Climate Change and Variability in Tanzania: An Account of Smallholder Farmers from Chololo Village in Dodoma.

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Abstract

Climate change and its impacts need to be understood to everyone as a matter of urgency. Many rural communities struggle in the face of increasingly climate variability and unpredictable weather. Individuals and communities invent different strategiesto mitigate and adapt to climate change impacts. Climate change and variabilityaffect the socio-economic and environmental aspects, since it entails cross-cutting impacts on a range of sustainable development dimensions e.g. water and sanitation, agriculture, forestry, fishing, infrastructure, settlement, tourism, roads and transport, industry, trade, energy and other sectors. Therefore, this paper explores smallholder farmers' perceptions of climate change and variability, its impacts and adaptations. The paper recommends enhanced synergy between farmers, researchers and extension services for sustainable agricultural production and productivity in semi-arid areas, and Tanzania in particular.

Key words: Climate change; Smallholder Farmers; Adaptations; Mitigation.

1.0Background

Climate change and variability are serious impediments to sustainable development which threaten rain-fed farming systems. While climate change occurs over a long-term period, usually a minimum of 30 years, climate variability is a short-term change which occurs through variation of weather variables within or between growing seasons, between or within a year and between or within a decade (IPCC, 2007). In this paper variability is considered between years as well as between and within growing seasons. In drought stricken rural and semi-arid Africa (Tanzania in particular) poverty is a common phenomenon, livelihoods are largely anchored on farming, pastoralism and agro-pastoralism. The dependence on rain-fed agriculture is 80% at global level and about 95% in sub-Saharan Africa. In Tanzania, nearly all the smallholder farmers and agro-pastoralists in semiarid areas depend on rainfall (IFAD, 2010; Mongi, et.al., 2010). According to Burke et al., (2009) climate variability can adversely affect rain dependent livelihood options in semi-arid agro-ecological zones compared to other regions because rainfall is uncertain. Notwithstanding their adaptation, crop yields can be more affected compared to livestock production system when climate variability occurs at a critical stage of growth (Midgley et al., 2012)

The aforesaid effects of climate change are not instantaneous and easily observable by ordinary people and businesses. While it is predicted the reverse of climate change may take a long time, even after action is taken, it is considered necessary to involve different stakeholders to combat climate change. Thus, the complexity and cross-cutting nature of climate change topic compels for collective actions. This calls for a common understanding and cause of actions for effective mitigation and adaptation. Knowledge of farmers' perception of climate change and variability forms an important the pillar of this consensus between farmer, research and extension to gain a win-win situation in the war against climate change impacts.The rural communities are struggling in the face of increasingly unpredictable weather and climatic variability. Information, resources, and locally relevant practical interventions are required to adapt and respond to climate change impacts. Thus, working together with farmers can produce effective local solutions to local problems in a cost effective manner. As ideas, practices and locally relevant interventions derived collectively may provide an insight into the reality of the changes that most rural communities are experiencing. Thus, this paper intends todrawthe smallholder famers'understanding of climate change and variabilitywhich can be used to develop adaptable solutions to climate change impacts. Specifically, the paper explores the perceptions of climate change and its impacts for smallholder farmers in Dodoma and provides empirical analysis of rainfall and temperature data for a period of 30 years (1980-2010).

2.0Tanzania: Agriculture and Smallholder Farmers

Tanzania's economy is heavily dependent on agriculture, which accounts for about 66% of merchandise export and is a significant portion of GDP (over 45% in 2008) (Nyankweli, 2012). The sector employs about 75% to 80% of the rural population; who cultivate the land by hand using crude tools (Mbelle, 2007). However, the impressive growth of the economy is not been sufficient to tackle persistent poverty. It is marred by high levels of poverty at household level, both in urban and rural areas (Maliti & Mnenwa, 2008). About 28.2% of the population fall below the poverty line for basic needs and 19% fall below poverty line for food (NBS, 2013). Ninety percent of citizens live under $2 per day (NBS, 2013). In 2013, life expectancy at birth was estimated 61 years, whereby 59.58 for men and 58 years for women (UNDP, 2014) and the HIV prevalence rate stood at 5.1% (2012 est.)

Despite Tanzania being characterized as "agriculture-based," that is, agriculture is the mainstay of the economy. The sector is dominated by smallholder farmers who occupy the majority of land and produce most of the crop and livestock products. The key long-standing challenge of the smallholder farmers is low productivity stemming from the lack of access to markets, credit, and technology, in recent years compounded by the volatile food and energy prices. These factors are intensified by the impact climate change and climate variability as agriculture is rain-fed dependent and characterized with low capital

investment. Over 75 percent of the total agricultural outputs in East African countries (including Tanzania) are produced by smallholder farmers with farm sizes of about 2.5ha on average, producing mainly for home-consumption, and using traditional technologies. Moreover, food security remains a challenge, notwithstanding the potential to boost agricultural production in the region.
According to Salami, et.al, (2010) smallholder farmers can be categorized on the basis of: (i) the agro-ecological zones in which they operate; (ii) the type and composition of their farm portfolio and landholding; or (iii) on the basis of annual revenue they generate from farming activities. In areas with high population densities, smallholder farmers usually cultivate less than one hectare of land, which may increase up to 10 ha or more in sparsely populated semi-arid areas, sometimes in combination with livestock of up to 10 animals (Dixon et al, 2003). On the basis of farm revenue, smallholder farmers range from those producing crops only for family consumption to those in developed countries earning as much as USD 50,000 a year (ibid). Most smallholder operations occur in farming systems with the family as the center of planning, decision-making and implementation, operating within a network of relations at the community level. In this paper, smallholder farmers are defined on the basis of land and livestock holdings, cultivate less than 2 hectares of land and own only a few heads of livestock. Since agriculture is hit the most by climate change impacts, smallholder farmers offers an ideal subject to understand the perception and adaptations the phenomenon.

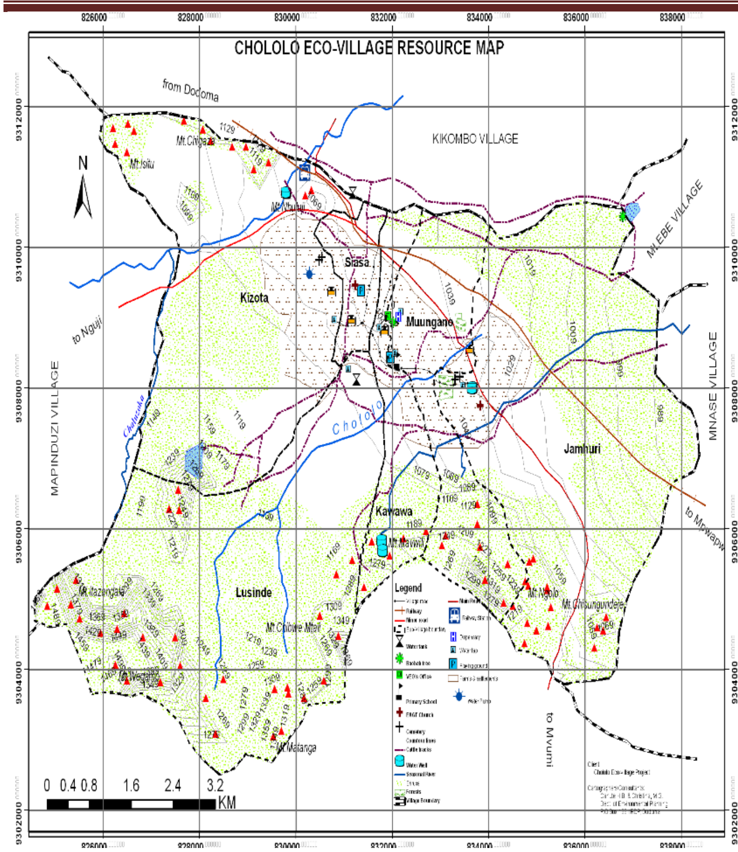
The population was estimated at 47.4 million in 2014, Tanzania's population is projected to rise to 71.7 million by year 2025 (WPR, 2014). Population density had increased from 39 people per square kilometre in 2002 to 54 people per square kilometre in 2014, a 38.4% increase. The population distribution is influenced by a number of factors, such as access to social services, climate, availability of land and access to reliable economic activities. Population growth rates have been consistently high in Tanzania for over 50 years, with greater fluctuation in the last decade. From 2.6% in 1967, they reached an all-time high of 3.2 in 1978, gradually declining to their lowest 1.7% in 2003, and then starting along another upward trend reaching 3.1% in 2012 (Nyankweli,2012; URT,2013). This population growth rate is high compared to international average and Tanzania's population continues to grow in absolute numbers (Madulu *et al.*, 2007).

Dodoma and Chololo Village

This study was carried out at Chololo village, Kikombo ward in Dodoma Municipal. The village is comprised of six sub-villages these are Jamhuri, Lusinde, Muungano, Kizota, Siasa and Kawawa. The study took place in Chololo because of the existing data base of the Chololo Eco-village project and the fact that is one of the most affected areas in the region. Dodoma Municipality is one of the seven administrative Districts of Dodoma region. Others are Bahi, Kongwa, Kondoa, Mpwapwa, Chamwino and Chemba. The district is located on the central plateau of Tanzania. It borders with Chamwino in the East and Bahi in the West. The district lies between Latitudes 6.00^0 and 6.30^0 South, and Longitude 35.30^0 and 36.02^0 East. The village lies at 6 degree 14min 42.95 S, 35 degree 59min 58.59 E (Figure 1 &2).

Figure 1: Map of Tanzania: Regional boundaries.

Figure 2: Chololo village resource map showing different land uses



3.0Methods

The study employed a cross-sectional research design in which data were collected at one point in time; due to limited resources in terms of finance and time. It was a qualitative research using primary and secondary data available at the Chololo Eco-village project. The data provided a useful understanding of the processes behind observed results and smallholder farmers' perceptions on climate change and variability as well as its impacts. Primary data were collected from the field by using focus group discussions and in-depth interviews. Secondary sources of data were published and unpublished reports from the Chololo Eco-Village Project and Other government offices (village, ward, municipal and ministerial levels). These included baseline survey and evaluation reports, and meteorological data for (rainfall and temperatures) for 30 years starting from 1980 to 2010. The meteorological data were collected from the Hombolo Agricultural Research Institute (ARI) and Dodoma Municipal meteorological stations.

The data collection techniques were in two fold, first, a desk research whereby various existing documented literature on climate change impacts, its mitigation and adaptation were reviewed and second, a field survey was conducted whereby focus group discussions with smallholder farmers and key informants were carried out as well as a participatory climate risk assessment. The sampling frame was 1,111 households of Chololo village and a household was considered as unit of analysis. Smallholder farmers were selected through systematic random sampling technique. Whereby every tenth farmer was picked from the list provided by the village executive officer, starting with the sixth in the list, who was determined by use of random numbers table. The design was convenient due to its relative advantage in resource saving especially in time and money (Goon *et al*., 2001). The process enabled the selection of 80 smallholder farmers who were engaged in the focus group discussions, participatory climate risk assessment and 42 in the in-depth interviews. Thus making a sample size of 122 respondents. The data collected were coded on a sheet of paper then captured in a computer. Responses and proceedings of the focus group discussions were recorded. Content analysis method (Stewart & Shamdasani, 1990; Robson, 2002) was used to select the relevant themes from various farmers' focus groups, which was compiled, forming the results of the study.

4.0Results and Discussions

4.1 Smallholder Farmers' Knowledge and Understanding of Climate Change and Variability

According to Heathcote (1969) drought definition is determined by an individual's environment and its characteristics. An understanding of the local perceptions of drought is necessary to link individual's behavior to the environment (Agnew and Warren, 1996). As farmers observe their surroundings and act according to what they see. The social and political environments are inter-linked to the physical environment (Basiago, 1999) and thus people do not just adapt to the environment but shape it both physically as well as from the possibility they see (Croll and Parkin, 1992). An individual builds up understanding of the environment that is closest to him or her, makes decision on how to respond and behave in that environment (Park, 1999). The Social, economic, political and cultural settings influence the way people perceive their environment and the way they react to it. These settings influence the goals of human environmental actions, the distribution of the resources and the constraints people experience (Orlove, 1980). Therefore an understanding of farmers' agrarian system and practices provides a snapshot of their perceptions of drought and other climate change impacts.

Farmers in Dodoma perceive drought in a broader perspectives. Most farmers stated that they never experienced drought, but rather narrate of having a "good" and/or "bad" year. For instance farmers at Chololo village talk of the good year to indicate bumper harvest and bad year is vice versa. Any factor that limit harvest causes a bad year but water deficiency constitutes the principle problem. Slegers (2008) and Ostberg and Slegers, (2010) found similar phenomenon in the neighboring District of Kondoa. Scientists identified human-induced land degradation as a major factor limiting productivity while farmers ascribed declining harvests to drought (Slegers & Stroosnijder, 2008; Stroosnijder, 2008). Most commonly farmers described this problem based on weather conditions- the insufficient amount and distribution of rainfall and scorching sunshine – "*jua-kali*". One informant noted "When there is a strong sunshine the soil dries fast and the crops burn easily". All these processes are taking place locally, and each environment shows a different level of resilience to environmental stress while local land users have different adaptive management strategies to cope with such stress. At Chololo village farmers relate reduced production to erratic rainfall. Majority of farmers felt that the variability of rainfall had increased over the past decade or two, and drought had become more frequent and severe (Table 1).

4.1.1 Local farmer's perception on climate change

Table 1 indicates that majority of the respondents have knowledge on climate change, as ninety-four percent (94.7%) have noted changes in weather patterns. Men were more aware compared to women on climate change. It was indicated that 98.4% of men versus 90.6% of women. Specifically over sixty percent (65%) attested to have noted increase in temperature, rainfall unpredictability, reduced amount of rainfall, early stopping of rains, increased drought and more wind. Few households (14 – 38%) have noted late or early start of rainfall, late stopping of rains and experienced floods. There was a significant variation (P=0.001) between male and female on the late rainfall with more male spotted the late of rainfall while female noted early rainfall.

Table 1: Respondents knowledge on climate change and variability

Variable	Men	Women	Both	Chi-square tests
Noticed changes in weather patterns	60(98.4)	48(90.6)	108(94.7)	χ^2=3.456,P= 0.063
Noticed increased temperatures	46(75.4)	32(60.4)	78(68.4)	χ^2=2.966,P= 0.085
Noticed increased rainfall unpredictability	47(77.0)	36(67.9)	83(72.8)	χ^2=1.193,P= 0.275
Noticed reduced amount of rainfall	46(75.4)	38(71.7)	84(73.7)	χ^2= 0.201,P= 0.654
Noticed late rainfall	31(50.8)	12(22.6)	43(37.7)	χ^2= 9.585, P= 0.002*
Noticed early rainfall	20(32.8)	21(39.6)	41(36.0)	χ^2= 0.575, P= 0.448
Noticed rains stopping late	10(16.4)	5(9.4)	15(13.2)	χ^2= 1.202, P= 0.273
Noticed rains stopping early	42(68.9)	34(64.2)	76(66.7)	χ^2= 0.282, P= 0.595
Noticed increased drought	47(77.0)	37(69.8)	84(73.7)	χ^2= 0.766, P= 0.381
Noticed more floods	11(18.0)	6(11.3)	17(14.9)	χ^2= 1.007, P= 0.316
Noticed more wind	43(70.5)	32(60.4)	75(65.8)	χ^2= 1.289, P= 0.259

4.1.2 Crop Production

Farmers at Chololo village grow groundnuts, sunflower and sesame for cash. About sixty (60%) per cent of households grow groundnuts and sunflower at an average of 1.5 acre each. While sesame is an emerging crop grown by 20% of households at an average of 1.2 acres. Pearly millet, sorghum and maize are popular food crops at the village. Eighty-five (85%) of households grow pearly millet and 68% of households grow sorghum. While 42% of households grow maize. All the cash and food crops are drought resistant except maize. The choice of drought tolerant or low moisture demanding crops attributes to the farmers experience, knowledge and coping practices to adapt the climate and weather variability in the environment, thus giving a snapshot of their perceptions of drought and climate change in Dodoma. Maize is preferred due to its good taste and its flexible position as a cash crop and food crop.Bambara nut is also a food and drought resistant crop grown by 35.1% in an average area of 0.7acres per household. (Table 2)

*As one farmer attested (*Maligana, male, 59 years old*)*"our major staple food- "*ndigwa*" is pearly millet but currently sorghum is becoming popular. Maize is preferred for its beauty and taste. It always fetch attractive market prices and it's on demand in nearby villages and other town centres despite all the shortfalls of notwithstanding drought conditions. It is in farmers hearts. In events of prolonged dry spell it fails completely. Nevertheless it is the farmers' passion*"*.

Table 2: Proportion of households growing different crops and acreage (n=114)

Crop	Frequency	Percentage	Average farm size (acres)
Millet	97	85.1	2.3
Groundnuts	104	91.2	1.5
Maize	48	42.1	1.2
Bambara nuts	40	35.1	0.7
Sorghum	78	68.4	1.7
Sunflower	70	61.4	1.5
Sesame	23	20.2	1.2

4.1.3 Crop Productivity

Table 3, shows that crop yield per acre is generally low for all crops. Comparatively, among the cereal crops, millet had highest production per acre (260.9 kg/acre) followed by sorghum (217.6kg/acre) and lastly maize (189kg/acre). For oil/cash crops, sesame production was higher (241.7 kg/acre) as compared to sunflower (152kg/acre). However, sesame is not grown by many farmers, only 20% of households (Table 2). The low crop productivity is attributed to the type of seeds used and poor agronomic practices. Farmers in Dodoma traditionally practice zero tillage commonly known as '*kuberega*'. *Kuberega* involves slush and burn, then sowing of seeds. This practice leads to loss of nutrients in form of run-off and wind erosion as the soil is impermeable to water when it rains.

Table 3: Average crop yield in Chololo village (n=114)

Crop	Annual yield (kg)	Average farm size (acre)	Production per acre (kg)
(a) Food crops			
Millet	600	2.3	260.9
Sorghum	370	1.7	217.6
Maize	226.8	1.2	189.0
Bambara nuts	100	0.7	142.9
(b) Cash crops			
Sunflower	228	1.5	152.3
Sesame	290	1.2	241.7

4.1.4 Number of meals consumed per household

The amount of food crops produced has a direct influence on the number of meals to be consumed per day especially for farmers who do not possess other alternative sources of income than agriculture. As indicated in Table 4 almost 75% consume two meals per day. This is closely related to amount of food crops produced per year. Other households (25%) can consume 3 meals per day and these are those having large farms and other income sources. Similar results were reported by Nyaruhucha *et al., 2006)* in Simanjiro district. Shepherd (2006) suggested that it is not only children who suffer for little food available but also for adults who need energy for working. Without food adults cannot work properly and this results in poor working efficiency. Interestingly, having more household members does not restrict the number of meals per day. In Chololo village, households with more family members (4 and above) are more likely to consume three meals per day than households with only 1-3 members who rarely eat more than two meals per day. The tendency of farmers to adjust their food consumptions in bad and good years. This tendency is locally termed as '*kufunga mikanda*' meaning 'tightening our belts'. This is a reflection of farmers' knowledge and understanding of the ecological patterns of meteorological variables at their environment which is highly influenced by both climate variability and climate change.

Table 4: Number of meals consumed per household **(n=114)**

	Number of meals		
Household size	**2 meals**	**3 meals**	**Mean**
1-3 members	21(95.5)	1(4.5)	
4-6 members	35(68.6)	16(31.4)	
7 or more members	29(70.7)	12(29.3)	
All	85(74.6)	29(25.4)	2.25

Figures in brackets are percentages. χ^2=6.327, df =2, P= 0.042*)

4.1.5 Households' food sufficiency

Food shortage to Chololo village households is common (Table 5). In all years (1996/07 to 2010/11) there was food shortage. Years with acute food shortage were 1996/07 to 2009/2010 where more than 68% of households had insufficient food. In year 2010/2011 food shortage was not acute because 53% of household had enough food. In all reported years food shortage was for 7 months per year. Food is sufficient for only 5 months i.e. from May – September. The food shortages force 75% of households to have two or one meal per day. However, the food production is low compared to the requirements thus making majority to stay with less food for a long period of time. The food shortages are mainly caused by the impacts of climate change such as prolonged droughts. The insufficient competency in climate change adaptation and poor agronomic practices amongst farmers accelerate the food shortages in the village.

Table 5: Proportion of households with food sufficiency 2006/07 – 2010/11 **(n=114)**

Growing season	**Households with food sufficiency**	**Households with food shortage**	**Number of months with food shortage**
2006/2007	33(28.9)	81 (71.1)	7.3
2007/2008	34(29.8)	80 (70.2)	6.9
2008/2009	33(28.9)	81 (71.1)	7.4
2009/2010	36(31.6)	78 (68.4)	7.3
2010/2011	61(53.5)	53 (46.5)	7.0

(Figures in brackets are percentages)

4.2Climate Change Risk Assessment

Farmers perceptions of climate change was well reflected in a participatory climate change risk assessment (PCCRA). During the survey farmers were facilitated to carry out a PCCRA. In the process farmers identified eight sectors that are likely to be affected by hazards borne out of climate variability. These sectors include agriculture, water, health, livestock, education and industry. Others were culture and infrastructure. The sectors are likely to succumb were drought locally known as '*ukame*', floods - '*mafuriko*', and strong wind storms '*kimbunga*' (Table 6).

Table 6: Vulnerable sectors

s/n	sectors	hazards	
1	Agriculture	drought	flood
2	Water	drought	flood
3	Health	drought	flood
4	Livestock	drought	flood
5	Education	drought	flood
6	Industry	drought	flood
7	Culture (*Utamaduni*)	drought	flood
8	Infrastructure	----------	flood

According to farmers views the hazards have a cross-cutting impact on all sectors of development in their village. For instance in agriculture farmers accounted the vulnerable elements of risks for crops (maize, sorghum, millet, sunflower, sesame and peas) are prone to drought. Livestock are equally prone to drought as for crops (cattle, goat, sheep and chicken); infrastructure (affected roads, bridges and homes are prone to floods). Roads and bridges become impassable affecting transportation of farm produce and hence, farmers' access to market and other social services. This consequently cripple the livelihoods of many households in the area. Water resources depends on rainfall availability, any change on rainfall affect domestic water supplies, crop production, animal health and production as well as increases women workload as they have to walk long distances to get it.

Health sector is also affected as emergence of diseases increases and affect the dynamics in other sectors such as crop production and productivity of labor, animal production, attendance in schools etc. the most commonly diseases mentioned were trachoma, malnutrition, malaria, diarrhea and cholera. East coast fever '*ndigana kali*', worms, foot and mouth diseases, pneumonia and rift valley fever for livestock. Education sector, despite poor attendance, also famine and malnutrition affect performance of students and school quarantines due to emergence of cholera and structural damage due to floods and wind storms which increases government spending due to repairs and disaster management. Livestock health and feeding regimes are heavily affected due to poor pastures and water deficit which may result on death of animals, low prices of livestock in a market due to weight loss and diseases. Thus, the widely social and economic risks that are climate related is an additional testimony of the farmers understanding and mastery capacity to deal with their environment as well as adapting to climate change and its impacts. (Table 7).

Table 7: Vulnerable Community Elements

Types of Element	Specific Element	Hazard	
Crops	Maize	Drought	Flood
	Sorghum	Drought	Flood
	Millet	Drought	Flood
	Sunflower	Drought	Flood
	Sesame (*ufuta*)	Drought	Flood
	Lentils (pulse)	Drought	Flood
	Chick peas (Mbaazi)	Drought	Flood
	Pigion peas (kunde)	Drought	Flood
Livestock	Cattle	Drought	Flood
	Sheep	Drought	Flood
	Goat	Drought	Flood
	Chicken	Drought	Flood
			Flood
Structural damage (infrastructure)	Roads, bridges and houses	----------------	Flood
Water	Water source	Drought	Flood
Health	People	Drought	Flood
Education	Students/pupils/teachers	Drought	Flood
Cultural	Societies	Floods	Flood
Industry	Scarcity of manpower and law materials.	Floods	Flood

4.3Empirical Analysis of temperature and rainfall data

Local perceptions by farmers in Chololo village with respect to changes in temperature as well as increasing rainfall variability (Table 1) are closely matching to empirical analysis of rainfall and temperature trends in Dodoma.

4.3.1 Temperature Changes

Temperature in Dodoma region varies according to altitude but generally the average maximum and minimum is 31^{o}C and 18^{o}C respectively. In June – August, temperatures are at times very high with hot afternoons up to 35^{o}C and chilly nights on hilly areas low to 10^{o}C (URT, 2001b).Atmospheric temperature increase is one of the indicators of climate change. Chololo households have noted these changes as revealed by the findings in Table 1. Data from Dodoma and Hombolo meteorological stations depicts the average annual temperature for 30 years (a period from 1980-2010). Figures 3 and 4 indicate that temperature has increased by 0.4 ^{o}C and 0.8 ^{o}C for Dodoma Municipal and Hombolo respectively. In a similar climatic condition Mary and Majule (2007) reported an increase of annual average temperature of 0.7 ^{o}C in Singida between 1984 -2004. While Yanda *et al* 2008, noted an increase of temperature of 1.9^{o}C in Zanzibar and 1.1^{o}C in Arusha for the period of 1961–2005. These information indicates the trend of increase in temperature varies depending on location. Various literature shows that the main cause of atmospheric temperature increase is mainly caused by increase of greenhouse gases (CHGs) in the atmosphere mainly carbon dioxide (CO_2) and methane (CH_4). The CHGs accelerate the greenhouse effect and hence more heat is retained in the atmosphere. In Tanzania and other developing countries, GHG are mainly increased by deforestation, forest fire and poor agriculture practiced. In developed countries GHG are increased through utilization of fossil fuel in industrialization and transportation.

Figure 3: Trends of average annual temperature from 1980-2010 in Dodoma-Hombolo

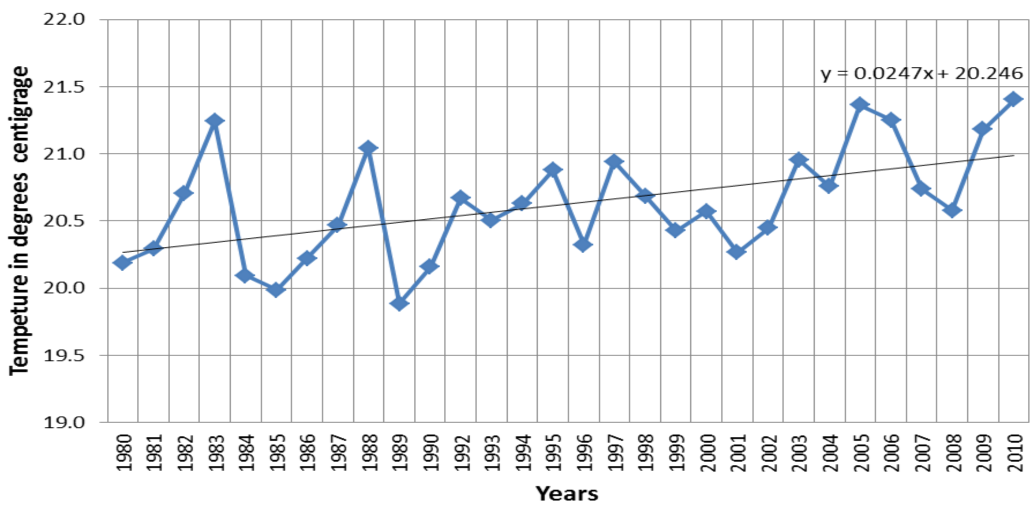
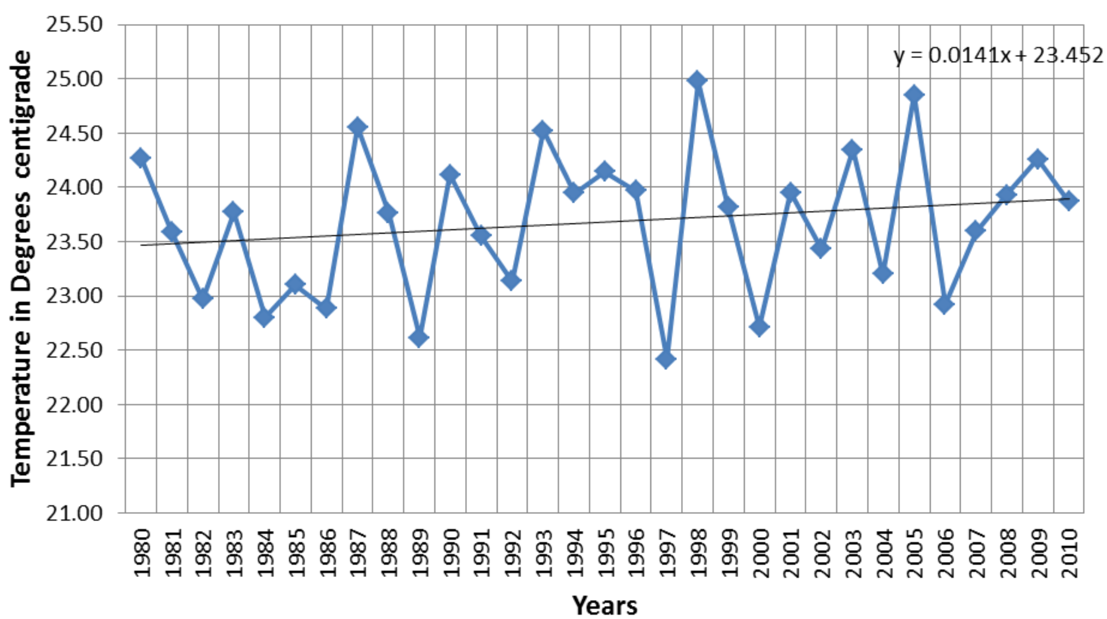


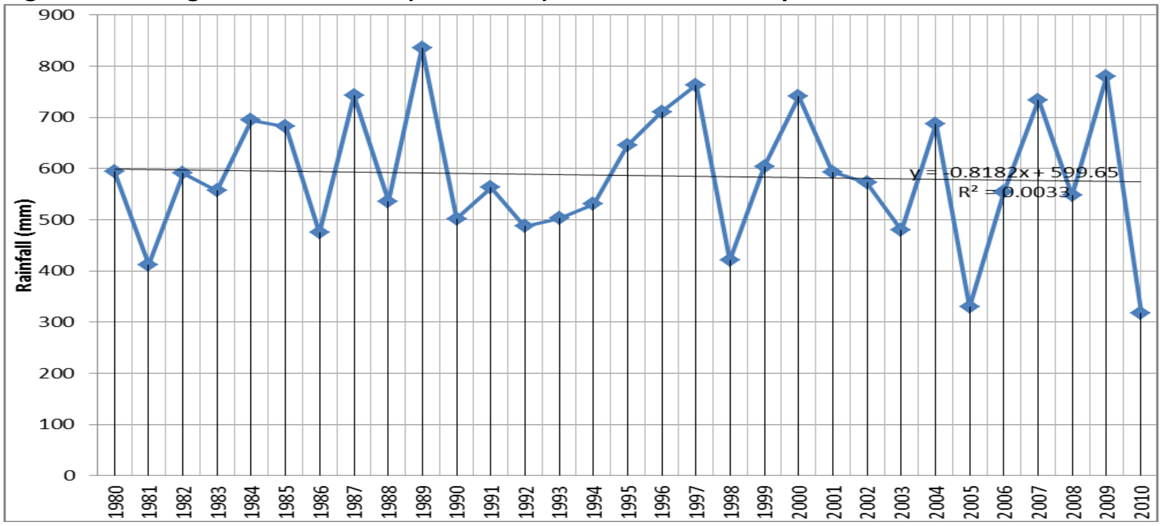
Figure 4: Trends of average annual temperature from 1980 -2010 in Dodoma Municipal



4.3.2 Rainfall changes and variability

The average annual rainfall for Dodoma - municipal for 30 years from 1980 – 2010 is 586.5mm. Trend analysis of rainfall (Figure 5) indicates annual rainfall decreased by 258.1mm from 1980 to 2010. The highest amount was 836mm in 1989 and lowest amount was 318mm in 2010. Years of droughts (less rains below 500 mm) were 1981, 1986, 1992, 1998, 2003, 2005 and 2010 and years of higher rainfall (above 700mm) were 1987, 1989, 1997, 2000, 2007 and 2009.

Figure 5: Average annual rainfall (1980-2010) in Dodoma Municipal

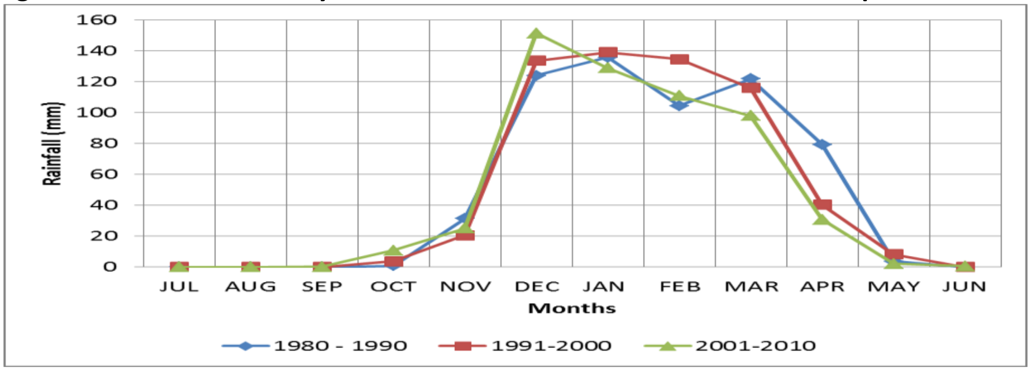


Monthly rainfall data for the past three decades (Figure 6) indicates that rainfall in Dodoma Municipal starts from November and ends in May. The data shows that the amount of first rains differs among the three decades. The amount of starting rainfall for the decade of 1980 – 1990 was higher (31.3mm) than the decades of 1991 – 2000 (20.5mm) and 2001 – 2010 (25.1mm). This implies that farmers planting in November are at a very high risk of poor seed germination due to moisture stress especially for crops which are not drought tolerant. Also the figure show that there were changes in the peak rainfall, for the two decades from 1980 -2000, the peak rainfall was in January but for the decade of 2001-2010 the pick rainfall was in December and rainfall decline sharply than other decades. This implies that in the current decade planting can be done in late December because there is adequate moisture for seed germination for most crops. Risks for poor seed germination is minimal in December to early January. Planting in early November to early December may lead to poor germination and if there is good seed germination for crops which are not drought tolerant such as maize will not survive the dry spell of January to February. This observation lead farmers to change their tactics of planting their crops in late November and hence defying the common slogan in Tanzania that 'early rain indicate the start of a planting season'.

As Asnath Masianga, (female, 36 years) testifies during the in-depth interview 'the sowing of seeds at the onset of early rains is no longer practiced because once we do that, there is a follow up of two to three weeks dry period before the rain comes again at around Christmas time, which find the seedlings have died due to lack of water. In the village our new slogan is plant at Christmas time. This small change has proved to be different as we do not have to repeat sowing in our fields and we have experienced good harvests'.

Mary and Majule, (2009) reported that changes in rainfall pattern and amount can result into increased risk of crop failure, due to poor seed germination, washing away of seeds and crops as well as stunted growth and drying of crops caused by increased evapotranspiration. This lead to sometimes to re-ploughing and re-planting thereby increasing production cost. For livestock, changes in rainfall pattern and amount results into decreased pasture and increased parasites and diseases due to drought and flooding. Furthermore IPCC (2009) reported that changes in rainfall amount and pattern also affect soil erosion rates and soil moisture, both of which are important for crop and animal production.

Figure 6: Trends of monthly rainfall from 1980 -2010 in Dodoma Municipal



5.0CONCLUSION AND RECOMMENDATIONS

Climate change is real and has been around since time immemorial. Smallholder farmers are most vulnerable to climate change and variability as their agricultural practices depends on rain as a source of moisture to grow their crops and feed their livestock. Farmers learn to adapt and respond to various natural events and build resilience to it. The farmers' accounts to various phenomenon related to climate change and variability tells it all. This study concur with many other findings thatthe social, economic, political and cultural settings influence the way farmers perceive their environment and the way they react to it (Stroosnijder, 2008; Slegers, 2008 and Osteberg and Slegers,2010). These factors influence the goals of human-environmental actions, the distribution of the resources and the constraints people experience (Orlove, 1980). Therefore an understanding of farmers' agrarian system and practices should be the cornerstone for cost effective mitigation to climate change and variability. Thus, enhancement of the synergy between farmers, researchers and extension services should be nurtured for sustainable agricultural production and productivity in semi-arid areas, and Tanzania in particular.

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