The Cost of Climate Change in Tanzania: Impacts and Adaptations

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Abstract: In recent years, Tanzania has witnessed a number of climate related disasters namely, flooding, droughts, widespread crop failures, livestock deaths and intensification of climate sensitive diseases among others. Regular climate discussions in the country have often underestimate crucial problems related to climate change like chronic energy crisis and influx of people to urban areas arguably because of failing agriculture in farming areas. This paper has highlighted the fact that the poor, usually with limited resources and who contribute the least to the causes of climate change are the most affected in many ways. In addition, it gives a detailed account of the issues of climate change in Tanzania and explains the effects of climate variability using examples. The effects of climate change in the country are widespread and significantly interfere with agriculture, while at the same time, reducing the ability of the society to deliver services. Indigenous knowledge such as survival skills and coping mechanisms adopted by different societies in Tanzania, have been discussed in the paper. Such coping mechanisms however are overwhelmed by the impacts of climate change on the people. Different institutions including the government have taken some positive steps towards combating climate change; however the efforts done so far are insufficient. In addition, addressing climate change in Tanzania is hindered with inadequate resources, corruption and poor coordination and implementation of combating measures. Generally current climate variability in the nation is an issue of concern for all future plans and must be addressed. [Journal of American Science 2010; 6(3):182-196]. (ISSN: 1545-1003).

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1.0. Introduction

Human development, especially industrialization has led to an increase in greenhouse gases (GHGs) into the atmosphere that has resulted to weather changes (IPCC, 2007). Arguably, two major problems facing the world today are global climate change and population growth, the link between the two being food quality and quantity. Unfortunately climate change has badly affected food availability and many people find it hard to meet their basic needs (IPCC, 2001, Mwandosya, et al., 1998).

Until recently, many people had considered climate change impacts to be only potential effects and/or of a few isolated cases (places and individuals). However, it is increasingly clear that climate change is happening now, and widespread to the extent that humanity is not prepared for and must act. Today, few individuals deny the facts and impacts of climate change to humanity compared to a few decades ago (IPCC, 2001, 2007). As a result, scientists, economists and politicians across the world are trying to agree on the best way forward in dealing with climate variability. Climate change impacts have direct consequences on the economy, ecosystems, water resources, weather events, health issues, desertification, sea level rise (IPCC, 2001) and even on political and social stability like displacement of people and conflicts (Christian Aid, 2006). The impacts of climate variability in developing countries are numerous; for example, the recent drought in Kenya has resulted into unprecedented water shortages and triggered inter-communal conflicts and misunderstandings with neighboring Uganda (Ibid). The unrest are not limited to Kenya and Uganda, they are increasingly widespread in many places like Somalia, Ethiopia (Ibid), Tanzania (URT, 2007) among others. Climate change is already projected to result into 50 million environmental refuges as early as 2010 (Myers, 1993). Consequently, countries that had historically found it difficult to compromise economic development for climate change have joined into the international efforts to combat the variability. Traditionally, developing countries, including the emerging economies like India, China and Brazil have argued that they contributed less to the climate change causes and are still poor to be held responsible in combating measures, which often include some economic sacrifices (IPCC, 2007). While such arguments are true, they are not helpful as almost everywhere today the effects of climate change are increasing. Studies have shown that climate change will cause more casualties in developing countries than developed countries on account that those countries tend to have fewer resources to cope with the effects and generally live in vulnerable locations (IPCC, 2001, 2007). African countries are especially vulnerable to the effects of climate change because of the over-

dependence of rain-fed agriculture, recurrent droughts, inadequate land distribution and policies, and widespread poverty (Ibid). Poor people are particularly vulnerable because poverty is associated with high reliance on natural resources which are already impacted by climate change and in turn it constrains community's adaptive options. In developing countries like Tanzania, major pressing issues like food security, poverty, and water availability are all interconnected with climate change.

However, climate change effects impact different groups of the societies differently. In Tanzania, consequences of climate change have even taken a gender dimension in which women are seen to be more vulnerable on account of deep-rooted socio-economical and historical barriers (Lambrou and Piana, 2005). Climate change in Tanzania is also linked to increasing problem of plant toxicity to livestock and potentially to man. In the recent past, significant losses of livestock during drought episodes were linked to plant toxicity (Ngomuo, et al., 2001). Studies in other parts of the world also indicate that the problem of plant poisoning is worsened and/or triggered by climate change, specifically drought (Thurow and Taylor, 1999).

Probably, the worst impact of climate variability in Tanzania is its interference with food security (URT, 2003). Today climate change plays a diminishing role in nearly all value chains in Tanzania including to more than 90 % of the population dependent on agriculture or agricultural related activities. Agriculture in the country largely depends on rainfall which is increasingly becoming unpredictable and unreliable with worsening climate change impacts. In addition, some societies in Tanzania namely, Masaai, Barabaig and Nyaturu have their livelihood largely dependent on livestock husbandry (URT, 2003, 2007*)*. Livestock sector in the country is among the worst hit by the climate variability via repeated droughts. Food insecurity most times renders working populations weak and unable to work in the fields for the next harvests hence any food shortage outbreak could have long term effects. Malnutrition from food shortage, which is already seen as a direct consequence of climate change in the country, decreases immunity and expose the affected to opportunistic diseases that would otherwise be resisted. Reliable water availability, whether in the form of rain or water sources is also linked to human health and generally economic stability of families. Shortage of water for agriculture and domestic use is often followed by sky-rocketing food price and outbreak of disease like malaria, Cholera, diarrhea, typhoid, all of which are climate sensitive (Yanda, 2005).

Climate change in Tanzania will have many more negative impacts to the population. Increased CO_2 concentration in vegetation will decrease protein content with consequences to both livestock and human health; in addition it will cause a decline in environmental services like water and biodiversity. High sea temperatures will disrupt marine ecosystems and increased evapo-transpiration rate whilst heat stress to plants will reduce crop yields. On the other hand, salt water incursion and sea level rise will disrupt water supplies, further damage ecosystems, accelerate loss of land and undermine agriculture among others (Mwandosya, et, al., 1998). Worth noting, these effects are already being felt in many places in the country.

1.1 Country background information

1.1.1 Location

Tanzania is the largest country in East Africa, covering an area of 945,200 km^2, 60,000 of which is inland water. Tanzania lies close to the equator in the East Coast of Africa between parallel 1^{0}S and 12^{0}S and meridians 30^{0}E and 40^{0}E (Fig. 1). By being close to the equator, the climate variations in temperature are not very extreme. Tanzania's area includes island areas of Pemba, Zanzibar, Mafia and a narrow coastal line strip. Apart from a small belt along the coast of about 800km^2 which is less than 200m a.s.l., the rest of the country is well above 1000m a.s.l. Tanzania extends from Lake Tanganyika in the West to the Indian Ocean in the East. Lake Nyasa and River Ruvuma are in the South whilst Lake Victoria is found in the North. It borders Uganda (North), Rwanda and Burundi (North-West), Malawi and Zambia (South-West), Mozambique (South), Kenya (North-East) and Indian Ocean (East) (URT, 2007).

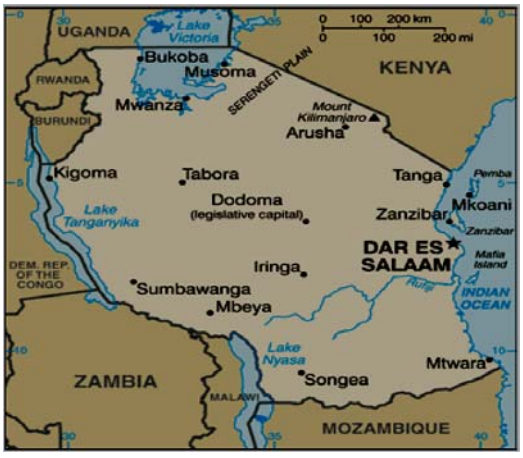

Figure 1: The map of Tanzania showing location and neighbors

1.1.2 Biodiversity and natural resources

Tanzania is among top African countries in terms of biodiversity of both flora and fauna

species in its terrestrial and marine ecosystems. It has numerous vegetation cover distributed along the diverse landscapes. Its characteristic geographic location, i.e. located close to the equator and elevation ranging from sea level to Africa's highest point (5985m a.s.l), makes Tanzania home to a number of endemic plants and animal species most of which are of world importance. It has very rare ecosystems in several of its natural forests namely East and West Usambara, Kilimanjaro National Park and spectacular wildlife ecosystems in the Serengeti, Ngorongoro, Mikumi, Manyara, Tarangire, Selous nature reserves to mention just a few. Tanzania is home to more than a third of total plants species in Africa (UNEP, 1998). In all, it has more than 12,700 plants species unevenly distributed across the country. In summary, the biodiversity and the degree of endemism of animal species are made up of primates (20 species, 4 of which are endemic), antelopes (34 species and 2 endemic) fish (with many endemic in Lake Victoria, Tanganyika and Nyasa and other small lakes and rivers), reptiles (290 species, 75 of which are endemic), amphibians (40 endemic), invertebrates and plants around 11,000 species including many endemic (URT, 2007). The great Mount Kilimanjaro with its glaciated peak is iconic and a major socio-economic asset for Tanzania. Tanzania is also among the richest countries in terms of geological deposits of useful minerals such as gold, diamond and tanzanite, the latter only found in Tanzania (Mwandosya, et, al, 1998).

1.1.4 Land use and climate

Proportionally, Tanzania has larger protected land areas (29% of the total land size) than most of African countries. The protected areas comprises of important ecosystems including 12 national parks, 28 game reserves, the Ngorongoro conservation area, and 38 game-controlled areas, the total of which is 240,000 km^2. Moreover, it has 540 forest reserves covering an area 132,000 km^2 (15% of the total wood land of Tanzania). About 42% of the land is under some form of cultivation whilst 26% of the land is infected by tsetse flies thus rendered unusable for livestock and agricultural activities (UNEP, 1998).

As a result of its geographic position and geological features again, Tanzania has interesting climate patterns. It has a mixture of climatic conditions from tropical (coastal areas) to temperate and alpine deserts (on slopes of Mount Kilimanjaro). The north-east monsoon wind blows from December to March bringing the hot weather, whilst the southeast monsoon winds blow from March to September bringing intermittent rains. Across the country, temperature and precipitation vary between (20^0C to 32^0C) and 600mm to 1800mm) respectively. The mean duration of the dry season is between 5 to 6 months.

In Tanzania altitude is an important factor in rainfall patterns; higher elevations usually receive more precipitation than lower ones. Tanzania has both bimodal and unimodal rainfall patterns. The former, consisting of long rains (locally referred to as *Masika)* come between March to May and short rains, (*Vuli)*, between October to December. According to Mwandosya, et al., 1998, however, the total amount of rainfall is not so much. Only about half of the country receives more than 762 mm of rainfall annually. Variations in rainfall in the country are strongly related to the sea surface temperature variations (SST) in the Indian and the Atlantic Oceans which may sometimes alter standard oscillation outcomes (Paavola, 2003). Moreover, the climate of Tanzania is also greatly influenced by El Niño and La Nina both of which have serious climatic problems. In Tanzania, the first and second years of El Nino brings less and more than usual amount of rainfall. Like in the rest of Africa, La Nina reduces rainfall in the first year and increases it in the second year. This alteration results into flooding and drought, the commonest climatic hazards in the country (Ibid).

2.0. Overview of climate change in Tanzania

The wider global climate change trends are greatly reflected in Tanzania's climate. Because of her geographical location and the topographical characteristics, the country offers the best opportunity to study and further understand global climate trends. Recent researches have suggested that, alongside other East African countries, climate change has badly affected the country. Deteriorating water quality and quantity, loss of biodiversity and declining agricultural productivity due to climate change, are no longer potential threats but rather threats that have already struck and caused Tanzanians repeated misery (Yanda, 2005).

Studies show that in Tanzania mean annual temperatures and average daily temperatures will rise by between 2 to 4^oC by 2075 as a direct consequence of climate change (URT, 2003). Putting Tanzania into a wider African context however, it is projected to warm up less than many countries notably north-western and southern Africa (URT, 2007). Interestingly, the interior parts of the country are projected to face higher temperature increases than coastal areas whilst cold and dry seasons will warm more than warm and wet seasons (Mwandosya, et al., 1998).

Apart from temperature data, change in rainfall patterns is likely to be more torturous and with immediate severe effects. In Tanzania, rainfall models indicate that rainfall will become less predictable and their intensity more volatile (IPCC,

2001). Tanzania expects to have a decrease in rainfall by between 0 to 20% in the inner parts of the land. Northeast, southeast and the Lake Victoria basin however, expects to have a total increase in rainfall by between 20 to 50% (Mwandosya, et al., 1998, Hulme, et al., 2001). Such major changes in rainfall patterns will inevitably have severe consequences to the society, some of which (repeated droughts and floods) are already happening (Ibid).

Recent studies on climate change in Tanzania show that there will be an increase in extreme weather events (URT, 2003). The extreme weather events in Tanzania are associated with flooding, droughts, cyclones, tropical storms all of which are projected to be more intense, frequent and unpredictable (Ibid). The vulnerability of the country to extreme weather events can specifically be looked at in terms of the recurring drought conditions and the recent El Niño seasons of 1992-1993 and 1997-1998. In terms of impacts to the society, the named El Niño episodes were very significant because they were accompanied with heavy socio-economic losses. The episodes resulted into nationwide power blackout and rationing, food shortages and sky rocketing prices, massive losses of livestock and agricultural crops (Paavola, 2003). Consequently, the government had to introduce emergency food aids to many parts of the country during which families walked for up to 50kms to receive their handouts. Most importantly, the El Niño resulted into widespread of diseases namely malaria, diarrhea and cholera which added economic hardships to the government and families. Moreover, there were widespread infrastructural, human settlements, livelihood and other property damages all of which overwhelmed the country and its people (URT, 2003).

Regardless of her low level of development, Tanzania has its contribution to global warming. The major ways by which Tanzania contributes to climate change include deforestation, large animal herds with accompanied overgrazing, mining activities, air pollution especially from industries, and vehicles, land use changes, and waste management especially poor solid waste collection and disposal mechanisms. Generally however, Tanzania's contribution to causes of climate change is generally very low compared to other countries. In terms of contribution by sector, land use change in the country contributes more to the problems than fossil fuel emission primarily because of its low level of development. Thus, efforts to combat climate variability in the country will have to focus more on land use change sector (UNEP, 1999). On the other side, Tanzania contributes significantly in carbon sinking/sequestration via its massive ocean environment, wetlands, forests and land.

To best explain the cost of climate change impacts and adaptations in Tanzania, it is best to look at it in the following contexts.

2.1. Health sector

It is already known that climate variability plays a central role in the geographical distribution and reproduction of vectors responsible for a number of diseases in Tanzania (URT, 2007). According to Lindsay and Martens, (1998) distribution of vector borne diseases in humans is limited by too cold temperatures, thus the increasing global warming pauses an eminent risk to human life via infectious diseases epidemics, and other health risks like heat stress to bio-forms. For example, the climate sensitive diseases, such as cholera, malaria, rift valley fever (Paavola, 2003) and meningitis were all eminent during the El Niño season of 1992-1993. Yet warmer climate will increase water born diseases like schistosomiasis and trypanosomiasis, whilst elevated frequency of flooding and drought would increase water borne diseases like typhoid and cholera (Paavola, 2003, URT, 2007). Although climate change has resulted to many heath complications in Tanzania (URT, 2003, 2007), two major diseases namely malaria and cholera (which affects many people and have wider socio-economic implications to Tanzania) have been discussed in this paper.

2.1.1. Malaria

Inter-governmental Panel on Climate Change (IPCC, 2001) conclusion show that more than 90% of global mortality due to malaria occurs in Africa i.e. up to 1 million deaths annually. Malaria is the number one killer of children, pregnant women and the elderly on the continent (IPCC, 2007). It is also the leading cause of infant mortality (20%) and constitutes 10% of the continent's overall disease burden (Ibid).

Malaria is the most important public health concern in Tanzania, especially so in children under five years of age and among pregnant women (four times more likely to suffer from malaria than the average population). Tanzania squarely lies in the malaria zone (MOH, 1997) and thus very vulnerable to the disease. The disease accounts for 16.7% of all reported deaths and is one of the leading causes of morbidity, ranging from 24.4% in Rukwa region to 48.9% in Dar es Salaam (URT, 2003, 2007). Likewise, it is a leading cause of morbidity in both outpatient attendance and inpatient admissions, responsible for up to 40% of overall outpatient attendances (MOH, 1997).

Malaria is a tropical disease caused by four different species of *Plasmodium species.* The commonest and most dangerous species of the plasmodium in Tanzania being *Plasmodium falciparum* (MOH, 1997). The latter is known to

cause cerebral malaria. The parasites are transmitted from one person to another via female anopheles mosquitoes. Transmission depends upon the number of times the infected mosquito bites and duration of the mosquito lifespan which is largely a function of climatic conditions. Survival of adult *anopheles* is usually influenced by variables like temperature, humidity and rainfall (Craig, et al., 2004). Rainfall and drought influence breeding habitats for Anopheles. The former forms new stagnant water pools whilst the later results into reduction in water volume of water bodies, e.g. streams, rivers and lakes to form many pools of stagnant water which in turn favours mosquito multiplication. Maximum larval development of anopheles mosquitoes occurs at 28^0C whilst an adult anopheles develops best at around 32^0C. Thus, temperature plays an important role in aquatic development stage of anopheles mosquitoes. In recent years in Tanzania more cases of malaria have been reported due to continuing warming up across the country including in highland areas (URT, 2007).

In places where anopheles mosquitoes cannot survive there is no transmission of malaria. Statistics show that in East African highlands, there had not been a recorded malaria epidemic between to 1960s to early 1980s. However over the last two decades, there have been widespread cases of recorded malaria in the areas. Malaria cases have slowly been moving upwards from the traditional low-lands. Generally, the warming up in Tanzania has resulted into otherwise non-natural ranges for anopheles mosquitoes increasingly becoming favorable for their survival (Matola, et al., 1987; Fowler, et al., 1993). Cases of malaria are increasingly becoming common in mountainous areas e.g. Lushoto (Tanga region), Njombe (Iringa region) and Kilimanjaro region where a few years ago it was not a problem (WHO 1998, URT, 2007, Lindsay and Martens, 1998, URT, 2003, URT, 2007). Yanda, (2005) reports that malaria cases are creeping from the traditional low-land to highlands. According to Yanda, (2005) for example climate, land use changes and increasing human population have a close relationship with increasing malaria and diarrhea diseases outbreak in the Lake Victoria region.

In recent years however, apart from climate change, malaria problem has also been complicated by the growing parasite resistance to first line anti-malarial drugs and mosquito resistance to insecticides. Moreover, the widespread outbreaks of the diseases have also been linked to the El Niño phenomenon with increase in both rainfall and temperature (Lindblade, et al., 1999). According to IPCC, 2001, El Niño results into strangely elevated precipitation in certain parts of equatorial East Africa and can result in resurgence in malaria cases. Other studies have given similar results that unusual rainfall patterns and elevated maximum temperatures have a close relationship with malaria outbreaks (Craig, et al., 2004).

Economically, malaria is one of the biggest burdens in Tanzania and generally Africa. According to W.H.O, 2002, malaria claims more that US$ 12 billion every year of the African GDP. If climate change is to continue unchecked, it is likely that more people in uninfected regions in Tanzania would suffer financial burdens from the disease and require government attention. In Tanzania malaria continues to pose challenges on the community, the effects varying from school absenteeism to low productivity at workplaces. Agricultural productivity and outputs from other economic sectors are thus directly affected by malaria (URT, 2007, MOH, 1997).

2.1.2. Cholera

In Tanzania, cholera outbreak was for the first time reported in 1936 (Yanda, 2005). Cholera outbreaks are usually associated with wet seasons; therefore any increase in the amount of rainfall would add to cases of cholera. The current climate change has positively played in favour of both spread and intensity of cholera in Tanzania. The recent spread and outbreak are concomitant with the climate prediction in the country. As already earlier, rainfall is projected to increase in North East, South East, Lake Victoria basin and coastal areas (Mwandosya, et al., 1998, Hulme, et al., 2001). It is in the named region where most cholera outbreaks have been reported in the recent years. Furthermore, coastal residents are increasingly getting cholera outbreaks from extreme weather events of the recent developments (IPCC, 2001). In Tanzania, cholera has serious economic implications including cost of treating the sick, controlling the outbreak and reduced labor. Specifically, cholera outbreaks are economically detrimental since its control often involves closing of some businesses like food centers, adding the costs of water treatments and disinfections, all of which requires economic sacrifices (URT, 2003).

2.2. Agriculture, livestock and food security

In Tanzania climate change posses its worst impact through interference with food security to the growing population. According to the government, 19% of the populations live below the food poverty line whilst 36% of the population lives below the wider poverty line (URT, 2005). Agriculture is an important sector in Tanzania; it is named the backbone of the country on account of its contribution to the GDP and employment opportunities it offers. Agriculture typically contributes around 25.8% of GDP and comprises up to 40% of export earnings (URT, 2007);

accordingly, the sector continues to drive economic growth. For example in 1992, it contributed 42. 9 % of the GDP (URT, 2001), more recently however, its contribution to the GDP has been severely reduced among other reasons due to climate-related agriculture failures. Because the agricultural system is largely-rain fed which is increasingly becoming unpredictable and unreliable with the continuing effects of climate change, the largest employer of the population is kept in jeopardy (Paavola, 2003, URT, 2003). Worth noting, about 80% of poor Tanzanians live in rural areas where agriculture accounts for more than 75% of rural household incomes. In addition, agricultural holdings are typically dominated by small scale, subsistence farmers cultivating plots ranging from 0.9 to 3 ha (URT, 2007). Furthermore, agricultural system in the country is almost entirely targeted at food production.

The impacts of climate variability on agriculture sector in Tanzania include shifting in agro-ecological zones, prolonged dry episodes, unpredictability in rainfall, uncertainty in cropping patterns, increased weed competition with crops for (moisture, nutrients and light) and ecological changes for pests and diseases (Paavola, 2003, URT, 2007). Shortening and/or change of the growing season, a trend that has already been observed in Tanzania is seen as a direct consequence of the warming up and changes in rainfall (Ibid). According to Funk, et al., 2005, in Tanzania and East Africa at large, there has been a decrease in long-cycle crops and rainfall between March and May from 1996 to 2003. Even more worrisome, climate variability will require plants to adapt to the new situation, which keeps on changing (Paavola, 2003). Moreover, there is enough scientific evidence pertaining to pests, diseases and weeds intensifying with warming up of the environment (Ibid).

The recent droughts and associated crop failures have led to severe hunger to many places in Tanzania that forced the government to organize food aid to the people. For example in Dodoma region there had been an 80% decrease in harvests as a direct result of poor or late arrival of rainfall. In 2005, the *Vuli*, short rains were very poor in many regions including areas where the rains are usually plenty, like Kilimanjaro region. The shortage of the mentioned rains again triggered food aids to the starving people especially in coastal and north-east regions (URT, 2007). Moreover, in 2003 FAO described Tanzania as having a very high level of undernourishment, with 43% of the population being under nourished directly because of drought related food shortages (FAO, 2003a). In 1992 for instance the average food supply in kcal/person/day was 2080, whereas by 2001 it had fallen to 1770. Similarly, in percentage terms, the undernourished comprised 35% of the population in 1992 and 43% in 2001. The effects of the climate variability have contributed to shortage of food and increase in the rate of malnutrition to children in the country (URT, 2007, MOH, 1997). Studies already show dim figures for the continuing failure in agricultural productivity in Tanzania. Being a staple food for most Tanzanians, maize that is widely grown in Tanzania is projected to be affected the most by recent climate variability. Mwandosya, et al., 1998 had projected that if the greenhouse gas CO_2, will double and average temperature increase by between 2^0C to 4^0C, then maize harvest will decrease by up to 33%. The situation will even be bad in some place (Dodoma and Tabora) where up to 80% of this important source of carbohydrate will be lost (Paavola, 2003). Statistics show that maize is not the only crop that will be affected in the nation, according to URT, (2007), cotton yields could as well decrease by between 10%-20% with major economical implications.

The alternative to effects of drought in Tanzania's agriculture would be to strengthen irrigation projects; however irrigation in the country is also suffering from poor water supply. Water for irrigation is becoming very unreliable and thus places where their major economic activities depend on irrigated agriculture will have severe economic hardships on account of the continuing climate variability (URT, 2003).

Even worse, in places where climate change is said to increase rainfall and thus flooding like coastal regions further effects on agriculture are eminent. Flooding are associated with nutrients leaching, water logging and sweeping away of crops and the top fertile soils. These effects have already been reported in many places in the those regions (URT, 2003, 2007). In addition, infrastructures like roads are also swept away by floods which complicates the transportation of agricultural produce and farm inputs to market places and farming areas respectively, hence poverty intensification.

2.2.1. Livestock

With the current climate variability, livestock productivity, survival and distribution will be affected through reduced quantity and quality of range-land and prevalence of vector-born livestock diseases (IPCC, 2001, URT, 2003). Deaths of large numbers of livestock due to lack of water and pasture has been of repeated occurrence in Tanzania in recent years hence threatening livelihood of pastoralists in the country. Some hopes however exist as a number of pastoralist societies have started to learn alternative livelihood support activities. Such adaptations however are only useful for short-term and non-severe effects of

climate change. In addition, distribution of tsetse flies could shift into North East Tanzania and thus reduce land for human settlements, grazing ranges and other developments (IPCC, 2001). Sadly, the latter location has many pastoralist communities in the country (URT, 2007). Other effects on livestock include reduced productivity (draught power, milk and meat) as increased carbon dioxide reduces protein available from vegetation and eruption of new pests and diseases for example ticks, snails and other pests. Studies show that milk and meat production will be reduced following the stress on the grazing lands (URT, 2003, 2007, IPCC, 2001). Worth noting, the number of livestock already overwhelms the carrying capacity of many grazing grounds in central and north-west Tanzania where droughts are common. As a result, pastoralists are forced to relocate to places where pasture and water are available (Shayo, 2006, URT, 2007). However, the tendency has already caused conflicts between different pastoralist societies on one hand and farmers and pastoralists on the other. Moreover there are reported conflicts between livestock and wildlife (Ibid).

2.3. Fisheries, coastal and water resources

2.3.1. Fresh water resources

Studies have indicated that Tanzania water resources will have non-uniform impacts as a result of climate change. Among the impacts Tanzania is likely to face include, water logging, water pollution, increasing river flow in some basins, drying up of some water bodies, intrusion of sea water into fresh water bodies including groundwater e.t.c (URT, 2007). In the recent past, 2/3 of rivers in Tanzania have had reduced water volume as a result of decreased rainfall (Orindi and Murray, 2005). However, while Pangani and Ruvu rivers are projected to have a decrease in water flow, Rufiji, will have a slight increase (Mwandosya, et, al 1998). At the national level nevertheless water flow is projected to become more seasonal and scarce. Other studies have shown dim predictions that by 2025 the availability of fresh water in Tanzania will be reduced to half the rates of 1990 (Sharma, et al., 1996). The projection is that water flow change will be between 5 to 10% in all basins in Tanzania (Mwandosya, et al., 1998). To be more specific, Ruvu basin is projected to have up to 10% decline in its runoff (URT, 2003). The basin is very important to Tanzania as it supplies water to the huge population of Dar es Salaam. Sadly, the trend above has been widely observed in many other places in Tanzania. Most small rivers and springs have either disappeared or become seasonal as a result there has been a steady encroachment into wetlands and water bodies in the country (URT, 2007).

Changes in water flow in these basins have already caused some socio-economic and ecological impacts in Tanzania. They include decreased HEP generation, decreased biodiversity, lowered agricultural productivity (e.g. irrigation projects), domestic water shortage etc. All these add hardships to already struggling communities (Orinda and Murray, 2005). Lake Victoria has already been impacted by climate change and its water level is likely to be variable in the future (Mwandosya, et al, 1998, Yanda, 2005). The Pangani basin, which is economically and ecologically important to Tanzania, is under threat from losing most of its resources partly because of the melting of the Kilimanjaro glaciers which feed it (Thompson, et al., 2002). Currently, rationing of both water and electricity is of repeated occurrence in many places across the country. Further deterioration in water availability will have major effects in Tanzania where already some communities (25% of the population) are walking an average of over 30 minutes looking for water (URT, 2003).

Hemp, (2005) has given a closer look at the overall effects of climate change in water supply as directly related to reduced precipitation and humidity. According to Hemp, (2005) there has been an increase in the intensity and frequency of wild fire on the forests on Mount Kilimanjaro partly because of dry conditions there hence affecting the hydrological balance. The forest of Kilimanjaro contributes up to 500 m^3 of water to the Pangani basin by collecting rain and fog at higher altitudes of the Mountain. Even more worrying, the effects of climate change are not limited to Mount Kilimanjaro alone, a more or less similar trend is observed in other highland forests and mountains in Tanzania (URT, 2003, 2007). Moreover, the warming up and changes in rainfall patterns may potentially affect groundwater recharge with considerable hydrological implications in the country (Paavola, 2003). That will have catastrophic impacts as some drought-prone areas in Tanzania like the capital-Dodoma, entirely depends of the groundwater system (Paavola, 2003). Historically, water resources have been a source of tension between nations for many years (Christian Aid, 2006). Arguably, as a sign of worsening situation, there have in recent years been tensions on water resources within the national borders (Paavola, 2003).

2.3.2. Coastal resources

Following the continuing melting of the polar ice caps, expansion of the surface sea water molecules due to increasing temperature and hence the projections by the IPCC of 8-96cm rise of the sea by 2100, Tanzania is among the likely countries to suffer significant impacts in her coastal regions

and ecosystems. Tanzania enjoys an 800km^2 long coastal line that varies in width from about 20km to 70 km. Major cities of national and international importance like Zanzibar, Bagamoyo and Pangani lie in the coast (Mwaipopo, 2001). Tanzania's coast has many important resources that support a large population; these include the Rufiji delta, mangrove forests and swamps, tidal marshes, sand and mudflats among others. Unlike inner parts of the country, the coastal areas are projected to be less affected by droughts. Unfortunately, the coastal areas are geared to experience increased mean rainfall and cyclical variation, which could aggravate both frequency and severity of flooding (Paavola, 2003, Mwandosya, et al., 1998). The projected sea level rise in the nation will have major impacts namely land losses of between 247-494 km^2 (based on sea-level rise of 0.5 and 1m respectively), coastal erosion, saline intrusion in fresh water bodies (e.g. the Rufiji delta), extreme weather events, inundation of low-lying coastal areas and small islands, coral bleaching, damage to coastal structures and properties, loss of coastal and marine habitats and ecosystems e.g. mangroves and fishes (URT, 2007). Maziwe Island in Pangani district is already submerged as a direct result of climate change.With about 16% of the population found within the 800km^2 coast-line, the projected sea level rise will have detrimental consequences to the coastal communities including on the ecosystems they directly depend on. The government of Tanzania is aware of the eminent danger to the coastal line and has estimated the damages of sea level rise in Dar es Salaam alone to be between 48-82 million USD for a 0.5 to 1m sea level rise respectively. Other coastal areas under the same threat include coast Region, Mtwara and Lindi (URT, 2003). Important economic activities to the local communities in the areas like salt making, tourism and fishing are very likely to further be impacted if climate change continues (Mwandosya, et al., 1998, Paavola, 2y003).

2.3.3. Fisheries

Warm temperatures are usually associated with faster depletion of oxygen supply in water thus affect fisheries (Fick, et al., 2005). According to Roessig, et al., (2004), warm temperatures have been noticed to have depressing impacts on fisheries of the whole of East African region in both fresh water and sea water. Fishing employs many people and offers an important source of food in Tanzania. Any major imbalances in the sector will have major detrimental effects to both food security and economic opportunities (Mwandosya, et, al., 1998, Paavola, 2003).

2.4 Energy issues and climate change

Tanzania's energy balance is dominated by biomass (90%), mostly fuel-wood, charcoal and plant residues. Commercial energy sources like petroleum and electricity accounts for only 8% and 1% respectively (UNEP, 1999); the former is mainly from hydropower (Mwandosya, et al., 1998). Coal and natural gas accounts for less than 1% of the energy balance in Tanzania. Thus, much of the demand for fuel wood is met from forests. However, wood is becoming increasingly scarce because drought and desertification all of which collapse the energy pyramid in the country. Some studies have shown that charcoal and fuel-wood usage in Tanzania is estimated at 32m^3 million tons per annum which has contributed to deforestation (UNEP, 1999). Traditionally, women and children are responsible for fuel-wood gathering in Tanzania. As wood becomes rare in neighborhoods, they travel long distances to collect firewood where they risk harassment and many school hours for the children lost.

Effects of climate change in energy sector in Tanzania can be discussed from diverse angles namely availability, production or distribution of energy. The recent climate variability has posed significant challenges in major sources of energy in the country, namely biomass and hydropower power (URT, 2007). The effects in energy, industry and transport in Tanzania can be looked at either drying up of water bodies which produce electricity, destruction of infrastructure (roads, railways, gas pipelines and electric poles) to transport and distribute energy or ecological imbalances, deforestation and desertification and thus reduction of wood energy.

Since electricity generation in Tanzania largely depends on hydropower, changes in water flow have affected the capacity of Tanzania to supply power to its fast growing population. Low water levels in electricity generating dams in recent years have forced them to be temporarily shut down thus affecting the main source of electricity in the country (URT, 2007, Paavola, 2003, Mwandosya, et al., 1998). For example, the hydro-electric power crisis of 2006/2007 which was accompanied by power blackouts and rationing in the nation (URT, 2007) was directly a consequence of drought related climate change. Currently, Tanzania is having major power shortage and again there is a nationwide rationing. The recent energy crisis due to drought (hence impacts on HEP generation) in Tanzania has been very serious to the extent that it resulted into resignation of the former prime minister. The former prime minister and two of his cabinet ministers resigned after an emergency electric generation scandal. The scandal was related to abuse of power in contracting a fake American company called Richmond to produce

emergence electricity using generators (Transparency International, 2009).

2.5 Forestry, grasslands, wildlife

Tanzania is among the leading nations in terms of the forested land in Africa, the forests land makes 338,000 km^2 which is an equivalent of 44% of the total land area (UNEP, 1998). These forests offer basic household needs like fuel wood (firewood and charcoal), vegetables, medicines, honey, etc, hence very important. Up to 50% needs of some families in Tanzania directly depend on forests resources (Paavola, 2003). In addition, the majority of endangered species and precious biodiversity in Tanzania directly depend on these forest ecosystems (World Bank, 2002).

Although Tanzania is among the richest countries in terms of biodiversity (UNEP, 1998, URT, 2007), her forests are under major continuing danger of deforestation from both anthropogenic activities and climate change. In 2002, it was estimated that deforestation rate in the country was about 91,276 hectares per year. Among the main anthropogenic activities responsible for deforestation include overgrazing, high demands for wood energy, wildfires, and over-exploitation of wood resources for commercial purposes and clearing for agriculture and settlement. The named activities have been contributing a significant amount of CO_2 in the atmosphere while increasingly reducing carbon sinks (URT, 2007).

Like in many other countries in Africa, the biodiversity of Tanzania is expected to change as different species try to adjust and cope with the impacts of climate change (Lovett, et al, 2005). Much more, climate change may trigger loss of some species; displacement and forced migration of ecosystems and potentially adjust seasons and migratory roots of birds and animals. Yet entire genetic structures, as affected by changes in breading rates, could be altered (Rubenstein, 1992). According to URT, (2007), changes in forest types, species composition and distribution will have major ecological implications in the country. Already some displacements and changes in species composition are witnessed in Mount Kilimanjaro (Hemp, 2005) and East Usambara Mountains (Shemsanga, 2003). Because of the climate variability, the bulky of forests in Tanzania are set to be shifted to drier ecosystems (URT, 2003). Due to increased ambient temperatures and decreasing precipitation, many important forests are likely to be substituted by grasslands and woodlands. Moreover, climate change has direct effects on the species invasiveness. It is already known that invasive species tends to adapt better to changing climate (Malcolm, 2002). In some places in the nation, important forest reserves like the East Usambara forest reserve are already struggling with a number of invasive species like *Lantana camara* and *Maesopsis eminii* (Shemsanga, 2003). Moreover, there could be elevated conflicts between man and wildlife for resources (URT, 2003, URT, 2007). Climate variability is increasing occurrence and severity of wild fires (Hemp, 2005) that in turn is affecting the distribution of species, changes in land-cover, reducing the forests size and subsequently drying up of streams and rivers (Paavola, 2003). In addition, because 90% of Tanzania's energy use is based on biomass, mainly fuel-wood and charcoal any major shifts in availability of wood energy would disturb a huge numbers of people both in rural and urban areas. Worth mentioning, in Tanzania cooking energy directly touches on the crucial issue of nutrition value of food (Paavola, 2003). The effects of climate change under this category are especially worrisome because it is through this sector the country gains its foreign currency via tourism and forest products thus there is an eminent danger of decrease in employment and foreign exchange (URT, 2007).

2.6 Retreating glaciers on Mount Kilimanjaro

Mount Kilimanjaro is the highest mountain in Africa that stands 5,895m tall. The volcanic mountain is located on Kenya-Tanzania border (3°04'S, 37°21'E). Apart from offering an excellent site to study climate change (Thompson, et al., 2002), the mountain is also a biodiversity hot-spot with up to 3000 plant species. As a result, the mountain has been sustaining large populations of local inhabitants in addition to being a source of water for an even larger population downstream.

Arguably, Mount Kilimanjaro offers the best opportunity to study climate change in Tanzania. Although the retreat of glaciers of Mount Kilimanjaro has been recorded since 1850, the current recession is possible the fastest and most alarming (Mwaipopo, 2001). The early retreat of glaciers on the Kilimanjaro was due to natural climatic shifts whilst the warming up of the Earth after the industrial era has led to current faster recession of the glaciers. There is no argument today regarding the retreat of Kilimanjaro glacier; the glaciers have been retreating in unprecedented scale in the recent years directly because of climate change (Hemp, 2005, Thompson, et al., 2002). The retreat of the glaciers is probably the most iconic indication of climate change impacts in Tanzania (Ibid). The most recent available data shows that the glaciers were about 4.2km^2 in 1976 (Hastenrath and Greischar, 1997). In 2000, the remaining glaciers were only 2.6km^2 (Thompson, et al., 2002). It is projected that there will be no glaciers on the mountain by the year 2020 (Ibid). The melting of glacier is supported by modern climatic data recorded on the Mountain. There has been a

decline of about 177mils (11%) of rainfall since 1935 on the Mountain. On the other hand, temperature has been observed to increase on the mountain at different periods. Based on measurement records on the mountain, temperature increased drastically over the period of 25 years from 1976 and that the daily annual temperature average increase at a rate of 0.275^0C per year (Altmann, et al., 2002). Tanzania Meteorological Agency gives more shocking statistics; it estimates that about 80% of the snow at Mt. Kilimanjaro has already disappeared leading to reduced water flow to millions of people downstream (URT, 2007).

Concomitant with the retreat the glaciers, there has been an increase in wildfire on the Mountain due to climate change and other human factors (Hemp, 2005). The consequences of melting glaciers on the mountain have important socio-economic implications to Tanzania. Retreat and potential disappearance of the glaciers accompanied with forest fires have put the lives of over a million people on the Mountain slopes at jeopardy of water stress and will have other hydrological imbalance in the region. The glaciers are approximated to contribute 1 million m^3 of water supply in the Pangani basin. The water of the Mountain which proceeds as Pangani River has important socio-economic use including at *Nyumba ya Mungu* hydropower dam, irrigation and domestic use by millions of Tanzanian downstream (URT, 2003).

The evidence of climate change in the Kilimanjaro is enormous. There are already changes in migration behaviours and population dynamics of animals on the mountain (Mwaipopo, 2001). The retreat of the glaciers and other ecosystem changes on the mountain are likely to significantly interfere with tourism industry in the country. Noteworthy, Kilimanjaro National Park stands to be the major attraction for both tourists and researchers in Tanzania. Apart from tourism offering foreign currency to the government, it offers significant employment to many Tanzanians (URT, 2007).

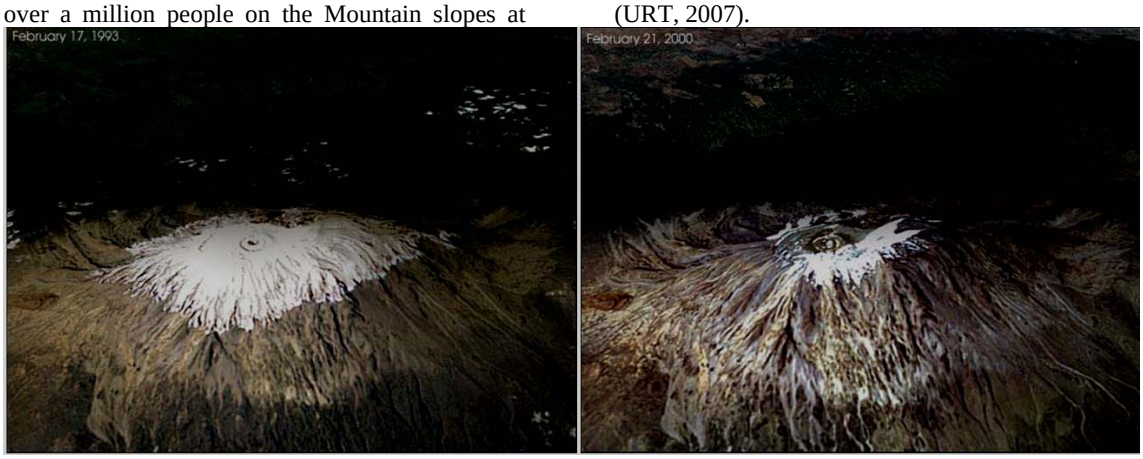

Figure 2: Showing loss of ice cap on Mt. Kilimanjaro between 1993 and 2000 (Source: URT, 2007)

3.0. An overview of response and adaptation measures to climate change in Tanzania

Addressing climate change is one thing Tanzania must do. Any successful breakthrough in poverty alleviation in the country will have to include climate change mitigations by the government and its institutions, private sector and the general community at various levels. Generally, climate change adaptation measures in Tanzania will be different from society to society owing to its geographical, sociological and economical characteristics. Some studies have shown that some societies in Tanzania are already coping with the effects of climate change (Shayo, 2006, Ponte, 1998). However, such adaptation mechanisms are hampered by the severity and the speed of climate change effects, widespread corruption and resource constraints. In this paper, adaptation measures in the country will be addressed separately for local people and the government and its institutions.

3.1. Local level: Indigenous initiatives to living with climate change vulnerability

As the effects of climate change in Tanzania continue to impoverish the population, became more severe and of repeated nature, different societies developed/relied on diverse local strategies to cope with the challenge. Worth noting, most local people find it hard to cope with climate change using modern technologies like high input agriculture and biotechnology and have relied on their indigenous skills. However, most of these local copping strategies could only be applicable in a short term and/or less severe impacts. The strategies are likely to leave populations vulnerable to both climate change and the associated poverty in the longer term (Orindi and Murray, 2005). The various coping strategies by different societies in the country are collectively discussed hereunder.

As a direct outcome of climate change, local people in some parts of Tanzania have adopted to other activities apart from their traditional livelihood, agriculture. In places where climate change has resulted into repeated agricultural failures, it is now common to find members of typical farming villages doing extra farm activities to maximize survival. Such activities may include, charcoal burning, brick making, fishing, casual laboring depending on the geographical locations and seasons (Shayo, 2006). Climate change has also forced people to move from their villages to urban areas for paid employment. For example, it is common to find young people mostly after primary education moving to big cities to look for jobs. Sadly, employment opportunities are limited and some end up being jobless and even harassed.

In addition both farmers and pastoralists have adapted to some local ways of predicting short to long term climatic changes such as drought. Once the drought is locally predicted, pastoralist would distribute livestock and/or shifting herd to safer places to reduce risk. Northern societies namely Barabaig and Masaai have particularly been involved in transhumance. For example, Morogoro region has observed huge influx of pastoralists with large herd of livestock (Paavola, 2003).

In addition, when drought is likely, pastoralists in drought-prone areas have adapted to reserve pasture for weak stocks such as sick, young, and lactating animals. Such a method would enable them to survive during the drought season and reduce deaths of weak individuals (Shayo, 2006). Moreover, the repeated occurrence of climate disasters has forced some pastoralist societies in Tanzania to reduce the numbers of their herd as a coping mechanism. Interestingly, some pastoralist societies have even strategized into paid employments in cities and cultivation of food crops (Ibid).

Farmers on the other hand, would grow traditionally drought-resistant crops such as sorghum, cassava and millet rather than maize (which has been failing many farmers) when drought is anticipated (Ibid). In addition, intercropping with the aim of maximizing harvest is becoming common. According to Shayo, (2006), it is common to find more than five different crops being grown in a piece of land in the common drought-prone areas. Yet some farmers would open up of larger pieces of land for agricultural activities and applying more agricultural inputs in attempting to have better harvest. Places where irrigated agriculture is possible people have been trying to water their crops in the absence of rainfall. Apart from that, some farmers have also changed planting seasons as affected by potential drought occurrence (Orinda and Murray, 2005).

Interestingly also, some local people have developed their own skills related to disease control to crops, animals and even stored of grains. According to (Shayo, 2006), some societies use their local skills to control livestock diseases as an adaptive strategy to counter the effect climate change. Grains are preserved using traditional skills rather than the conventional methods in the country. It is common to find local people storing their grains especially seeds above kitchen so that the smoke will help to preserve the grains against seed pests. Some skills also exist in terms of animal disease control (Ibid).

Furthermore, as climate change continues to increase scarcity of wood near neighborhoods, some societies have turned into growing their own trees for fuel wood consumption instead of relying on the scarce and unreliable supply from the surrounding areas. Regions where tree planting is becoming common include Tanga, Kilimanjaro and Morogoro among others. Usually fast growing trees such as *Gravellia robusta* and *Eucalyptus spp* are popular. Regrettably, the latter species is known for its own environmental problems (FAO, 1998). In addition, rainfall is scarce and many trees grow with difficult and take longer to grow. Yet many people are adapting to the use of fuel saving stoves which generally, are affordable, easy to make and use less fuel wood.

3.2. National level: The government and institutions

Tanzania government has done a lot to address the crucial issue of climate change and wider environmental issues in the country. In the international arena for example, Tanzania is also a signatory to and has acceded to a number of international and regional environmental treaties (NEMC, 1994, URT, 2007). Efforts to effectively achieve ends have however been hit by corruption, inadequate skills, low technology and generally low ability of the government to implement strategies to combat environmental challenges. Exceptionally, corruption remains to be such a deadlock in many socio-economic issues in Tanzania.

3.2.1 Policy issues on climate change in Tanzania

It is difficult to address policy issues pertaining to climate change without looking at the wider environmental challenges. Addressing climate change likewise requires more than local efforts as it recognizes no national boundaries (IPPC, 2001). When the effects of climate change and general environmental degradation became more severe and revealing, and with the widespread concession that poverty alleviation strategies would not be successful without integrations of

sustainable environmental management, the government of Tanzania took decisive steps towards a comprehensive environmental policy in 1994. Several interconnected issues had forced the government to take such steps. These included, the vulnerability of some local environments and especially loss of wildlife habitats and biodiversity, deterioration of marine and freshwater ecosystems, widespread deforestation, land degradation, soil erosion and inadequate land and water management at various levels, pollution, high population growth, persistent poverty to the population and climate change. Thus a National Environmental Action Plan was formulated in 1994 (URT, 1994). This plan later laid the foundation for National Environmental Action Policy, (URT, 1997b, UNEP, 1998) and thus clear acknowledgement between poverty, human health and environmental degradation was indicated and accounted for.

The government of Tanzania has realized that dealing with climate change requires local, regional and international efforts as both the causes and effects of climate change recognize no geographical boundaries. Tanzania has taken some steps in addressing the issue of climate change in its widest sense. It ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1996. Generally, notable progress has been made to address climate variability in Tanzania. Consequently, DANIDA recently gave funds to Tanzania to develop methodology and capacity building in GHG mitigation assessment. However, Tanzania still faces difficulty in coping with climate change due to many factors including rapid growing populations, urbanization, and inability of the government to deliver services to its citizens. Since major contributions to emissions to GHG in Tanzania is through land use change and forests related sources, any mitigation of climate change including carbon sequestration should target forests and land use sector (UNEP, 1999). Regrettably, forest management and other natural management in Tanzania are faced with corruption and incompetence (Jansen, 2009).

3.2.2. Government's efforts on adaptation strategies to climate change vulnerability

Dealing with the issue of climate change in Tanzania requires a wide range of measures. The country has done its part in setting standard measures and responses to the impacts of climate variability. Apart from policy issues discussed above, the government's adaptation measures to vulnerability in the main areas under climate change considerations in this paper are summarized in table (1) below.

Table 1: Government's strategies to climate change vulnerability (URT, 2007, NEMC, 1994, 2002, Mwandosya, et al., 1998)

Agriculture and livestock sector	Forests, grassland and wildlife	Water resource	Coastal resources	Energy sector	Health sector
Investment in research and development on drought and diseases tolerant seed varieties	Establishment of collaborative forest management in various districts	Integrated water resource Management	Establishment of numerous marine and coastal environment management programmes and projects in the country	Improvement and intensification of clean thermal power generation projects	Establishment of the integrated diseases surveillance response system to prevent, mitigate and respond to epidemics in the country by the Ministry of Health
Strengthening of agriculture extension services to farmers and livestock keepers	Ensure ecosystem stability through conservation of forest biodiversity, water catchment and soil fertility e.g., Eastern Arc Conservation Project	New water infrastructure development e.g. new dam sites, reservoir construction	The National integrated coastal environment management strategy	Protection of hydropower water catchments	Presence of emergency plan response unit, which coordinates and manages all health related hazards, including epidemics, accidents, drought and flood
Facilitation of small scale irrigation schemes	The ongoing national-wide tree planting campaign	Conjunctive water use and Inter-basin transfers	Mangrove management programme	Increasing availability of biomass resources	Strengthening the use of traditional/alternative medicines nation wide
Diversification of agriculture, involving growing different	Enforcement of	Protection of water catchments,		Improvement of biomass to	Establishment of the Traditional Medicines

crops on different land units	participatory forest management programmes throughout the country	groundwater and diversification the use of ground water in drought prone areas like the capital Dodoma		energy conversion efficiency	Research Unit at Muhimbili Medical Research Institute to run parallel with conventional medicine
Water harvesting from rainfall to be used during water scarcity		Rainwater Harvesting and water conservation		Improvement in end-use energy efficiency Programmes	Increasing the number of rural health centers and personnel

4.0. Conclusion

Climate change is already affecting Tanzania both economically and socially. There has been a vivid underestimation of impacts of climate change in the country. This study concludes that rural dwellers in Tanzania are more vulnerable to the effects of climate change than urban dwellers partly because of their limited resources, poor exposure to various technologies and their overdependence on natural resources which are threatened by climate change. In addition, because of Tanzania's overdependence on biomass and hydropower for energy needs, she is faced with an energy crisis unless the declining wood availability stops and/or alternative forms of energy are made available and affordable.

Survival skills and local responses to the effects of climate variability have done little to help the poor in the country, should the impacts continue and/or become severe, they are unlikely to be useful. Local strategies, like seed preservation however, can be incorporated into national strategies to combating climate change impacts.

The government and other institutions in the country have taken some measures to address challenges of climate change. Among the positive things done includes creation of relatively sound policies and operationalizing of several institutions dealing with climate change and environmental management. However the efforts done are not enough and most institutions dealing with climate change are ill equipped to address the complex issue of climate change in the country. More can still be done to include participatory approaches in a wider perspective in the nation regarding the issue of environmental management.

5.0. Recommendations: the way forward

Different adaptations and strategies are hereunder proposed as possible responses to climate change impacts in Tanzania. Coal, is among the leading cause of GHG in the world (IPCC, 2007). It has increasingly been used in many developing and developed countries and blamed for immediate deterioration of the air quality and for the global warming (IPCC, 2001, 2007). Unfortunately, Tanzania government has recently started to use coal to generate electricity and plans to expand its application even further. As an alternative to capitalization on coal, Tanzania is rich in natural gas which is seen as a reliable and relatively clean source of energy.

Although hydropower generation is seriously being hit by climate change, efforts can still be made to strengthen its potentials by improving the existing hydropower centers and building reservoirs to reserve rain water when available and thus be used during droughts. The good side of climate change in Tanzania is that there are some basins when climate change is actually predicted to increase rainfall/river runoff. Efforts can be concentrated to those areas and improve efficiency of other dams so as to have better energy security. The government should try to limit the importation of used vehicles which are often unwanted in their former countries. Other recommendations on dealing with climate causes and impacts of climate variability in Tanzania are stipulated hereunder.

- Reduce the number of livestock by keeping a few productive numbers, and enhance intensive agro-pastoral activities such as zero grazing where possible.
- Continued efforts in afforestation and ecosystem restoration across the country and control of forest fires. Farm afforestation will reduce pressure on natural forests for wood.
- Implementation and improving counter-measures against devastating events on livelihoods e.g. early warning systems to and relocation to vulnerable areas/people.
- Introduction of crop species resistant to environmental stresses like drought, pests and diseases to reduce crop failures.
- Promotion of non-agricultural income generating activities to vulnerable areas so as to reduce pressure on natural resources.
- Cross-sectoral coordination for improved livelihood of the people by harmonising all policy issues. There should be one environmental law that addresses all issues concerning the environment rather than having diverse pieces of legislations under different

authorities which often times contradict with each other. Enhancement in participatory policy in all aspects of the society e.g. resources management and utilization.
- Good governance and accountability with renewed fight against corruption of all forms.
- Restoration of mangroves and construction of ocean currents protection walls.
- Energy diversification in both rural and urban areas so as to reduce pressure on biomass. Dissemination and expansion of the cheap and readily available technology like fuel wood serving stoves and continued investment in alternative forms of energy like wind and solar.
- Implementation of the rapid bus transit project in big cities to minimize congestion and subsequent air pollution from vehicles.

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