

# Climate change and its variability on crop production in semiarid areas of Iramba and Meatu Districts, Tanzania

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## Abstract

Climate change and its variability are increasingly threatening livelihoods of Tanzania's predominantly rural population and in particular those households with low incomes. Based on the above reality, a study was conducted in two semi-arid areas of central Tanzania. The overall objective was to determine how climate change and its variability have affected rural households' crop production over time. Specifically, the paper aims at; assessing farmers' preferred food and cash crops, determining the impact of rainfall variability on crop production in the semi-arid areas of central Tanzania and determining communities' perception of climate change. The study on which the paper is based used a mixed method approach whereby both quantitative and qualitative data were collected to complement each other thus improving quality of the results regarding the impact of climate change and its variability on rural households' crop production. Primary data was collected using a pre-structured questionnaire and focus group discussions' checklist. Whereas quantitative data was analyzed using the Statistical Software for Social Scientists, qualitative data was analyzed using content analysis. Findings generally show that climate change and climate variability have occurred in the study area and consequently crop production has adversely been affected leading to households' vulnerability to food insecurity. In addition, food shortages have become frequent threatening households livelihood security. Based on the findings, rural households' capacity to respond to the challenges of climate change and climate variability is a matter of urgency. Therefore, the government, in addition to the efforts already undertaken, should put in place institutional and policy framework to support rural households' efforts to minimize the impacts of the phenomena.

**Keywords:** climate change, semi-arid, crop production, livelihood

## Introduction

Climate change and its variability are long and short-term changes in the average statistics of weather. These have, as well, significant long and short-term impacts on the livelihoods and living conditions of the poor in developing countries such as Tanzania. They are contemporary global issues, which have the potential to impact everyone, yet these impacts are not equally distributed or felt. All over the world natural climatic variability exacerbated by human-induced climate change are putting societies, particularly women, the poor and vulnerable, at greater risk (IPCC, 2001). The impact of climate change and its variability in Tanzania as elsewhere in the

world is therefore increasingly threatening the livelihoods of rural population especially those with low income, food insecurity, inadequate health services, unstable energy supplies, and fragile natural ecosystems. The relationship between the phenomena and people's livelihoods is seen to have strong linkages to poverty. All over the world natural climatic variability exacerbated by human-induced climate change is disproportionately affecting the rural poor whose livelihood greatly relies on agriculture and the allied sectors.

The Agricultural sector still holds an important role in poverty reduction in most developing countries (World Bank (WB henceforth), 2007). The WB argues in the 2008 world Development Report that the sector offers a great promise for growth, poverty reduction and environmental service. Nonetheless, the WB cautions that realizing the above requires the visible hand of the state, an improvement of the investment climate, regulation of natural resources management and securing of desirable social outcomes. Another major challenge facing the agricultural sector and, which could hinder achievement of the above is climate change and its variability.

Agriculture in Sub-Saharan Africa (SSA) supports the economy and sustenance in terms of food and income to most rural households. However, in most of these countries agriculture mainly depends on availability and adequacy of rains, due to this it has been quite challenging in terms of meeting food needs both in the rural and urban areas. According to Mary and Majule (2009) the factors affecting agricultural sector's ability to enable households meet their needs includes climate change. The others are; lack of appropriate means of production, environmental degradation, changes in policies and strategies including removal of subsidies. FAO (2007) argues that the profound effects of climate change on agriculture and other livelihood options combined with the low resiliency and high vulnerability of this population to shocks could severely alter their ability to manage natural resources, affecting their livelihoods, food security and well-being.

Livelihoods in most economies of developing countries, Tanzania inclusive, mostly depend on natural resources in particular forests, agricultural land, water, fisheries and minerals. Nonetheless, livelihoods of many rural farming households in Tanzania are increasingly being threatened by climate change and its variability. No wonder the government has identified agriculture, water, energy, health and forestry as the most vulnerable sectors of the economy under climate change impacts and the strategies to address the impacts are stipulated clearly in the National Adaptation Programme of Action (NAPA) (URT, 2007). Moreover, Tanzania and other African countries were in the past blessed with relative land abundance. However, this is no longer the case in most of the countries (Lund et al., 2006). Lund et al. argue that competition for access to arable land, pastures and open land has increased in Africa and that this may cause conflicts or intensify those already in existence. Generally, the shrinkage in available arable land has been due to the expansion of the desert, arid and semi-arid areas. According to Ekaya (2007), dry lands in Africa comprise 43 % of the continent's surface area and this excludes the deserts. In addition, the semi-arid areas of Africa are inhabited by about 40% of the continent's population (i.e. about 268 million people). Furthermore, cultivable dry land is scarce, and farm holdings are getting smaller consequently increasing pressure on the land available. Under conditions of climate change and variability, the above conditions worsen leading to an ill

well-being of the rural masses whose livelihood is dependent on agriculture and other natural resources.

Generally, climate change impacts will aggravate changes caused by other factors such as soil degradation due to poor land use practices. Dry lands, in Tanzania and elsewhere, are likely to be more affected. These areas are characterized by low, erratic and unreliable rainfall (500 - 800 mm. per annum.) falling in between 70 - 90 days from December to March, leading to repeated water shortages, periodic famine and high pressure of overgrazing and of dry land cultivation in marginal area. Drought makes farming and natural resources management more difficult and is the main constraint to food security in those areas. Ikeme (2003) argues that extreme climatic events such as drought, heavy rainfall and changing seasonality are exposing rural dwellers to new and, in many cases, unfamiliar conditions. According to URT (2007) and Chipeta (2009), the impact of climate change on people's livelihoods has strong linkages to poverty and that the former has the potential of magnifying existing inequality patterns, including gender inequality. This paper therefore, intends to show how and the extent to which, climate change and its variability have affected crop production in semi-arid areas of central Tanzania over time. Specifically, the paper aims at; assessing farmers' preferred food and cash crops, to determine the impact of rainfall variability on crop production in the semi-arid areas of central Tanzania and to determine communities' perception of climate change.

## **Methodology**

### **Description of the study area**

The study on which the paper is based was conducted in two semi arid regions of Simiyu and Singida in central Tanzania. Specifically, the study was done in one district in each of the above regions, i.e. Meatu and Iramba respectively. Simiyu Region is located North of Tanzania and South East of Lake Victoria, it lies between Latitude 201° and 40 South of Equator and between 3303° and 3501° East of Greenwich. The rainfall regime in Simiyu Region is unimodal, starting from November to April (Kabote et al., 2013). Generally, the rainfall pattern is unequal and unpredictable: average rainfall ranges from 600 mm to 900 mm. The region also experiences moderate and decent temperatures ranging from 180C to 310C annually. The Topography of the region is characterized of flat, gently undulating plans and lowly sparsely vegetation and in some places covered with Miombo woodland (RCO, 2013:2). Singida Region also shares the semi arid conditions of Simiyu. According to Awaddh and Starkey (2006)' Singida region has a large plateau of an average elevation of 1000 meters extending from the centre towards the south and south west of Singida township (regional headquarters), while in the north west of the region, the Iramba plateau rises to an elevation of about 1,500 meters above sea level. The region covers an area of 49,341sq.km of which 23% is arable, 40% is used for grazing, 36% is forests and woodland, 1% is water body. Topographically, its landscape drops eastwards to the rift valley and westward to the Wembere depression.

### **Meatu District**

Meatu District is one of the semi-arid areas of Tanzania. And according to Rubanza et al., (2005) and González-Brenes (2003) Meatu is lies between latitudes 3o-4o S and longitudes 34o-35o E, south of Lake Victoria and its altitude ranges between 1000-1500 m above sea level. The district receives low uni-modal rainfall of 600-800 mm per annum between mid November

through mid May and that minimum and maximum temperature varies annually from 26.8 to 33.6°C, respectively (Rubanza et al., (2005). Meatu is characterized by small hills with black clay loam soils on the lower valleys, and with sandy loamy soils on the uplands. Vegetation is purely savanna, characterized by short grasses with scattered shrubs and trees that are dominated by *Acacia* spp. and *Dichrostachys* spp. (Rubanza et al., (2005).

The economy of the district depends mainly on rain-fed agriculture. Food crops grown include maize, sorghum, paddy, sweet potatoes, cassava, pulses and groundnuts. Cotton is Meatu's major cash crop. However, frequent droughts lead to its low productivity, for example in 2011, the harvests from cotton in the district were expected to fall from 44,000 tonnes to 24,000 tonnes (Philemon, 2011). And according to Gonzalez-Brenes (2003) about 60% of households cultivate cotton. In addition to crop production, about half of all households in the district own some cattle (Gonzalez-Brenes, 2003). A majority of the people in the district are living in poverty. According to Gonzalez-Brenes (2003) Meatu is a poor district even by Tanzanian standards, whereby in 2001 the per capita income stood at US\$184, roughly two-thirds of the World Bank estimate for Tanzania as a whole.

### ***Iramba District***

Iramba district, the other study area is found in Singida Region in central Tanzania. The district is located 193 Kilometers north of the approximate center of Tanzania and 596 Kilometers North-west of Dar es Salaam. Like in Meatu District, the majority of people in Iramba District live in rural areas engaging in farming activities. The main staple crops include bulrush millet, sorghum and maize. Maize is grown in many areas despite low yields, due to taste preference. Agricultural production is poorly performing, mainly due to low and erratic rainfall, which ranges between 500 and 800 mm per annum. As it is in Singida region as a whole, famine is a common phenomenon in the district due to lack of rainfall and droughts. In addition to crop production households in Iramba also keep livestock namely; cows, sheep and donkeys. Other activities include mining (gold at misigiri village), processing industries (sunflower oil). Generally, livelihoods in Singida, Iramba included are very dependent on the climate

### **Methods of Data Collection and Analysis**

The study on which this paper is based collected both primary and secondary data. The primary data used in the paper comes from a baseline survey carried out in Iramba (Kidaru) and Meatu (Mwamanimba and Mwashata) districts. The survey mainly aimed at getting the respondents perception of climate change, their preferred food and cash crops and their perception of climate change. Primary data was collected using a pre-structured questionnaire and focus group discussions (FGDs). In addition to the primary data, secondary data was collected from Meatu and Iramba district agricultural offices and Tanzania Metrological Agency (TMA). The data from the agricultural offices was on area under crop production, types of crops grown and amount harvested, the data from TMA was on rainfall.

Quantitative data collected through a baseline survey of 150 households (51-Iramba and 99-Meatu) was analyzed using the Statistical Package for Social Sciences (SPSS 16). For univariate analysis, descriptive statistics (frequencies, means, range and percentages) were determined. These aimed at giving a picture of the relevant distribution of respondents in relation to the variables of interests. Qualitative data collected through FGDs were analyzed using content analysis whereby information was organized and interpreted thematically. Six FGDs were conducted, one in each village and each FGD comprised of 10-12 participants. FGD

participants were selected in such a way that they covered a whole village. The participants were of different age groups: young people (aged 18-25), middle-aged people (30-45) and old people (50 and above).

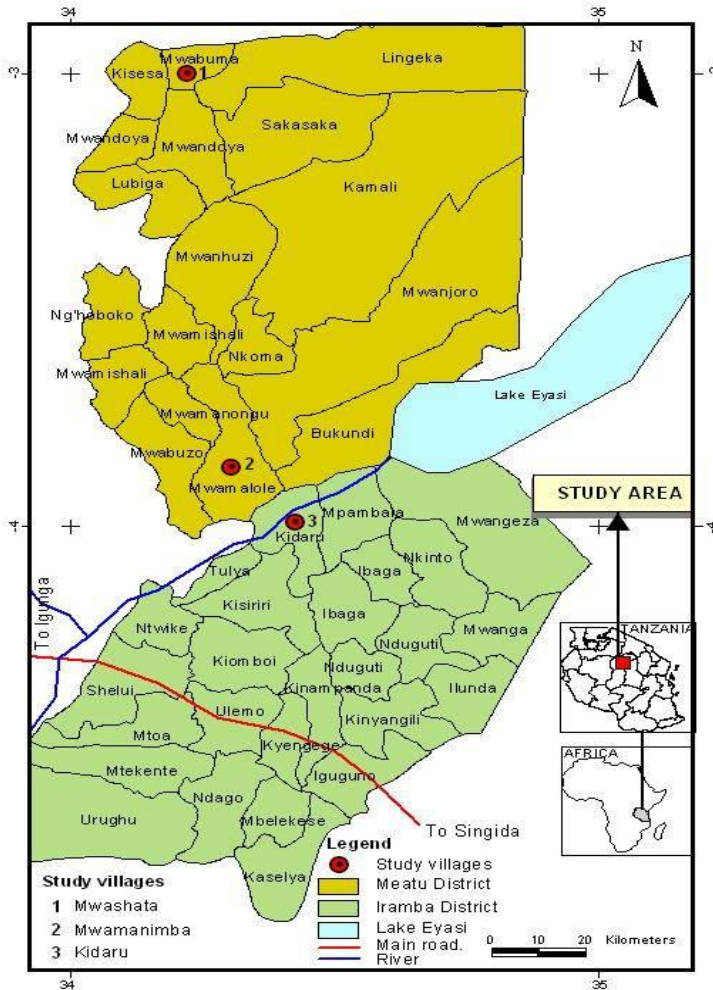


Figure 1: Map of Tanzania showing the study villages (Kabote et al., 2013).

## Results and Discussion

### Socio-economic characteristics of surveyed households

Table 1 presents the respondents socio-economic characteristics, these include; household heads age, sex, education level and occupation and respondent's category. These characteristics, in addition to having some influence on the surveyed households' crop production; they also

have a bearing on how climate changed is perceived. For example, older respondents who have stayed in an area for a period of 30 or more years are better placed in saying whether climate change is a reality in their area or not. Such people are also vested with great experience in the changes that households have gone through in response to the effects of climate change and its variability.

Table 1: Socio-economic characteristics of surveyed households

Characteristic		DISTRICT		
		Meatu	Iramba	Overall
Household head's Sex (n=150)	Male	78 (78.8)	27 (52.9)	105 (70)
	Female	21(21.2)	24 (47.1)	45 (30)
Household head's Age Category (n=148)	< 35 Years	19 (19.6)	12 (23.5)	31 (21)
	36 to 60 Years	59 (60.8)	30 (58.8)	89 (60.1)
	> 60 Years	19 (19.6)	9 (17.7)	28 (18.9)
Household head's Education Level (n=146)	No formal education	40 (42.1)	12 (23.5)	52 (35.6)
	Primary School education	51(53.7)	38 (74.5)	89 (61)
	Secondary School education	4 (4.2)	1 (2)	5 (3.4)
Household head's main occupation (n=144)	Crop production	90 (96.8)	46 (90.2)	136( 94.4)
	Livestock production	0 (0)	3 (5.9)	3 (2.1)
	Formal employment	2 (2.2)	1 (2)	3 (2.1)
	Mixed farming	1 (1.1)	1 (2)	2 (1.4)
Respondent's category (n=150)	Household head	69 (60.7)	44 (86.3)	113 (75.3)
	Household head's spouse	20 (20.2)	5 (9.8)	25 (16.7)
	Grown up child	10 (10.1)	2 (3.9)	12 (8.0)

**NB:** Numbers in brackets indicate percent

Education level of respondents also enables its bearers to make well informed decisions when it comes to what crops to be grown by households. Results in Table 1 show more than two thirds (70%) of the surveyed households were headed by males, most (80%) household heads were above the age of 35, households heads with more than primary school education were very few (3.4%). In addition, most (75.3%) of the respondents were household heads. The respondents mix provides the opportunity to get the right information in relation to climate change and its variability in the surveyed areas (i.e. Kidaru- Iramba and Mwanimimba and Mwashata in Meatu District).

### Major food crops for surveyed households

In Tanzania maize (*Zea mays*) is an important staple. However, observations from the baseline data suggest that in the studied areas there was a variation on the importance accorded to maize and sorghum (*Sorghum bicolor*) as the number one food crops. According to the above figures, whereas maize was the most important food crop in Meatu district, in Iramba District (Kidaru more specifically) sorghum was the number one food crop followed by bulrush/pearl millet. The observation comes as no surprise though Meatu district borders Iramba district (Kidaru), the former receives relatively more rainfall and particularly in the northern parts of the district where Mwashata one of the villages involved in the study is situated. Compared to Meatu's second village (Mwanimimba) most of the household in the northern part of the district (Mwashata included) grow maize for food; in Mwanimimba most households were growing sorghum.

Sorghum was mentioned as the main crop by about a quarter (25%) of the respondents in Meatu district.

Generally, sorghum and other crops such as bulrush millet/pearl millet (*Pennisetum americanum*) and finger millet (*Eleusine coracana*) require less moisture and hence are more suited for areas such as Mwamanimba (Meatu) and Kidaru (Iramba) (Creswell and Martin, 1998). Growing such crops enables smallholder households in arid and semi-arid areas to get a harvest that can sustain their households. Moreover, in the tropics, maize requires a rainfall of 600 to 900 mm for a good performance (Purseglove, 1988). According to Creswell and Martin (1998), bulrush/pearl millet has a higher drought tolerance level of 2.5 compared to both sorghum and maize whose tolerance level is 1.5 and 1 respectively. Bulrush millet can grow on poor sandy soils and within a range of rainfall from 350 to 700 mm per annum. In addition, the preferred food crops generally reflect the growing conditions of the particular areas and what Creswell and Martin (1998) refer to as accumulated wisdom of the communities. The two argue that, choosing the right crops for arid regions might involve considerable experimentation in a particular region and native systems, as crude as they may appear, usually represent the accumulated wisdom of centuries of experimentation. Moreover, a study by Thornton et al. (2007) as cited Mary and Majule (2009) showed that, reduction in the length of the growth period in some parts of East Africa was likely to result in substitution of some crops species, for example, maize could be substituted by sorghum and millet as these are more suited to drier environments.

### **Major cash crops for surveyed households**

Observations from the study show that the most important cash crops in Iramba and Meatu districts were sunflower (*Helianthus annuus*) and cotton respectively. The popularity of sunflower as a cash crop in Singida region spans back to about a decade ago. On the other hand cotton is a crop that has been grown in the Lake Zone (Meatu district included since the colonial times (before 1961 when Tanzania got her independence). Whereas cotton is a long established cash crop in the Lake zone sunflower is a new introduction in many parts of Tanzania, Iramba district included. The ranking of sunflower as the most important cash crop in Kidaru (Iramba) comes as no surprise, according to RLDC (Rural Livelihood Development Company). Singida region in which the district is found is among Tanzania's four leading regions with regards to the crop's (2008) production. RLDC further point out that over 50% of the country's sunflower is grown in four regions: Dodoma (22.5%), Kilimanjaro (13.2%), Arusha/Manyara (13.1%) and Singida (8.9%). Other major growing areas are Mbeya, Mtwara, and Rufiji (RLDC, 2008:10). A study by ASA and RLDC (2012) reported sunflower to be the priority cash crop in all the districts of Singida region.

### **Rainfall and crop production trends in Iramba and Meatu districts**

The results generally show a shift in importance of crops grown by households due to rainfall variability. In addition, even where the same crops are grown for example maize, households have opted for early maturing varieties. During the FGDs, it was reported that smallholder farmers have adopted new crops as a coping strategy to climate change and climate variability. In Iramba, there has been a change in the type of crops grown due to climate change. In the past

(back to 1943), households used to grow sorghum, maize (local varieties), finger millet, cotton, bambara nut (*Vigna subterranea*), bulrush millet and sweet potatoes (*Ipomoea batatas*). Since the 1990's, households now cultivate Simsim that was introduced as a cash crop in 1980s in place of cotton whose market was unreliable. During the same period, there was introduction of green gram (*Phasleolus aureus*) and rice (*Oriza sativa*), which are used as both a food and cash crops. Sunflower has also been adopted as a major cash crop. Due to climate change, maize and paddy are grown along river valleys where land is moist, which is helpful to food secure.

Generally, secondary data seem to echo what respondents and the FGDs reported on declining crop productivity due to climate change and its variability. Crop productivity in both Meatu and Iramba has declined. For example the correlation coefficient for maize production based on available rainfall data shows maize productivity was negative (-0.014). In Iramba, crops with negative correlation coefficients were, bulrush millet (-0.2), sweet potatoes (-0.2) and cassava (-0.1). Therefore, the observations seem to suggest the influence of climate change and its variability on the reported crops.

Observations further show that climate change and climate variability have also led to changes in crop ownership between men and women. During the FGDs participants pointed out that there has been a shift on the importance accorded to crops grown by households. For example whereas sweet potatoes were cultivated in the past by women for household consumption, men currently cultivate the same as a cash crop leading to competition for land. Sweet potatoes have become an important income source. Sweet potatoes are short duration crops that are relatively drought tolerant therefore, the high importance in food security in semi-arid areas.

Generally, both the baseline survey respondents and the FGDs participants believe climate change and climate variability have occurred and they are realities. The majority of respondents and FGD participants pointed out that climate change was manifesting itself through decrease in amount of rainfall received, low intensity of the rains and that these have been aggravating over time. The respondents and FGD participants also reported increased incidences of droughts. They added that the above have in the recent past increased considerably compared to the situation in the 1970s and 1980s. In Kidaru village the worst changes however, have occurred since the year 2000s leading to recurrent of crop failures. Other details of the respondents' perceptions are presented in Table 2.

Table 2: Respondents Perception of Climate Change (n=150)

Variable		Iramba (n=51)	Meatu
Change in amount of rainfall over time	No	2 (3.9)	2 (2.1)
	Yes	49 (96.1)	95 (97.9)
Direction of changes with respect to rainfall	Increasing over time	5 (10.2)	10 (10.3)
	Decreasing over time	44 (89.8)	87 (89.7)
Frequency of drought and floods since 2000	More frequent	33 (68.8)	51 (51.5)
	More prolonged	8 (16.7)	44 (44.4)
	No difference	7 (14.5)	4 (4)
Manifestation of changes in rainfall	Increased drought	46 (93.9)	89 (92.7)
	Decreased drought	1 (2.0)	7 (7.3)
	Increased floods	2 (4.1)	-

**NB:** Number in brackets indicate percent, in addition, for some variables the responses recorded differ with the sample size (n) due to missing values. Therefore, calculations for the percent are based on actual responses.



## Conclusions

The paper aimed at showing how climate change and climate variability are affecting crop production in the semi-arid areas of Meatu and Iramba districts of Tanzania. On basis of the field observations and secondary data the paper concludes that climate change and its variability particularly insufficient precipitation/rainfall to raise crops have increased in frequency and intensity and this has seriously affected farming households' crop production in Meatu and Iramba. It is also concluded that farmers are aware of the occurrence of climate change and its variability and they have adopted some coping strategies such as change of crops cultivated. It is also concluded that due to the phenomena, there is now competition for control of produce and income from crops that were traditionally cultivated and controlled by women. Therefore, efforts need to be taken to enable farming households cope with climate change and its variability.

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## References

- ASA (Agricultural Seed Agency) and RLDC (Rural Livelihood Company) (2012). Twelve Districts Sunflower Value Chain Mini-Survey Report Change.pdf [22/04/2015]
- Chipeta, L. (2009). Gender and Climate Change: Examining the gender Variation in Coping and Adaptation to Climate Change in Malawi. In: Maro, P.S and Majule, A.E (Eds). A Chapter in a Book Strengthening Local Agricultural Innovations to adapt to climate Change in Botswana, Malawi, South Africa and Tanzania.
- Creswell, R. and Martin, F. W. (1998). Dryland Farming: Crops & Techniques for Arid Regions. Published 1993; Revised 1998 by ECHO Staff. Echo Technical Note.
- Ekaya, W. N. (2007). Strategies for Developing Dry land Agriculture: Role of Knowledge. <http://knowledge.cta.int/en/Dossiers/Demanding-Innovation/Dryland-Agriculture/Articles/Strategies-for-Developing-Dryland-Agriculture-Role-of-Knowledge>
- FAO (2007). People-Centered climate Change Adaptation: Integrating Gender Issues. <ftp://ftp.fao.org/docrep/fao/010/a1395e/a1395e00.pdf>[01/09/2011]
- González-Brenes, M. (2003). Domestic Violence, Bargaining and Fertility in Rural Tanzania. [http://www.sscnet.ucla.edu/polisci/wgape/papers/4\\_Gonzalez.pdf](http://www.sscnet.ucla.edu/polisci/wgape/papers/4_Gonzalez.pdf)[12/08/2011]
- Ikeme, J. (2003). Climate Change Adaptation Deficiencies in Developing Countries: the Case of Sub-Saharan Africa. *Mitigation and Adaptation Strategies for Global Change*, 8(1):29-52

- IPCC (Intergovernmental Panel on Climate Change) (2001). Climate Change 2001. Synthesis of the Third Assessment Report. Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press. Cambridge.
- Kabote, S.J., Mamiro, D., Synnevåg, G., Urassa, J.K., Mattee, A.Z., Mbwambo, J.S., Nombo, C.I., Masolwa, L.M and Chingonikaya, E.E. (2013). Inter-annual Anomaly and Seasonal Variability of Rainfall and Temperature in Selected Semi-arid Areas of Tanzania. *Journal of Continuing Education and Extension* 4(2): 295-317.
- Lund, C., Odgaard, R. and Sjaastad, E. (2006). Land Rights and Land Conflicts in Africa: A review of issues and experiences. [http://www.diiis.dk/graphics/Events/2006/Lund-%20Odgaard %20and%20Sjaastad.pdf](http://www.diiis.dk/graphics/Events/2006/Lund-%20Odgaard%20and%20Sjaastad.pdf) [23/06/2011]
- 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 Environmental Science and Technology* Vol. 3 (8), pp. 206-218
- Purseglove, J.W. (1998). Tropical Crops: Monocotyledons. Longman Scientific and Technical, Longman Group UK Limited, Essex, England. pp 607
- RCO (Regional Commissioner's Office) (2013). Simiyu Investment Profile – 2013. Regional Commissioner's Office, Simiyu
- RLDC (2008). Sunflower Sector: Market Development Strategy. [www.rldp.org/downloads/sunflower\\_strategy.pdf](http://www.rldp.org/downloads/sunflower_strategy.pdf)[20/04/2015]
- Rubanza, C. D. K., Shem, M. N., Bakengesa, S. S. Ichinohe, T. and Fujiyama, T. (2005). Content of macro and micro minerals of deferred forages in silvo-pastoral traditional fodder banks (Ngitiri) of Meatu district of central north-western Tanzania. *Livestock Research for Rural Development* 17 (12)
- United Republic of Tanzania (2002). 2002 Population and Housing Census, Volume II. Age and Sex Distribution. National Bureau of Statistics, Dar es Salaam
- United Republic of Tanzania (2007). National Adaptation Programme of Action (NAPA). Vice President's Office, Division of Environment. 52 p.
- World Bank (2007). World Development Report (WDR). Agriculture and Development. The World Bank, Washington DC ISBN: 978-0-8213-7297-5