farmers' Perception of Changes in Rainfall Pattern

Field results show a decrease in rainfall, whereby 98% of respondents (Table 2) observed that the rain was decreasing comparing to two or more past decades. The meteorological data also show total annual rainfall in Iringa District is decreasing with time (Fig. 2), though the rainfall trend of 54 years shows the decrease is not statistically significant at $P < 0.05$. Thus smallholder farmers' perception on decrease in rainfall might be influenced by other factors such as distribution of rainfall. A similar trend has been noted in Usangu Plains in Tanzania (Kihupi *et al.*, 2007), and Shinyanga Rural District (Lyimo and Kangalawe, 2010) that annual rainfall

amount had been in declining trends, but the decrease was not statistically significant. This implies that the area might be receiving the same amount of rainfall, but there are changes in its distribution. Kingamkono *et al* (1994) and Kihupi *et al.*, (2007) argue that the timing and distribution of rainfall determine both the length and quality of the growing season, and hence have important implications for agricultural production and food security

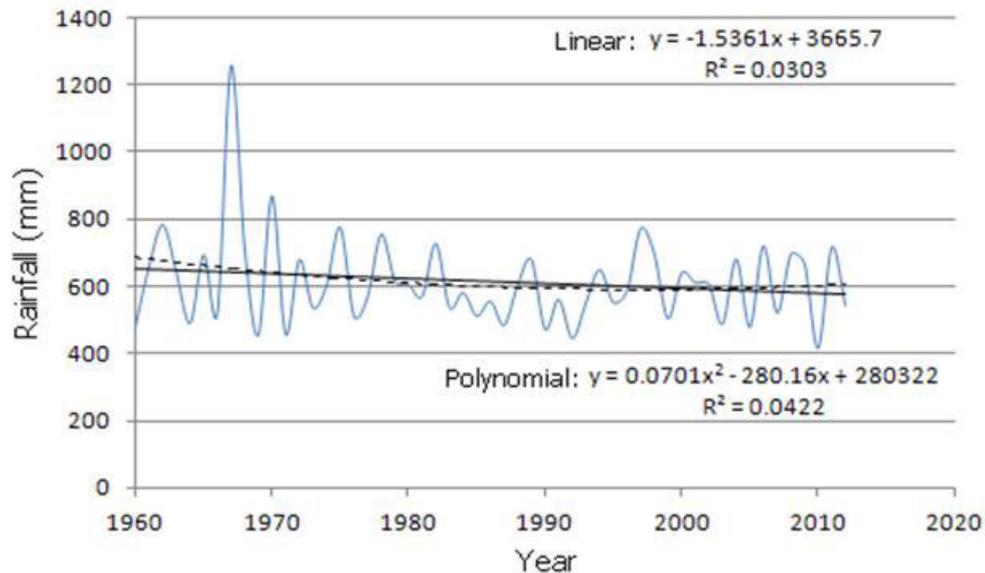


Figure 2: Trend of annual rainfall for Iringa (Solid line = linear; dashed line = polynomial)

Rainfall from farmer's point of view entails the onset, cessation and length of rain season (Kihupi *et al.*, 2007). Field results show that the rain falls much in a short period of time living other months dry during rainy seasons. This was noted by 96% of respondents (Table 2). Also about 98% of respondents (Table 2) agreed that there was change in timing of rains. These results were also confirmed in meteorological data which showed the beginning and ending of rains has changed significantly (Fig. 3 and 4). The trend shows the onset of rains in 1960s and early 1970s was in November but currently has shifted to mid December; the trend was statistically highly significant at $P < 0.01$ (Fig. 3). Also the trend of cessation dates was changing. Rainfall cessation in 1960s and early 1970s was in May, but currently it has shifted to April. The trend of cessation was statistically very highly significant at $P < 0.001$ (Fig.4). These trends (onset and cessation) imply that, the rain season starts late and ends early. This has repercussion on the growing season. The length of growing season has declined with time and the change was statistically very highly significant at $P < 0.001$ (Fig.5). The results were similar to those of Bukita District in Zimbabwe (Simbarashe, 2013) that showed a general increase in temperature and declining in rainfall and shortening of crop growing season. The same had been reported by farmers of Laikipia District in Kenya (Ogalleh *et al.*, 2012) that were experiencing shorter rain than in the past. As Lobell and Marshall (2010) reported, climate was reducing and expected to further reduce growing season length throughout much of the tropics. This has impact to smallholder farmers because traditional seed varieties cannot reach their full maturity under such shortened growing season. The situation calls for attention on adaptation measures, such as planting early maturing seed varieties, drought resistant crops and irrigation so as to improve agriculture production in semi-arid areas of Iringa District.

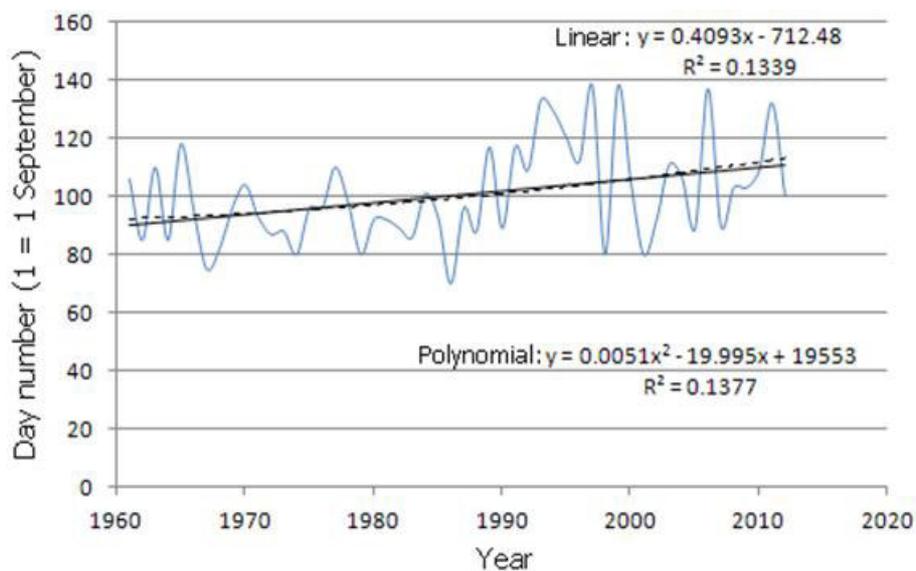


Figure 3: Trend of rainfall onset dates for Iringa (Solid line = linear; dashed line = polynomial)

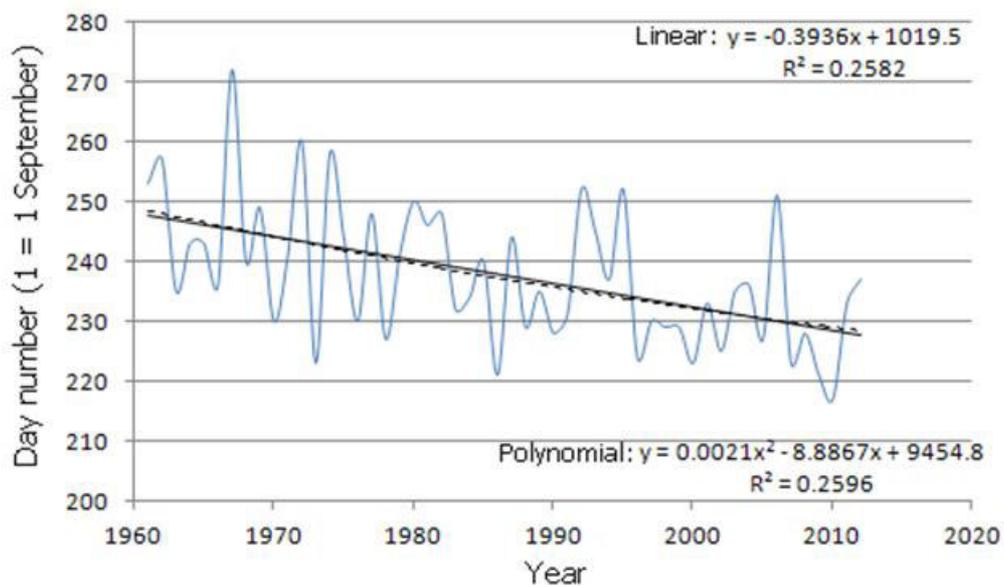


Figure 4: Trend of rainfall cessation dates for Iringa (Solid line = linear; dashed line = polynomial)

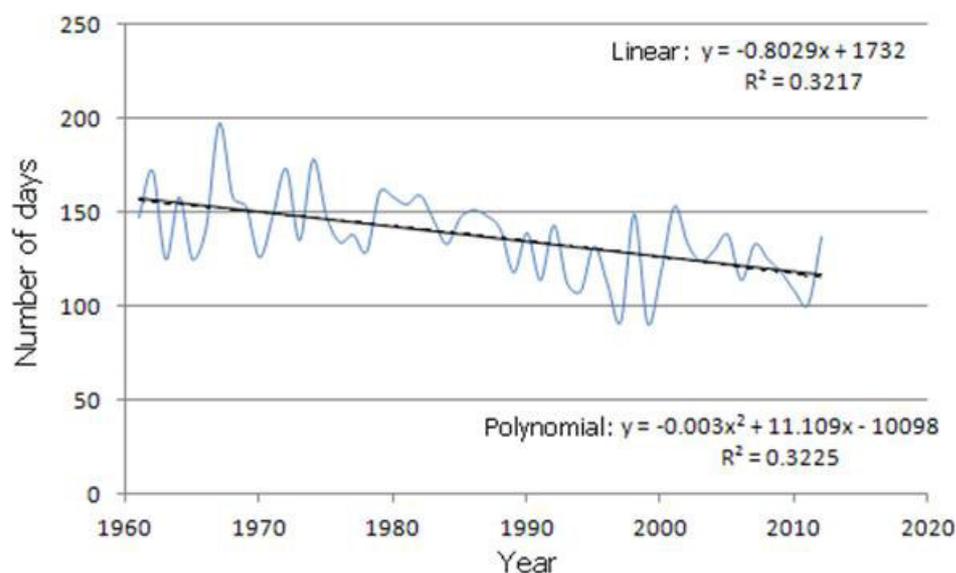


Figure 5: Trend of growing season length for Iringa (Solid line = linear; dashed line = polynomial)

Field results show increase in drought frequency, as reported by 98.8% of respondents (Table 2). These field results are reflected in meteorological data (Fig. 6 and 7). The quality of growing season is influenced by the magnitude of intervening dry spells (Kihupi *et al.*, 2007). The number of wet days within the growing season in Iringa District is decreasing and highly statistically significant at $P < 0.01$ (Fig. 6). Meteorological data shows increase in the occurrence of dry spells during rainy season in Iringa District (Fig. 7). The probability of having a 7-day or more dry spell within a 30-day during growing season is high now comparing to 1961-1977 period. These results are similar to those of Laikipia District in Kenya (Ogalleh *et al.*, 2012) who asserted that farmers in Laikipia District are experiencing increase in frequency of droughts. The same has been noted in Manyoni District in Tanzania (Swai and Majule, 2009) whereby farmers were experiencing increase in dry spells.

During focus group discussion and key informant interview, it was revealed that, there were prolonged dry spells in February which affected crops especially early maturing maize varieties that were said to be intolerant to drought conditions. This means increased risk of crop failure to smallholder farmers due to poor germination, stunted growth and drying of crops before their maturity caused by changes in rainfall pattern. Also focus group discussions and key informant interviews revealed that, smallholder farmers sometimes had to re-plough and re-plant crops due to unpredictability of rainfall, hence, increase in production costs. The results were similar with those of Dodoma in Tanzania (Nelson and Stathers, 2009) whereby farmers had to replant bulrush millet and groundnuts more often due to unpredictable rains. This means that time and seeds were wasted and quality of crops was affected. Farmers also in semi-arid areas of Iringa District reported changes in rainfall pattern, that rains used to fall throughout the entire village or across villages at a time, but nowadays it rains in patches in the same village. This was reported by 99% of respondents (Table 2). All these changes in climate have impacts on crops, food security and wellbeing of smallholder farmers who depend mostly on farming activities.

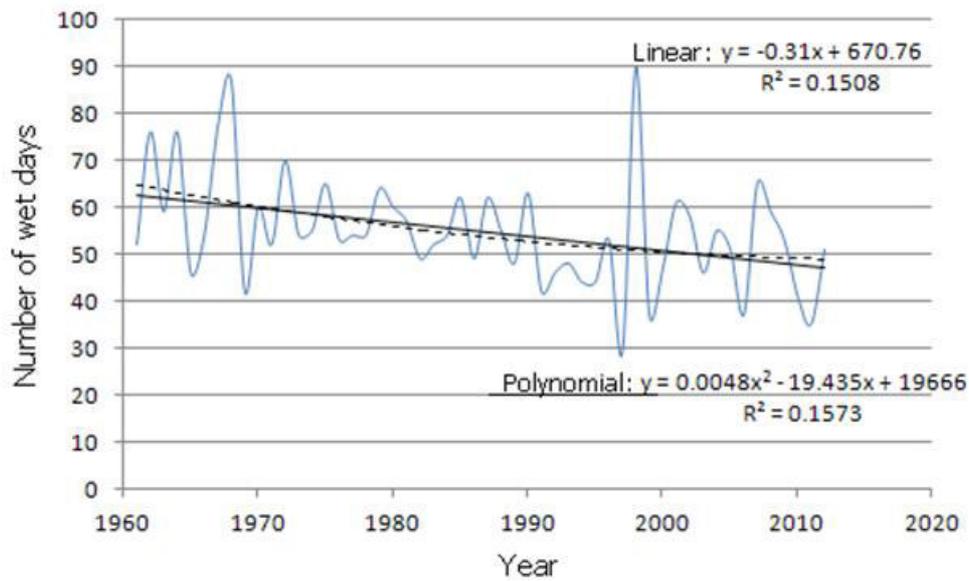


Figure 6: Trend of number of wet days for Iringa (Solid line = linear; dashed line = polynomial)

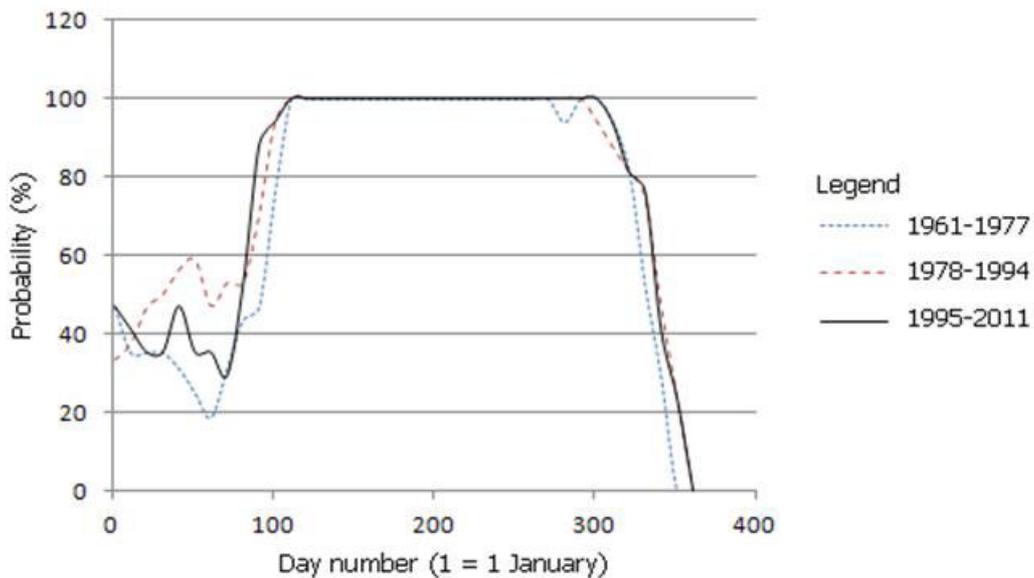


Figure 7: Trend of probability of a 7-day dry spell within a 30-day period following the date indicated on the horizontal axis for Iringa for the respective temporal periods

3.3 Smallholder farmers' Perception on Increase in Diseases and Pests

The study revealed that, there is increase in diseases and pests such as malaria to human being due to increase in temperature favouring environment for multiplication of host insects and pests. About 65% of respondents (Table 2) claimed that there was increase in malaria in the study area. Malaria has been increasing and spreading even in cold areas of Tanzania like Njombe and Arusha where formerly there was no malaria. This is due to increase in temperature creating favourable environment for mosquito (URT, 2012). Mosquito is responsible for spread of vector bone disease malaria. About 28% of respondents (Table 2) did not agree that malaria is increasing. This was complemented with focus group discussions where some members said malaria incidences were decreasing due to provision of free mosquito nets in Tanzania. Also the study revealed that there was increase in crop disease and pests which were not there or were at small scales in two or more past decades as reported by 59% of respondents (Table 1). Crop diseases and pests have impact on crop production, especially to smallholder farmers due to increase in pests and crop diseases; farmers have to buy pesticides which are expensive, hence, increasing production costs.

4. Conclusion and Recommendation

Smallholder farmers have perceived that the climate is changing and it is getting worse over time. There is a concern that the temperature is increasing and rainfall is unreliable and unpredictable; the onset and ending of rain have changed leading to significant reduction in growing season. Also dry spells have increased causing poor germination and drying of crops before reaching a maturity stage. This sometimes led to re-planting of crops adding more cost of production to smallholder farmers. These perceptions on climate change could be influenced by other factors such as availability of irrigation water, soil fertility, and information from media on climate change. Meteorological data trends (from Nduli station in Iringa District) of temperature, rainfall, onset and cessation of rain, growing seasons, number of wet days and probability of occurrence of dry spells provide evidence that the climate is changing. Change in rainfall pattern, temperature pattern and occurrence of pests and diseases has significant impact on household of smallholder farmers whose livelihood depends on rain fed farming. Therefore smallholder farmers need to adapt to the changing climate.

It is recommended that there is a need for development of appropriate adaptation strategies to climate change which was perceived by smallholder farmers in semi-arid areas of Iringa District. This can be achieved by helping smallholder farmers use their local knowledge in combination with introduced innovations to enhance adaptation to the impact of climate change. Joint action among researchers, extension officers, smallholder farmers and policy makers will enable development of adaptations strategies which are more efficient to overcome impact of climate change.

Acknowledgements

We would like to express our profound gratitude to the Mwalimu Nyerere Memorial Academy management for sponsoring this study. We also express our profound gratitude to the Vice Chancellor of Sokoine University of Agriculture. He introduced us to the relevant authorities through his letter to ensure our attachment with central government and local government authorities. We would like to express our special thanks to smallholder farmers of Ismani and Pawaga Division for their cooperation during field survey. This enabled us to collect data for this study.

References

- Acquah, H. and Onumah, E. E. (2011). Farmers' perception and adaptation to climate change: an estimation of willingness to pay. *Agris-on-line papers in Economics and Informatics* 3(4): 31-39.
- Babbie, E. (1990) *Survey research methods*, Second Edition. Wadsworth, Cengage Learning, Belmont, USA. 395 pp.
- Bailey, D. K. (1998), *Methods of social science research*. The free Press Collier Macmillan Publisher, London.345 pp.
- Bello, M., Salau, E. S., Galadimal, O. E. and Ali, I. (2013). Knowledge, perception and adaptation strategies to climate change among farmers of Central State Nigeria. *Sustainable Agriculture Research* 2(3): 107-117.
- Deressa, T. T., Hassan, R. M. and Ringler, C. (2011). Perception and adaptation to climate change by farmers in the Nile basin of Ethiopia. *Journal of Agricultural Science* 149(01): 23-31.
- Desanker, P. and Magadza, C. (2001). Africa. Climate change 2001. In: *Impacts, adaptation, and vulnerability*. Contribution of working group II to the third assessment report of Intergovernmental Panel on Climate Change. (Edited by McCarthy, J. J., Canziani, O. F., Leary, N. A., Dokken, D. J. and White, K. S.), Cambridge University Press, Cambridge. 487-531.
- FAO, (2008). *climate change and food security. A Framework document*. FAO, Rome. 107pp
- Gbetibouo, G. A. (2009). 'Understanding farmers' perception and Adaptations to Climate Change and Variability: The case of the Lipopo Basin, South Africa'. IFPRI Discussion paper 00849 Washington, DC. 36 pp.
- Hassan, R. and Nhemachena, C. (2008). Determinants of African farmers' strategies for adapting to climate change: multinomial choice analysis. *African Journal of Agricultural and Resource Economics* 2(1): 83-104.
- Hisali, E., Birungi, P., and Buyinza, F. (2011). Adaptation to climate change in Uganda: evidence from micro level data. *Global Environmental Change* 21: 1245-1261
- IPCC (2007a). Summary for Policy Makers. In: *Climate Change 2007: The physical science basis*. Contribution of working group I to the fourth assessment report International Panel on Climate Change. (edited by Solomon, S., Qin, D., Manning, M., Chen, Z. Marquis, M., Averyt, K.B., Tignor, M. and Miller, H. L.). Cambridge University Press, Cambridge, UK and New York , USA. 1-18.

- IPCC (2007b). Summary for Policy Makers. In: *Climate change 2007: impacts, adaptation and vulnerability*. Contribution of working group II to the fourth assessment report International Panel on Climate Change. (Edited by Parry, M. I., Canziani, O. F., Palutikof, G. P van der Linden, P.J., and Hanson, C.E.), Cambridge University Press, Cambridge, UK. 7-22.
- Kihupi, N. I., Tarimo, A. K. P. R., and Dihenga, H. O. (2007). Spatial and temporal variation of growing season characteristics in Tanzania. *Journal of the Geographical Association of Tanzania* 32: 33-49.
- Kingamkono, R. M. L., Kihupi, N. I. and Dihenga, H. O. (1994). Length of growing season vis-a-vis rainfall distribution in Tanzania. In: Proceedings of the fifth annual scientific conference held on October 10-14, 1994, Harare, Zimbabwe, 141-155.
- Kitinya, K. T., Onwonga, R. N., Onyango, C., Mbuvi, J. P. and Kironchi, G. (2012). Climate change and variability: farmers' perception, experience and adaptation strategies in Makueni County, Kenya. *Asian Journal of Agriculture and Rural Development* 2(3): 411-421.
- Komba, C. and Muchapondwa, E. (2012). *Smallholder farmers in Tanzania*. ERSA working paper 299. Economic Research South Africa. 33pp. [<http://econrsa.org/home/index.php?option=comdocman&task=docdownload&gid=443&Itemid=67>] Site visited on 05/07/2012.
- Kurukulasuriya, P. and Mandelsohn, R. (2008). crop switching as an adaptation strategy to climate change. *African Journal of Agricultural and Resource Economics* 2(1): 105 – 127.
- Lamichhane, K. (2010). *Sustainable livelihood approach in assessment of vulnerability to the impacts of climate change: A study of Chhekampar VDC, Gorkha District of Nepal*. Project work submitted for Award of Bachelor Degree of Arts in Development Studies Kathmandu, Nepal. 88pp.
- Leary, N. and Kulkarni, J. (2007). *Climate change vulnerability and adaptation in developing country regions*. Draft Final Report of the AIACC Project. UNEP, Nairobi, Kenya. 208pp.
- Lobell, D. and Burke, M. B. (eds) (2010). *Climate change and food security, advances in global change research*. Springer science + Business media, Stanford. 152 pp.
- Lobell, D. Burke, M. B., Tebaldi, C., Mastrandrea, M. D., Falcon, W.P. and Naylor, R.L. (2008). Prioritizing climate change and adaptation needs for food security in 2030. *Science* 319: 607-610.
- Lobell, D. B. and Marshall, B. (2010). Food security and adaptation to climate change: What do we know? In: *Climate Change and Food Security Adapting Agriculture to a Warmer World*. (Edited by Lobell, D. B. and Marshall, B.), Dordrecht, New York: Springer. 133-154pp.
- Lyimo, J. G. and Kangalawe, R.Y.M. (2010). Vulnerability and adaptive strategies to impact of climate change and variability. The case of rural households in semi-arid Tanzania. *Environmental Economics Journal* 1 (2): 87-97.
- Maddison, D. (2007). *The perception of and adaptation to climate change in Africa*. Policy Research Working Paper 4308. CEEPA, Pretoria. 53pp.
- Mary, A. L. and Majule, A. E. (2009). Impacts of climate change, variability and adaptation strategies on agriculture in semi arid areas of Tanzania: The case of Manyoni District in Singida Region Tanzania. *African Journal of Environment Science and Technology* 3(8): 206-218.
- Mengistu, D. K. (2011). Farmers' perception and knowledge of climate change and their coping strategies to the related hazards: Case study from Adiha, central Tigray, Ethiopia. *Agricultural Sciences* 2(2): 138-145.
- Mkavidanda, T. A. J. and Kaswamila, A. L. (2001). *The role of traditional irrigation systems (Vinyungu) in alleviating poverty in Iringa Rural District, Tanzania*: Repoa, Dar es salaam. 45 pp.
- Mongi, H., Majule, A. E., and Lyimo, J. G. (2010). Vulnerability and adaptation of rain fed agriculture to climate change and climate variability in semi – arid Tanzania. *African Journal of Environmental Science and Technology* 4(6): 371 – 381.
- Moyo, M., Mvumi, B. M., Kunzekweguta, M., Mazvimavi, R., Craufurd, P. and Dorward, P. (2012). Farmers' perceptions on climate change and variability in semi-arid Zimbabwe in relation to climatology evidence. *African Crop Science Journal* 20(2):317-335
- Musei, A., Kihupi, J., Ngailo, J., Murro, J., Mughogho, R. and Mwakimbwala, R. (2012). 'Iringa rural District farming system basic data'. ARI-Uyole, Mbeya. 6pp.
- Nelson, V. and Stathers, T. (2009). Resilience, power, culture and climate: a case study from semi – arid Tanzania and new research directions. *Gender and Development* 17(1): 81-94.
- Okonya, J. S., Syndikus, K. and Kroschel, J. (2013). Farmers' perception of and coping strategies to climate change: Evidence from six agro-ecological zones of Uganda. *Journal of Agricultural Science* 5(8): 252-263.
- Ogalleh, S. A., Vogl, C. R., Eitzinger, J. and Hauser, M. (2012). Local perception and responses to climate

- change and variability: The case of Laikipia District in Kenya. *Sustainability* 4: 3302-3325
- Shemsanga, C., Omambia, A. N. and Gu, Y (2010). The cost of climate change in Tanzania: Impacts and Adaptations. *Journal of American Science* 6(3): 182-196.
- Slegers, M. F. W. (2008) "If only it would rain" farmers' perceptions of rainfall and drought in semi-arid central Tanzania. *Journal of Arid Environment* 72(11): 2106-2123pp.
- Seo, N., Mendelsohn, R., Kurukulasuriya, P., Dinar, A. and Hassan, R. (2008). 'Differential Adaptation Strategies to Climate Change in African Cropland by Agro-Ecological Zones'. Policy Research working paper 4600. The World Bank. 40pp.
- Traerup, S. L. M., Ortiz, R. A. and Markandya, A. (2010). 'The Health impacts of climate change: A study of cholera in Tanzania'. Basque Centre for Climate Change. Working paper 2010-01. Bilbao, Spain:BC3 24pp.
- URT (2005) *Iringa region socio-economic profile*. National Bureau of Statistics, Dar es salaam, 261pp.
- URT (2007) *National adaptation programme of action (NAPA)*. Vice President's Office, Division of Environment, Dar es Salaam. 61 pp.
- URT (2010). *National strategy for growth and reduction of poverty II (NSGRP II)*. Ministry of Finance and Economic Affairs. 184pp.
- URT (2012). *National climate change strategy*. Vice President's Office, Division of Environment, Dar es Salaam. 116pp.
- Yanda, P., Wandiga, S., Kangalawe, R., Opondo, M., Olago, D., Githeko, A., Downs, T., Kabumbuli, R., Opere, A., Githui, F., Kathuri, J., Olaka, L., Apindi, E., Marshall, M., Ogallo, L., Mugambi, P., Kirumira, E., Nanyunja, R., Baguma, T., Sigalla, R., and Achola, P. (2006). Adaptation to climate change/variability. Induced highland malaria and cholera in the lake Victoria Region. AIACC Working Paper No. 43, [www.aiuccproject.org]. Site visited on 20/09/2012.
- Yanda, P. Z. and Mubaya, C. P. (2011). *Managing a changing climate in Africa: Local level vulnerabilities and adaptation experiences*. Mkuki na Nyota, Dar es Salaam. 190pp.
- Weber, E. U. (2010). What shapes perceptions of climate change. *Journal of WIREs Climate Change* 1: 332-342.
- WMO, (1992). International Meteorological vocabulary, 2nd edition. Publication NO. 182. http://meteoterm.wmo.int/meteoterm/ns?a=T_PI.start&direct=yes#expanded. Site visited on 15/06/2012.

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:

<http://www.iiste.org>

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: <http://www.iiste.org/journals/> All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: <http://www.iiste.org/book/>

Academic conference: <http://www.iiste.org/conference/upcoming-conferences-call-for-paper/>

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digital Library, NewJour, Google Scholar

