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Smallholder Farmers' Adaptation Strategies to Impact of Climate Change in Semi-arid Areas of Iringa District Tanzania

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Abstract
The current climate is already marginal with respect to precipitation in many parts of Africa, especially in semi-arid areas. Impact of climate change will bring substantial losses especially to smallholder farmers whose main source of livelihood derives from agriculture. Such impacts can be significantly reduced through adaptation. Given the high dependence on rain-fed agriculture and prevailing drought condition of semi-arid areas of Iringa district, the area may be quite vulnerable to the current and future climatic changes. The frequency supply of food relief from the Tanzania government to smallholder farmers in Ismani, emphasizes its vulnerability to climate changes. Therefore, this study determined adaptation measures carried out in semi-arid areas of Iringa District Ismani and Pawaga Divisions in particular. The research design was cross sectional. A multistage sampling procedure was applied in selecting divisions, wards, villages and households. Ismani and Pawaga divisions were purposeful selected basing on their climatic condition. A total of 240 respondents were selected randomly from eight villages. Data were collected through household survey, key informant interview, observation and focus group discussion methods. Quantitative data analysis was done using SPSS whereby descriptive statistics were computed. Qualitative data were analyzed using content analysis. The findings revealed that smallholder farmers in Pawaga and Ismani divisions were adapting to impact of climate change through irrigation, crop diversification, planting early maturing maize varieties, planting drought resistant crops, changing of planting dates, and agriculture diversification and non-farm activities. It can be concluded that the smallholder farmers in both divisions used various adaption strategies against climate change impact. However, the farmers in the two divisions still face the impact of climate change in their livelihoods. Based on the conclusion made in this study, there are required efforts from various stakeholders including government to improve the adaptation strategies to be appropriate and effective.

Key words: Climate change; adaptation strategies; smallholder farmers; semi-arid, Iringa District

1. Introduction

Countries in Sub-Saharan Africa are particularly vulnerable to impact of climate change, given dependence on agriculture production and limited adaptive capacity (Bryan *et al.,* 2013). A number of countries in Africa already face semi-arid conditions that make agriculture challenging (Boko *et al.,* 2007). Climate change adversely affects agricultural production in Africa through reduction in the length of growing season and force large regions of marginal agriculture out of production (Boko *et al.,* 2007). Experts are concerned that the agricultural sector in Africa will be especially sensitive to future climate change and any increase in climate variability (IPCC, 2007). The current climate is already marginal with respect to precipitation in many parts of Africa (Dinar *et al.,* 2008). Further warming in semi-arid areas is likely to be devastating to agriculture. Various climate models suggest median temperature increase between 3^0C and 4^0C in Africa by the end of the 21st century, roughly 1.5 times the global mean response (Schlenker and Lobell, 2010), which is likely to affect agriculture. Even in the moist tropics, increased heat is expected to reduce crop yields (Dinar *et al.,* 2008). As a consequence, staple crops such as maize, sorghum, millet and cassava, are likely to result in significant yield losses of between 8 and 22 percent by 2050 (Schlenker and Lobell, 2010). Projected reductions in crop yield in some countries could fall by as much as 50 percent by 2020, and crop net revenues could fall as much as 90 percent by 2100, with smallholder farmers being the most affected (Boko et al., 2007). Climate may change more rapidly than expected and is projected to have complex, long term effects for the environment, and for Tanzanian production system (URT, 2012). It is clear that climate change will bring about substantial losses especially to smallholder farmers whose main source of livelihood is derived from agriculture (Komba and Muchapondwa, 2012).

Agronomic studies suggest that yields could fall quite dramatically in the absence of costly adaptation measures (Dinar *et al.,* 2008). Empirical studies measuring the economic impacts of climate change on agriculture in Africa show that such impacts can be significantly reduced through adaptation strategies (Kurukulasuriya and Mendelsohn, 2006; Seo and Mendelsohn, 2006). Therefore key investments are needed to improve agricultural productivity under climate risk (Schlenker and Lobell, 2010). Adaptation can be classified either as planned adaptation or as autonomous adaptation. There are various definitions of adaptation to climate change. However, there is slight differences that exist among those definitions and may have some practical implications under certain circumstances.

This study adopted the Intergovernmental Panel on Climate Change (IPCC) definition that adaptation is "adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effect" (Smit and Pilifosova, 2001). Other definitions are as follows; UNDP (2005) refers "adaptation to a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed and implemented". Adaptation to climate change also refers to "a process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climate environment provides" (Burton, 1992 cited in Smit *et al*., 2000). "Adaptation involves adjustments to enhance the viability of social and economic activities and to reduce their vulnerability to climate, including its current variability, and extreme events as well as longer term climate change" (Smit, 1993, cited in Smit *et al.,* 2000). "The term adaptation means adjustment, whether passive, reactive or anticipatory that is proposed as a means for ameliorating the anticipated adverse consequences associated with climate change" (Stakhiv, 1993 cited in Smit *et al.*, 2000). "Adaptation to climate change includes all adjustments in behavior or economic structure that reduce the vulnerability of society to changes in climatic system" (Smith *et al*., 1996 cited in Smit *et al*., 2000)
Adaptive capacity is the "potential or ability of a system, region or community to adapt to the effects or impacts of climate change" (Smit and Pilifosova, 2001). Adaptation strategies refer to "all responses to climate change that may be used to reduce vulnerability" (Burton *et al.,* 1998).

Adaptation can be autonomous that does not constitute a conscious response to climatic stimuli, but triggered by ecological changes in natural systems and by market or welfare changes in human systems. It is also referred to as spontaneous adaptation (IPCC, 2001). On the other hand, adaptation can be planned, that is the result of deliberative policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, to maintain, or to achieve a desired state (IPCC, 2001). Autonomous adaptations are usually reactive. They are also widely considered initiated by private actors (individuals, households or private companies) (IPCC 2001) instead of government. Planned adaptations refer to as public adaptations (initiated and implemented by government at all levels) (IPCC 2001). Most of adaptation measures carried in Tanzania are autonomous adaptations.

Agriculture is a dominant sector in Tanzanian economy providing livelihood, income and employment to over 80 percent of the population. Nevertheless it experiences vulnerability in terms of decrease in crop production of different crops exacerbated by climatic variability and unpredictability of seasonality (URT, 2007). Climate change and variability threatens the livelihood of smallholder farmers who depend on subsistence agriculture, which is almost entirely rain fed. Also over 70% of population depends on agriculture (mostly carried by smallholder farmers) (Mary and Majule, 2009). However, rain fed agriculture is particularly sensitive to climate change (Lyimo and Kangalawe, 2010; Boko *et al.* 2007). Therefore dealing with climate change is an economic necessity to avoid serious disruption to global and national socio-economic development. Adaptation is an overriding priority for developing countries like Tanzania (URT, 2012).

Smallholder farmers in different parts of Tanzania have adapted to impact of climate change through planting drought resistant seed varieties and crops, intercropping, irrigation, changed planting dates, increased use of water and soil conservation techniques, diversification from farm to non-farm activities such as casual labour and moving to other places (Shemsanga, *et al.,* 2010; Komba and Mchapondwa, 2012; Lyimo and Kangalawe, 2010; Mary and Majule, 2009). However, there is little empirical evidence of adaptation strategies in semi-arid areas of Iringa District. Given the high dependence on rain-fed agriculture and prevailing drought condition of semi-arid areas of Iringa district, the area may be quite vulnerable to the current and future climatic changes. The frequency supply of food relief from the Tanzania government to smallholder farmers in Ismani, emphasizes its vulnerability to climate changes. In addition to that, adaptation strategies depend on agro-climatic zone and

indigenous knowledge (Hisali *et al.,* 2011) which, vary even among different semi-arid agro-ecological zones. Therefore, this study determined adaptation strategies carried out in semi-arid areas of Iringa District Ismani and Pawaga Divisions in particular.

This study is in line with Tanzania's Vision 2025, which, aims at attaining high quality livelihood for its people and develop a strong and competitive economy among other things. These aims may not be attained if climate change adaptation concerns are not factored in development process in the context of sustainable development. It is in this context that climate change is one of the priority areas in the second National Strategy for Growth and Reduction of Poverty (NSGRP II) (URT, 2010). 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 Vision 2025 and Millennium Development Goals from failure due to the climate change impacts.

2. Research Methodology

The study was conducted in Iringa District in Iringa Region, Tanzania. The District is one of the four districts of the Iringa Region. Iringa District has six administrative divisions. Two divisions (Ismani and Pawaga) out of six were selected for the study basing on their climatic condition. Rainfall in Pawaga Division is 500 – 600 mm, in Ismani Division is below 600 mm. Temperature in Pawaga Divisions is over 25 ^{0}C and 20 – 25 ^{0}C in Ismani Divisions (Mussei *et al.,* 2012). Most households in Iringa District depend on agricultural sector for their livelihood. Agricultural activities mostly are carried out by smallholder farmers. About 90 percent of its population earns their living from agriculture and livestock production (Mkavidanda and Kaswamila, 2001; URT, 2005). Weather condition is the major determinant of agricultural performance in the study area.

The rationale for choosing Iringa District for the study is twofold. First, Iringa District was one of the major maize producing districts in Iringa Region until the early 1970s, but in recent years, the agricultural production has been increasingly becoming low due to unreliable rainfalls. According to Mussei *et al.* (2012), food availability is not sufficient in four divisions (Ismani, Kalenga, Pawaga and Idodi) out of six of Iringa District. Secondly, Iringa District especially in Ismani and Pawaga Divisions experiences recurrent drought conditions, therefore, it is more vulnerable to impact of climate change than other areas in the region.

The study used a cross – sectional research design which involved collection of data at a single point in time (Babbie, 1990; Bailey, 1998). The nature of study objective dictated this study to adopt this study 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. Two divisions out of six were purposeful selected basing on their climatic condition to make a comparative study so that variability of study area could be addressed. A total of four wards were randomly selected from the two divisions. 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 formulated of both open- ended and closed-ended questions. The questionnaire was pre-tested on 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 such as crop diversification, agricultural diversification, and nonfarm activities; and other adaptations were gathered through this method. Qualitative data were gathered through focus group discussion, key informant interview and field observation methods.

Quantitative data collected through household survey method were analyzed using descriptive statistics. Multiple responses were conducted using descriptive statistics where measures of central tendency such as frequency, and percentage were calculated through Statistical Package for Social Sciences (SPSS). Qualitative data collected through focus group discussions, key informant interviews and observations methods were analyzed using content analysis.

3. Results and Discussion

Smallholder farmers in semi-arid areas of Iringa district are affected by impact of climate change through

unpredictable rainfall, increased temperature and prolonged dry spells. This led to low crop yield/crop failure. In response to the prevailing climatic condition, households in Pawaga and Ismani Division used different adaptation strategies to reduce the impact of climate change. These are on farm adaptation strategies (irrigation, planting early maturing maize varieties, planting drought resistant crop such as sorghum, changing planting dates and application of fertilizer); and non-farm strategies (petty business, casual labour and making local brew) (Table 1).

Table 1. Smallholder Farmers Adaptation Strategies in Ismani and Pawaga Division (n=240)

	Ismani		Pawaga	
Adaptation strategies	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Drought resistant crop	176	97.8	-	-
Crop diversification	172	95.6	7	11.7
Change in planting dates	172	95.6	2	3.3
Early maturing maize varieties	165	91.7	-	-
Agriculture diversification	148	82.2	26	43.3
Application of fertilizer	99	55.0	2	3.3
Petty business	82	45.6	26	43.3
Casual labour	67	37.2	3	5.0
Making local brew	53	29.4	3	5.0
Moving to different area	12	6.7	1	1.7
Irrigation	7	3.9	60	100
Furniture making	4	2.2	2	3.3
Building activities	4	2.2	3	5.0
Change from farming to non-farming activities	2	1.1	1	1.7
Hair dressing	2	1.1	1	1.7
Sewing clothes	2	1.1	5	8.3
Application of pesticides	1	0.6	4	6.7
Fishing	1	0.6	1	1.7

3.1 Drought Resistant Crops

Smallholder farmers in Ismani, adapted drought resistant (98%) of respondents by introducing sorghum as a substitute for maize (Table 1). In Pawaga smallholder farmers do not plant drought resistant crops. However, it was revealed that, sorghum had been forced by local government through by-laws that required every individual in Ismani to plant two acres of sorghum. Failure to do so; a household was supposed pay 50,000 Tanzanian shillings as a fine. The crop had been performing badly and the production was very low. Among other factors, smallholder farmers in Ismani have not been putting more effort in production of sorghum comparing to maize. Most of smallholder farmers in Ismani normally cultivate sorghum after cultivation of maize when the planting season is almost over. Policies to promote adaptation to impact of climate change and risks often rely on the cooperation of the intended beneficiaries at their own will. If these beneficiaries disagree with policy makers about the need for adaptation, or effectiveness of the measures they are being asked to undertake, then implementation of the policy is likely to fail (Patty and Schroter, 2008). That is the case with sorghum in Ismani division.

During focus group discussions and key informant interviews, it was revealed that, majority of household did not like sorghum for food as opposed to maize. Some said "sorghum is not for us but for '*wagogo*' (a tribe from Dodoma region in Tanzania)". Others said, "We cultivate sorghum for government". Also during focus group discussions it was revealed that sorghum has low market value in Ismani. Lobell and Marshall (2010) claimed that local consumer taste preferences are likely to inhibit adaptation among crops. Therefore, sorghum may be one of the drought resistance crops, especially in semi arid areas like Ismani Division, but adaptation of this crop (sorghum) is likely to fail in Ismani. This may be due to taste preference among Ismani people (they prefer maize to Sorghum). It may also be due to the fact that sorghum has low market value.

3.2 Crop Diversification

Crop diversification was another adaptation measure taken in Ismani whereby 96% of respondents (Table 1)

admitted to have been planting different crops in their field such as maize, sunflower, cowpeas, sesame, and groundnuts. In Pawaga about 12% of respondents (Table 1) claimed to cultivate more than one crop in their fields. However, crop diversification in Pawaga is done during dry season through irrigation, whereby maize, tomatoes and different types of vegetables are grown in the field for food supplement as well as for sell. The growing of more than one crop is an insurance against total crop failure, thus reducing the risk of complete failure since different crops are affected differently by climate event. These findings are in line with those reported by Orindi and Murray (2005), and Hassan and Nhemachena (2008).
Generally, in Tanzania, maize is grown mainly for food consumption although sometimes it is sold so that farmers can get money to fulfill their other needs. Sunflower, cowpeas and groundnuts are mainly for commercial purpose so as to increase smallholder farmers' household income. These results concur with that of Nelson and Stathers (2009) for Kongwa and Bahi Districts in Dodoma Tanzania that claimed, groundnuts, bambara nuts and cowpeas are being grown in Dodoma more widely to earn cash.

Crop diversification is one among promising adaptation strategies. Smallholder farmers take advantage of the different maturing times of crops, to strengthen their resilience to impacts associated with climate change and variability (Simbarashe, 2013). Crop diversification to some extent guarantees at least small harvest in case of worse year (Ogalleh et al., 2012). Nevertheless, there are years which farmers in Ismani reported to have total crop failure and being supported with food relief. This implies that crop diversification in spite of its advantages and assurance of crop harvest was not enough to overcome impact of climate change and variability in Ismani Division. Such adaptation strategy at farm level can become insufficient when droughts are more widespread and severe, particularly when consecutive drought years lead to loss of seed stocks combined with low capital reserves and other economic and social stresses to the food system.

3.3 Changes in Planting Dates

Almost 96% and 3% of respondents (Table 1) in Ismani and Pawaga respectively admitted that they have changed planting dates as one of strategies to cope with unpredictability and unreliability of rainfall. During focus group discussion, respondents said that they used to put seed in the ground before rain, so that when rain comes the seeds germinate. But nowadays if you do the same, you will end up replanting seeds. This is because; rainfall may come but not enough to reach the seed in the ground. Therefore most smallholder farmers wait for the rain to plant their seeds. These findings resemble those reported by other studies done in Dodoma, Kongwa and Bahi Districts Tanzania (Nelson and Stathers, 2009) and in Manyoni Tanzania (Majule, 2008). Although 96% of respondents claimed to change planting dates to cope with unreliability of rainfall, the study revealed that maize yield to majority is still low in the study area. This may be due to lack of ploughing tools that causes smallholder farmers to plough the land late or other factors that hinder this adaptation strategy hence harvesting low. Therefore this strategy will be efficient if smallholder famers are equipped with ploughing tools such as oxen drawn plough; this will allow them to maximize use of the shortened planting season.

3.4 Early Maturing Maize Varieties

Farmers are choosing different early maturing maize varieties, because the rainy season is now so short that their traditional varieties cannot mature in time. About 92% (Table 1) of respondents in Ismani said they used early maturing maize varieties but in Pawaga smallholder farmers do not cultivate maize nowadays, they switched to paddy. This result concurs with that of Nelson and Stathers (2009), that farmers use different fast maturing sorghum varieties due to the fact that the traditional varieties cannot mature in time in the light of the shortened rainy season. Also the findings agree with that of ActionAid (2006) in Malawi, that farmers opt for short –season hybrid maize varieties because the growing season in Malawi has become shorter in such a way it cannot support long-season local indigenous maize varieties. Though early maturing maize varieties has high yield, they can be affected by the long drought spell in February and lead to crop failure. This was due to the fact that, early maturing varieties grown in Ismani were not drought resistance. This was revealed during focus group discussions and key informant interviews conducted in Ismani. Nevertheless, maize yield in Ismani Division is still low. This implies that, there are factors that affect this promising adaptation measure

Hybrid maize (early maturing varieties) is capital intensive (ActionAid, 2006) in terms of seeds and fertilizer. Although 92% of respondents said they used early maize maturing varieties, only 55% of respondents use fertilizer (Table 1). This means, some of smallholder farmers in Ismani do not use fertilizer though their soil fertility is depleted. Also it was revealed during focus group discussions that, the majority of those who claimed to use fertilizer did not apply it in all of their fields. They only use fertilizer in fields which seem to be more

depleted. Only 3% of respondents (Table 1) use fertilizer in Pawaga.

However, there was a challenge on fertilizer itself "*minjingu*" which was brought in Ismani in reduced price "*vocha*" as an incentive to farmers; "*Minjingu*" fertilizer produced in Tanzania seem not to be favourable in Ismani division. There were complains that "minjingu" fertilizer takes long time to decompose and also needs a lot of water, therefore, such fertilizer is not suitable in Ismani where rainfall is little and unreliable. In other words, this fertilizer discourages farmers from using it, hence low harvest and hindrance to adaptation measures.

3.5 Agriculture Diversification

In addition to cropping, smallholder farmers kept livestock such as cow, donkey, duck, chicken, pig, sheep, and goat. About 82.2% of respondents in Ismani and 43.3% of respondents in Pawaga (Table 1) claimed to keep livestock. In case of total crop failure, they sell part of their livestock to meet their food insufficient situation as well as cater for other necessities such as health services, and education. During focus group discussions and key informant interview in Pawaga, It was revealed that livestock keeping serve as insurance in case of market price failure as it was the case in the year 2012/2013 in Pawaga Division. The price of paddy was very low in such a way that it could not recover the production cost. These findings agree with those of Simbarashe, (2013) who found that, rural communities in Zimbabwe sale their household assets like livestock in an attempt to cope with the effect of climate variability. Also livestock such as cows are used in ploughing the land helping farmer to cultivate in time hence maximizing the shorted rain season in Ismani. Donkey carries water and other goods from a far distance, helping farmers in adapting to impact of climate change. However, in case of severe drought conditions many livestock such as cow, got and donkey may die due to drought stress. Selling of livestock in case of total crop failure or crop market failure is a coping strategy.

3.6 Irrigation

Irrigation was the major adaptation strategy in Pawaga division. All respondents (100 %) depended on irrigation for their paddy fields and agriculture in general (Table 1). There were only 4% of respondents in Ismani used to irrigate their crops specifically vegetables. Though Pawaga and Ismani divisions experience unreliable rainfalls, Pawaga smallholder farmers have access to Ruaha river water. Therefore farmers mainly depend on irrigated farms along Ruaha River (URT, 2005). The major crop under irrigation is paddy and to a lesser extent vegetables during dry season. Before 2002, smallholder farmers in Pawaga were also cultivating maize and sorghum in highlands in additional to paddy, but later on after establishment of irrigation scheme, all smallholder farmers have been involving in paddy cultivation. This is because paddy is a high value crop.

During focus group discussions it was revealed that, smallholder farmers in Pawaga division depend on rains falling elsewhere up the river source. One of respondent said," we do not count on rains falling in Pawaga for cultivation, this is because the rains in our area is very little and unpredictable. So we cultivate our fields when the river is full due to rains falling in highlands such as Dabaga and Iringa municipal". During key informant interviews, one respondent said that "we thank this irrigation scheme because; people are prospering building nice houses, others are demolishing the traditional ones (thatched with mud walls and soil on top of the roof) and building modern ones". Also he said "there is development in general, people use solar energy and watch televisions because of the irrigation scheme". The key informant interview's declaration was complemented by field observation method whereby new buildings were viewed and the use of solar energy was common in Itunundu and Kimande villages. It should be noted that the national grid has not reached the area yet for power supply. Field observation also revealed fruit trees in the area and there was no problem on availability of domestic water.

These findings are quite contrary to those found in Ismani division although both divisions experience semi-arid conditions. This implies that irrigation is an important strategy in overcoming impact of climate change. As it was stated in the Tanzania national water policy (URT, 2002) irrigation provides protection against drought and ensures availability of food reserve. It also contributes to the reduction of poverty since it can facilitate many farmers to cultivate high value crops such as paddy, fruits and vegetables. The findings also agree with those of Gbetibouo, (2009) and Deressa *et al.,* (2009) which indicated that, water for irrigation increases farmers' resilience to climate change and variability. Therefore, there is need for greater investment on potential areas for irrigation. This strategy will help smallholder farmers to overcome impact of climate change in semi arid areas like Ismani and Pawaga division.

3.7 Non-farm Strategies

Non-farm strategies against impact of climate change in Ismani are petty business, casual labour and local brew making (46%, 37% and 29% of respondents respectively) (Table 1), while in Pawaga mostly is petty business whereby 43% of respondents (Table 1) claimed to be involved so as to increase their household income. Petty business in Pawaga and Ismani divisions mostly was based on agricultural product such as buying and selling paddy or rice, selling vegetables and tomatoes in Pawaga, while in Ismani smallholder farmers were involved in buying and selling sunflower, maize, and tomato. In case of casual labour, most of activities for casual labour are available during rainy season; these are planting, weeding and harvesting. People involved in casual labour mostly are poor, they use more time in casual labour so that they can get money to buy food and other necessities, hence, spending little time in their own fields. This may lead to the situation whereby, food insecurity becomes persistence in their households.

Local brew making is mostly being practiced by women in Ismani and Pawaga divisions so as to increase income in their households and buy food supplement in case of crop failure. These findings concur with those of Simbarashe (2013) who mentioned that brew of traditional beer "*Ndari*" in Bukita District, Zimbabwe is one of adaptation strategies to impact of climate change which provide an alternative source of income for many people who brew it commercially. The problem with local brew in Ismani commonly known as '*komoni'* is that, it uses a big amount of maize therefore it may subject the households to food insecurity.

Gbetibouo (2009) argue that non-farm income sources increase the probability to afford adaptation measures. Simbarashe (2013) also argues that diversification of livelihood activities such as petty trading, commercial brick moulding, firewood trading and beer brewing among other activities widened the smallholders' source of income and hence enhancing sustainable livelihoods and food security. Diversification or working in different activities helps to spread risk and manage uncertainty. Ellis (2000) asserts that livelihood diversification has become an effective and reliable survival strategy for rural households in developing countries. This is so because, due to the effects of climate change and variability, farming on its own is failing to provide a sufficient means of survival in rural areas.

Lobell and Mashall (2010) argue that diversifying income to non-farm income sources which are less climate sensitive is a good strategy against impact of climate change, but it might not help because rural non-farm economy is linked to agricultural productivity. If most people in a village are farmers, and all experience a yield decline simultaneously, then demand for both agricultural wage labour and non-farm goods and services will certainly fail and thus income (Jayachandran, 2006; World Bank, 2008). This is the case with Ismani and Pawaga, where most of non-farm strategies carried out were related to agriculture. This means Ismani and Pawaga people's economy is tightly linked to agricultural sector and whenever this sector is deeply affected by impact of climate change, income from non-farm activities will be affected too. Therefore, non-farm activities adaptation strategies against impact of climate change in rural areas especially Ismani and Pawaga divisions are less promising.

4. Conclusion and Recommendation

Smallholder farmers in Ismani division are adapting to the impact of climate change using various strategies such as crop diversification, use of early maturing maize varieties, planting drought resistant crops, changing of planting dates, and agriculture diversification. Other strategies are petty business, casual labour and making local brew. In Pawaga adaptation strategies include irrigation, agriculture diversification, and petty business. Smallholder farmers in Ismani seem to have various adaptation strategies; however, they are the ones who mostly receive government food aid due to crop failure as a result of drought. Meanwhile, Pawaga has mainly three adaptation measures and irrigation being the major one that the whole population in Pawaga depends.

Sorghum being one of the drought resistant crop in Ismani, does not perform well, in spite of the force imposed by the local government, therefore, smallholder famers and local government executives have to reach an agreement on the importance of sorghum or replacing sorghum with another relevant crop in overcoming impact of climate change. Otherwise, smallholder farmers will continue to waste their effort and resource on the crop that does not pay back. Policies for adaptation to impact of climate change should involve smallholder farmers; this is due to the facts that, they are the ones who are supposed to implement those strategies.

Although adaptation strategies taken by smallholder farmers in Ismani and Pawaga do not differ from those

mentioned by different studies done in different parts of Africa, sub-Saharan Africa and other parts of Tanzania, the problem of low harvest leading to food insecurity is persistent in semi-arid areas of Iringa district. Therefore, there is need for further studies on the effectiveness of those adaptation strategies carried in the semi-arid areas of Iringa district.

Adaptation is one of the policy options for reducing the negative impact of climate change. Therefore, the government and other stakeholders should help smallholder farmers in implementing appropriate and effective adaptation strategies. Investment in large scale irrigation schemes can help smallholder farmers to fight against impact of climate change.

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