ASSESSMENT OF AGRICULTURE DROUGHT RISK MANAGEMENT AND ADAPTATION EFFICIENCY USING THE CONCEPT OF MOVE FRAMEWORK: CASE STUDY OF SEMI-ARID ZONE IN TANZANIA

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ABSTRACT

Drought is considered as the second devastative natural hazard after flood which impacts lives and livelihood of societies. Given the fact that climate is changing and more extremes weather events such as drought are increasing there is a need for addressing effective adaptation measures in reducing drought risk. However, on a global scale there is lack of effective measures on climate change and weather extreme growing. Therefore, this research aims to evaluate the assessment of agriculture drought risk and adaptation efficiency in semi-arid zone Tanzania by adapting MOVE conceptual framework. The zone is situated within administrative boundary of Kilimanjaro, Manyara, Arusha, Singida, Shinyanga, Morogoro and Dodoma.

Methods followed in this research include Standardize Precipitation Index (SPI) and Precipitation Anomaly Percentage (PAP) which used to characterize drought in terms of drought duration, severity and spatial coverage. By field survey through questionnaires and focus group discussion information on drought vulnerability, drought risk governance and drought adaptation strategies were collected.

From the results obtained it shows that drought occurred frequent in the study area as many drought years were observed in the period of 1981 to 2018. For instance, drought year observed by both SPI and PAP include 1982, 1988, 1993, 1994, 1997, 2000, 2005 just to mention few. Also finding show that women are more vulnerable to drought compare to the other groups as most of women engaged in agriculture production. Based on the effects of drought in Tanzania, both community and government are coming up with ways to adapt to drought in order to minimize the effects of drought. Some of adaptation strategies used in the study area include use of drought tolerant seed, early maturity crops, use of organic manure, use of climate smart agriculture practises such as minimum tillage, irrigation, crop rotation, agroforest, rain water harvest, mulching to mention few.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1. Background

Drought is one of the most pervasive natural hazard caused by prolonged deficit of precipitation over a long period of time, resulting in water scarcity for both human use and ecosystem's demands (Balint, Mutua, Muchiri, & Omuto, 2013). Drought doesn't imply precipitation deficit only but is the result of persistent deficit of humidity below long team average condition in the atmosphere as a result of continuous unbalanced precipitation and evapotranspiration (Şen, 2015). It is recurrent and global devastative phenomena which is accountable for; famine and hunger, deterioration of water resources, increasing wildfire, decline in agriculture production, society conflicts, death of people and livestock among others.

Due to these effects, globally drought has long been considered as the second most devastative and destructive hazard after floods (Belal, El-Ramady, Mohamed, & Saleh, 2014). In India for instance, 330 million people were affected by the 2015-2016 drought, while in China and Ethiopia 10 million people each were affected by 2016 drought (Guha-sapir, Hoyois, Wallemacq, & Below, 2016). In 2015 to 2017 in sub-Saharan Africa, 17 countries experienced drought and over 38 million people were affected (Anyadike, 2017). The recent available data from EMDAT indicate that about 8 million and 2 million people were affected by drought in 2018 in Africa and Asia respectively, in addition to that, over 11 thousand people in America were affected by drought in 2018 (emdat_db, 2018). According to FAO (2018), drought is the leading risk of global agricultural which pose threat to 40% of the global population who depend on agriculture.

These figures show the urgency to improve vulnerability and build more resilient drought societies. One of the method for vulnerability improvement is addressed by Birkmann et al., (2013) in the MOVE framework (Method for the Improvement of Vulnerability Assessment in Europe. The framework underlines hazards, society vulnerability, risk, risk governance and adaptation as key factors to lessening risk and improve adaptation for many hazards including drought. Considering drought is a creeping phenomenon since it effects accumulate slowly over time, it make hard in figuring out it onset and end (Wilhite, Sivakumar, & Pulwarty, 2014). Following this, many studies have been conducted to monitor and analyze drought in order to build more understanding of the processes and how to mitigate, cope and to adapt efficient to it adverse impacts.

Remote sensing is a source of information on drought characterization. For drought monitor, Musyimi (2011) addressed the use of soil moisture and Normalized Difference Vegetation Index (NDVI) using Moderate Resolution Imaging Spectroradiometer (MODIS). Resent study by Su et al., (2017), also addressed drought monitoring using drought indices for example, Palmer Drought Severity Index (PDSI), Drought Severity Index (DSI) and Standardised Precipitation Index (SPI) to mention few to determine severity and duration of events. Due to uncertainties of gauge station meteorological rainfall data which also has missing data some studies have combine both gauge station meteorological data and satellite precipitation data in drought monitoring. For example, studies by Bayissa et al., (2017) and Zhou et al., (2014) compares time series Remote Sensing rainfall satellite data to monitored drought. The main advantages of satellite rainfall data are captures the spatial temporal rainfall variability and the data are recorded over long period which are useful in studying drought (Bayissa et al., 2017).

Despite of the vital role played by remote sensing in drought monitoring and assessment, it's not sufficient in prevent and prepare for drought globally. Therefore, it's necessary to understand underlying factors for drought and established efficiency adaptation measures to reduce the adverse impact. Adaptation means adjustment of human and natural system to climate change so that to lessening the adverse effects associate with climate change (IPCC, 2012). Studies have been conducted in develop effective adaptation measure to drought. For example study by Opiyo et al., (2015) indicate that livelihood diversification, training on livestock husbandry and develop water infrastructure as some of adaptation measures farmers has been use to adapt to drought situation in Northern Kenya. Another study by Nurrahman & Pamungkas, (2014) proposed efficient use of water, use of tolerant crop and changing farming system as drought adaptation.

Given the fact that globally drought and heat events are expected to increase as a result of climate change (Su et al., 2017). Thus, there is a need for robust drought adaptation strategies to be taken from national level to policy levels to lessening drought effects and build more resilient drought communities (Wilhite et al., 2014). To develop robust and effective adaptation measures strategy one needs to assess and evaluate effectiveness of existing drought policies and adaptation measures in reducing drought risks.

1.2. Research problem

Because drought is a creeping hazard as it effects for example water crisis and famine are seen when drought reach it severity, this make hard for drought detection and preparedness. Therefore, study by Wilhite (2016), suggest three pillars namely drought monitoring and early warning, risk assessment and mitigation and response measures as main component to consider in addressing drought management plan. The first pillar on monitoring and early warning focus more on provision of effective and timely information on drought so to reduce and mitigate drought risk in early stage (Wilhite, 2016). The second pillar on drought risk assessment mainly focus to determine element at risk and what factors make them vulnerable and to analyse vulnerability dynamics as vulnerability changes in time depend age, gender, adaptive capacity to mention few (Wilhite, 2016). The last pillar is on drought mitigation and response measure which mainly based on risk assessment at pillar two. Once risk assessment is carried out it easy to plan for effective adaptation measures to reduce impacts of drought at all levels (Wilhite, 2016). There is a need for continuous evaluation of effective adaptation and mitigation measures communities undertake to adjust to adverse effects of drought.

Limited studies have tried to come up with the way to evaluate the effectiveness of adaptation measures. Example study by (Gay, Stubbs, & Galindo-Gonzalez, 2016) uses two approaches namely participatory matrix ranking and scoring and pairwise ranking matrix in decision making. Participatory matrix ranking and scoring method is a systematic procedure which compares a range of options by using ranking and score method, while pairwise ranking matrix it compares listed options against each other's (Gay et al., 2016). Other study by Weiland, S et al., (2014), evaluate effectiveness of adaptation measures in Europe by using outcome approach which considering the outcome of adaptation measures. If the outcome is good it considers as effective. Arfanuzzaman et al., (2016) evaluated effectiveness of climate change adaptation practices in the agriculture sector of Bangladesh based on Adaptation Decision Matrix (ADM) and cost benefit analysis. The effectiveness of adaptation measures is important tool for government to adjust their policies towards drought and climate change.

Knowing that climate change might increase drought hazard, mainly in semi-arid regions (Mary & Majule, 2009 and Wilhite, 2011), there is a need to take necessary actions on assessing and evaluate effectiveness of drought policy and adaptation measures used by communities in drought mitigation. A study by (Mary & Majule, 2009) mentioned adaptation strategies used by community to adapt to the impacts of drought, however he recommended that the adaptation measures needs to be strength. This can be done by analyze the effectiveness of adaptation measures and based on effective adaptation measures selected there is a need for government and policy maker to intervene in strengthen them either by provision of fund, establishment of project to raise drought adaptive capacity of community and formulation of drought policy.

To stress on drought impacts of drought in many Africa countries, first African conference on drought was held in 2016 in Namibia, the key issue addressed was impacts and risk reduction of drought in Africa (Crossman, 2018). The emphasis on drought risk reduction was put in drought monitoring, mitigation, drought policies and reduce causal factors of drought (Crossman, 2018). Also, studies have been indicated the need for nation drought policies and showcase multiple adaptation strategies communities undertake to adjust to adverse effects of drought.

However, most of implemented adaptation strategies in semi-arid areas are reactive which treats the symptoms and effects of drought instead of underlining causes. There is a need of moving from reactive response towards drought planning management. As study by Wilhite (2017) indicate, on a global scale there is lack of effective measures on climate change and weather extreme growing.

Therefore, this study proposes a strategy to evaluate effectiveness of agriculture drought adaptation strategies in the semi-arid zone of Tanzania based on existing national policies. To do so, this study employs adaptation of Method for the Improvement of Vulnerability Assessment in Europe (MOVE) framework which underlines hazards, society vulnerability, risk, risk governance and adaptation as key factors to lessening risk and improve adaptation (Birkmann et al., 2013). MOVE is a framework for vulnerability, adaptation and risk assessment which outline multiple factors to be considered when addressing natural hazard vulnerability (Birkmann et al., 2013). The framework outlines three key vulnerability factors; susceptibility, resilience of a community and exposure of the community to natural hazard to be considered when addressing vulnerability (Birkmann et al., 2013). In additional, MOVE framework is a multidimensional framework which combine different aspect of Disaster Risk Management (DRM) such as risk and risk governance management, adaptation and hazard assessment (Birkmann et al., 2013).

1.3. Research objectives and questions

1.3.1. Main objective

To assess agricultural drought risk management and adaptation efficiency in semi-arid zone in Tanzania by adapting the MOVE conceptual framework.

1.3.2. Specific objectives and research questions

1. To characterize agriculture drought hazard and its severity in semi-arid zone Tanzania, in space and time
   1.1. What are the characteristics of drought in terms of intensity, duration and spatial coverage?

2. To analyze societal vulnerability to drought risk base on exposure, susceptibility and resilience
   2.1. Who does government consider as most vulnerable to drought?
   2.2. What are the causal factors which make them susceptible to drought hazard?
   2.3. What are the strategies and actions government undertake to improve drought resilience (capacity to anticipate, cope and recovery) from drought hazard?

3. To identify available drought governance and their implementation that make people less vulnerable considering exposure, susceptibility and lack of resilience
   3.1. What are the roles of national governmental organizations in drought risk management?
   3.2 What are the pre and post impact government/non-government intervention polices on drought adaptation?

4. Evaluating drought adaptation strategies in the study area
   4.1. What are the existing drought adaptation strategies followed by farmers?
   4.2. Which drought adaptations are more effective and why?

To show the linkage between research objectives and the MOVE framework, the linkage is summarized in figure 1 below.

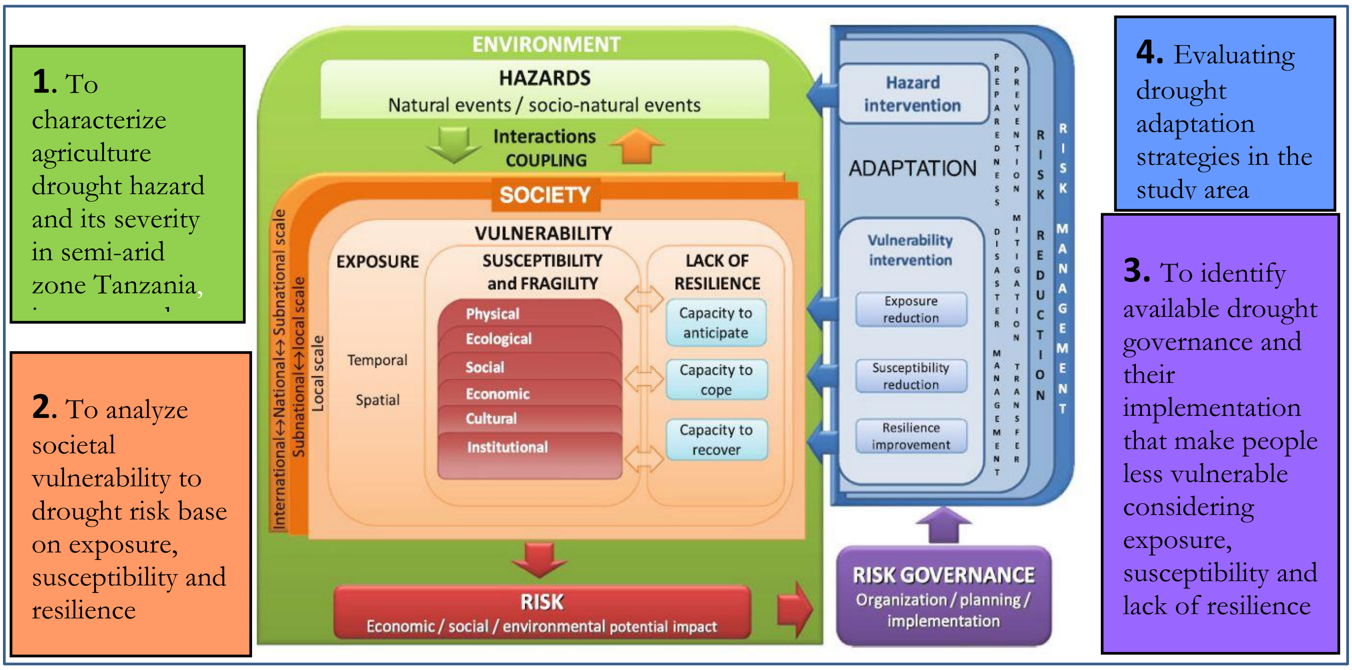


Figure 1: Linkage between research objectives and the MOVE framework

As it shown in the figure 1 above, each objective (numbered from 1 to 4) is linked to different MOVE framework key elements. For instance, objective 1 is linked to the hazard part of the framework, objective 2 is linked to society vulnerability part, objective 3 to risk governance and objective 4 to adaptation part of the framework.

1.4. Structure of the thesis

The structure of this thesis consists of nine chapters. Chapter one is introduction which gives a detail background of the study, research problem, research objectives and questions. Chapter two comprises of literature review which underlines concepts of drought, drought hazard assessment, vulnerability assessment, risk governance concept and adaptation concept in the context of disaster management. Chapter three consists of detail description of the study area including, study area location description, climate overview of the study area and land use of the study area. Chapter four provides methods used to archive research objectives in this study. Chapter five, six, seven eight, provides results of drought hazard assessment, vulnerability analysis, risk governance analysis, adaptation analysis respectively. Chapter nine provides discussion of results and chapter ten provides main conclusion per each research objectives, recommendations and limitation of this research.

2. LITERATURE REVIEW

This chapter provide a detailed description of key concepts used in this study based on literature review. This chapter if divided into seven section. Section 2.1 describes Drought concept, section 2.2 describes Drought types, section 2.3 give a detail description of Drought hazard assessment framework. Section 2.4 illustrate Drought hazard assessement, section 2.5 describes Drought vulnerability, section 2.6 illustrate Drought risk governance in Tanzania and last section 2.7 describes Drought adaptation in Tanzania.

2.1. Drought concept

Drought is complex hazard caused mainly by extreme deficit of precipitation on an area below it long-term average mean (Balint et al., 2013). Drought is not caused only by precipitation deficit, also factors like extreme temperature, low relative humidity, changing in weather patterns like El Nino and La Nina, human factors (deforestation) intensify drought severity (Wilhite et al., 2014). It is difficult to predict drought as it is considered as a creeping phenomenon as its gradually developed and its effects accumulate slowly over time, which make hard in figuring out onset and drought end (Wilhite, 2014, Loon, 2015, Şen, 2015, Tadesse, 2016).

Due to creepiness nature of drought, it makes hard to detect and predict it development on its early stage resulting into negative impacts. By drought impacts means adverse effects resulting from drought occurrence , and can be classified as social, economic and environmental impacts (Şen, 2015). Economic impacts of drought include economic loss due to agriculture loss and crop failure, reduction in agriculture land, low production (meat and milk), forest fire, and plants diseases among others (Şen, 2015). Social impacts of drought include, unemployment to people whose livelihood depend on agriculture, food insecurity result from crop failure, increase in poverty level to mention few (Katalakute et al., 2016). Lastly, environmental impacts of drought include land degradation, reduction of water quality, environmental pollution, water salinity and destruction to animal and plant species (Şen, 2015).

Droughts differs from one type to another depending on three vital characteristics namely; duration, spatial coverage and intensity (Wilhite et al., 2014). Intensity is the extent of drought impacts which can be measured by parting of drought indicators for example precipitation deficit, reduction of stream flow and reservoirs level (Wilhite et al., 2014). The duration is the overall period of drought from it commenced to it end, and ranges from months and extends to years (Lee et al., 2017). Furthermore, drought can be distinguished based on characteristic of its spatial coverage. Spatial coverage refers to extent of area covered by drought which develops slowly and can extend to other region (Wilhite et al., 2014).

2.2. Drought types

Drought can be classified into three distinct types namely; meteorological, agricultural, and hydrological drought (Belal et al., 2014, Loon, 2015, Nagarajan, 2009). Figure 2 show the above mentioned three drought types and concatenation of drought occurrence with their impacts and causal factors.

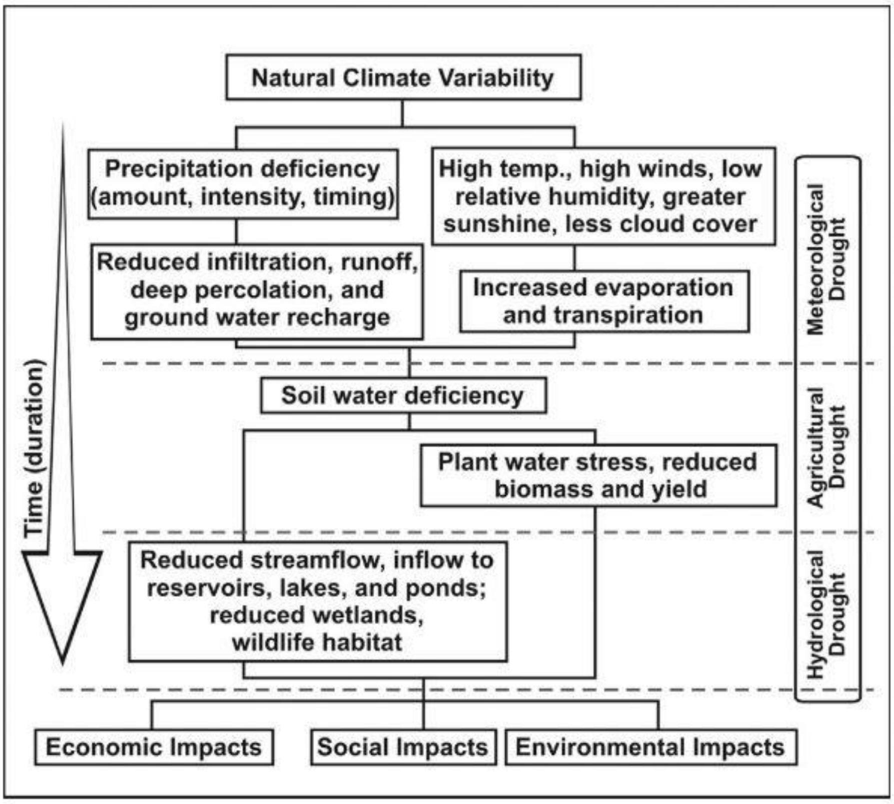


Figure 2: Drought types, characteristics and causal factors; Source: (NDMC, 2019)

Figure 2 above show linkage between various types of drought, its characteristics and causal factors. Meteorological drought refers to shortage of rainfall below long team average observed in a region (Nagarajan, 2009). It mainly caused by precipitation deficiency, but factors like high temperature, high wind, less cloud cover and low relative humidity escalating it severity (NDMC, 2019). Meteorological drought can be measured by precipitation deficit in terms of decade, yearly and seasonal based (Nagarajan, 2009). Agricultural drought is defined by deficit in amount of soil moisture and water to support plant growth. Deficiency in amount of soil moisture has a direct effect on agricultural crop production, resulting into crops water stress, reduction in biomass and crop yield (NDMC, 2019). Hydrological drought does not consider precipitation shortfall only but also take into account decrease in surface and subsurface water availability which causes low stream flow, reduction in groundwater level and low level of rivers, lakes and reservoirs (Şen, 2015). All drought types emerge from precipitation shortfall, but factors like climate change, temperature rise, low relative humidity and high prevailing winds increase its intensity (Wilhite et al., 2014). For instance meteorological drought is more associated to precipitation deficit, but when it persist for a extended duration other drought types such as agriculture and hydrological develop (Wilhite, 2000).

2.3. Drought hazard assessment framework

To reduce drought impacts in the societies, different studies have come up with framework on how to assess drought hazard and reduce its impacts. In recent study by Crossman, 2018, came up with a framework of drought assessment called Drought Resilience, Adaptation and Management Policy (DRAMP) Framework. To lessening drought impacts, DRAMP framing drought hazard into six elements namely; exposure reduction, vulnerability reduction, resilience increase, drought risk transfer, transformation and drought preparedness, response and recovery (Crossman, 2018). DRAMP framework act as holistic approach in reducing drought impact by integrating the above mentioned elements (Crossman, 2018).

Another framework of drought hazard is Methods for the Improvement of Vulnerability Assessment in Europe (MOVE). MOVE is a multidimensional and holistic framework for assessing vulnerability to hazard which take into consideration hazard, vulnerability, adaptation and risk governance to lessening the negative effect of hazard(Birkmann et al., 2013). It was developed for flooding, drought, heat waves, forest fire and storms, earthquakes, landslides and mudslides, earthquakes. The overall goal of MOVE framework is to improve knowledge and understanding for assessing vulnerability to natural hazard taking into consideration key causal factors for hazard like resilience, exposure and susceptibility. Also, the framework underlines adaptation and risk governance for hazard as key element needed to be considered in reducing societal risk and improving resilience, capacity to cope, adapt and recover from hazard (Birkmann et al., 2013). Key elements for vulnerability used in the MOVE framework are the exposure, susceptibility and lack of resilience. Starting with exposure, it describes how element at risk (people, infrastructure, economies, livelihood) fall inside the hazard prone area (UNISDR, 2017). Element at risk are exposed to drought risk for different reasons. Susceptibility define the probability for element at risk to get harm from a risk to hazard. Lack of resilience, in a society lack of resilience can be determined by the restrains which limit the community to respond effectively on hazard which can be because of limited resources in respond and recover from hazard (Birkmann et al., 2013). And lastly, the framework underlines risk governance as all activities performed by government institutions, NGO's, research institutions to oversee and put implementation measures in place to mitigate, managed and reduce societal risk from hazard (Birkmann et al., 2013).

In this research conceptual MOVE framework (figure 1) for evaluating drought risk, vulnerability and adaptation strategies is followed. The choice of adapting MOVE framework in this research because it's a holistic and multidimensional approach which act as a linkage between many concepts of disaster risk reduction and consider hazard, adaptation, and governance, vulnerability which are key element in this study. Therefore, the MOVE framework is a perfect tool for assess drought hazard in this research as it integrates all important element in this study such as adaptation, vulnerability (i.e. exposure reduction, susceptibility and lack of resilience) and risk governance which helps in risk reduction and improve adaptation. Therefore, in the coming section, key elements of this study (hazard assessment, vulnerability, risk governance and adaptation assessment) which are also key component of MOVE framework will be explained in the context of Tanzania.

2.4. Drought hazard assessement

Tanzania has a long record in suffering from periods of natural hazards and one among them been drought. Drought is the most affecting hazard in Tanzania especial in the central and Northern part of Tanzania where livelihood depends much on rain fed agriculture (Yanda et al., 2015, Red Cross, 2011). Study by Kajumba, 2018, shows that, the trend of rainfall in Dar es salaam, Tanga, Dodoma, Kilimanjaro, Arusha, Manyara, Morogoro, Singida, Shinyanga regions in Tanzania has decreased over the period of 1982 - 2012. Since 1980 to 2008 Tanzania has suffered from 65 major hazards 26 been epidemic diseases, 24 flood and 6 drought, where drought has been considered as the most deadliest hazard which affect many people than other hazards (Costella & Machume, 2009).

Drought have caused adverse socio-economic and environmental impacts in Tanzania economy. Annually, the agriculture sector in Tanzania lose 200 million US dollar because of drought, also in the Northern regions of the country, about 80% of livestock died following the 2009 drought (World Bank, 2017). According to Kilasara et al., (2015) about 45% to 55% of households in central regions of Tanzania are food insecure caused by drought. In additional to that by 2030, 5% of central regions population will undergo famine even if drought severity and intensity will remain constant (Swiss Re, 2018). Furthermore, drought pose a threat to industrial sector in Tanzania which largely depend on hydroelectrical power for example, hydroelectric power crisis of 2006/2007 cause blackout and power rationing which affect production activities in the nation (Shemsanga, Omambia, & Gu, 2010). To reduce drought risk and its impact, it necessary to build more resilient drought communities by reducing exposure, vulnerability, risk through risk transfer, (Crossman, 2018).

Drought hazard have been assessed using different methods, for instance Normalized Difference Vegetation Index (NDVI), Palmer Drought Severity Index (PDSI), and Standardised Precipitation Index (SPI) (Belal et al., 2014). SPI based drought assessment is the index used to characterize drought and it severity based on accumulative rainfall observed on a weather station for a long period, preferred over 30 years (WMO, 2012). While PDSI use two indicators which are precipitation and potential evaporation in drought assessment (Belal et al., 2014). NDVI is a remote sensing based indicator which use near infrared and visible band to assesses the health (greenness) of vegetation (Nagarajan, 2009). Other method used in drought hazard assessment is precipitation anomaly percentage (PAP). PAP is a drought assessment index which show percentage of precipitation observed in a region as an average of a long term rainfall mean (Yang & Wu, 2010). In this study two approaches are used in assessing drought hazard SPI and PAP. Reason for selection of PAP and SPI is because most of drought occurred in East Africa are associated with meteorological drought which is assessed mainly by precipitation indicator as both indices use precipitation to assess drought (Ntale & Gan, 2003). Also in the same study of Ntale & Gan, 2003, shows that, SPI is the best index in assessing drought in East Africa as it adapt well to Est Africa climate, easy to calculate and it produce more uniform results over East Africa (Ntale & Gan, 2003).

2.5. Drought vulnerability

In Tanzania factors which are contribute to any hazard vulnerability are gender, education, location, poverty, special need groups (children, disabled and elderly) (URT, 2012). About 80% of Tanzania economy depend in agriculture which is mainly rainfed agriculture which make the sector to be more vulnerable to drought (URT, 2012, FAO, 2016, & Hamisi, 2013) . Big percentage of working group in agriculture in Tanzania are women (Mollet & Barelli, 2016) hence make them more vulnerable. In most African country's women tend to suffer more to drought because of the gender role and gender stereotype (FAO, 2016). This is because women are assigned to household activities most especially in food production (Ncube, Mangwaya, & Ogundeji, 2018). About 34% of population in Tanzania live below poverty line due to low income which makes many people to be vulnerable to hazard due to limited resource to anticipate, cope, and recover from any hazard shock (URT, 2012). Considering agriculture in Tanzania is mainly rainfed, it makes people engaged in agriculture to be more exposed and susceptible to drought.

2.6. Drought risk governance in Tanzania

Disaster Management Department (DMD) under Prime minister's office in Tanzania, is the main actor and focal point for disaster management (URT, 2012). DMD collaborate with Tanzania Meteorological Agency (TMA), research institutions, NGO's, UN agencies, Environmental division Unit under Vice President's office and Ministries including Ministries of agriculture, Ministry of Livestock and fisheries, Ministry of water in managing drought condition (S. Osima, 2013). Under DMD there is Tanzania Disaster Relief Committee (TANDREC), Disaster Management Committees (from regional to village level) and Department of Regional administration and local government (PMO-RALG) with the role of coordinate and monitor emergency, develop emergency plan for hazards and provide relief support to the community affected by hazard (URT, 2012). On the other hand, TMA is the leading agency for monitoring and providing timely and effective drought early warning to the community.

2.7. Drought adaptation in Tanzania

In Tanzania adaptation measures to drought differs depending on agroecological zone as different agroecology have it adaptations measures which are suitable in that area compare to the rest (URT, 2017). Agroecological zones in Tanzania, differs in terms of the climatic condition on each zone and the amount of rainfall surplus. Tanzania Ministry of Agriculture has developed a guideline for improving drought adaptation in agriculture sector called Climate Smart Agriculture (CSA). The CSA package are developed to adapt to climate change and drought in agriculture sector based. For example, use of drought resistance seeds (cassava, sorghum, millet), water harvesting, conservation agriculture example crop rotation, mulching to mention few (URT, 2017). Tanzania also is a representative of The United Nations Convention to Combat Desertification (UNCCD). And as a member Tanzania has develop project for adapting and combat desertification like tree KIJANICHA Dodoma project aiming at turning Dodoma region to be green by planting trees which will reduce the impacts of drought (Majule, 2018). Also study by Mongi et al., 2010 & Mary & Majule, 2009 indicate that, farmers in Tanzania are adapting to drought hazard by livelihood diversification (engaged in non-agriculture activities), cultivating on wetland, improvement of soil fertility, mixing crop cultivation and soil tillage practises.

3. LOCATION AND STUDY AREA DESCRIPTION

This chapter provides a detailed description of the study area. Section 3.1 describes Study area location, section 3.2 describesClimate overview of the study area including agroecological zones, rainfall patterns and agriculture crop calendar. Lastly, section 3.3 provide a detailed description of the dataset used in this study.

3.1. Study area location

The study area is situated within administrative boundaries of drought prone areas of arid and semi-arid land (ASAL) of the Central and Northern part of Tanzania, Africa (Figure 3). The area is comprising of several provinces including; Singida, Dodoma and Shinyanga to the Central part and Kilimanajro, Arusha, and Manyara to the Northern part and some part of Morogoro to the Southern part of Tanzania. The area has elevation ranging from 53m to 5778m above sea level which comprises with gently undulating landscape, rift valley, and rocky hills with poor drained soil which has low fertility (Yanda et al., 2015). The area is characterized by very long dry period with short rain season which falls from December to March. The main livelihood strategies on the study area is agriculture which is mainly rain fed (URT, 2017, Yanda et al., 2015, Barelli et al., 2016 & URT, 2012). Summary of characteristic of the study area which includes population per administrative boundary and economic activity is presented in Figure 3.

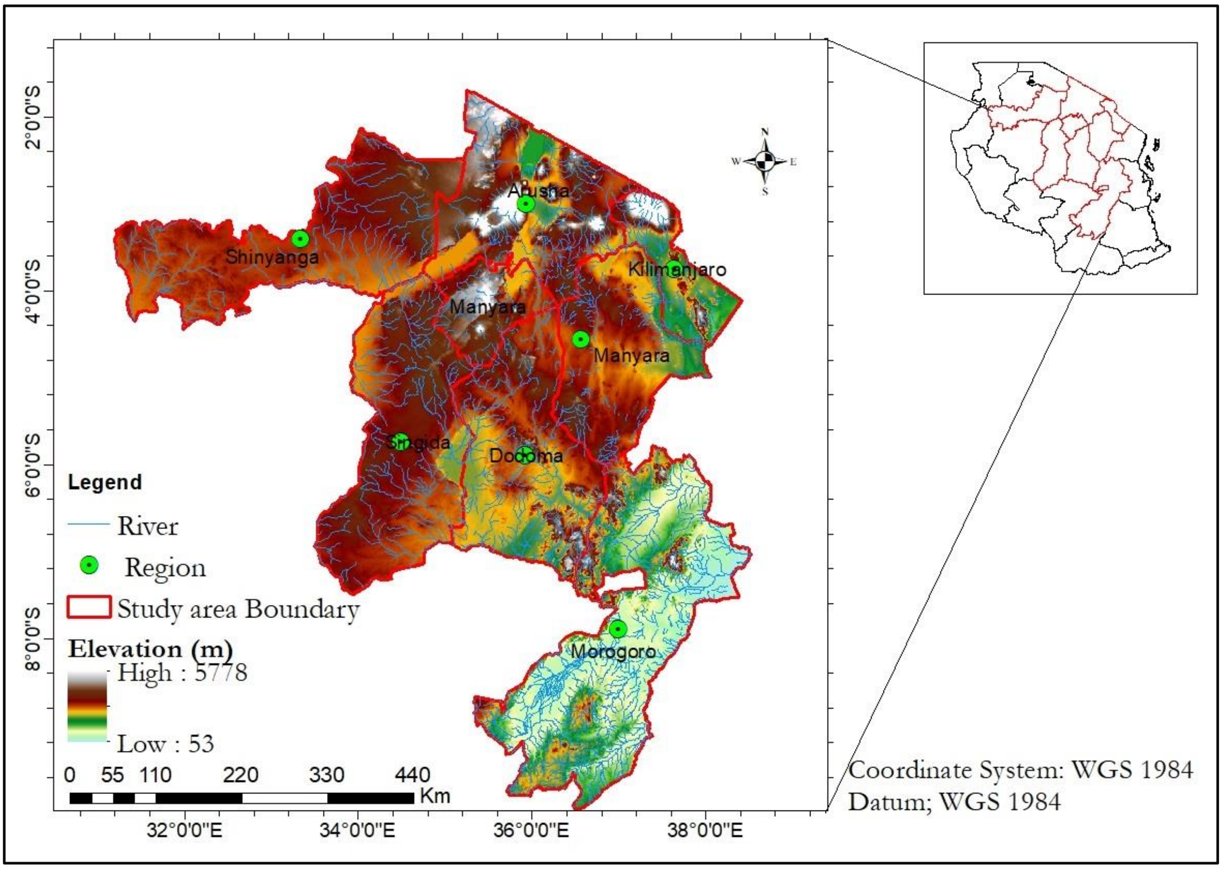


Figure 3: Location of the study area

Figure 3 above show the location of the study area with administrative boundaries which will be used to assess in drought hazard assessment using SPI and PAP as discussed under section 2.4 Drought hazard assessement. Furthermore, administrative boundaries will be used in assessing vulnerability. The selection of study area was chosen mainly because of two main reasons. The first reason is the area is prone to drought as it has been affected by frequent series drought from 1980 to 2008 hazards due to it arid and semi-arid climate (Costella & Machume, 2009). Second reason, most of areas within the ASAL are highly degraded due to human activities like overgrazing, deforestation, shifting agriculture which makes the area even drier and prone to drought (Figure 4).

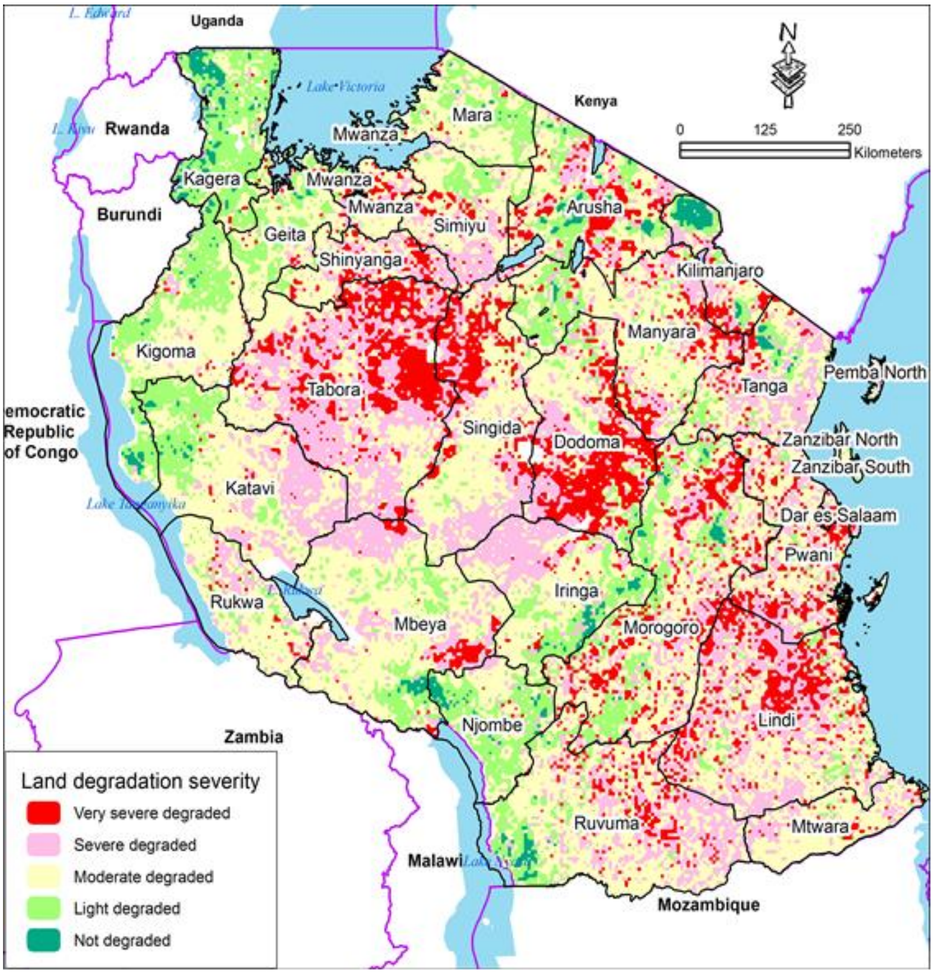


Figure 4: Land degradation severity map of Tanzania; Source: (Majule, 2018)

Figure 4 above show land degradation map of Tanzania. As it shown in figure five, areas which are present within ASL of Tanzania as discussed above are also highly degraded. Land degradation map of Tanzania was produce by three dataset, soil organic carbon, land productivity and land cover by using land degradation drivers such as poverty, deforestation through charcoal production, overgrazing and poor farming system (Majule, 2018).

Table 1 below show characteristics of study area including male and female population and employed population and percentage of women population employed in agriculture per regions.

Table 1: Characteristics of the study area based on census data of 2012; Source: (URT, 2016)

Regions	**Dodoma**	**Singida**	**Shinyanga**	**Kilimanjaro**	**Arusha**	**Manyara**	**Morogoro**
Population	Male						
	1,014,974	677,995	750,841	793,140	821,282	717,085	1,093,302
	Female						
	1,068,614	692,642	783,967	846,947	873,028	708,046	1,125,190
Economic activities	Total employed population						
	852,195	550,598	562,452	722,386	658,672	563,944	996,997
	Agriculture						
	71.5%	66.0%	60.9	60.4%	37.7%	57.8%	71.2%

From Table 1 above, more women employed in agriculture are found in Dodoma and Morogoro 71.5% and 71.2% respectively while the least region with low percentage of women in agriculture is Arusha.

3.2. Climate overview

In general Tanzania falls under tropical climate which influenced mainly by inter tropical convergence zone causing variability in dry and wet seasonality (Malozo, 2014 & Barelli et al., 2016). Agroecological zone develop as a result of variability and wet seasonality in Tanzania (Malozo, 2014). Agroecological zone varies in place to place depending on dry and wet condition for a particular regions (URT, 2017). Agroecological zone is shown in figure 5 below.

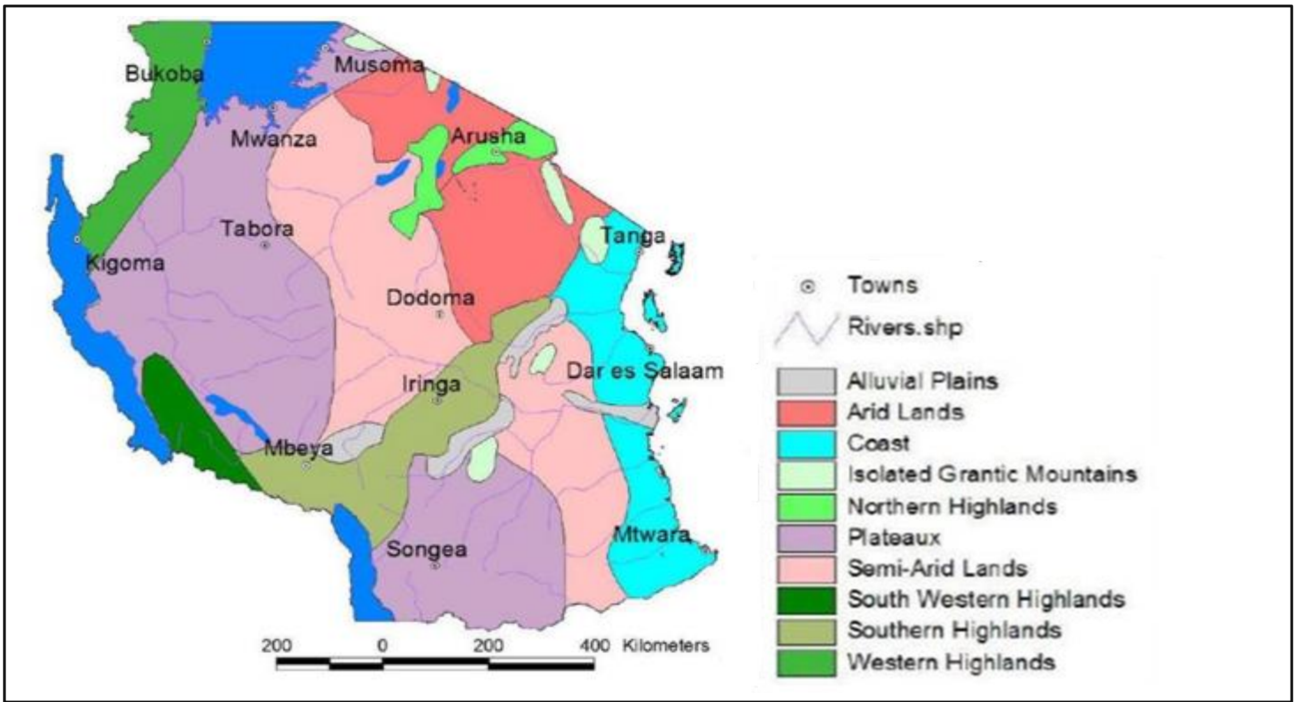


Figure 5 : Agroecological zone of Tanzania; Source: (Mollet & Barelli, 2016)

Figure 5 above shows the agroecological zones of Tanzania ranging from alluvial plains, arid and semi-arid lands, coast, high lands and plateaus. Administrative boundaries (Arusha, Kilimanjaro, Dodoma, Singida, Manyara, Shinyanga and Morogoro) lies within arid and semi-arid in agroecological zone.

3.2.1. Rainfall patterns

Study area follows two rainfall pattern regimes namely, unimodal and bimodal (Yanda et al., 2015). Unimodal rainfall regime is found in all the administrative region boundaries of the study area except for Arusha and Kilimanajro which follows bimodal rainfall regime (Red Cross, 2011). Unimodal rainfall regime or Msimu receive only one rain season starting from November to May while bimodal rainfall regime receive two rainfall seasons, short rainfall season (vuli) and long rainfall season (masika) (Yanda et al., 2015). Vuli rainfall starts from September to January while Masika rain starts from March to April (Red Cross, 2011). Rainfall ranges from 200mm to 1400mm per year (see figure 6 below). People who engaged in agriculture production, use these two regimes as a crop calendar in farming activities from planting to harvest. Figure 7 below indicate cropping calendar of Tanzania.

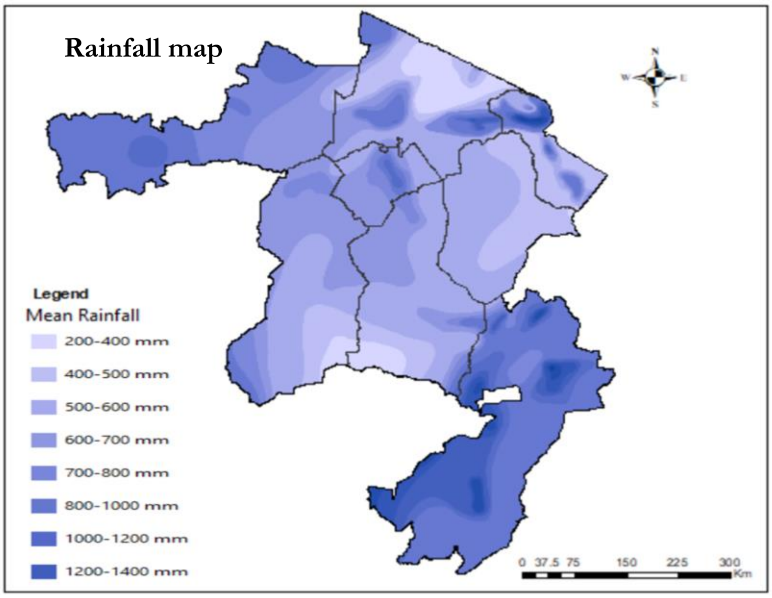


Figure 6: Rainfall map: Source: GIS online, 2019

Figure 6 above show spatial variation of rainfall in the study area. Rainfall ranges from 200mm to 1400mm per year. The region which receive less rainfall includes Dodoma, Manyara, Arusha, Singida while regions with high amount of rainfall is Morogoro and some part of Shinyanga.

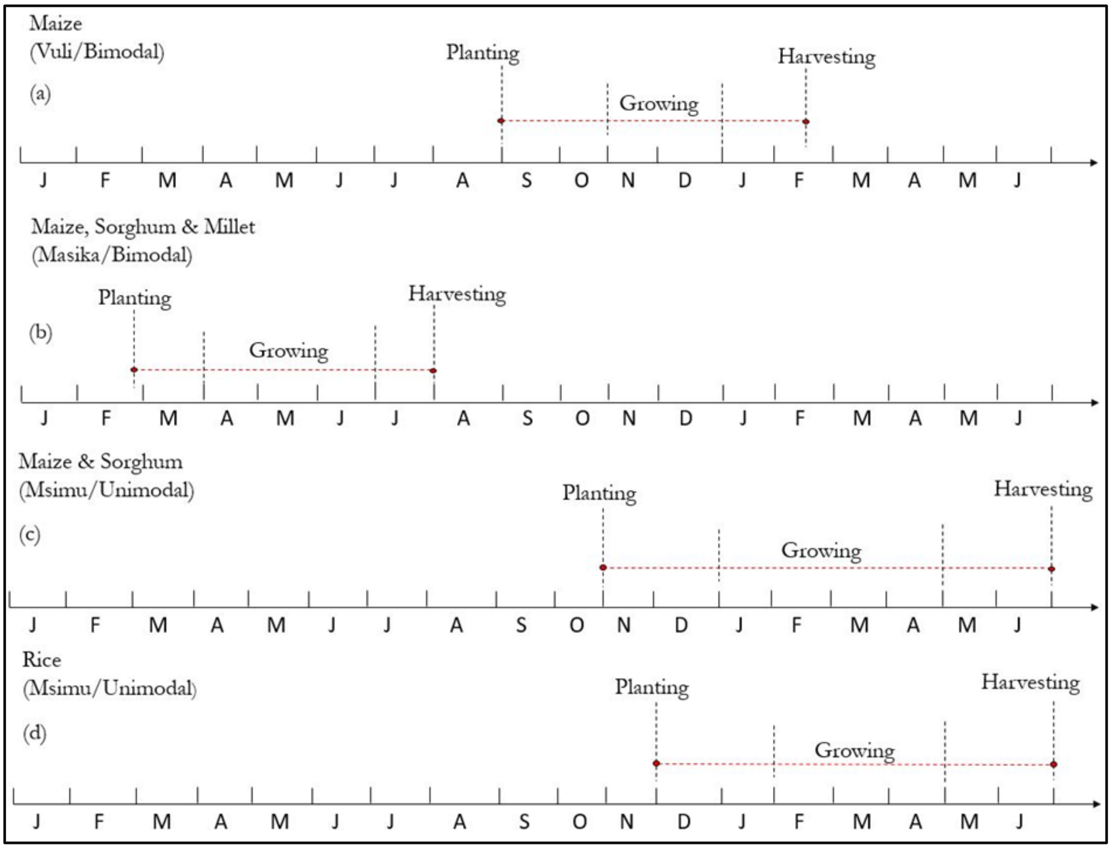


Figure 7: Crop calendar of Tanzania; Based on (FAO, 2018b)

Figure 7 above show crop calendar of Tanzania in unimodal and bimodal rainfall regimes with its main crops. It observed that, agriculture season start from September to mid-February in vuli (bimodal) and from mid-February to July Masika (bimodal) while unimodal (Msimu) starts from November to July.

3.3. Agriculture Land use and land cover map

Agriculture sector employs about 75% to 77% of Tanzania population and contributing 95% of the food security (Gacsa, 2016). Despite of the importance of agriculture in Tanzania economy the sector suffer much loss due to drought condition and over dependence on rainfed agriculture, as about 80% of population depend on rainfed agriculture (Gacsa, 2016). Therefore this make possible for most of the areas especially the semi-arid areas to adapt to the situation mainly through the use of drought tolerant varieties such as sorghum, millet and cassava (Yanda et al., 2015& Gacsa, 2016). Figure 8 below show agriculture land use in the study area.

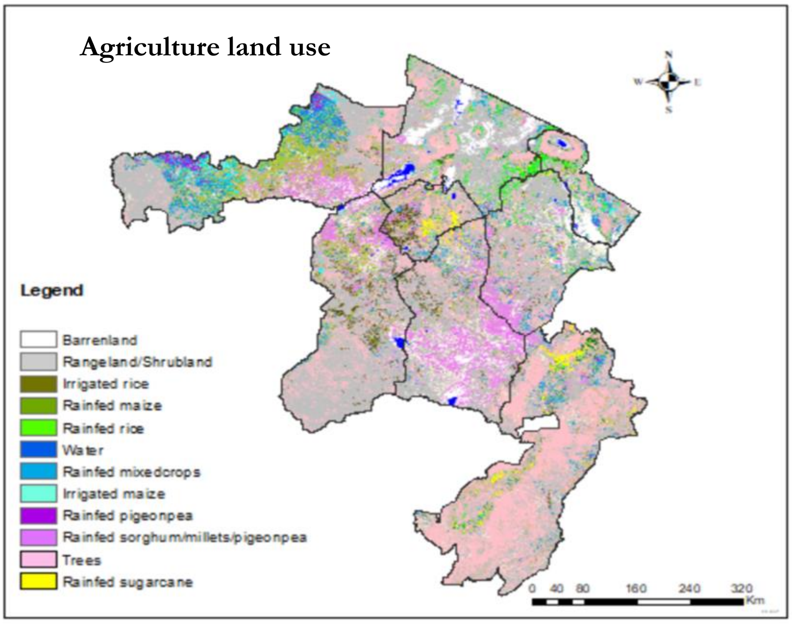


Figure 8: Agriculture land use map: Source; GIS online, 2019

From figure 8 above it shows agriculture land use in the study area is which include rainfed rice, maize, pigeon pea, sugarcane and mixed crops, also the map comprises of drought tolerant crops such as sorghum and millet which can be seen in most part of the study area. Furthermore, rangeland/shrubland is mostly dominated on the map.

4. DATASET AND METHODOLOGY

4.1. Data source

This study employed the use of both secondary and primary data. Primary data which was collected from the field comprises of key informants' questionnaires and key informant interviews from Tanzania government Ministries, focus group discussion and transect walk from farmers in Kikombo village in Dodoma. Secondary data include Climate Hazards group Infrared Precipitation with Stations (CHIRPS) satellite rainfall dataset from1981 to 2017 retrieved from http://chg.geog.ucsb.edu/data/chirps/. CHIRPS is a near global (50^0S 50^0N), with high resolution 0.05^0 timeseries dataset available from 1981 to present (Funk et al., 2015). CHIRPS data was produced by scientists at the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center to support Famine Early Warning System Network (FEWS NET) and drought monitoring (Funk et al., 2015). Unlike other satellite rainfall products like Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN), Climate Prediction Center MORPHing Technique (CMORPH), CHIRPS are blended with in situ station data to create a gridded precipitation dataset timeseries to fill the gaps on the gridded dataset. The reason for selecting CHIRPS dataset is because it is blended with station data which give good estimation on rainfall. Also, other secondary data set used in this study includes, Tanzania 2012 census data, Tanzania documents on agriculture drought adaptation and policies and GIS shapefiles of Tanzania. GIS shapefiles was then used to create a study area boundary. All dataset in this study together with their format, sources and their link to MOVE framework is summarized in table 2.

Table 2: Dataset summary with it format and source in relation to research questions and MOVE framework

Data type	**Data format**	**Data source**	**Acquisition date**	**Link to MOVE framework**
What are the characteristics of drought in terms of intensity, duration and spatial coverage?	Tif images	Online source	November 2018	Hazard
Who does government consider as most vulnerable to drought?	Questioners and Focus group discussion	Key Informants Field	October 2018	Vulnerability
What are the causal factors which make them susceptible to drought hazard?	Questioners, Focus group discussion and reports	Key Informants Field	October 2018	Vulnerability
What are the strategies and actions government undertake to improve drought resilience (capacity to anticipate, cope and recovery) from drought hazard?	Questioners	Key Informants	October 2018	Vulnerability
What are the roles of national governmental organizations in drought risk management?	Questioners, interviews and reports	Key Informants	October 2018	Risk governance

What are the pre and post impact government/non-government intervention polices on drought adaptation?	Questioners and reports	Key Informants	October 2018	Risk governance
What are the existing drought adaptation strategies followed by farmers?	Focus group discussion and reports	Field	October 2018	Adaptation
Which drought adaptations are more effective and why?	Focus group discussion	Field	October 2018	Adaptation

Table 2 above shows summary of dataset used in this study together with their format and source in relation to research questions and MOVE framework.

4.2. Pre-fieldwork phase

In this phase of research, it describes all the activities that was conducted before going to the field. The activities are outlined as follows:

- Working on design questionnaires, interviews and focus group discussion in relation to the research objectives and questions.
- Making further literature review on agriculture drought adaptation in Tanzania including reviewing on most drought prone areas, agriculture drought vulnerability, Tanzania agriculture drought governance, policies and agriculture adaptation strategies. This was done to get more insight of agriculture drought in Tanzania.
- Identification of potential stakeholders. Stakeholders was identified in the based on Key informants who work and have knowledge on drought problem in Tanzania from different organizations like government Ministries, research institutions, NGO's. Also, people who are directly affected by drought especially farmers.

4.3. Fieldwork phase

Under this phase, it involved all activities required to gather and collect both primary and secondary data. All activities conducted during fieldwork stage are as follows:

- Community entry
- Sample strategy design
- Key informant questionnaires
- Key informant interviews
- Transect walk
- Focus group discussion
- Documents review

4.3.1. Community entry

Community entry was conducted from 1st, 2nd, 3rd, and 11th October 2018. Under this step, it involved visiting specific identified Ministries (see table 3) for seeking to fulfil all protocols regarding the research and to identify entry points, contacting and seeking schedules/venues with Key informants. Also, to make the authority of about my research and what data I expected to collect. This gave the author a broad insight of which organizations to visit and collect more data on agriculture drought risk management and adaptation efficiency.

4.3.2. Sample design strategy

The selection of sample used under this study involves two main sampling techniques namely; Purposive or judgmental and Convenience sampling. Purposive or Judgmental sampling was used for selecting key informant stakeholders in administration of questionnaire survey who have more insight in agriculture drought in Tanzania. Purposive or judgmental is a sampling technique where respondents are selected based on the kind of information they have which is believe it cannot be found elsewhere (Taherdoost, 2016). This sample technique is useful when a researcher has a prior motive in mind. The reason for using purposive sampling method was because of gather information on policies, vulnerability and national adaptation which can be only provided by specified government ministries and officials. Another sampling method used was convenience in selecting members to engaged in focus group discussion in gathering data on agriculture drought adaptation from farmers perspectives. Convenience sample is the sampling technique where sample is selected by using respondents who are available at the moment (Taherdoost, 2016). This sample method was used to obtain responds from Kikombo village who were ready and present at that moment. The head of the village was the one who helped to organize and select participants who were then engaged in focus group discussion.

4.3.3. Key informants' questionnaires

Ten key informant questionnaires were carried out from 5th, 8th – 12th, and 15th October 2018. The purpose for conducting questionnaires was to collect drought information on vulnerability, governance, policies and agriculture drought adaptation strategies. The method used to administer the questionnaire was face to face interviews where interviewer ask questions direct to the respondents. The reason for selecting this type of questionnaire administration was that it was easy to explain the questions and clear misunderstands to the interviewee as to reduce bias and wrong interpretation of the questions. The interviewee were key stakeholders from government organizations whose roles are to conduct drought vulnerability assessment, drought adaptation guidelines and policies. The key stakeholders and their respective organisation visited during field work are summarized in table 3. The design of questionnaires consists of open and close ended questions, but majority being open ended questions (Appendix 1). The reason for choosing open ended questions was to elicit more information on agricultural drought from the respondents which can't be done using close ended questions. Key informant's questionnaire consists of two main parts:

Part 1: Agriculture drought vulnerability considering exposure, susceptibility and resilience: This part of questionnaire focus on elicit information on societal vulnerability to agriculture drought considering exposure, susceptibility and resilience. Most of the questions based much extract more information on things like indicators of drought vulnerability, most vulnerable people affected by drought, causal factors of drought vulnerability and practises government employed to build resilience to agriculture drought in drought prone areas. This part of questionnaires was employed to answer objective two and its corresponding research questions.

Part 2: Drought governance: This part of questionnaire covers drought governance in semi-arid area Tanzania. The focus of this section is to elicit information on which organization/institution engaged in drought issues, and what support services do they provide, kind of drought management approach they use, pre and post government intervention on drought adaptation. This session of questionnaires answers objective number three and its corresponding research questions.

Table 3: Summary of Key Informants stakeholders participated in questionnaires survey together with their respective organization/Institutions, department and position

Organization	Department	Position	Number of participants
Vice President Office (VPO) Division of Environment	Environment	Forest officer	1
		Project Coordinator of Reversing Land Degradation trends and increasing Food Security in degraded ecosystems of semi-arid areas of Tanzania (LDFS)	1
Ministry of Agriculture	Environment	Agriculture officer	1
	National Food Security	Agriculture officer	1
Prime Minister's Office (PMO)	Disaster Management Department (DMD)	Disaster Risk Reduction specialist	1
		Economist and Disaster Risk Reduction Coordinator	1
Ministry of Livestock and Fisheries Development	Policy and Planning	Economist	1
	Veteran services	Principle Officer	1
	Production	Assistance Director	1
Dodoma Regional Secretarial	Agriculture	Disaster Focal Personal	1

4.3.4. Key informant interviews

Key Informant interviews were conducted on October 4th and 11th 2018. The interviews were carried out to give more information on drought governance in Tanzania, focus on general drought organization structure from top to the bottom level, and all stakeholders involved in drought management and their roles. Key informant interviews were conducted by the means of note taking through face to face communication. Key informants participated in interview are summarized in table 4. The interview was semi-structured /focused with only two open ended questions:

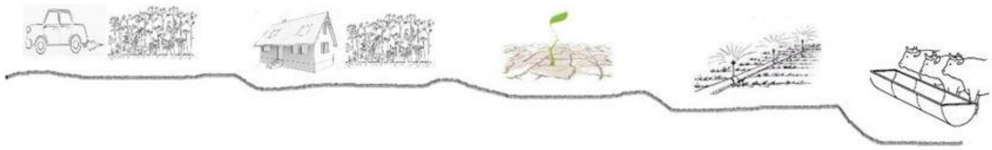
- In a descending order who is engaged/organizations in drought management in Tanzania
- What are their roles

Table 4: Summary of Key informants

Name	Organization	Department	Position	Date
Prosper Makundi	Ministry of Agriculture	Environmental Management Unit	Principle Agriculture Officer	4th October 2018
Ally J. Mwatima	Prime Minister's Office (PMO)	Disaster Management Department (DMD)	Economist and Disaster Risk Reduction Coordinator	11th October 2018

4.3.5. Transect walk

Transect walk was conducted on 13th October 2018 in Kikombo Village, Dodoma region. The purpose of transect walk in this research was to have a direct observation agricultural drought in one of semi-arid village in the study area and to see the resources and capacity in place to adapt to drought. Transect walk is a Participatory Rural Appraisal (PRA) tool for describing location, land use, vegetation cover, economic activities to mention few, of a place through walking on the study area along with community members (World Bank, 2016). Due to time limitation, only one village called Kikombo in Dodoma was visited. The choice for visiting Kikombo village was because is one of the most drought affected village in Dodoma (E. Nyankweli et al, 2016). Also, according to (URT , 2016 & Arce & Caballero, 2015), the village is in one among the most drought affected region in Tanzania. During survey in Kikombo village, transect walk was led by Village chairman (Eliakimu Nghambi Kutusha) along with other villagers in exploring adaptations used by farmers and drought impacts. A schematic diagram of transect walk route taken at Kikombo village during field visit is summarized in figure 9



Land use	Road	Settlement	Dry agriculture fields	Irrigated agriculture fields	Open yard for livestock
Vegetation	Trees and shrubs	Trees and shrubs	-	-	-
Crops	-	-	Maize, sorghum, millet	Maize, vegetables, grapes, tomatoes, millet, sorghum	-
Livestock	-	Chicken, goat, cow, duck	-	-	Cow, goat

Figure 9: Transect diagram of Kikombo village Dodoma: Source: Author, 2018

Figure 9 show a transect walk diagram of Kikombo village in Dodoma Tanzania produced by author in 2018. The transect walk diagram shows land use plan, vegetation, crops and livestock of the village.

4.3.6. Focus group discussion

Nine focus group discussion were conducted from 13th to 14th October 2018 in Kikombo village Dodoma. The purpose of conducting focus group discussion was to attain more information on agriculture drought adaptation strategies from farmers perspective. The questions were open ended focusing on existing agriculture drought adaptation and its efficiency. Also, the questions tried to elicit more information on vulnerable groups affected by agriculture drought and causal factors for vulnerability, effects of drought on agriculture production and practises employed by the government to build resilience to drought. Furthermore, the questions tried to outline how farmers preparing to cope with drought effects during normal years/no drought years, and adaptation used to cope with adverse impacts of drought, how do they measure the effectiveness of adaptation measures. And lastly, based on their opinion what should be done to improve efficiency of adaptation measure in compacting negative impacts of drought in agriculture sector. The participants involved in the focus group discussion varies based on gender, age group and religion difference. Each group had participants range from 4 to 6 and only agriculturalist with length of stay for about 20 years and above. This selection was made to include respondents who experienced drought events from 1981 to present to get more information on past drought adaptation strategies and their efficiency. A summary of participant engaged in focus group discussion is summarized in table 5 below.

Table 5: Summary of focus group discussion demographic

Date	Group Number	Female	Male
13th October 2018	1	3	3
	2	1	3
	3	2	2
	4	2	3
14th October 2018	5	2	2
	6	2	2
	7	1	1
	8	2	2
	9	4	2
	Total	**19**	**20**

4.3.7. Document analysis

Document analysis was done throughout the entire research process meaning that, before, during and after fieldwork phase. Document analysis is among qualitative data collection tool used in reviewing existing documents for the aim of analysing and interpret it content so as to gain more information to answer one's research question (Bowen, 2009). As a data collection tool, document analysis is used when a researcher wants to gather more information on a particular subject and gain understand on particular matter to answer the unknown (Bowen, 2009 & CDC, 2018). Document analysis has many advantages among few are it relative inexpensive data collection tool, consume less time to administer and it is a good source of information (WBI Evaluation Group, 2007 & Egbrink, 2013).

In this study document analysis was used in two part, one being to analyse agriculture drought adaptation strategies. On this part, relevant document was selected to study and analyse adaptation strategies to adapt to agriculture drought recommended by the government to be employed in semi-arid zone Tanzania. The second part of document analysis was to extract some quantitative data on causal factors of agriculture drought susceptibility. This section of document analysis was used as a means of triangulation between quantitative data collected from the field using questionnaires survey and quantitative statistic from the document to back up the qualitative data. All the document used under this study are presented on table 6.

Table 6: Document used for analysis in this study

Document Selected	**Data analysed**	**Data Source**
Climate smart agriculture guideline	Data on agriculture drought adaptation strategies from government perspective	Ministry of Agriculture
National Sample Census of Agriculture Small Holder Agriculture Volume II: Crop Sector – National Report	Quantitative data on causal factors for agriculture drought susceptibility	The National Bureau of Statistics (NBS)
Basic Demographic and Socio-Economic Profile 2012 Population and Housing Census of Dodoma, Singida, Shinyanga, Kilimanjaro, Arusha, Morogoro and Manyara regions		
Study of Rainfall Trends and Variability Over Tanzania		Online source (Author Juma Hamisi)

4.4. Post-fieldwork phase/ Data analysis methods

In this phase of research, it involves all activities needed to process and analyze data obtained during fieldwork, and presentation and discussion of results. Tools such as Microsoft Excel, Atlas Ti, Arc GIS, ILWIS, Standardized Precipitation Index (SPI) generator was used in processing and analyzing data. The methodology followed in this thesis are grouped into two main categories, first is rainfall analysis includes (drought hazard assessment). Second is qualitative analysis for data collected from field which comprises of vulnerability analysis, risk governance assessment, adaptation assessment. Figure 10 below show flow chart of the procedures used to archive the objectives of this research.

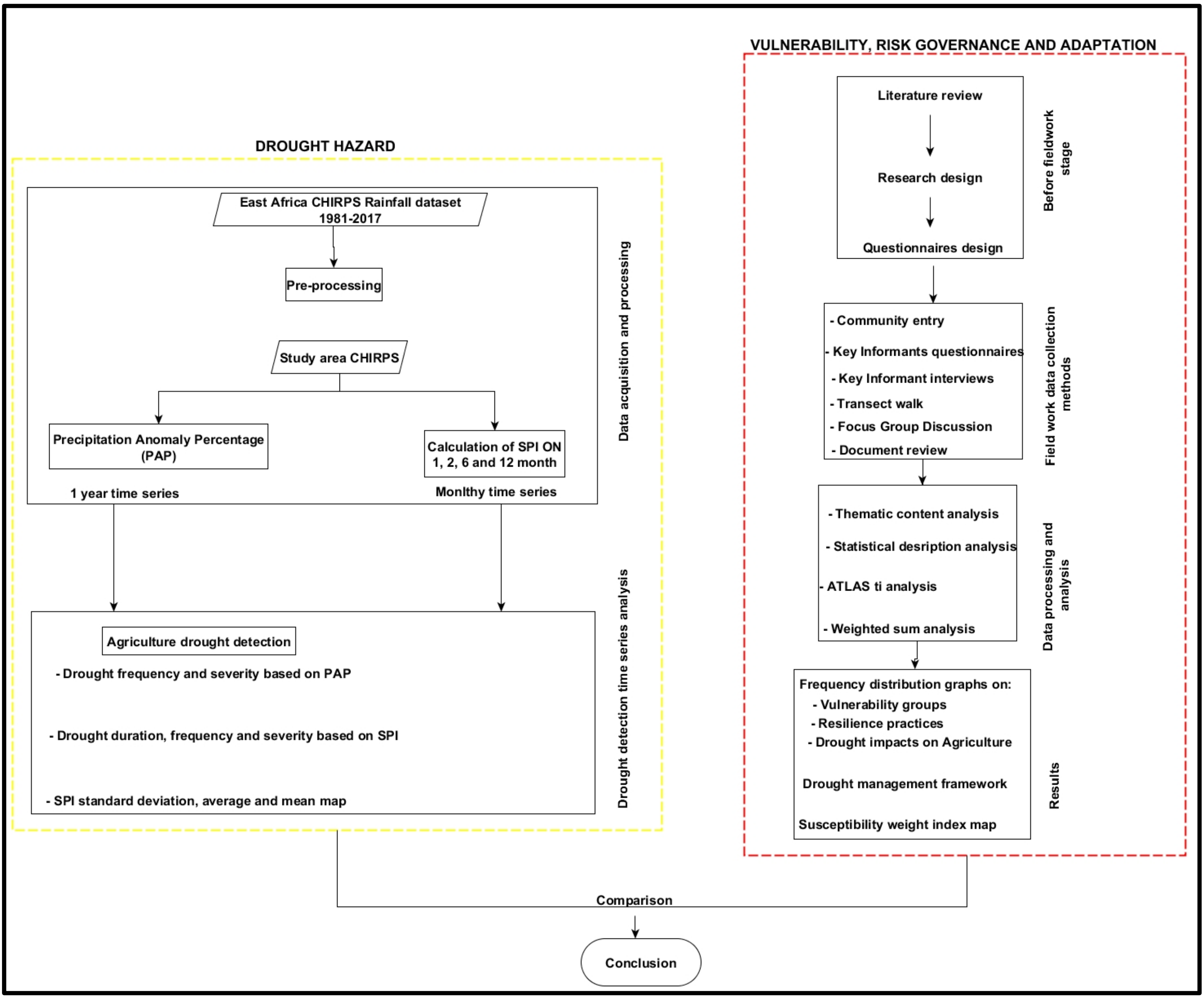


Figure 10: Flow chart for methodology followed in this research

4.5. Drought hazard assessment

Referring to the MOVE framework Figure 1: Linkage between research objectives and the MOVE framework, under this section two methods Standardized Precipitation Index (SPI) and Precipitation Anomaly Percentage (PAP) of drought hazard assessment will be explained.

4.5.1. Precipitation Anomaly Percentage (PAP)

Drought as a natural occurring hazard, develops gradually and it can only be identified after it has been well developed. Therefore, drought indicator like lack of precipitation can be useful in showing the variation in time and space of available precipitation. Using satellite rainfall time series data has the advantage that it shows drought variation on a spatial coverage, as the rain gauge network is very sparse in the region. Methodology used to analyze drought hazard using PAP method is summarized in figure 11 below.

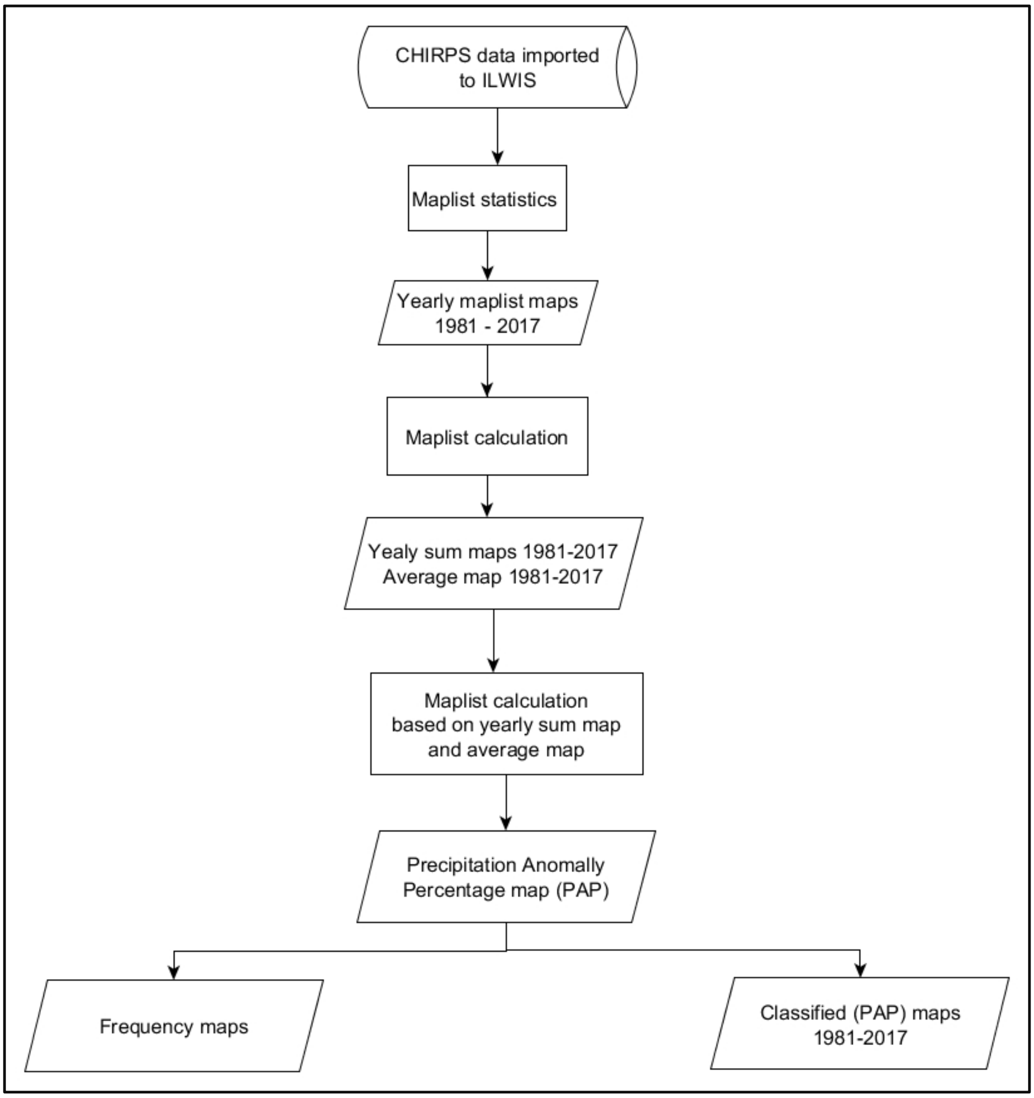


Figure 11: Methodology used to produce PAP maps for hazard assessment

As it shown in figure 11, first step was to import CHIRPS images into ILWIS, then maplist statistic was followed by stacking monthly images from October to September each year from 1981-2017. The reason for selecting October to September time scale in PAP analysis is because of start of rain season and cropping calendar refer to Rainfall patterns section under 3.2.1. After producing all maplist, maplist calculation was followed to produce yearly rainfall summation maps and average map from 1981-2017. PAP maps for each year was then created using maplist calculation. Example of maplist calculation script used to create PAP maps ((S_1981_1982-Avg1981_2017)/Avg_1981_2017) *100. Frequency map was then producing using three frequency classes PAP<50, -50<PAP<-25 and -25<PAP<0. This classification is based on study of (Yang & Wu, 2010). To see different severity of wet and dryness of the area which is a good indication for drought, PAP was classified into 9 classes as follows; -80 Extreme drought, -50 Heavy drought, -25 Moderate drought, 0 Light drought 25 Normal, 50 Light wet, 100 Moderate wet, 200 Heavy wet and 500 Extreme wet.

4.5.2. Standardized precipitation Index (SPI)

The Standardized Precipitation Index (SPI) was developed by T.B. McKee, N.J. Doesken, and J. Kleist in 1993 for drought monitoring (WMO, 2012). SPI is used to characterize drought based on rainfall accumulation over long period at list 30 years and above. Unlike other Indexes like Palmer Drought Severity Index (PDSI) and Drought Severity Index (DSI), SPI is simple and easy to compute as precipitation is the only required parameter. Also SPI provides drought early warning and it severity based on short compute time scale like 1, and 3 months SPI(WMO, 2012).

SPI can be computed using different time scale, example 1, 3, 6, 12 and 24 months to characterize drought in terms of its severity and duration. Different SPI time scale can detect and monitor short term and long-term drought. For instance, 1-3-month SPI reflects short term drought conditions associated with soil moisture and plant stress and it suitable in monitoring short term meteorological and agricultural drought (WMO, 2012). SPI 6 and 12 timescale provide medium, seasonal and long term drought condition respectively (WMO, 2012) (Table 7).

Time scale	SPI	Drought type
1-month	SPI-1	Meteorological
3-month	SPI-3	Agricultural
6-month	SPI-6	Hydrological
12-month	SPI-12	Extreme hydrological

Table 7: Different time scale with related drought type and SPI; Source: (WMO, 2012)

SPI is calculated based on historical rainfall accumulation at a weather station with at list 30 years for rainfall record and above. Due to lack of station data, SPI in this study was calculated using extracted pixel rainfall values from CHIRPS dataset. Long term precipitation at a weather station is fitted to a gamma probability function, which compute cumulative precipitation distribution of precipitation. Then the long-term precipitation which was fitted into a gamma probability function is normalized and turned into a normal distribution. The results are SPI values for a point location.

The results of SPI values range from +2 or more to -2 or less, with positive SPI values indicate wet condition while negative SPI values indicate dry condition. According to SPI, drought is defined when SPI values is equal or below 1 (Table 8).

Table 8: SPI value with related wet and dry categories; Source: (WMO, 2012)

SPI value	Category
+2.00 or above	Extreme wet
1.50 to 1.99	Severe wet
1.00 to 1.49	Moderate wet
0 to 0.99	Mild wet
0 to -0.99	Mild drought
-1 to -1.49	Moderate drought
-1.50 to -1.99	Severe drought
-2.00 or less	Extreme drought

In this thesis SPI was computed using special SPI program called SPI generator developed by National Drought Mitigation Centre (NDMC). The program was downloaded from the following link: https://drought.unl.edu/droughtmonitoring/SPI/SPIProgram.aspx.

Average SPI 6 and 12 scale maps was produced in GIS. The procedures for producing SPI map are summarized in figure 12 below.

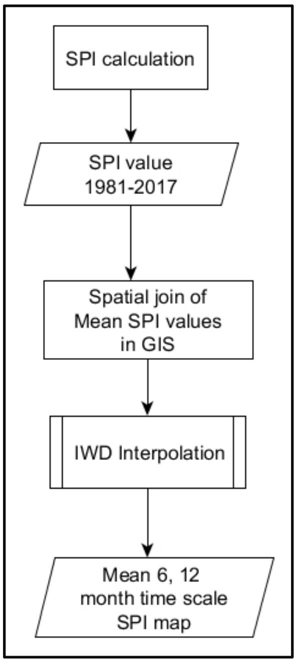


Figure 12: Procedures used in producing average SPI maps in GIS

As it shows in figure 12 above, SPI was first calculated using SPI generator as explained under section 4.1.2 above. Then Average SPI from 1981-2017 for each district was calculated in Excel and imported into GIS by using spatial joint analytical tool. Using inverse weight distance interpolation method, average spi 6 and 12 was created. Research carried out to determine the interpolation algorithms to use for SPI concluded that IDW interpolation works best (Landman & Engelbrecht, 2012; Vasiliades & Loukas, 2013; Rhee, Carbone, & Hussey, 2008). Hence IDW interpolation algorithm was used to interpolate the SPI values.

4.6. Quantitative/qualitative anaalysis methodology for data collected from fieldwork

4.6.1. Key Informant Questionnaire and Focus Group Discussion Analysis

Both qualitative data from key informant questionnaires (appendix 1) on objective two and three on analysis of societal vulnerability to drought risk base on exposure, susceptibility and resilience and identify available drought governance and their implementation that make people less vulnerable considering exposure, susceptibility and lack of resilience and focus group discussion on objective four on evaluation of adaptation strategies in the study area were transcribed using thematic content analysis and analysed in Microsoft Excel using descriptive statistic method. Thematic content analysis as a method of qualitative research it aims at finding patterns across qualitative dataset. This pattern/transcribed data process was done by first familiarized with dataset, categorize and classify dataset based on identified themes. Based on questionnaire and focus group discussion open ended questions, each question from all 10 questionnaires and 9 focus group discussion were transcribed and clustered. For instance, question like *what are the causal factors which makes people more susceptible to drought* presented both on key informant questionnaire (appendix 1) question number 4 on objective two on analysis of drought vulnerability and on focus group discussion (appendix 1) question number 2 were transcribed and clustered together. Also, the rest of open-ended questions were also transcribed and clustered based on each question before importing to Microsoft excel for further analysis.

In Microsoft excel, transcribed data was analysed using statistical description method known as frequency distribution and presented using table and graphs. By using frequency distribution method, number of counts(frequency) respondents respond to a certain question in the questionnaire/ focus group discussion was obtained. Then the score of all frequency for a particular question was then summed up and percentage of each question was calculated. In addition, close ended questions example *in order of importance which implementation level do you consider most important in drought vulnerability reduction* (appendix 1 from key informant questionnaire, section C question number 1) was analysed using frequency distribution method any presented using radar chart to visualize concentration of level of importance in vulnerability reduction from national to local level.

4.6.2. Key Informants Interviews Analysis

The qualitative data collected through key informant interviews collected for the purpose of additional information on drought governance in Tanzania, focus on general drought organization structure from top to the bottom level, and all stakeholders involved in drought management and their roles was also analyzed using thematic content analysis. Information regarding Tanzania drought management framework was analyzed by transcribe and conceptualized in a word document and the results was presented used graphical diagram for better visualization. For the part of roles play by stakeholders in drought management, was also transcribed and codes were generated to identify pattern within the dataset, and results was presented based on identified patterns/themes through description method.

4.6.3. Document analysis

4.6.3.1. Document analysis on agriculture drought adaptation strategies from government perspective

Document on qualitative dataset on agriculture drought adaptation from government perspective were transcribed and analysed using ATLAS ti software. ATLAS ti is the computer assistance qualitative data analysis software (CAQDAS) that facilitate the analysis of structure and semi structured data (Susanne, 2017). ATLAS ti is a powerful tool for a range of qualitative data from text format (including pdf, word document), excel sheet, video, images and audio data (Susanne, 2013). The software provide support for a research during data analysis through the use of different analytical tools, for example, a body of text can be analyzed by using codding, where a researcher highlights and code a specific body of text which can support in achieving research objectives (Raewyn, 2014). Furthermore, the software provides a choice for network building analysis where a researcher can build a network of codes and memos he creates in a visual diagram (Susanne, 2017). In addition to that, the software supports a quick content analysis of a body of text by using two tools either word cloud or word list (Susanne, 2013). Both word cloud and word list help in generating most frequent and relevant words used and how many times they have occurred in the article. This gives a researcher an overview of what is the document about. Figure 13 below show the word cloud resulting Tanzania National Climate Smart Agriculture guidelines (CSA)

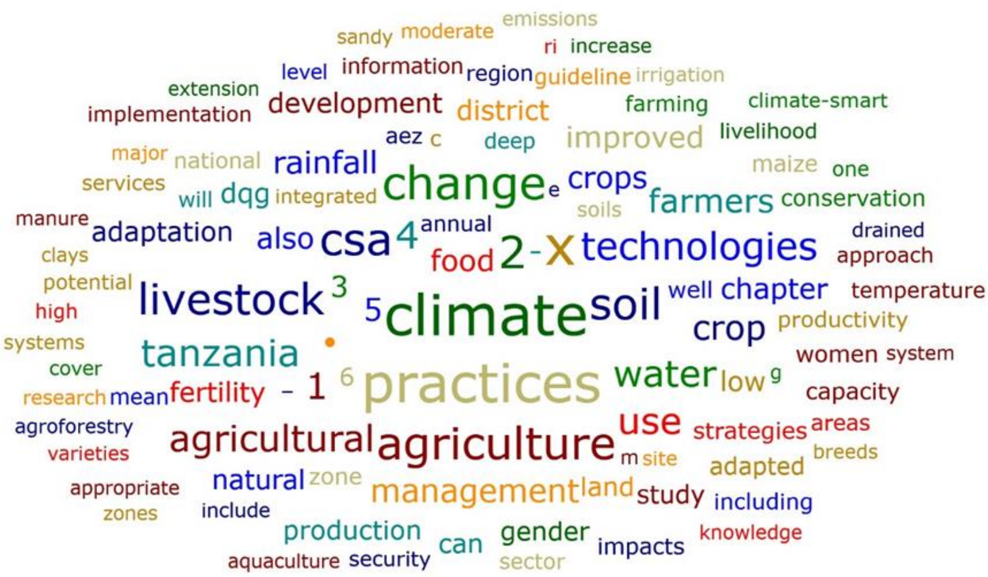


Figure 13: Word cloud for the Tanzania National Climate Smart Agriculture Guidelines (CSA) generated by ATLAS ti; Source: (URT, 2017)

In this study ATLAS ti method is applied to study agricultural drought adaptation strategies and their efficiency in semi-arid zone Tanzania. Climate smart agriculture document on agriculture drought adaptation measures was analyzed using ATLAS ti software. The document was loaded into the software and analyzed using codding and network analysis (appendix 3). Codes were generated by highlighting body of texts focusing on recommended agriculture drought adaptation measures from government perspectives. By using code manager tool, group code for drought adaptation strategies was created and then through network analysis manager, the group code on agriculture drought adaptation was drawn and visualized in a network diagram.

4.6.3.2. Document analysis on quantitative data on causal factors for agriculture drought susceptibility

In this study quantitative data were extracted from documents presented in table 6. The aim of this data was to backup qualitative data on causal factors for agriculture droughty susceptibility collected in the field using questionnaire survey. Statistics on each factor were extracted from the mentioned documents in table 6 and analysed using weighted sum method in Arc GIS software. Drought susceptibility causal factor maps were created in Arc GIS using the extracted statistic on the document. Methodology followed in creating susceptibility factors map was spatial join whereby attribute table were all study are regions was created and statistic on each causal factor for every region on the study area was added in the attribute table. Then symbology, susceptibility causal factors maps were created by drawing categories using unique values added to the attribute table. After creating all factor maps, by using polygon to raster converter all the maps were rasterized as a final input for produce susceptibility index map. Then by using weighted sum in Arc GIS susceptibility factors maps were then combined and produce drought susceptibility index. The procedures are further summarized in figure 14.

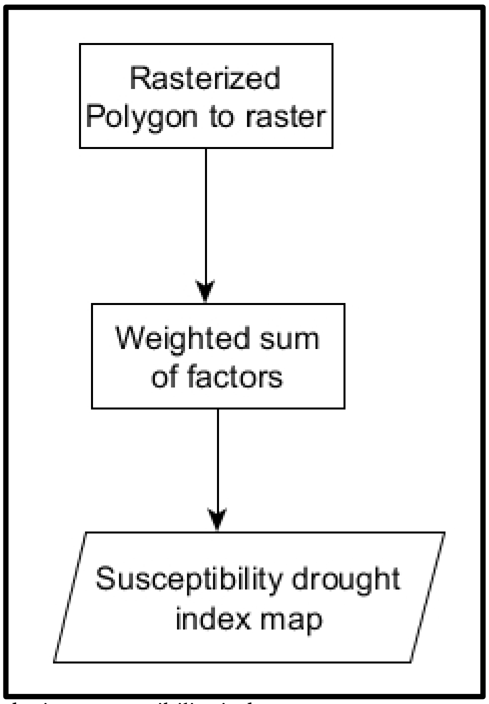


Figure 14: Steps used in producing susceptibility index map.

Susceptibility factors were weighted based on questionnaire results on percentage of frequency given to each factor during field work. Susceptibility factors were weighted in a scale of 0 to 100. The factors and with weight assigned are shown in table 9 below.

Table 9: Drought susceptibility factors with it assigned weight

Susceptibility factors	Weight
Rainfed agriculture	90
Low irrigation	70
Rainfall variability	60
Low capability	50
Poverty	40
Limited agriculture skills	30

4.7. Software used

Software used in this research are presented in table 10 below.

Table 10: Software used in research.

Software	Software usage description
ILWIS	Image processing Analysis of precipitation anomalies percentage (PAP) map
ArcMap 10.6.1	Results visualization
Statistical R Software	Computation of average rainfall per month from 1981-2017
SPI generator	Computation of drought duration, frequency and SPI values in 1- 3- 6-and 12-month time scale
Microsoft Excel	Qualitative analysis of questionnaires survey field data
ATLAS	Literature based analysis

The summary of methods used in relation to research objectives are presented in table 11 below.

Table 11: Summary of methods used in this research in relation to objectives.

Research objectives	Methods
1. To characterize agriculture drought hazard and its severity in semi-arid zone Tanzania, in space and time	➢ Precipitation Anomaly Percentage (PAP) ➢ Standardized Precipitation Index (SPI)
2. To analyze societal vulnerability to drought risk base on exposure, susceptibility and resilience	➢ Frequency from questionnaire and focus group discussion ➢ Weighted sum
3. To identify available drought governance and their implementation that make people less vulnerable considering exposure, susceptibility and lack of resilience	➢ Thematic content analysis ➢ Frequency from questionnaire and focus group discussion
4. Evaluating drought adaptation strategies in the study area	➢ Thematic content analysis ➢ Frequency from questionnaire and focus group discussion

4.8. Maptionnaire

Maptionnaire is an online participation tool which allows users to create questionnaires based map and to involves specified respondents in answering those question online (Kathleen Emerson, 2016). In this tool, a researcher can ask, collect data, analyze data, understanding and discuss the results of the analyzed data. In this study maptionnaire was employed in collecting additional data on agriculture drought vulnerability in Dodoma region. The reason for choosing Dodoma region is because it's one of the region I visited during field work and also it one among the most affected regions by drought (E. Nyankweli et al, 2016 URT , 2016 & Arce & Caballero, 2015). Few question were created on the maptionnaire website and link to the online maptionnaire survey was distribute to few key informant stakeholder presented under table Table 3: Summary of Key Informants stakeholders participated in questionnaires survey together with their respective organization/Institutions, department and position. Some of the key informant were asked by the research to help in distribute the link to other stakeholder working within the identified government organization.

This method was adapted because its a powerful tool in collecting and elicit spatial knowledge and it can reach anonymous people, its time and cost efficiency as it saves time because it does not involve facilitation. Maptionnaire collect all the field data and presented in the Microsoft Excel where it simplifies the analysis of data as data are analyzed automatic using descriptive statistics and presented on graphs (appendix 4).

5. RESULTS OF DROUGHT HAZARD

This chapter provides the results of the first objective of drought hazard assessment. Drought hazard assessment was carried out using two methods, namely SPI analysis and Annual Precipitation Anomaly Percentage (PAP) analysis as discussed under 4.5.

5.1. Average Annual Rainfall Analysis from 1981-2017

To calculate annual precipitation anomaly percentage maps, it requires to analyse the overall average of precipitation for the entire time scale which is from October 1981 to September 2017 and result map is shown in figure 15.

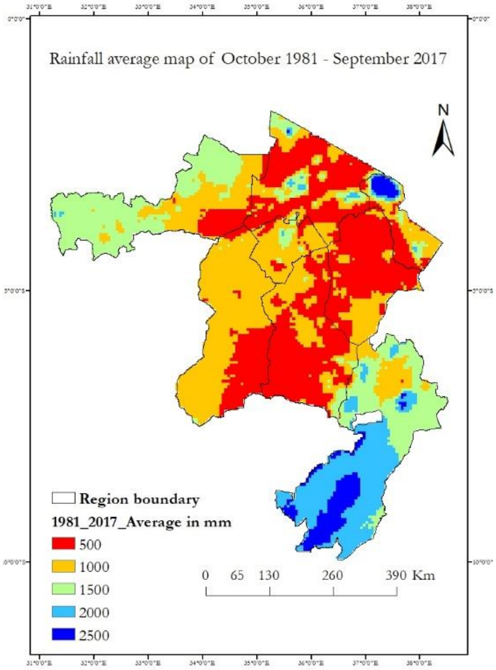


Figure 15: Average annual rainfall in mm from 1981-2017

In figure 15, shows average annual rainfall on the study area varies place to place. It observed that regions with low annual average rainfall are highly found in Dodoma, Manyara and Arusha as most of area have annual rainfall of 500mm. It also, observed high annual average rainfall of 2000mm to 2500mm in the Southern part of the study area. Also, in the North part of the study are it observed to have high annual average rainfall of 2500mm this is because of orographic effect caused by Mountain Kilimanjaro. While average rainfall of 500mm to 1500mm is observed in the Central and North of the study area.

5.2. Annual Precipitation Anomaly Percentage (PAP) Drought-Based Analysis

Rainfall accumulation per year (October 1981- September 2017) and average rainfall for the period of 1981-2017 from CHIRPS dataset was used as input in producing the annual precipitation anomaly percentage maps. Anomaly analysis intended to show deviation of rainfall from its long-term average on the study area. Hence rainfall anomaly is used to give an indication on dry condition for an area as it shows if the year was characterized by wet or dry season. Variation on these rainfall anomalies can either depict precipitation stress/deficit (drought condition) and normal condition.

In figure 16, it shows the minimum pixel values for annual precipitation anomaly percentage. This indicate which areas have the big anomalies compare to the rest. As it shows in the map, the minimum annual precipitation anomaly percentage ranges from -16 to -63. The minimum anomaly was considered in order to determine the which areas on the study area have below average rainfall which depict that those areas are dry.

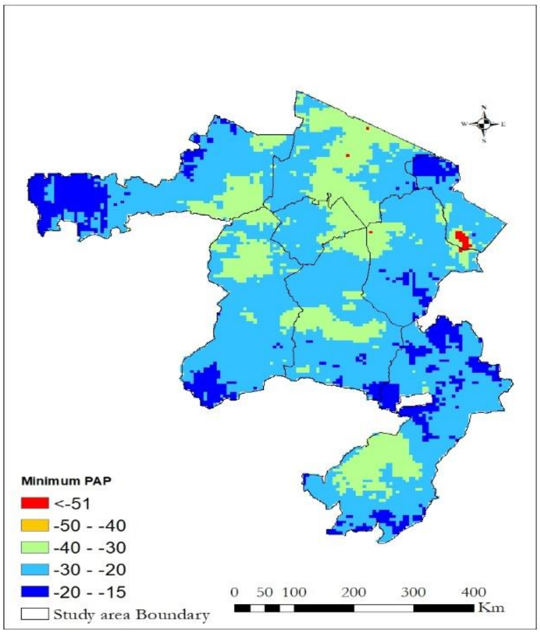


Figure 16: Minimum Annual Precipitation Anomaly Percentage (PAP)

For better visualization, PAP for all 36 years (1981-2017) were classified and produce frequency map. Since the minimum PAP values ranges from -16 to -63, three frequency classes PAP<50, -50<PAP<-25 and -25<PAP<0 were created. Figure 17 show PAP frequency for the three classes.

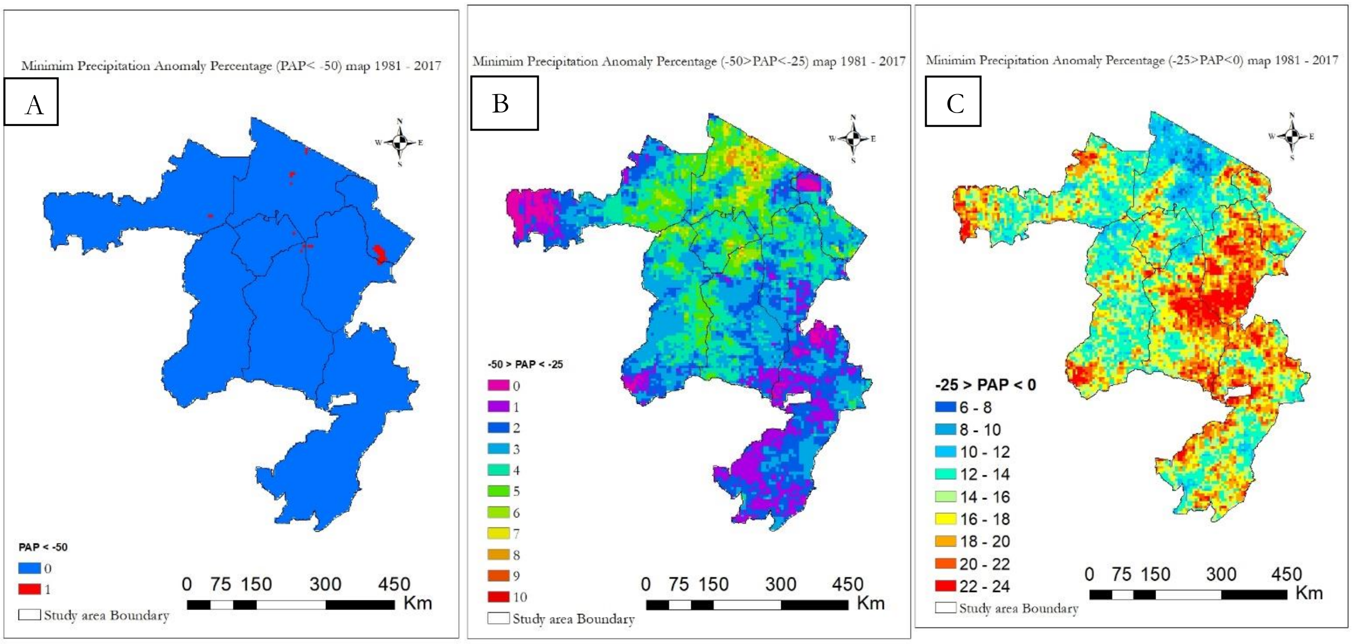


Figure 17: PAP frequency map

In the figure 17A, show the frequency PAP map where pixel value is less than -50 (PAP<-50). Referring to figure 17A only few places are observed to have PAP values less than -50 and the frequency if I year only. On the other hand, figure 17B (-50<PAP<-25) is observed to have a different pattern in frequency as in the Northern part of the study area it more severe as it ranges from 7 to 10 years frequency of occurrence for (-50<PAP<-25) while in the central part the frequency ranges from 3 to 6 years. But on the Southern part (-50<PAP<-25) is observed to have low frequency of 0 to 2 years. On figure 17C for (-25<PAP<0) depict that, most of the areas has a frequency of 20-24 years while in the North side of the study area it only 6 to 15 years.

To see different severity of wet and dryness of the area which is a good indication for drought, PAP was classified into 9 classes as follows; -80 - Extreme drought, -50 - Heavy drought, -25 - Moderate drought, 0 - Light drought, 25 - Normal, 50 - Light wet, 100 - Moderate wet, 200 - Heavy wet and 500 - Extreme wet. Figure 18 below shows the classified PAP from 1981 to 2017.

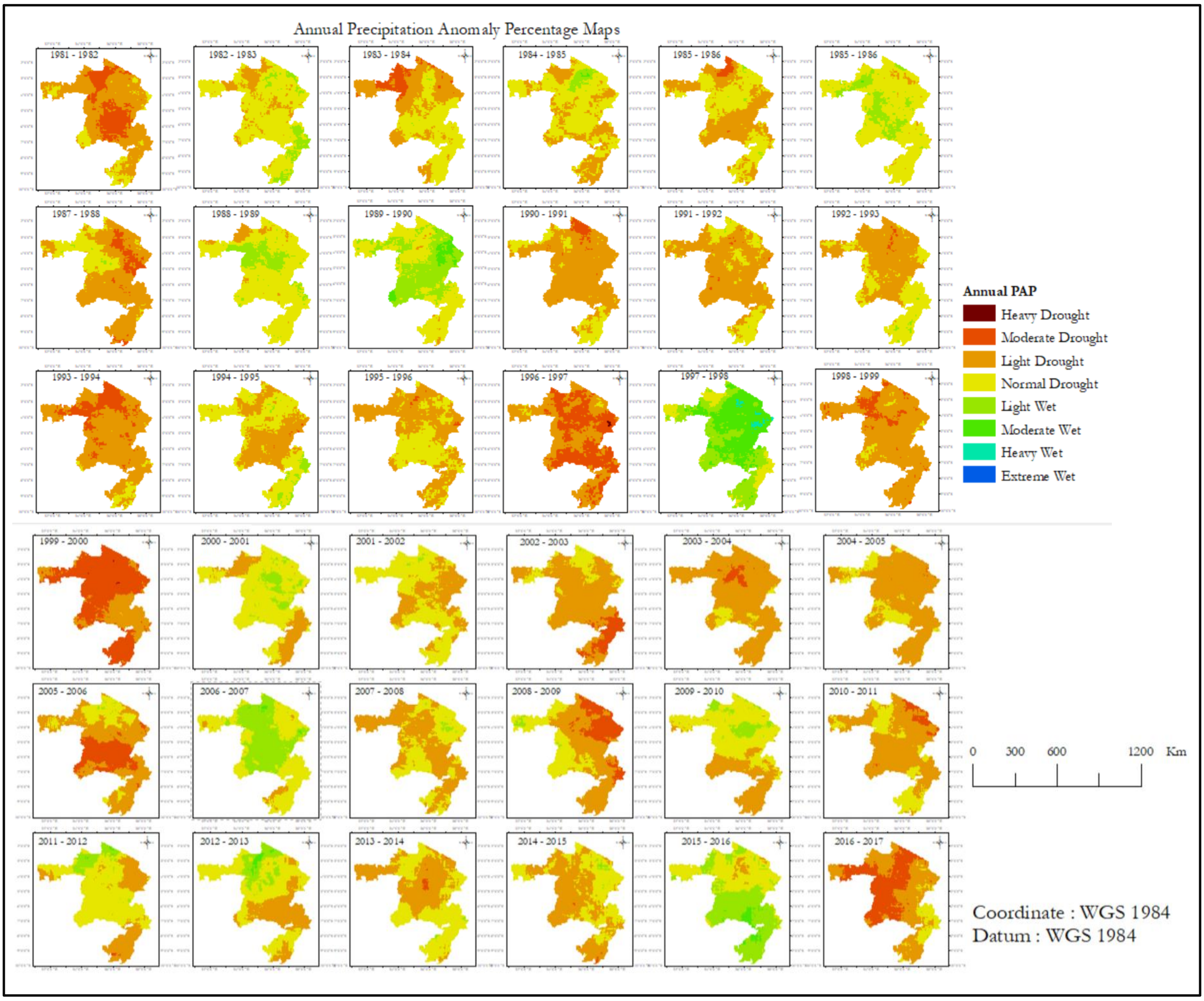


Figure 18: Classified annual Precipitation Anomaly Percentage (PAP) map 1981-2017

It observed the most affected years fall under heavy and moderate drought which are 1981-1982, 1996-1997, 1999-200, 2005-2006, and 2016-2017.

5.3. SPI Based Drought Analysis

In order to characterize drought base on duration and severity, SPI based drought analysis is applied as it has been discussed in section 4.5.2. SPI was calculated in 1, 3, 6- and 12-month time scale from 1981-2017 using CHIRPS pixel rainfall values for five regions on the study area. The choose for calculating three different SPI time scale (1, 3, 6 and 12 month) was to see which SPI time scale describe best drought condition in the study area, and to have comparison between the four.

5.3.1. Historical Drought Events Defined By SPI

Results of SPI calculation for different time scale is shown in figure 19 below.

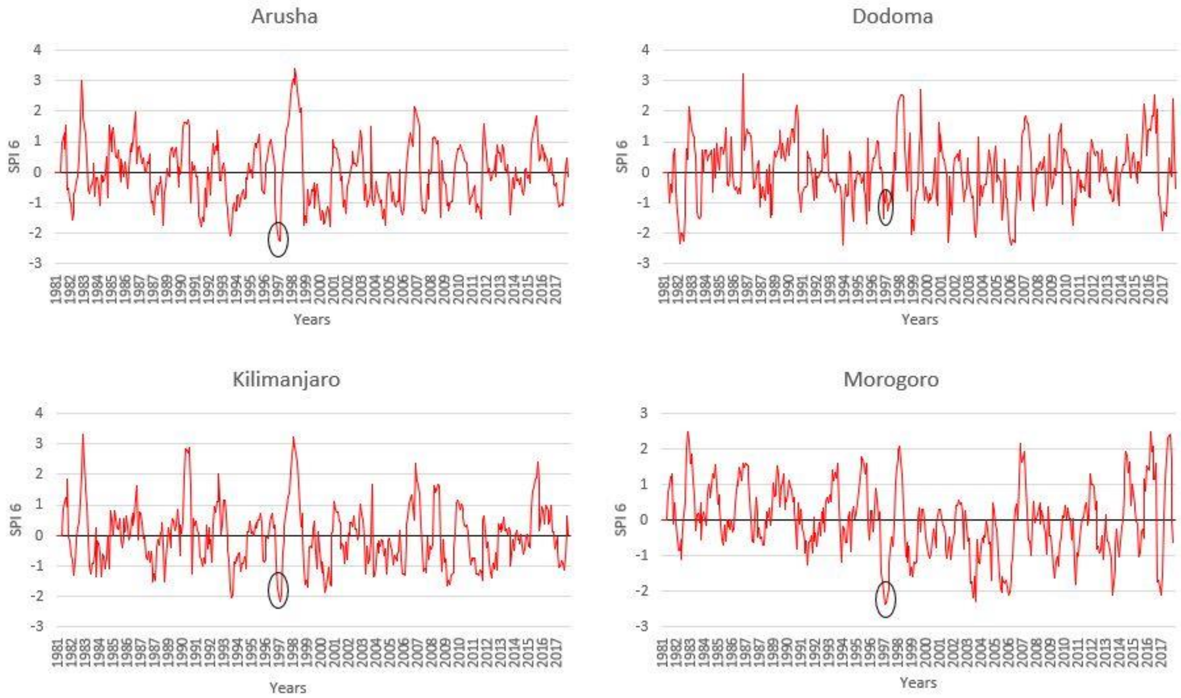


Figure 19: The 6-month SPI for Arusha, Dodoma, Kilimanjaro and Morogoro region (pixel value based) from 1981-2017

For 6-month SPI the highest drought events is observed in the year 1997(under black cycle) for all the regions except for Dodoma. Also, other drought events according to 6-month SPI are observed in the years 1982, 1987, 1988, 1991, 1994, 1993, 1997, 2000 and 2004 and 2017. Results of SPI 1,3 and 12 can be found in appendix 2.

5.3.2. Historical Drought Duration Defined by SPI

Historical drought duration was calculated for different SPI timescale (1, 3, 6 and 12 month). Table 12 show drought duration with its peak SPI value plus the year and moths of drought occurrence for 6-month SPI.

Table 12: 6-month SPI drought duration with years, months and SPI peak values.

Year	Month	Duration	SPI peak
1981	06-09	3	-1
1982	01-09	**8**	**-2.32**
1983	06-10	4	-1.52
1987-1988	12-06	6	-1.12
1988	09-12	3	-1.46
1990-1991	12-06	6	-1.3
1993-1994	12-06	**6**	**-2.37**
1994-1995	08-01	5	-1.6
1995	01	1	-1.71
1995-1996	11-01	2	-1.25

1996-1997	11-09	**10**	**-1.5**
1998-1999	12-06	**6**	**-2.03**
2000	02-08	6	-1.02
2000	10-11	1	-1.1
2001	07-12	**5**	**-2.31**
2003	06-10	**4**	**-2.13**
2003-2004	11-06	**7**	**-1.09**
2005	06-08	2	-1.55
2005-2006	12-08	**8**	**-2.36**
2007	09-12	3	-1.28
2008	09-11	2	-1.09
2009	10-11	1	-1.05
2010	07-12	5	-1.73
2013-2013	11-02	3	-1.07
2016-2017	12-07	**7**	**-1.89**

In table 12, the long drought duration is from 6, 7 8 and 10 months. The longest drought duration based on 6 months SPI is observed in1996-1997 with 10-month duration starting from November 1996 to September 1997 with -2.03 SPI peak. It followed by 8-month drought duration from 1982 with -2.32 SPI peak value and 2005-2006 with -2.36 SPI peak value. 7-month duration is depicted on years 2003-2004 and 2016-2017 with peak SPI values of -1.09 and -1.89 respectively.

6. RESULTS OF DROUGHT RISK GOVERNANCE

Referring to figure 1 (MOVE framework) in section 2.3 in the part of risk governance, this section describes in general drought risk governance in the context of Tanzania (semi-arid regions). It includes list of key stakeholders involved in drought management and their roles. Also, it includes drought related policies and their implementation that make people less vulnerable considering exposure, susceptibility and lack of resilience. And lastly it includes pre and post government interventions on drought risk management.

6.1. Stakeholders Involvement in Drought Management in Tanzania

To understand how drought risk is managed in Tanzania, it was necessary to identify key stakeholders and their roles in drought management. To have a glance at drought risk governance in Tanzania, organigram (organisation diagram) was created to show the topmost key stakeholders and their roles in Tanzania drought management. The Tanzania drought risk governance organigram is shown on figure 20 below. This framework is obtained from key informant interview discussed under section 4.3.4 and 4.6.2.

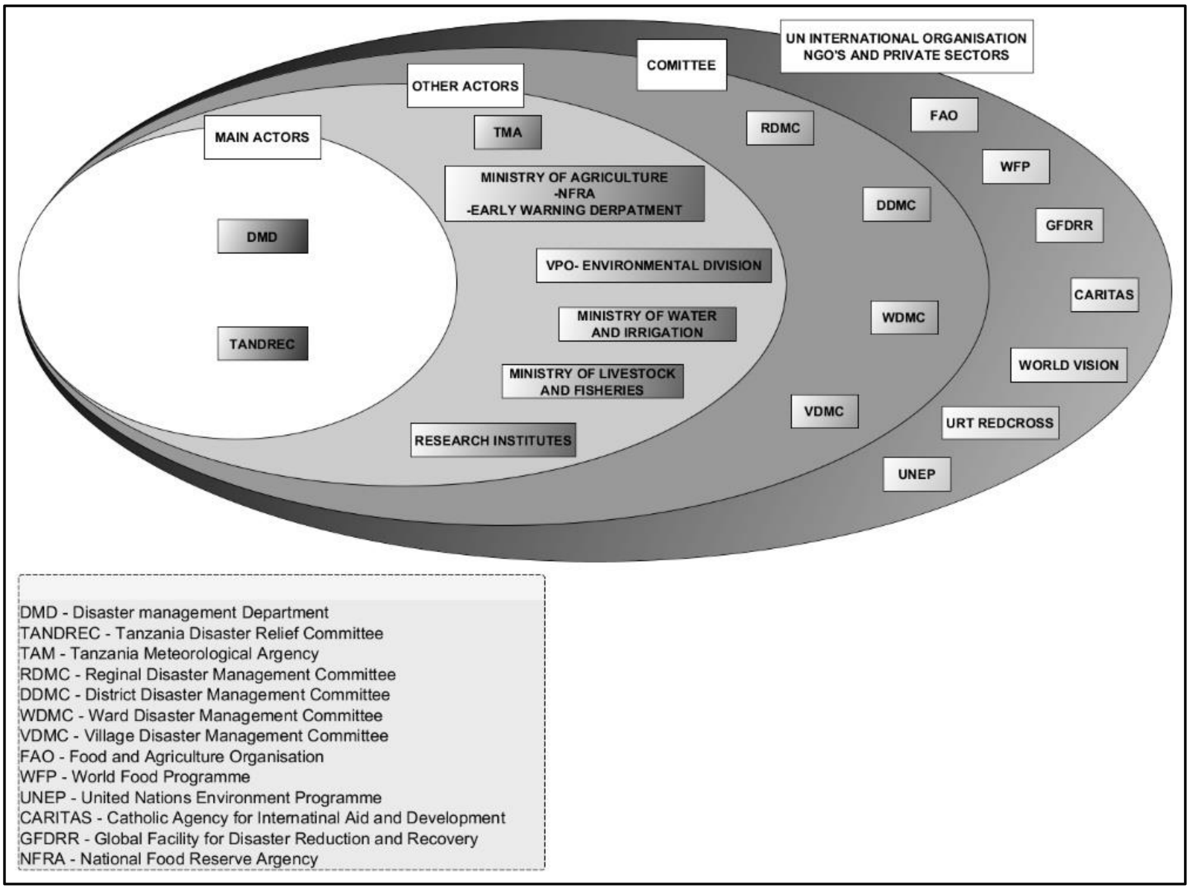


Figure 20: Tanzania drought risk management organisational framework (Organigram)

It can be observed that there are four key stakeholders' groups involving in drought management in Tanzania as it shown in figure 20. The key stakeholders in drought management are grouped into four distinct categories namely; main actors, other actors, drought management committee and UN agencies/NGO's/Private sectors.

Drought management main stakeholders are under Prime Minister's Office (PMO) in the department of Disaster Management Department (DMD). Under DMD, there is a disaster relief committee called Tanzania Disaster Relief Committee (TANDREC). DMD is the focal point for all disasters in Tanzania.

In case of drought, DMD collaborate with other stakeholders such as Tanzania Meteorological Agency (TMA) and various Ministries such as Ministries of agriculture, Ministry of Livestock and fisheries, Ministry of water. Furthermore, DMD collaborate with research institutions, NGO's, such as Catholic Agency for International Aid and Development (CARITAS) and Global Facility for Disaster Reduction and Recovery (GFDRR). Also, DMD collaborate with UN agencies, like World Food Programme (WFP), Food and Agriculture Organisation (FAO) to mention few and Environmental division Unit under Vice President's office. DMD also collaborate with Disaster Management Committees from regional to village level which are Regional Disaster Management Committee (RDMC), District Disaster Management Committee (DDMC), Ward Disaster Management Committee (WDMC) and Village Disaster Management Committee (VDMC). The roles and responsibility of each stakeholder are further explained in detailed under section 6.2.

6.2. Roles and Responsibility for Different Actors In Tanzania Drought Risk Management

Under this section, it describes roles and responsibility for each key stakeholder presented in section 6.1. The roles are grouped into 9 main distinct categories namely, Direction and control, Relief services, Guidelines and programmes, Early warning, Food security, Evacuation, Vulnerability reduction, Environmental management and Education and awareness. Table 13 show roles and responsibilities of key stakeholders in drought risk management. The table also categorize roles and responsibility of the main (M) and supportive (S) stakeholders in the drought risk management. Furthermore, the roles on the stakeholder in drought risk management presented on table 13 are made from key informant interviews data and key informant questionnaires part C on drought governance question number 2 and 3 (see appendix 1). The following section describes in detail the roles and responsibilities of main and supportive key stakeholders in drought risk management as it shown in table 13.

Table 13: Key stakeholders with their roles in Tanzania drought management

Key stakeholders	**Direction and Control**	**Relief Services**	**Guidelines and Programmes**	**Early Warning**	**Food Security**	**Evacuation**	**Vulnerability Reduction**	**Environmental Management**	**Education and Awareness**
Disaster Management Department (DMD)	**M**		**M**		**S**	**M**	**M**		
Tanzania Disaster Relief Committee (TANDREC)	**M**	**M**							
Vice president office (VPO)			**S**				**S**	**M**	**S**
Disaster Management Committee	**S**		**S**				**S**		**S**
Tanzania Meteorological Organisation (TMA)				**M**					
Ministry of agriculture		**S**	**S**	**S**	**M**				**S**
Ministry of Livestock and fisheries		**S**	**S**						
Ministry of water			**S**		**S**				
Research Institutes							**S**		**M**
UN organisation (FAO, WFP, UNEP, WV)		**S**			**S**		**S**		
NGO'S (CARITAS)		**S**			**S**				

6.2.1. Direction and Control

The main key stakeholder in charge with direction and control for drought in Tanzania is the Disaster Management Department (DMD) under Prime Minister's Office (PMO). DMD is the focal point for all disasters in Tanzania. Based on questionnaires survey from the field work, DMD is the leading organisation in drought management as it provides technical, financial and social support before and after drought occurrence. DMD is in charged with coordinate all drought management activities and collaborate with other stakeholders from national to local level in drought reduction and recovery.

As a direction and control organ, DMD collaborate with all stakeholders including Tanzania Meteorological Organisation, research institutes, Ministries and NGO's in drought management. DMD is in charged with conducting of Rapid Vulnerability Assessment to assess drought impacts in affected areas. Also, DMD provide food and subsides to affected regions in collaboration with Tanzania Disaster Relief Committee (TANDREC).

6.2.2. Relief Services

Key government stakeholder in charge with provision of reliefs and services to drought affected regions is Tanzania Disaster Relief Committee (TANDREC) under DMD. TANDREC provide food and subsides to the regions affected by drought such as cereal, drought tolerant seeds such as cassava, millet and sorghum. Furthermore, TANDREC in collaboration with other stakeholders such as NGO's (CARITAS, GFDRR), UN agencies (FAO, UNEP, WFP), Ministry of agriculture and Ministry of livestock in provision of relief support to the affected communities.

6.2.3. Guidelines and Programmes

DMD under Prime Minister's Office is the main actor in drought management in terms of provision of guidelines and programmes. DMD collaborate with other stakeholders in forming guidelines and programmes for drought reduction. For example, Ministry of agriculture produced guideline to reduce effects of drought and climate change in agriculture sector called, Climate Smart Agriculture (CSA). CSA guideline provide guidelines on how to reduce drought effects on agriculture based on effective agriculture methods which differs per regions depend on agroecological zone. For instance, in the arid and semi-arid agroecological zone of Tanzania, CSA guidelines insists on the use of drought tolerant crops, rain water harvest, agroforestry, mulching, ridges cultivation, irrigation schemes to be followed to reduce drought effects. Also, programme such as KIJANICHA DODOMA (meaning turning Dodoma region to be green) under Vice President's Office (VPO) by planting tress is one among the programme in drought management in semi-arid areas Tanzania. Different ministries such as Ministry of livestock and fisheries and Ministry of water also play a supportive role in guidelines and programmes for drought management. For example, Ministry of water engaged much in establishing irrigation scheme to reduce dependence of rainfed agriculture in most of regions in Tanzania while Ministry of livestock provides drought resistance breeds to livestock communities of arid and semi-arid regions. By this it helps in reduce the effects of drought.

6.2.4. Early Warning

Tanzania Meteorological Agency (TMA) is the key stakeholder in drought monitoring and early warning. TMA provides timely and effective daily and seasonal weather forecast in on rainfall patterns and trends which helps in monitoring drought events. TMA oversees drought monitoring and dissemination of early warning concerning drought to the community.

6.2.5. Food Security

Ministry of Agriculture is responsible for oversees food security in Tanzania. Under Ministry of agriculture there is department of National Food Reserve Agency (NFRA) which deals with reserving food which can be used during prolong drought period. Ministry of agriculture has a role to ensure the NFRA have adequate food reserved capable to feed many people during drought period.

6.2.6. Evacuation

During severe and prolong drought, DMD is responsible for evacuate people and their properties from drought affected areas to a safer location. From results of key stakeholder questionnaire survey during field visit, in case of severe drought livestock keepers with their animals are evacuated from drought prone areas to a safer location while agriculturalists are provided with incentive and food assistance.

6.2.7. Vulnerability Reduction

DMD is the leading stakeholder in vulnerability reduction as it oversees drought vulnerability by conducting Rapid vulnerability assessment. Other supportive stakeholders in vulnerability reduction includes VPO, Disaster Management Committees and NGO's. Therefore, DMD in collaboration with the above-mentioned stakeholder develop guidelines, and policies such as National Adaptation Plan (NAP) with the aim of reduce climatic related risk such as drought.

6.2.8. Environmental Management

Environmental Unit under Vice President's Office (VPO) is the leading stakeholder in environmental management issues which related to drought, for example land degradation and deforestation. In additional, the Environmental unit is accountable for assessing the status of land degradation in relation to drought as it seen in Figure 4: Land degradation severity map of Tanzania; Source: (Majule, 2018), as most of degraded regions suffers from periodic drought. Also, Environmental unit under VPO is a member of United Nations Convention to Combat Desertification (UNCCD). All these environmental management aim at reducing drought risk and it impacts.

6.2.9. Education and Awareness

Various research institutes such as Sokoine University of Agriculture, Institute of resource assessment, University of Dar es salaam, Institute of disaster management, University of Dodoma, and Ardhi University together with Ministries and Disaster management committee provides education and awareness to the community on drought management. For instance, provision of education on the use of drought resistance varieties such as cassava, sorghum and millet, the use of good farming practises such as conservation agriculture, agroforestry, irrigation, ridges cultivation and rain water harvest. All this provides community with knowledge and awareness on which agriculture techniques to use, and which plant variety to plant, hence reduce drought effect.

Despite of having different roles and responsibility in drought management, each key stakeholder has a highly importance in drought management implementation. Figure 21 show the level of importance in implementing drought activities from National to Local level. As it shows in figure 21 it has been observed that, the level of importance in implementing drought management activities is highly important from national to local level. Meaning that, each level involving in drought management activities are of high importance. This is because of interconnectedness and interaction of these levels in drought management as each level depends on another level for the success drought management.

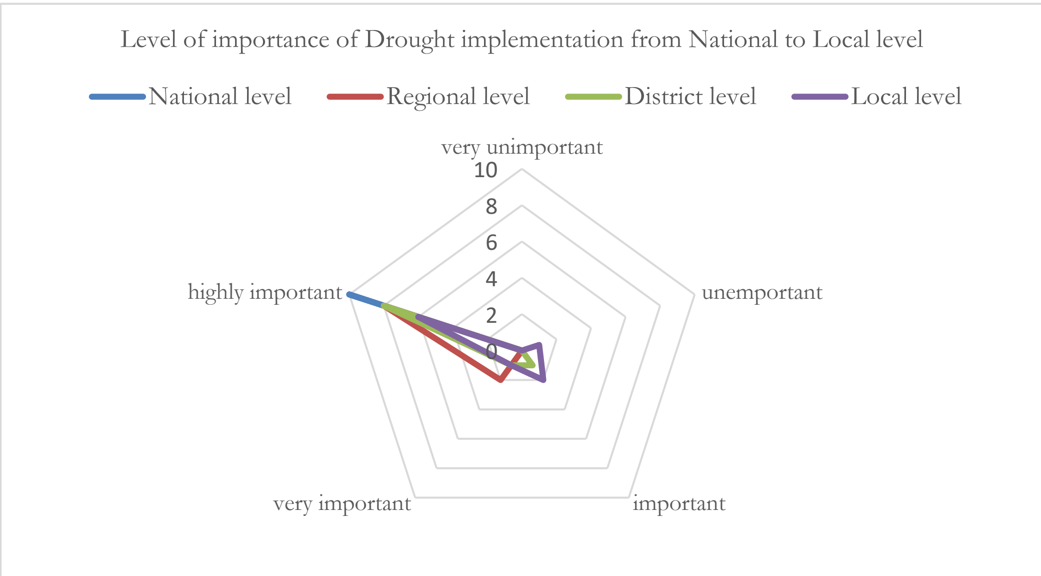


Figure 21: Level of importance of drought implementation from National to Local level: Source: Field survey data

Figure 21 above show the level of importance in implementation of drought management from local level to national level. The source of the figure if from key informant questionnaires from section C question number 1 (see appendix 1)

.

6.3. Government Intervention on Drought Management

In managing and reduce drought risk in semi-arid zone in Tanzania, the government and non-governmental organisation have been involving in different interventions to lessening drought risk and it impacts. In this section, government interventions on drought management are explained and further grouped into two distinct categories namely; pre and post interventions. This is summarised and shown on table 14 below which was made from key informant questionnaire data presented under section C question number 7.

Pre-interventions (Mitigation and preparedness)	**Post-interventions (Response and recovery)**
Early warning provision	Food provision
Develop strategies, guidelines and programmes on drought	Provision of drought tolerant seeds
Promote climate smart agriculture (CSA)	Provision of drought resistance livestock breads
Infrastructure development	Increase irrigation schemes
Pasture management	Promote climate smart agriculture (CSA)
	Evacuation
	Emergency relief (Livestock pasture and water)

Table 14: List of pre and post interventions on drought management

As it shown in table 14, pre-interventions on drought management in semi-arid zone Tanzania include early warning provision on drought risk to the community which is provided by TMA as discussed under section 6.2.4. Also, government through different ministries intervene in drought management by develop strategies, guidelines and programmes on drought management such as tree planting, education on good and resistance agriculture practises. Furthermore, promoting climate smart agriculture is one among government intervention on drought management in Tanzania. In additional to that, agriculture infrastructure development like establishment of irrigation schemes furrow irrigation practises around Kilimanjaro region for subsistence food crops, Mbarali irrigation scheme for rice production in Mbeya, Dakawa and Kilombelo sugar irrigation scheme for rice and sugar production in Morogoro region. Also, under Ministry of livestock and fisheries, they intervene in drought management through pasture management where the educate community on planting and reserve pasture for livestock during dry seasons.

On the other hand, post-intervention on drought management includes food provision which is mainly carried out under DMD and ministry of agriculture through NFRA as discussed in section 6.2.2 and 6.2.5 above. Provision of drought tolerant seeds such as cassava, millet and sorghum to semi-arid regions is one among the post intervention on drought management. Increase irrigation schemes in semi-arid regions and promote climate smart agriculture also are post-government intervention on drought management.

7. RESULTS OF VULNERABILITY ASSESSMENT

Referring to figure 1 (MOVE framework) in section 2.3, this section describes in general societal vulnerability as one among key element of the MOVE framework. In this section, it includes the results of the most vulnerable groups, the causal factors which makes people to be more susceptible and the actions government undertake to improve drought resilience.

7.1. Vulnerable Groups to Agriculture Drought in The Study Area

The analysis of the most vulnerable groups to drought in the study area was conducted using key informant questionnaires survey during fieldwork visit (see appendix 1). The findings from the questionnaire survey was then analysed in Microsoft excel using descriptive statistic presented under section 4.6.1. Ten questionnaires survey were used to analyse the vulnerable groups to drought, which was in five classes very high, high, moderate, low and very low. For each questionnaire, number of counts each respondent said a certain vulnerable group fall under the above-mentioned classes were then added to get the final score for each class.

By using clustered column, the result was plotted to compare different levels of vulnerability for different vulnerable groups. The four main vulnerable groups to agriculture drought in the study area are shown in figure 22, although the level of vulnerability differs per each group. About 80% of respondents mentioned women are more vulnerable than the rest of the groups followed by children with 50% high vulnerability level and elderly and disabled with 40% each.

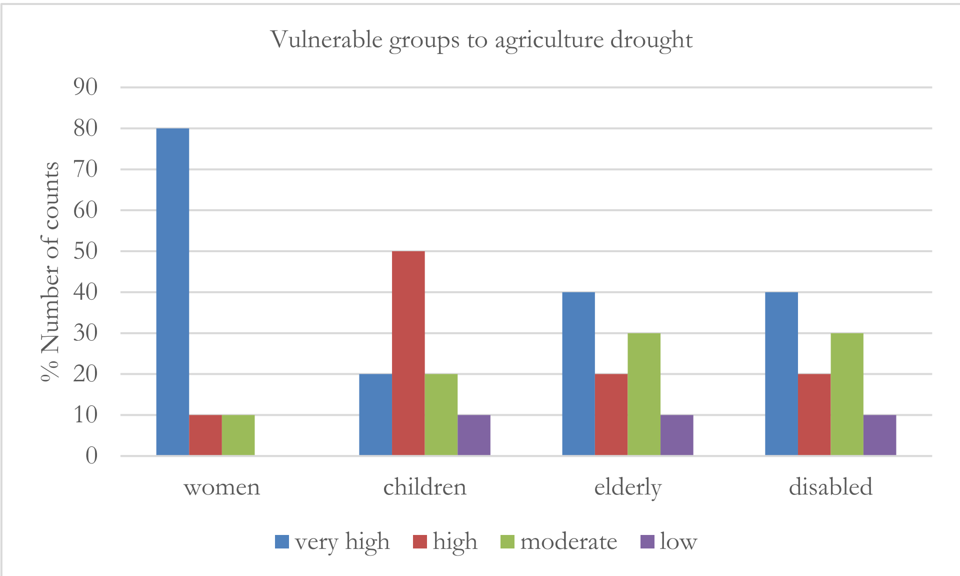


Figure 22: vulnerable groups with their vulnerability level

To have a general understanding on agriculture drought vulnerable groups, it was necessary to look at spatial distribution of these groups. In this section, spatial distribution of women is considered more than the rest of vulnerable groups because it has a high percentage of vulnerability compare to the rest of the vulnerable groups (children, elderly and disabled). The second reason to consider women is that, large percentage of people who engaged in agriculture in Tanzania are women. Statistics on women engaged in agriculture were extracted from Tanzania Regions Basic Demographic and Socio-Economic Profile population and housing census documents presented under section 4.3.7. Statistic on women who own farmland were considered in this case as there is a direct link of farmland ownership and agriculture activities. It assumed that, the percentage of women who own farm land also engaged in agriculture activities. Spatial distribution of women engaged in agriculture in semi-arid regions is shown in figure 23. The map was made using Arc GIS software discussed under document analysis section 4.6.3.2. All statistic used on this map were extracted from Tanzania Regions Basic Demographic and Socio-Economic Profile population and housing census documents presented under section 4.3.7 from page 116 to 128 on each regional census document.

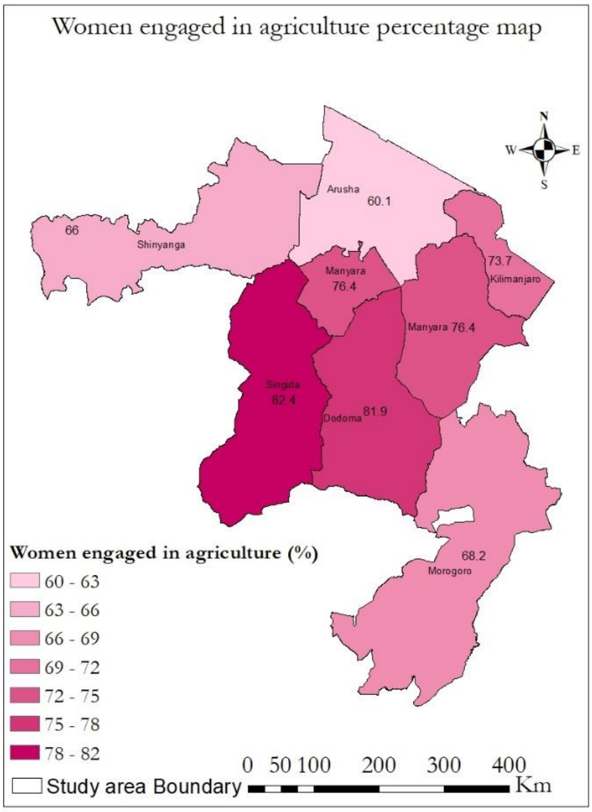


Figure 23: Percentage of women who engaged in agriculture: Data Source:(URT, 2016)

From figure 23, percentage of women engaged in agriculture is highly in Singida and Dodoma regions which counts for 82.4% and 81.9% respectively. While the least regions with women engaged in agriculture is Arusha with 60.1%.

7.2. Causal Factors for Agriculture Drought Susceptibility

Procedure used to analyse causal factor for drought susceptibility is the same as that of section 4.6.1. Figure 23 shows agriculture drought causal factors in the semi-arid regions derived from key informant questionnaire question number 4 under section B and question number 2 on focus group discussion conducted in Kikombo village with farmers. From figure 23, factors which highly contribute to agriculture drought susceptibility are dependence on rainfed agriculture, poor agriculture infrastructures, low rainfall and low capability. About 70% of respondents mentioned dependency on rain fed agriculture as major causal factor which make the women, children, elderly and disabled to be more susceptible to agriculture drought. The least causal factors for agriculture drought susceptibility are low government interventions, and climate variability with 5% each.

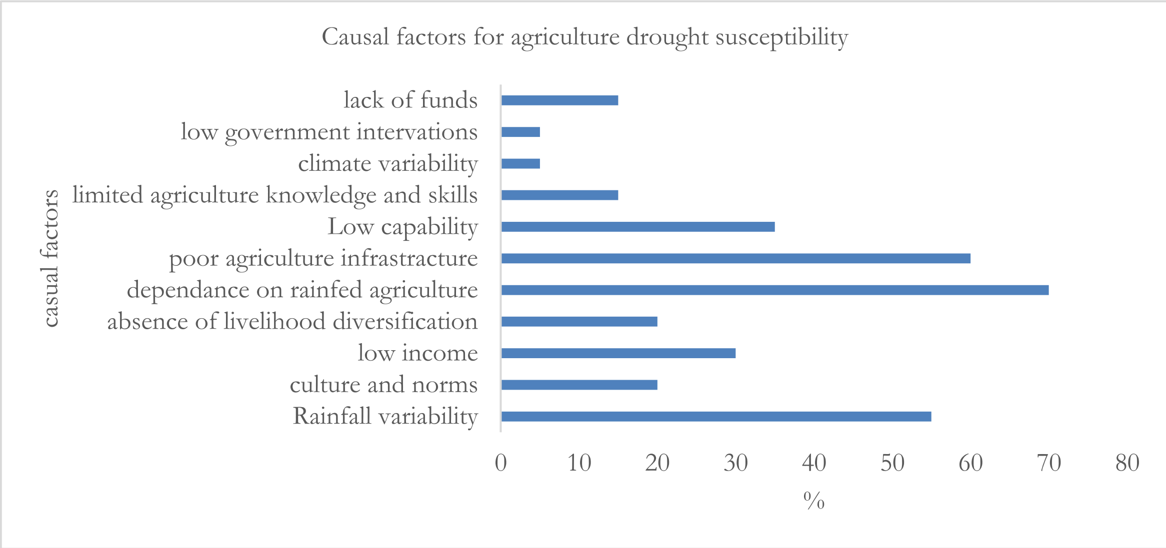


Figure 24: Causal factors for agriculture drought susceptibility: Source: Field data

Using existing literature and Tanzania documents from fieldwork mentioned under section 4.3.7, the causal factors for agriculture drought susceptibility for each region was then quantified. Procedures followed in producing causal factor maps for drought susceptibility is discussed and presented under section 4.6.3.2. This was important as it helps to see which regions are more susceptible than the other hence it will help in quantitative risk assessment for agriculture drought in those regions. Figure 25 to 27 show general spatial distribution of each causal factor in the study area.

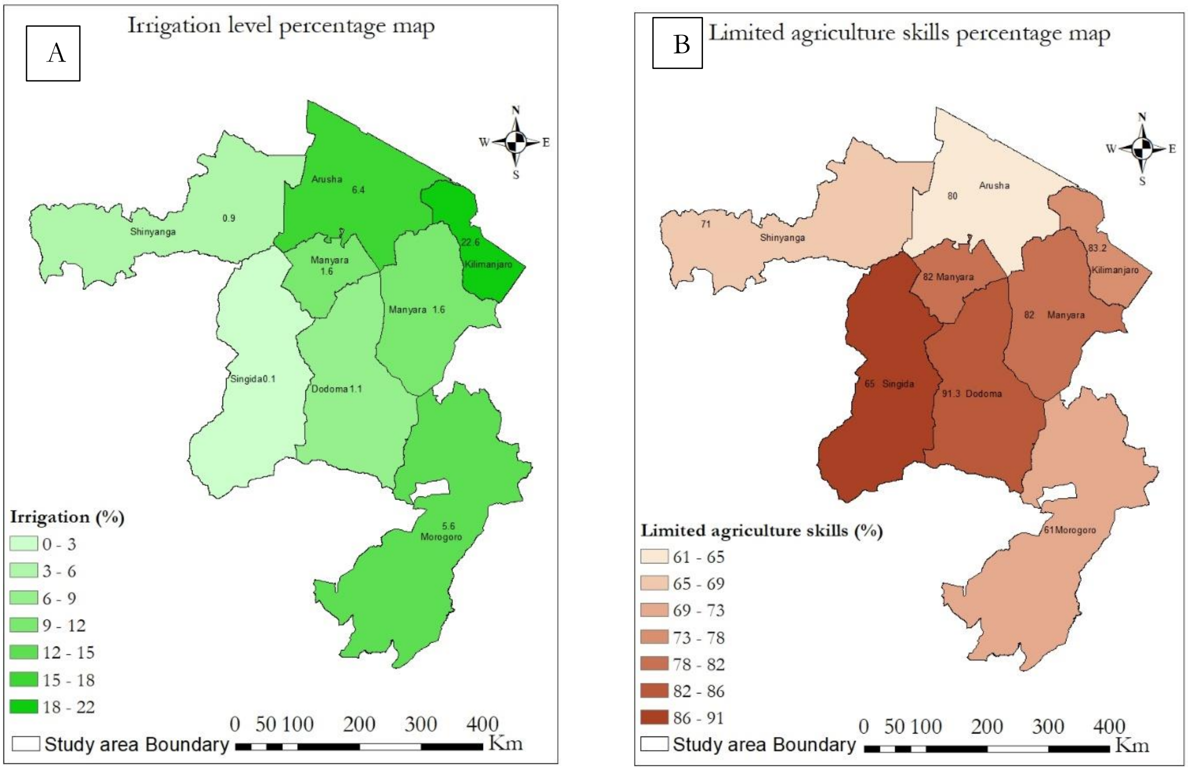


Figure 25 A/B: Percentage of Amount of irrigation practice and Limited agriculture skills per region: Source: (Ministry of Agriculture, 2016 & NBS, 2012) respectively.

Statistics used in creating figure 25A and 25B was from Annual Agriculture Sample Survey Crop and Livestock Report (Ministry of Agriculture, 2016 & NBS, 2012) page number 15 and 134, and the procedures used in creating this map is presented under section 4.6.3.2. From figure 25A results show that, Kilimanajro region is highly irrigated with 22.6% of irrigated area followed by Arusha and Morogoro regions with 6.4% and 5.5% respectively while the least irrigated region is Singida with 0.1% of total irrigated area. On the other hand, figure 25B shows percentage of limited agriculture skills per each region. Number of households receive extension advice on agriculture was used to describe limited agriculture skills as most of respondents in the field work mentioned agriculturalist are susceptible to agriculture drought because of limited agriculture skill cause by limited access to agriculture extension advice. As it seen on figure 21B percentage of household receive extension advice is high in Dodoma 90.3%, while the least region with low percent of household receive agriculture extension advice is observed in Morogoro about 61%.

In figure 26A/B also show distribution of poverty and low capability level as causal factors for agriculture drought susceptibility. Poverty level in Tanzania is measured using multiple indicator and one being percentage of household using hand hoe in agriculture (URT, 2016). Therefore, in this case percentage of household using hand hoe in agriculture was used as poverty indicator. On the other hand, low capability level indicator used in this case is presented as percentage of pesticides used in agriculture per region as most of households cannot afford the use of pesticide hence make them more susceptible to agriculture drought. Statistics used in creating these two maps are from Basic demographic and socio-economic profile 2012 population and housing census and Annual Agriculture Sample Survey Crop and Livestock Report (NBS, 2012)(URT, 2016).

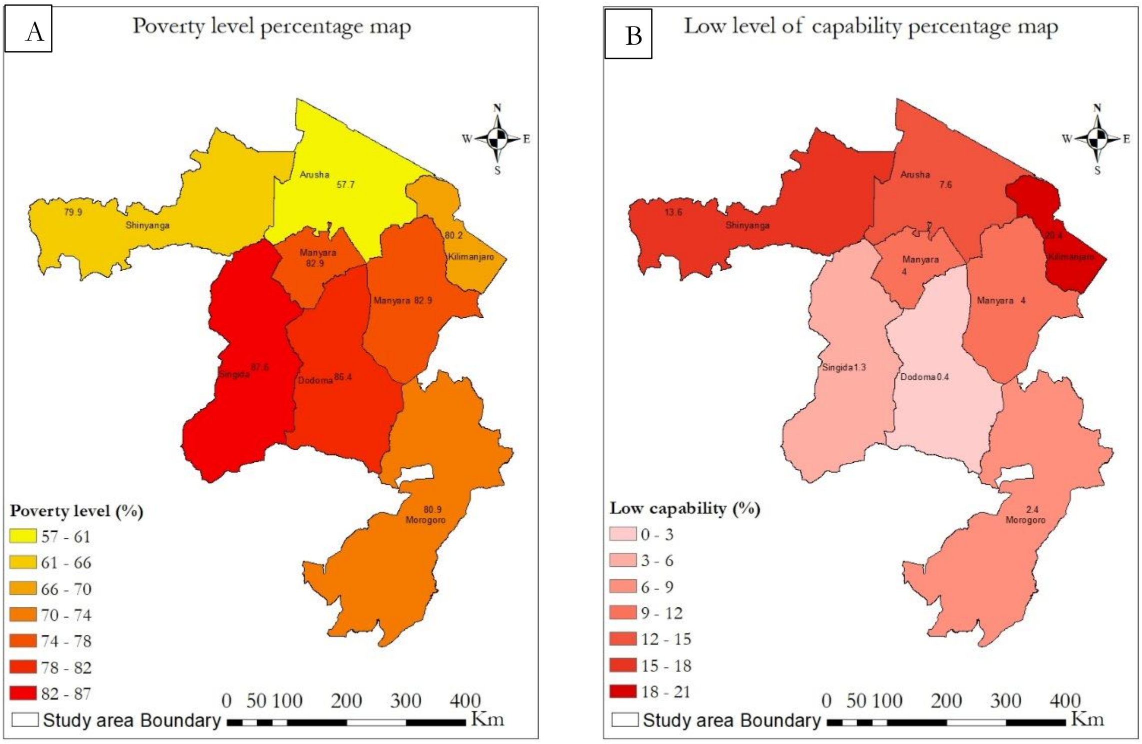


Figure 26A/B: Percentage of Poverty level and Low capability level per region in the study area: Source: (URT, 2016 & NBS, 2012).

Figure 26A observed that, poverty level is high in Singida 87.6% followed by Dodoma 86.4% while the regions with low poverty is observed in Arusha 57.7%. On the other hand, figure 26B is shows that, low level of capability in agriculture activities is highly observed in Dodoma 0.4%, followed by Singida 1.3%. While Kilimanjaro and Shinyanga are observed with high level of capability with 20.4% and 13.6% respectively.

The last causal factors for agriculture drought susceptibility are rainfall variability and dependence on rainfed agriculture. Rainfall variability in this case is little amount of rainfall received per regions. And the statistics of rainfall variability was extracted from a study on rainfall trend analysis in Tanzania from 1983 to 2012 which show trend of rainfall (Hamisi, 2013). And dependence on rainfall agriculture statistics was extracted from Tanzania agriculture census (NBS, 2012). Percentage of agriculture planted area during rainy season was used to show the dependence on rainfed agriculture as 80% of population in Tanzania depend on rainfed agriculture therefore the percentage of area planted during rainy season it has a direct link on rainfed agriculture. Also, the procedures followed in creating these two maps are presented under section 4.6.3.2. The results are shown in figure 27A/B.

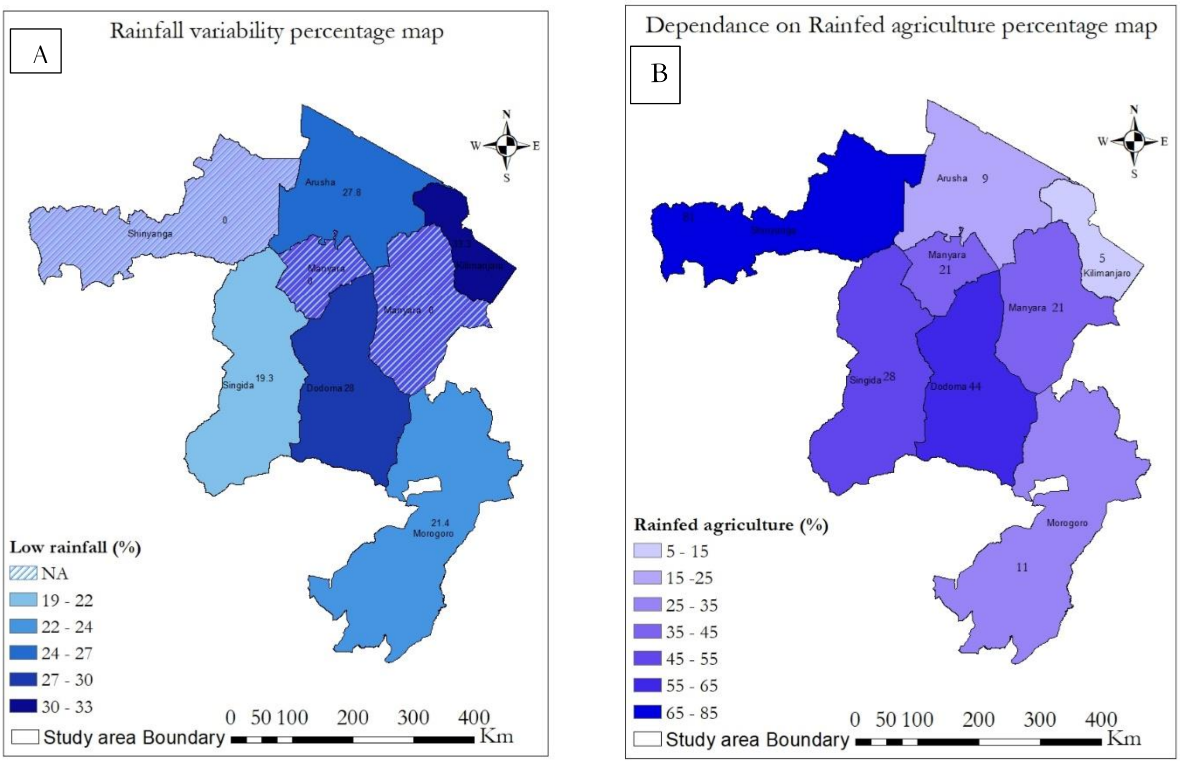


Figure 27 A/B: Percentage of Rainfall variability and Dependence on rainfed agriculture per region: Source: (NBS, 2012 & Hamisi, 2013)

In figure 27A it observed that, regions with high rainfall variability is Kilimanjaro 33.3%, followed by Dodoma 28%, while the regions with lowest rainfall variability is Singida 19.3%. Manyara and Shinyanga regions are empty due to no data availability. In figure 27B the regions with high dependence on rainfall agriculture is observed in Shinyanga 81% while the least regions in depending on rainfed agriculture is Kilimanjaro 5%.

Susceptibility weight index map was created based on combination of all the above discussed factors and shown in 28 below. The combined susceptibility index map was created in Arc map and the detailed procedures used in create the map presented under section 4.6.3.2

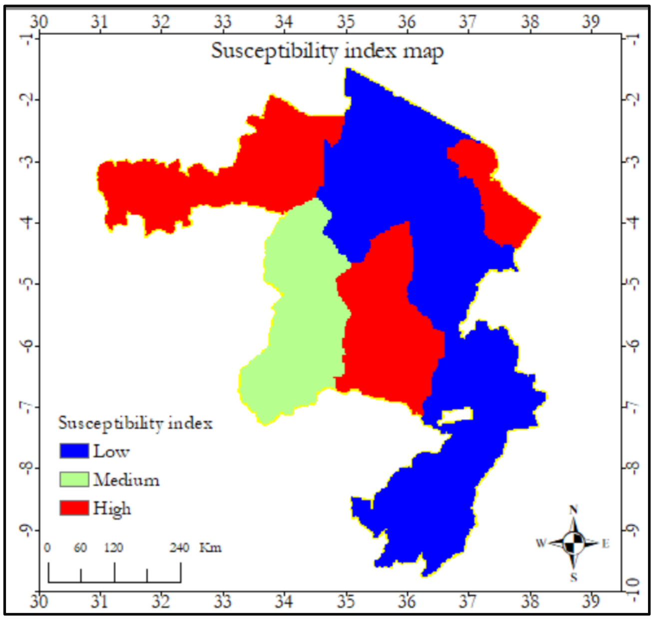


Figure 28: Susceptibility index map

From the susceptibility map, about 3 regions of the semi-arid zones are highly and lowly susceptible to agricultural drought. While Kilimanjaro, Dodoma, and Shinyanga are highly susceptible to agricultural drought, Arusha, Morogoro, and Manyara are least susceptible. Singida however is moderately susceptible.

7.3. Strategies for Improving Drought Resilience

Since drought in Tanzania is frequency and more recurrent hazard, government have managed to develop strategies and actions to improve drought resilience. The findings from figure 29 shows, among the actions taken by government to improve drought resilience. This figure is made from data collected through key informant questionnaire (Appendix 1) section B question number 5a and was analysed used method described under section 4.6.1

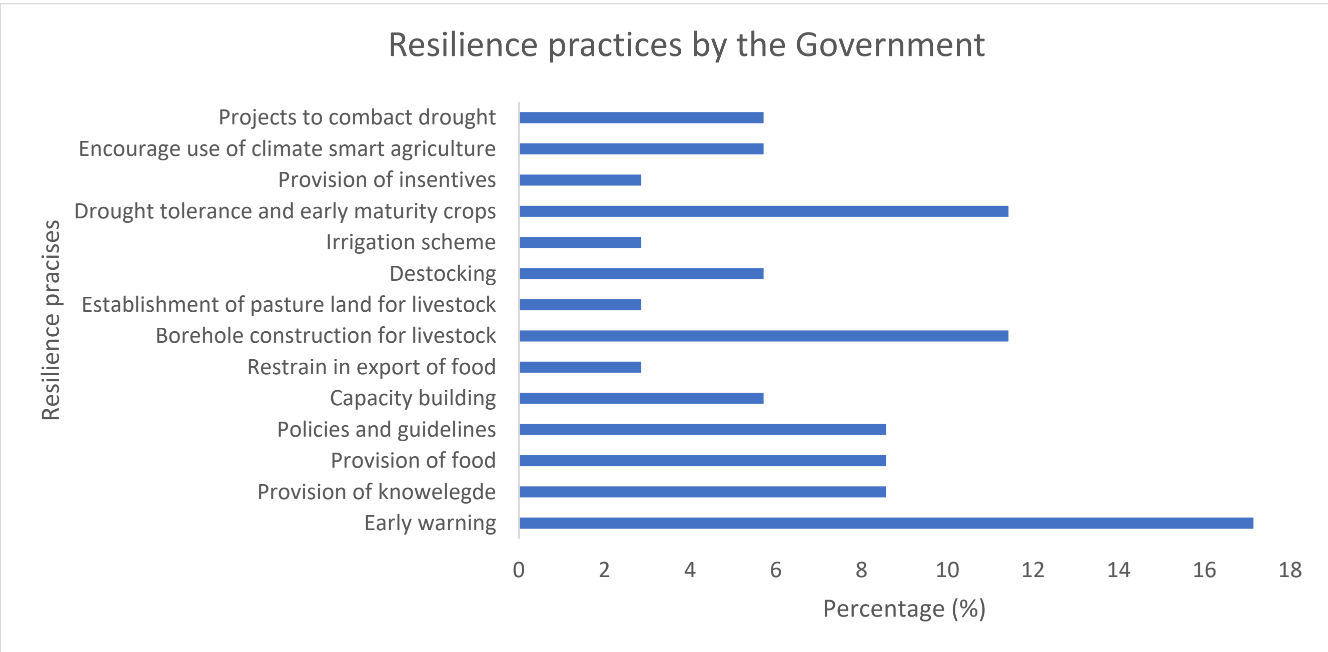


Figure 29: Drought resilience practices by government

Results from figure 29 above shows that, resilience practise highly done to build agriculture drought resilience community in Tanzania is through provision of early warning to farmers concerning drought also is a strategic measure to improve drought resilience as it counts for about 17% of the total response. Tanzania Meteorological Agency in cooperation with Ministry of agriculture under Early warning department is responsible in issuing early warning to farmers and country as whole for the coming unforeseen drought. This helps community to timely prepare for drought hence it reduces it effects. While the least build resilience practises were restraining from food export, provision of incentives and irrigation schemes.

Also, from farmers perspective the strategies and actions they take undertake to improve drought resilience are summarised in figure 30. Most of the findings are aligned well with that of the government as big percent mention the use of drought tolerant seed and early maturity crops and provision of education on good farming practises as the major strategies to improve drought resilience. While the least resilience practise being irrigation.

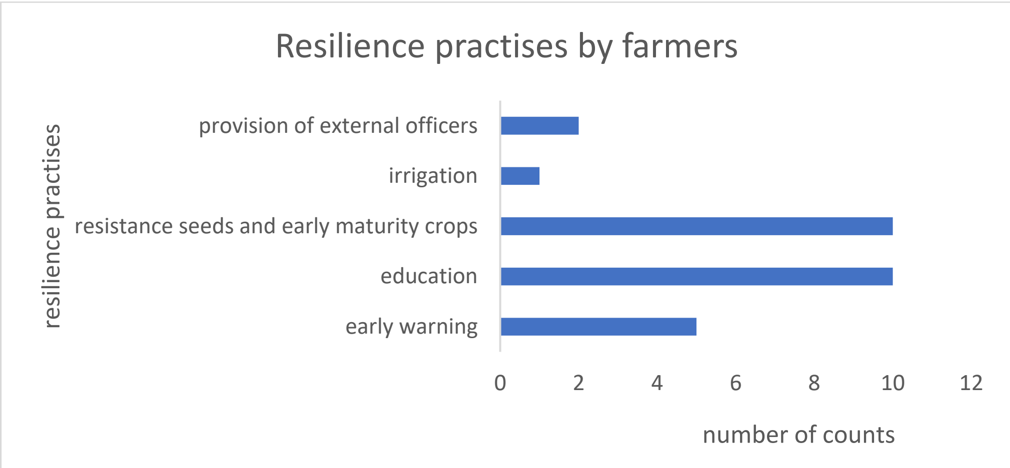


Figure 30: Drought resilience practices by farmers

8. RESULTS OF AGRICULTURE DROUGHT ADAPTATION EFFICIENCY

8.1. Agriculture Drought Impacts

Referring to the MOVE framework under section 2.3, this section describes in general the findings on agriculture drought impacts, adaptation strategies and adaptation efficiency in term of exposure reduction and improve resilience (capacity to cope, anticipate and recovery). Group discussion with farmers was used during field visit to get information on agriculture drought impacts, adaptation and their efficiency (appendix 1). Figure 31 below shows impacts of drought on agriculture to famers in Kikombo village in Dodoma region

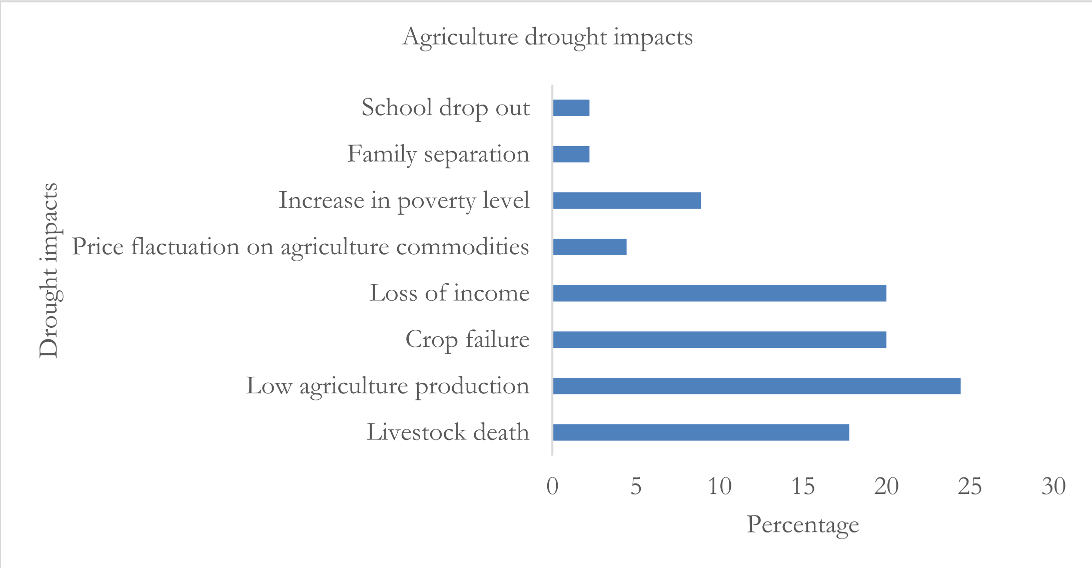


Figure 31: Agriculture drought impacts; Source: Field visit (Kikombo Village, Dodoma)

From figure 31 above it observed that, about 24% of respondents mention low agriculture production is the major impact of drought on agriculture followed by crop failure and loss of income 20% each. Also 18% of respondents mention livestock death as one of impact of drought. Family separation and school dropout were the least impacts of drought as they count for 2% each.

8.2. Agriculture Drought Adaptation Strategies

As agriculture drought cause loss and impacts to community as it has been discussed under section 8.1 above, it necessary for the community to adapt to these adverse impacts. Under this section, agriculture drought adaptation strategies and the coping capacity are discussed. In figure 32 below it shows agriculture drought adaptation strategies followed by famers in Kikombo Village Dodoma. As it shows in figure 32 below, it observed that majority of farmers in Kikombo village adapt to agriculture drought by use of organic manure and use of drought tolerant seeds such as cassava, millet and sorghum as it counts for 27% each. This followed by using of good farming practises which counts for 16% such as use of mixing crop cultivation, ridge cultivation, crop rotation and minimum tillage. The least adaptation followed by farmers is construction of water wells for livestock which counts for 5% are the least adaptation strategies followed. These practises are further shown on figure 32 below.

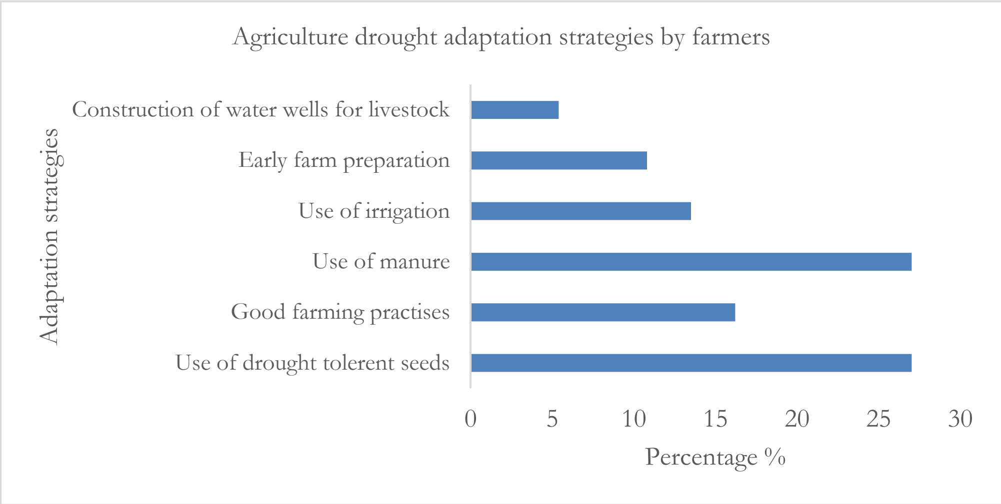


Figure 32: Agriculture drought adaptation strategies by farmers in Kikombo Village Dodoma

Furthermore, adaptation strategies followed by farmers in reducing drought effects on agriculture sectors were captured through transect walk described under section 4.3.5 during field visit in Kikombo village. Figure 33 shows the captured adaptation strategies which were present during field visit.

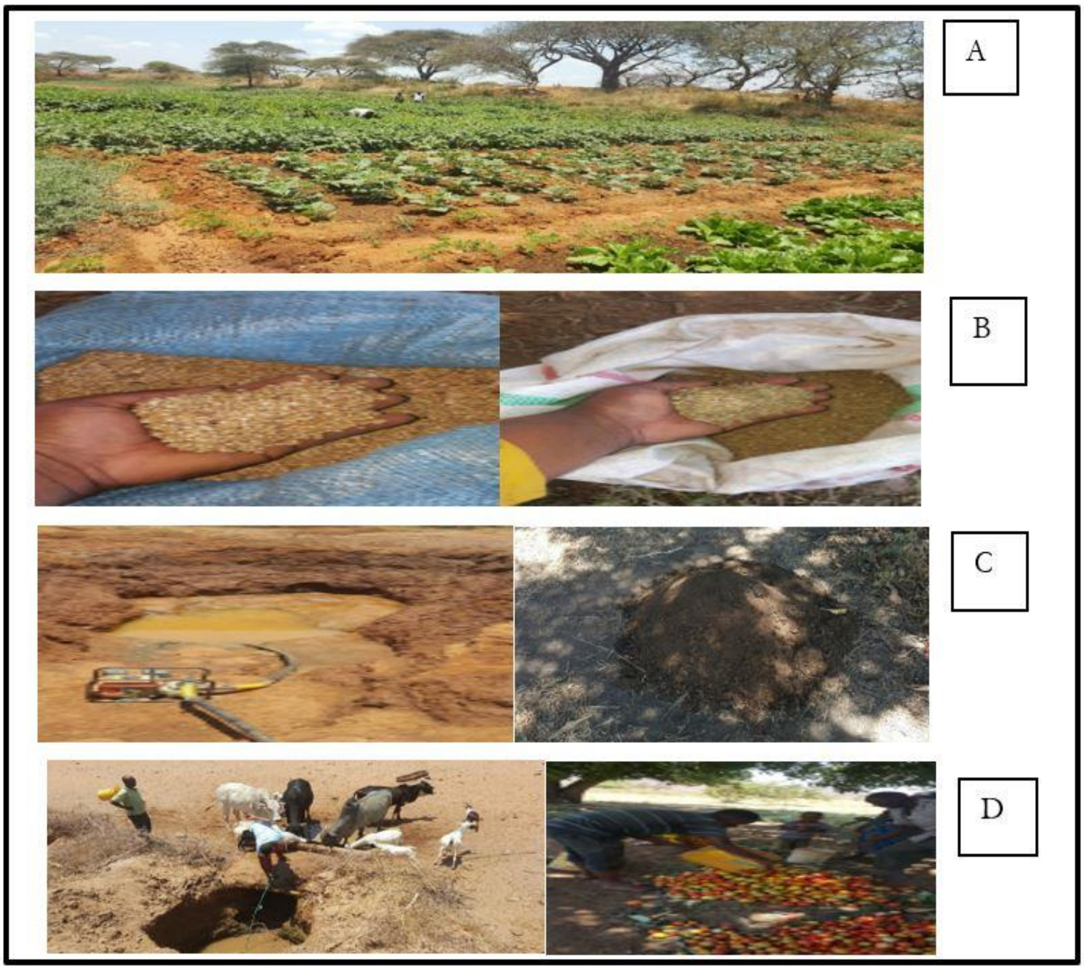


Figure 33: Adaptation strategies by farmers: Source: Field visit in Kikombo Village Dodoma

Figure 33 above show drought adaptation strategies followed by farmers in Kikombo Village. From the top (A) is minimum tillage followed by (B) drought tolerant seeds sorghum and millet, (C) is pumping irrigation and organic manure, and (D) is water wells for livestock and short term cultivated crops (tomatoes).

Also, information on adaptation to agriculture drought was also collected from government perspective using government document and analysed using ATLAS ti software. The document used to extract information on agriculture drought adaptation from government perceptive is presented under section 4.3.7 and procedures used in analysing the document can be found under section 4.6.3.1. Figure 34 below shows adaptation strategies recommended by government in adaption to agriculture drought. As it shown in figure 34 below some of recommended adaptation strategies to adapt to drought includes use of irrigation, ridge cultivation, drought tolerant crops varieties, use of agroforestry just to mention few.

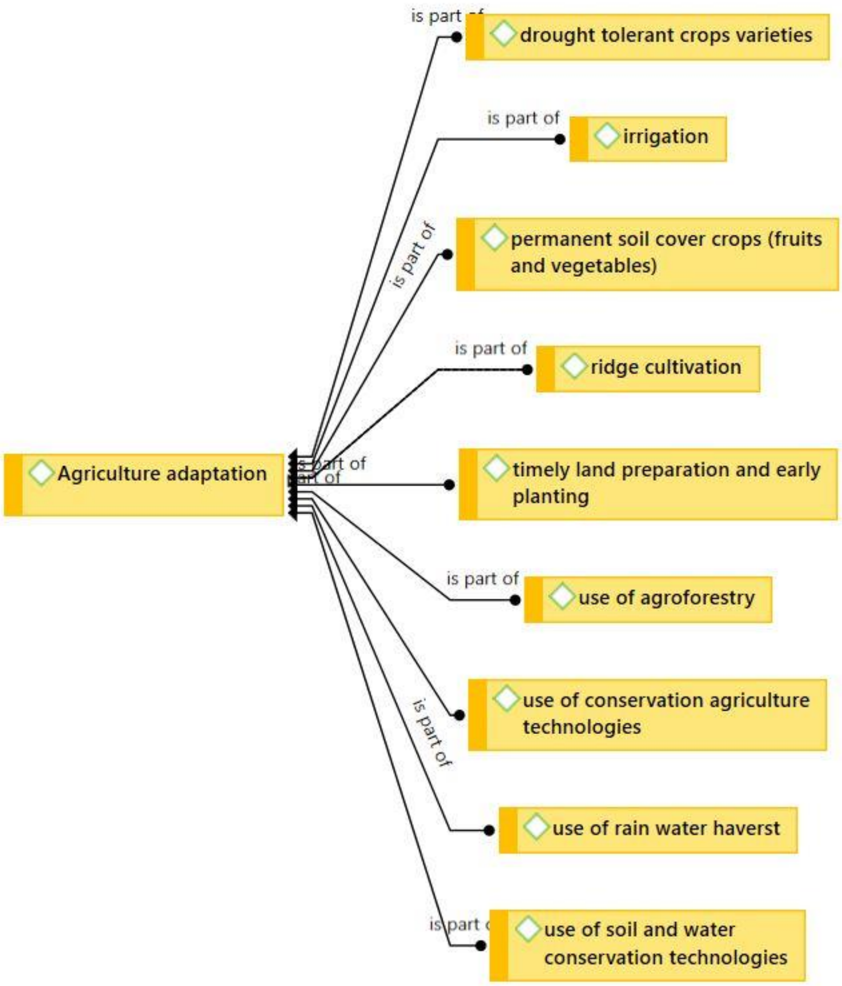


Figure 34: Agriculture adaptation strategies from government perspective: Source: (URT, 2017)

Also, respondents were asked to point out the coping strategies they are using during normal years (no drought years) to coping capacity in order to reduce adverse impacts of drought. Figure 35 below show the coping strategies used in the study area to cope with agriculture drought during normal years.

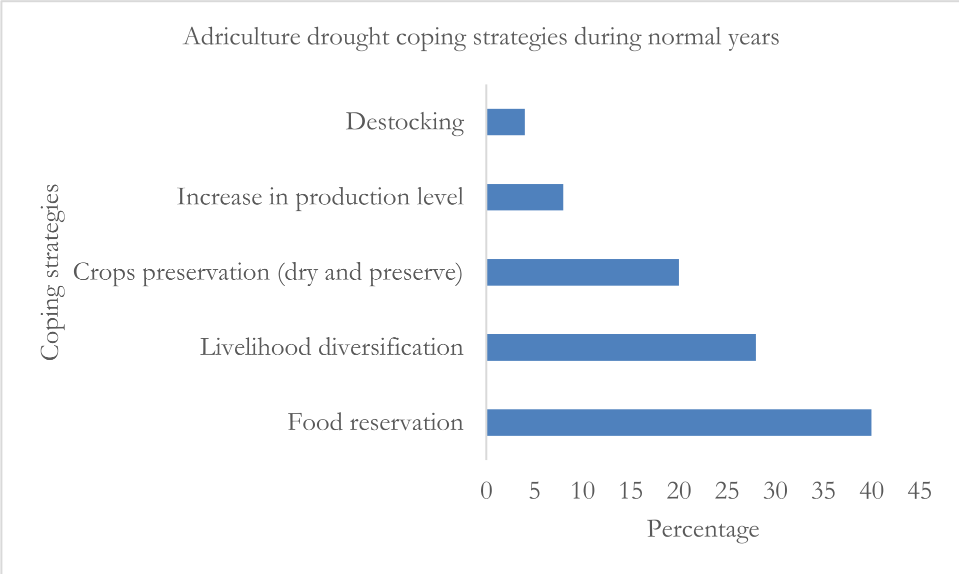


Figure 35: Agriculture drought coping strategies in Kikombo Village, Dodoma.

As seen in figure 35 above, 40% of respondents mention food reservation as main coping strategies to agriculture drought, followed by livelihood diversification 28%. During normal years farmers diversify their livelihood by engaged in other activities more than farming, for instance most engaged in small retail business. The least coping strategy which count 8% is destocking, where pastoralist minimise the number of cattle's by selling them and the money use to sustain life during dry years.

8.3. Efficiency of adaptation measures

To measure the effectiveness of adaptation measures, two indicators were used one being income level and another is production level. These indicators were provided by farmers during focus group discussion in Kikombo Village. Farmers rate the effectiveness of adaptation measures they use to adjust to agriculture drought through the level of production and income. For instance, agriculture production level increases when they use the above-mentioned adaptation strategies as the level of crop yield increase which results to high level of production. In terms of livestock keeping, high production come through high production of milk and meat. On the other hand, income level is used as indicator to measure the effectiveness of agriculture drought adaptation measures. In practical terms this means that, income level is increase through high sales of surplus agriculture crops and livestock.

8.4. Limitations

The main limitation of this research is data availability. The unavailability of rain gauge data to validate the satellite rainfall data made it impossible to calibrate the satellite rainfall models. Also, the incompleteness of field data especially from questionnaire survey influenced the study. For instance, spatial variation of drought in the region could not be assessed due to the nature of the questionnaire developed. Furthermore, due to the nature of questionnaires some questions were failed to be answered and some were answered in insufficient which made impossible for further analysis on those questions. Questions which were not answered/insufficiently answered under key informant questionnaire include questions number 1, 5b, 5c and 5d under section B and questions number 4, 5, 8, and 10 under section C. Also, the fieldwork duration made it impossible to gather information for all the semi-arid regions used for the research. In addition, the nature of the study area also was a limitation to this study. This is because semi-arid zone used in this study was quite too big and it was generalized/not area specific hence it can result into different results and conclusion in the part of vulnerability and adaptation efficiency. Also, the methods used in this study pose a little limitation due to inadequate sample size.

9. DISCUSSION

This chapter present the discussion of the objective results presented on chapter 5, 6, 7 and 8. As per objective, this chapter present further discussion on agriculture drought risk management and adaptation efficiency of semi-arid zone Tanzania in relation to the state of art present under this study.

9.1. To characterize agriculture drought hazard and its severity in semi-arid zone Tanzania, in space and time.

Agriculture is the main backbone economy of Tanzania as it employs about 80% of Tanzania population (Turuka, 2015, Gacsa, 2016, NBS, 2012 & Ministry of Agriculture, 2016). Despite of a vital role agriculture plays in Tanzania economy; the sector is most affected by frequent drought which pose a threat to large population depend on agriculture as a means of livelihood. Extreme drought events were observed in year 1982, 1987, 1988, 1991, 1994, 1993, 1997, 2000 and 2004 and 2017. This finding is well aligned with (S. E. Osima, n.d & Mdemu et al, 2000). Also in spatial variation drought is occur most frequent in northern and central part of Tanzania which includes regions like Kilimanjaro, Arusha, Manyara and Dodoma (Yanda et al., 2015, Red Cross, 2011). This find aligned well with the results presented under 5.2.

9.2. To identify available drought governance and their implementation that make people less vulnerable considering exposure, susceptibility and lack of resilience.

It must be noted that there is no single drought policy in Tanzania, but drought management issues are integrated into different sectors of the country. Also, there is no stand drought management framework present, it only general disaster management framework is available at present. Therefore, this study manages to fill this gape by constructing drought management framework through interviews, key informant questionnaires and literature review. In reduce drought risk, organisation which are involved in drought management from Nation level to local level work together for effective drought vulnerability reduction. Government has role in provision of early warning, tree planting, introducing drought tolerant crop varieties, provision of relief services, education and ratification in international agreement such as the United Nations Convention to Combat Desertification (UNCCD) in reducing agriculture drought vulnerability. This finding concurs with URT, (2017), Majule, (2018) and URT, (2012).

9.3. To analyse societal vulnerability to drought risk base on exposure, susceptibility and resilience.

Women are the most vulnerable group affected by agriculture drought in Tanzania. This is because agriculture is termed as the main source of income for about 80% of Tanzania population and big percent being women (Turuka, 2015).This find also concurs well with Mollet & Barelli, (2016), Gacsa, (2016), & URT, (2012). Due to failure of livelihood diversification most of women who engaged in agriculture suffer major loss during drought. Poor technology and farming system mentioned as causal factors which makes people to be susceptible to drought. Most of farmers still use traditional farming system like the use of hand hoe, organic manure which makes low production. Furthermore, lack of technology in most of areas also contribute as a factor for drought susceptibility. Technology like irrigation (pumping and drip irrigation) is not common in many of farming communities which makes farmers to be susceptible during the dry seasons as they only depend on rainfed agriculture. As agriculture is mainly rainfed in Tanzania (Gacsa, 2016, URT, 2012, FAO, 2016, & Hamisi, 2013). This contribute much to vulnerability of agriculture sector in the country. As results presented shows that most of semi-arid region are purely rainfed agriculture mostly in Shinyanga and Dodoma region while Kilimanjaro has low dependence on rainfed agriculture as it has high percentage of irrigation schemes.

9.4. Evaluating drought adaptation strategies in the study area

Use of drought tolerant crops varieties is the major adaptation strategies recommended by government and followed by most of farmers in reducing the adverse effects of agriculture drought in Tanzania. This finding aligns well with results of adaptation strategies from focus group discussion with Kikombo village farmers and that of key informant questionnaires from government ministries. Also study from Yanda et al., (2015) & URT, (2012) align well with this finding. Based on the severity/frequency of drought and land use, these adaptation strategies tend to vary on semi-arid zone Tanzania. For instance, Arusha region due to frequent drought and low rainfall, agriculture practises are limited, and most people engaged in livestock keeping. Therefore, most of the land use is based on livestock keeping. And the households who practises agriculture, use temporary mixed and mono crops cultivation and the main crop planted been cereal (NBS, 2007). On the other hand, region like Morogoro which receive more rainfall than all the semi-arid region it adapts different to drought than other regions. For instance, agriculture land use involves irrigation schemes and major crop planted under this region been rice and sugar. Example is Dakawa and Kilombelo sugar irrigation scheme for rice and sugar production in Morogoro region (Anna, 2014).

In measure effectiveness of adaptation strategies, only two indicators were mentioned which are increase in income level and production level as discuss under section 8.3. farmers mentioned that, through increase in level of production and increase in income generated from agriculture activities shows that the adaptation measures used on the ground are efficient. But this is so limited, therefore there is a need of further study to assess the efficiency of adaptation strategies. Alternatives ways of analyzing adaptation efficiency can be through damage function by analyse how many crops they had to throw away; how much less money they made in a year of drought, how many fewer employees they can employ. Or through compare how many farmers were exposed to droughts before or after drought adaptation measures, or how many were less susceptible, more resilient, etc.

10. CONCLUSION AND RECOMMENDATION

10.1. Conclusion

Tanzania has long been suffering from natural hazards especially drought. Drought is mostly experienced in the Central and Northern part of Tanzania, where livelihood depends much on rain fed agriculture. Due to extreme weather event (such as drought) caused by climate change, it is paramount to develop effective adaptation measures to reduce drought associated risk.

This study assessed agriculture drought risk and adaptation efficiency in the semi-arid zones of Tanzania and proposed strategies to evaluate the effectiveness of drought adaptation strategies. To do so, the Method for the Improvement of Vulnerability Assessment in Europe (MOVE) framework which underlines hazards, societal vulnerability, risk, risk governance and adaptation as key factors to lessening risk and improve adaptation. Remote sensing data (CHIRPS), qualitative data from governmental perspective and literature-based data were used to analyze the drought hazard, vulnerability, risk governance and adaptation strategies on drought. From the CHIRPS data, Standardize Precipitation Index (SPI) was used to characterize drought in terms of drought duration and severity. Also, field survey through key informant questionnaires, focus group discussion and reviewing available literature on national policies and drought adaptation strategies; societal vulnerability, risk governance and adaptation strategies was evaluated.
Based on the analysis, below are the conclusion to the research objectives.

Objective 1: To characterize agriculture drought hazard and its severity in semi-arid zone Tanzania, in space and time.
Rainfall attributes such as start of the rain season and lack of long-term cumulative rainfall can describe drought events in term of its severity and duration. In this study a mismatch is found between results of drought events described by Precipitation Anomaly Percentage (PAP) and 1 month and 3 months SPI as 1-month and 3-month SPI are mainly associated with soil moisture deficit and not agricultural drought. Drought years as depicted by 6-month and 12-month SPI are highly correlated to drought years classified using PAP.

Objective 2: To identify available drought governance and their implementation that make people less vulnerable considering exposure, susceptibility and lack of resilience.
Drought hazard management in Tanzania is governed through different governmental and non-governmental stakeholders from National level to Local level. The constructed drought management organisation framework of key stakeholders and their role in drought management show a clear understanding on how drought is managed and how is involved in drought management in Tanzania. From documents and interviews, the effectiveness of responsibility of each stakeholder in agriculture drought risk management is not clearly shown due to insufficient data. Based on key informant questionnaires it is observed that current government intervention is base much on crisis management (response and recovery) rather than risk management (mitigation and preparedness). And this makes the situation even more worse as people are based on treating the symptoms of agriculture drought instead of underline causes which will help in lessen the adverse effects of drought.

Objective 3: To analyse societal vulnerability to drought risk base on exposure, susceptibility and resilience.
The most vulnerable and exposed group to agriculture drought hazard in Tanzania are women. Agriculture sector is the backbone of Tanzania economy as it employs large population and about 80% been women. Due to tradition, customs and norms in Tanzania, women are the one who takes care of the family by insure there is food to feed the whole family, thus make them to engaged in agriculture food production. During dry season, female children are forced to drop out of school to help their mothers in search of water to irrigate crops and for household activities such as cooking Therefore, this make women more vulnerable to agriculture drought.

On the other hand, dependence on rainfed agriculture is the leading causal factor for agriculture drought in Tanzania. As the backbone economy, agriculture is most rainfed in Tanzania which make it even more susceptible to drought and the region which is most depend on rainfed agriculture been Shinyanga while Kilimanjaro region is less dependent on rainfed agriculture as it has high irrigation scheme. Also, poor agriculture infrastructure such as low irrigation schemes in most of the regions within administrative boundaries of semi-arid zone is highly contribute to vulnerability and the regions which are highly vulnerable are Shinyanga, Singida and Dodoma

Objective 4: Evaluating drought adaptation strategies in the study area
Drought tolerant seeds and early maturity crops are highly recommended to adapt to agriculture drought in semi-arid zone Tanzania. Although there are other adaptation measures taking place, but the efficiency of all measures is evaluated through the production of agriculture output produced through the adaptation strategies used by farmers. Most of the farmers mentioned use of drought resistance crops as most efficient adaptation measure as it yields more crops. To improve agriculture drought resilience both government stakeholder and farmers perceive that, effective early warning regarding drought and use of drought tolerant seed and maturity crops is highly recommended.

From the susceptibility map, about 42% of the semi-arid zones are highly and lowly susceptible to agricultural drought. While Kilimanjaro, Dodoma, and Shinyanga are highly susceptible to agricultural drought, Arusha, Morogoro, and Manyara are least susceptible. Singida however is moderately susceptible.

10.2. Recommendations

Drought can also be explained by vegetation. In drought periods, some vegetation loses it green pigment and some of the moisture content. These phenomena can be explained by using vegetation index such as normalized difference vegetation index and vegetation water content. Incorporating these phenomena can further improve drought hazard assessment.

Further studies should be made on assess the effectiveness of adaptation measures and not rely only on the agriculture output indicator as the measure of effectiveness. To determine the effectiveness of the adaptation measures, the long-term goal should be stated and assessed at regular duration. The assessment can be based on organizational capacity and resilience capacity.

Also, the nature of study area should be reduced maybe focusing only on one semi-arid region. This will provide a detailed analysis as the study will not try to generalize everything instead it will work on area specific. By doing this will make analysis even more detailed as author will only focus on providing information and analysis on specific semi-arid region.

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APPENDIX

Appendix 1: Key Informant Questionnaires and Focus Group Discussion
Part 1. Key informant questionnaires from government

Name	
Institution/Organization	
Department	
Position	
Address	

B. DROUGHT VULNERABILITY (EXPOSURE, SUSCPETIBILITY AND RESILENCE) PER DISTRICT

Objective 2. To analyse societal vulnerability to drought risk base on exposure, susceptibility and resilience

- Who/what does government consider as most vulnerable to drought?
- What are the causal factors make them susceptible to drought hazard?
- What are the strategies and actions government undertake to improve drought resilience (capacity to anticipate, cope and recover) from drought hazard?

1. What are the indicators of drought vulnerability do government consider in vulnerability assessment?

Physical:
Social:
Economical:

2. What are the vulnerable groups exposed to the adverse effects of drought?

3. How do you rate vulnerability level to the following vulnerable exposed groups?

Groups	Very high	High	Moderate	Low	Very low
Income level					
High income					
Middle income					
Low income					
Age					
Young					
Middle					
Elderly					
Groups					
Women					
Men					
Disabled					
Education level					

High					
Medium					
Low					
None					

4. What are the causative factors which makes people to be more suspect able to drought?

5a. What are the practises employed by the government and non-governmental organisation in building resilience to drought in the drought prone areas?

5b. How effective are the mentioned practises in building drought resilience?

Building Resilient Practise	Effectiveness level from 1-4 (1 not effective 4 very effective	Reason for effectiveness/ineffectiveness

5d. which criteria do you use to measure the effectiveness of practise employed to build drought resilience?

5c. If not effective, what should be done to make them more effective?

C. DROUGHT GOVERNANCE AND POLICIES AND THEIR IMPLEMENTATION

Objective 3. To identify available drought governance and policies and their implementation that make people less vulnerable considering exposure, susceptibility and lack of resilience

- What are the roles of national governmental organizations in drought risk management
- Where is key focus area of the government in drought risk management and adaptation?

• How far is United Republic of Tanzania (URT) on addressing and implementation three pillars of drought risk management policy (monitoring and early warning, risk assessment and mitigation and response measures)?

• What are the pre and post impact government/non-government intervention polices on drought adaptation?

1. In the order of importance, which implementation level do you consider most important in drought vulnerability reduction?

Levels	(1- very unimportant, 10- very important)									
	1	2	3	4	5	6	7	8	9	10
National level										
Regional level										
District level										
Local level										

2. What institutions agencies/department/organisation/NGO’s/ provide support services during drought?

Institution name	Support Services

3. What are the roles of national governmental organizations in drought risk management?

Institution name	Roles

4. Where is key focus area of the government in drought risk management and adaptation?
5. How far is Tanzania on addressing and implementation three pillars of drought risk management policy (monitoring and early warning, risk assessment and mitigation and response measures)?

Drought risk management pillars	Action taken in each pillar	How far			
		Excellent	Good	Somewhat	Poor
Monitor and early warning					
Risk assessment					
Mitigation and response					

6. Which kind of drought management approach most common used to limit drought impacts?
   a. Pro-active approach
   b. Reactive approach
7. What are the pre and post impact government/non-government intervention polices on drought adaptation?
   a. Pre-intervention:
   b. Post intervention:

8a. Is there any drought management policy/plan in the county?

a. Yes (if yes please provide the documents)
b. No
If no skip to question 9

8b. If yes, how effective is the policy/plan?
a. Not effective b. Not effective c. Very effective

8c. How do you measure a policy is effective?

8d. If not effective, what can be done to make them more effective?

8e. Can you name that policy/plan and drought management strategies included?

Drought Policy/Plan	Drought Management Strategies

9. What drought management strategies do you think should be developed in Tanzania to reduce drought vulnerability and it impacts?

10. Can you rate the level of indicators for measuring effectiveness of policy implementation for drought management at the local level

Indicators used to measure of effectiveness of the policy	Explanation (how is the indicator used)	Effectiveness
Local government funds		
Drought knowledge and technology		

Water efficiency projects Income diversification and improvement Social		
Social capital and networks, governance structures		
Access to resources		
Community participation		
Leadership		
Others		

Part 2: Focus group discussion from farmers in Kikombo village Dodoma

Name:	
Institution:	
Position:	
Address:	

DROUGHT ADAPTATION STRATEGIES

Objective 4. Evaluating drought adaptation strategies in the study area

- What are the existing drought adaptation strategies followed by farmers?
- Which drought adaptation are more effective? Why?

1. What are the vulnerable groups exposed to the adverse effects of drought?

2. What are the causative factors which makes people to be more suspect able to drought?

3. what are the effects of drought on agriculture and livestock? (1 example of tree diagram)

4. What are the practises employed by the government and non-governmental organisation in building resilience to drought in the drought prone areas?

5. Who provide information about drought?

6. Is the information time efficiency in prepare for drought?
   a. Yes
   b. No

7. How do you prepare during normal years to cope with adverse drought impacts?

8. Please list adaptation strategies followed by farmers to reduce effects of drought?

9. In a ranking order which adaptation strategies are more efficient?

10. How do you measures efficiency of adaptation measure?

Indicators to measure the efficiency	Reasons

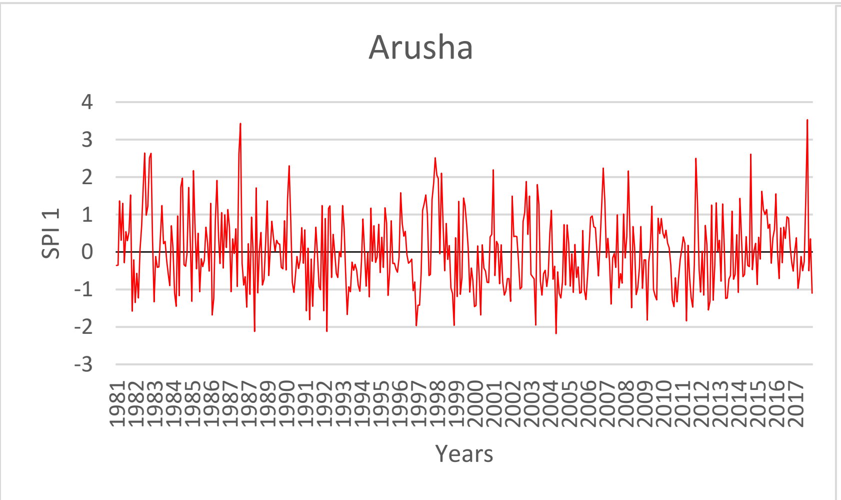
11. What should be done to improve efficiency of adaptation measures?

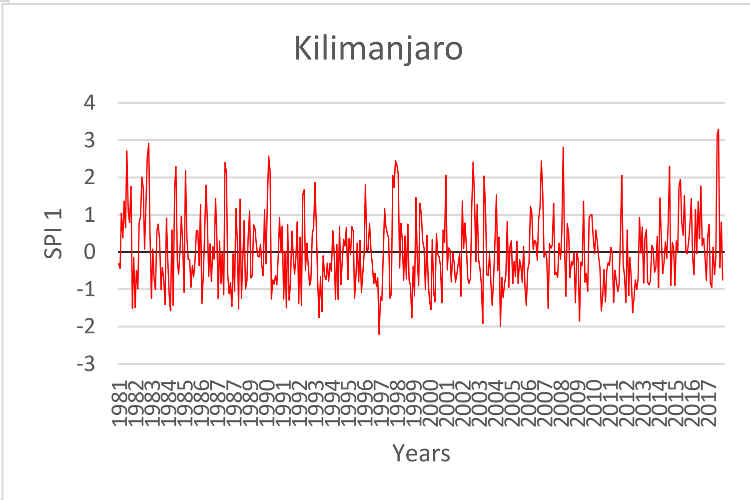
Appendix 2: SPI results

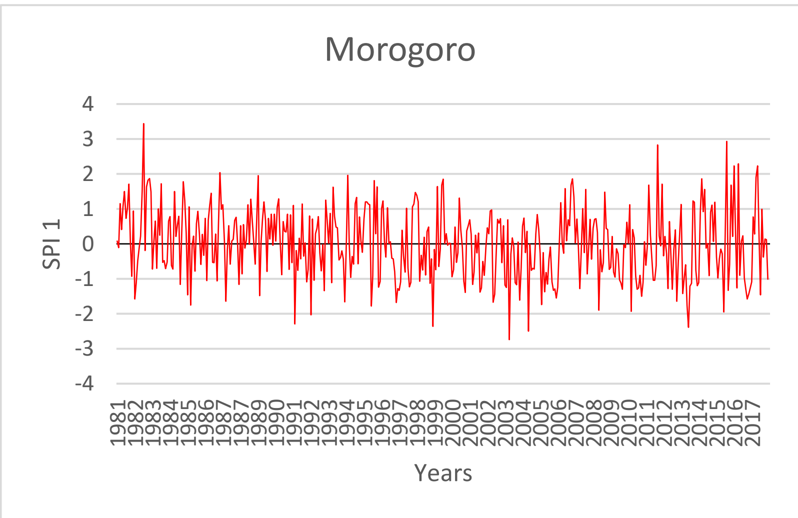
This section of appendix shows 1, 3 and 12 month SPI results and SPI average and mean map from 1981-2017.

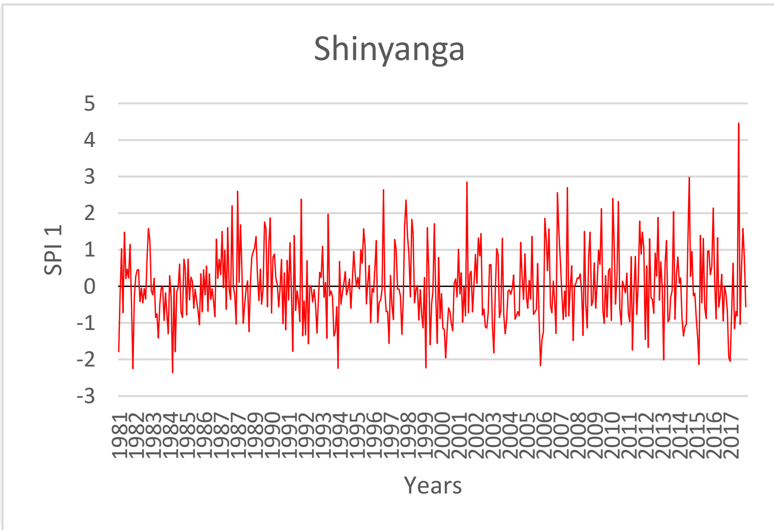
P*art 1: Drought events detected by SPI 1, 3 and 12*

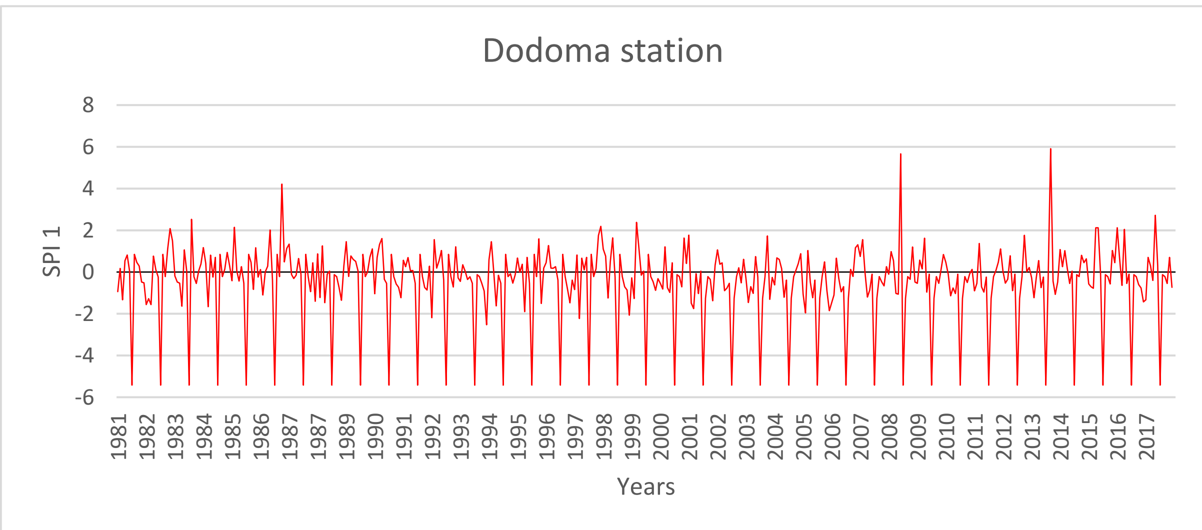
SPI 1



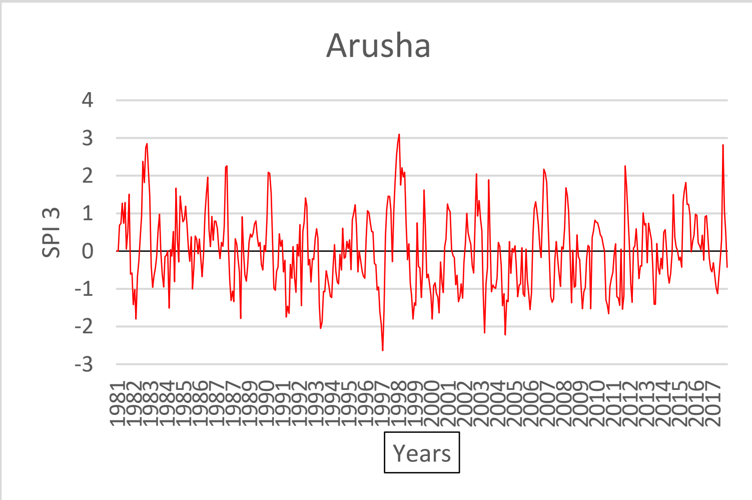


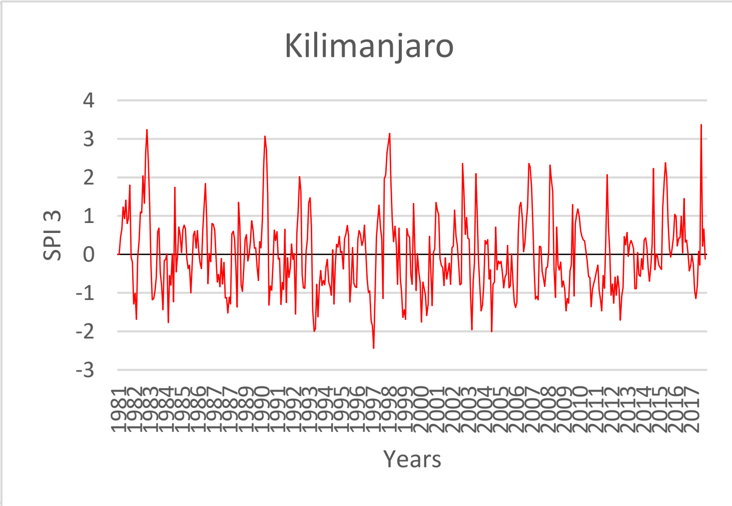


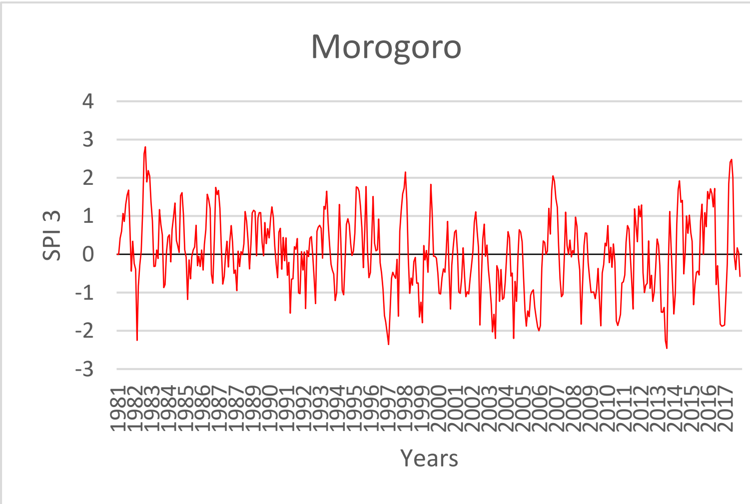


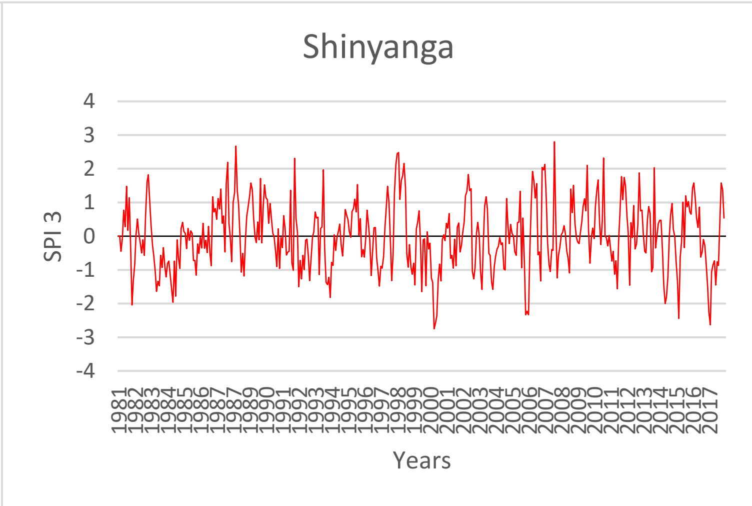


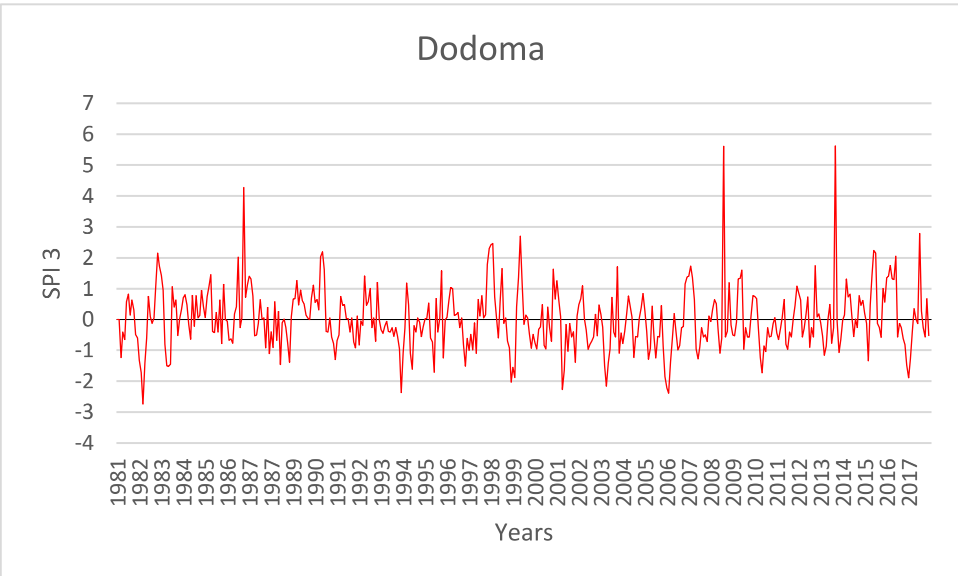
SPI 3


Arusha
4
3
2
1
0
-1
-2
-3
SPI 3
Years


Kilimanjaro
4
3
2
1
0
-1
-2
-3
SPI 3
Years


Morogoro
4
3
2
1
0
-1
-2
-3
SPI 3
Years


Shinyanga
4
3
2
1
0
-1
-2
-3
-4
SPI 3
Years


Dodoma
7
6
5
4
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2
1
0
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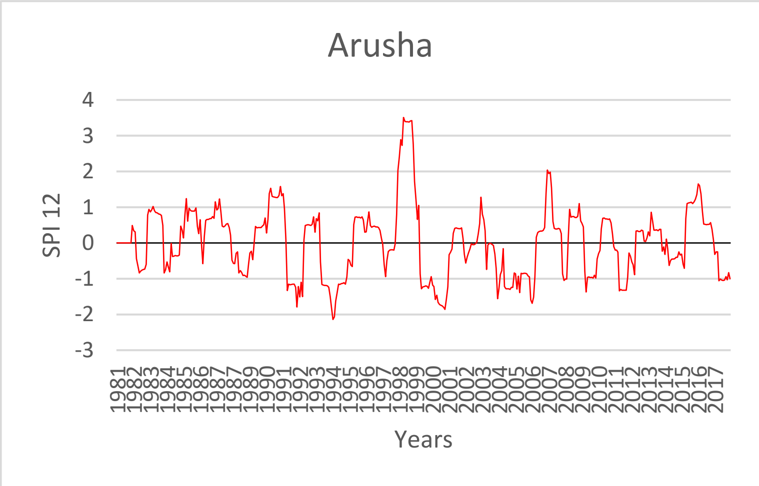
-2
-3
-4
SPI 3
Years

SPI 12


Arusha
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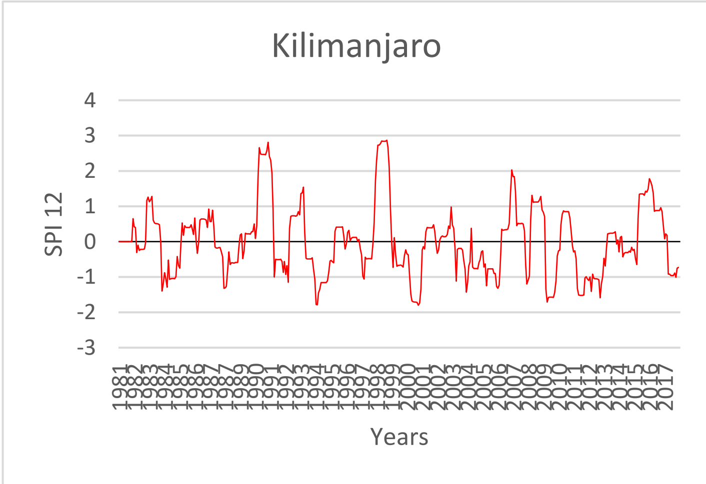
Years


Kilimanjaro
SPI 12
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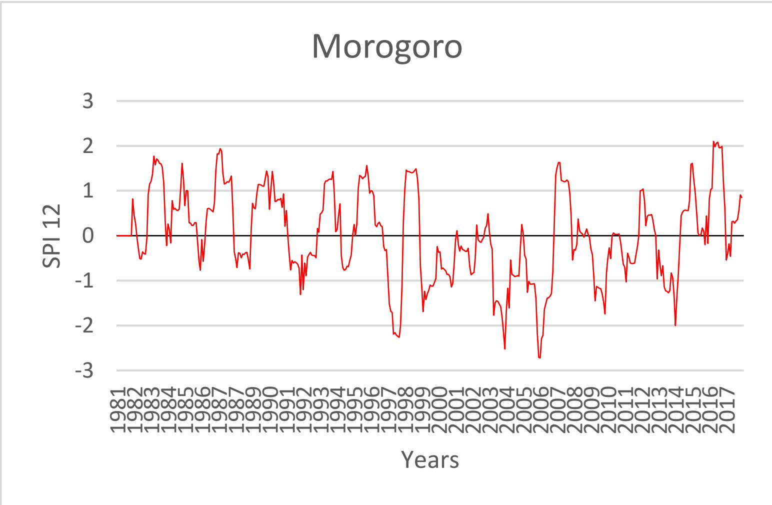
Morogoro
SPI 12
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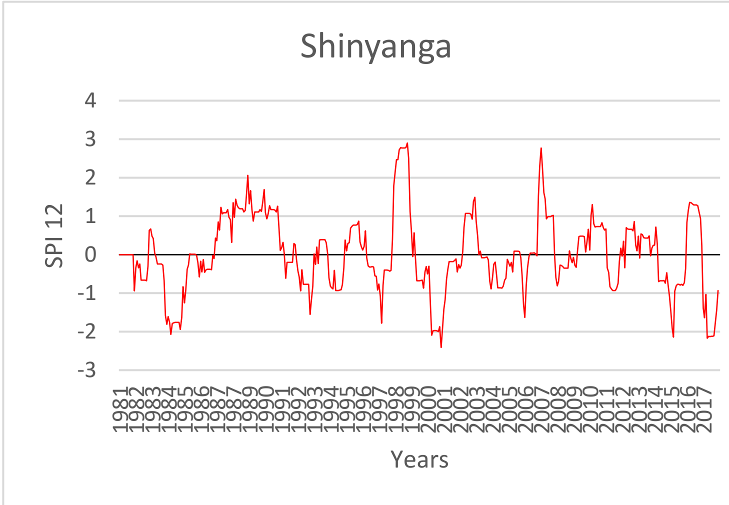
Years


Shinyanga
SPI 12
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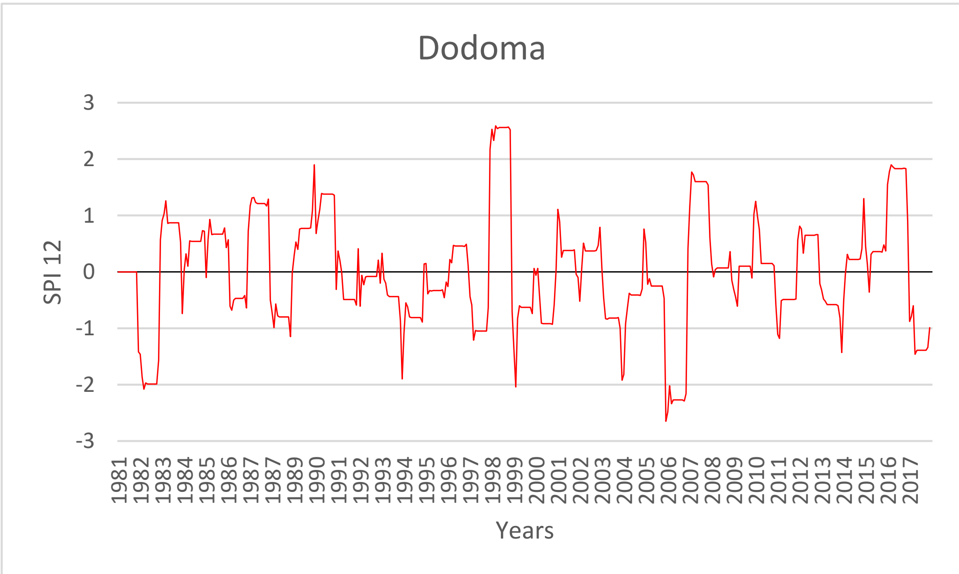
Years


Dodoma
SPI 12
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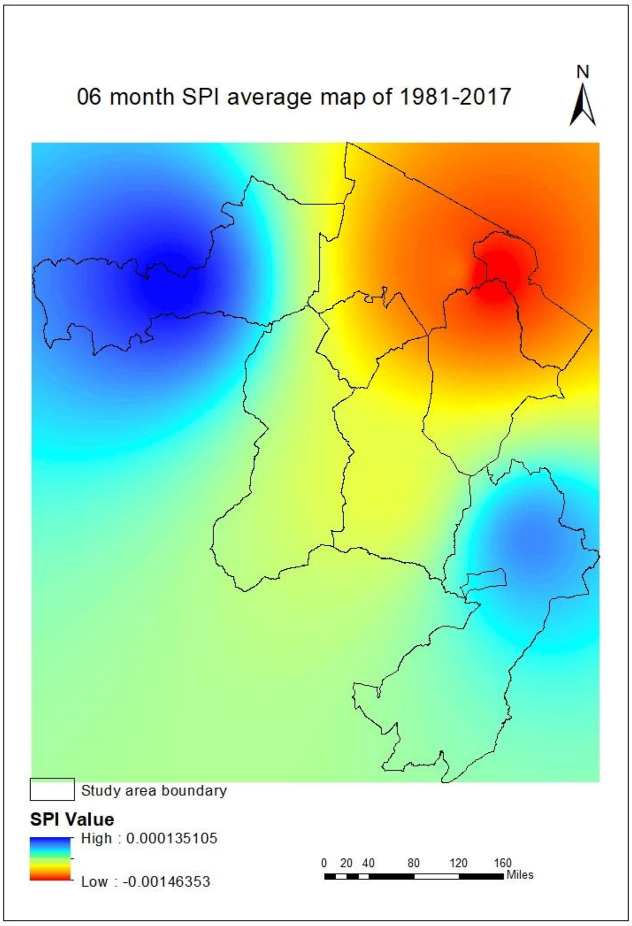
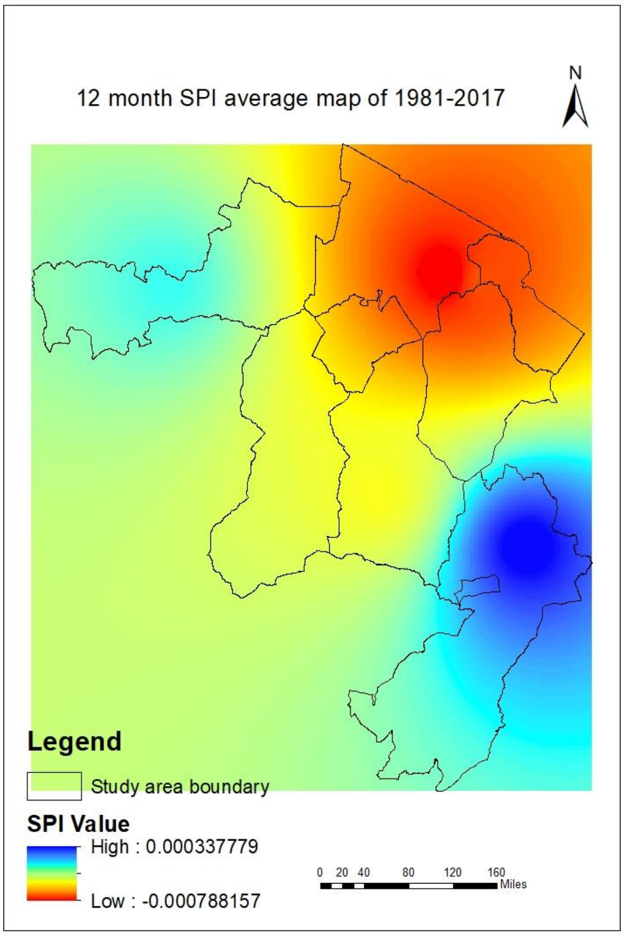
-2
-3
Years

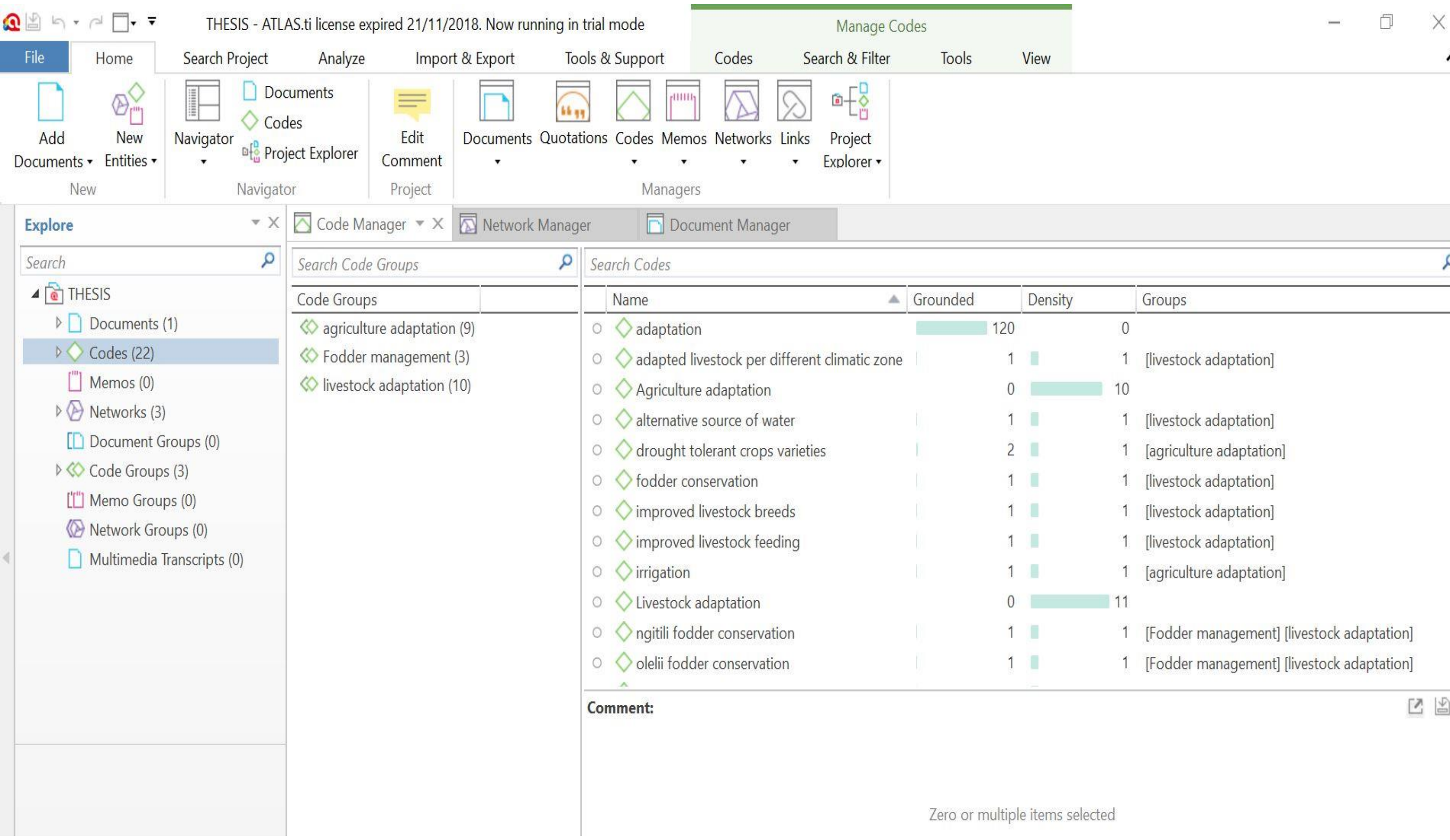
Part 2: SPI average maps





Appendix 3

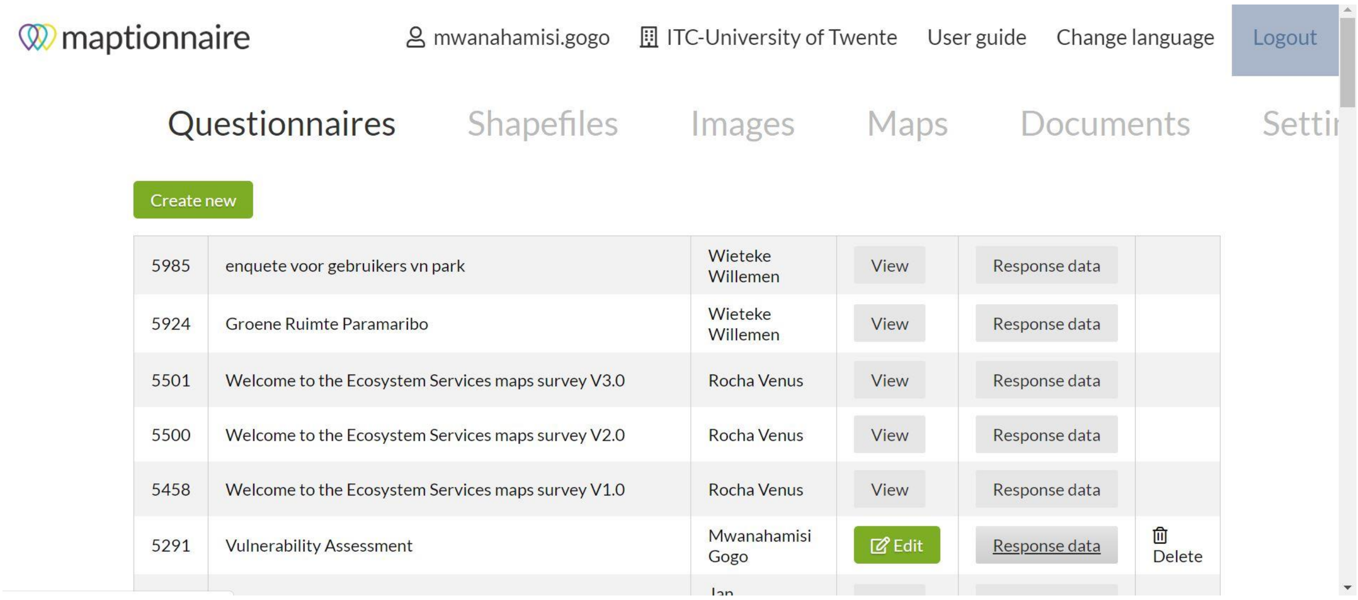
ATLAS ti software page of analysis showing document loaded into the software, codes generated and network analysis.

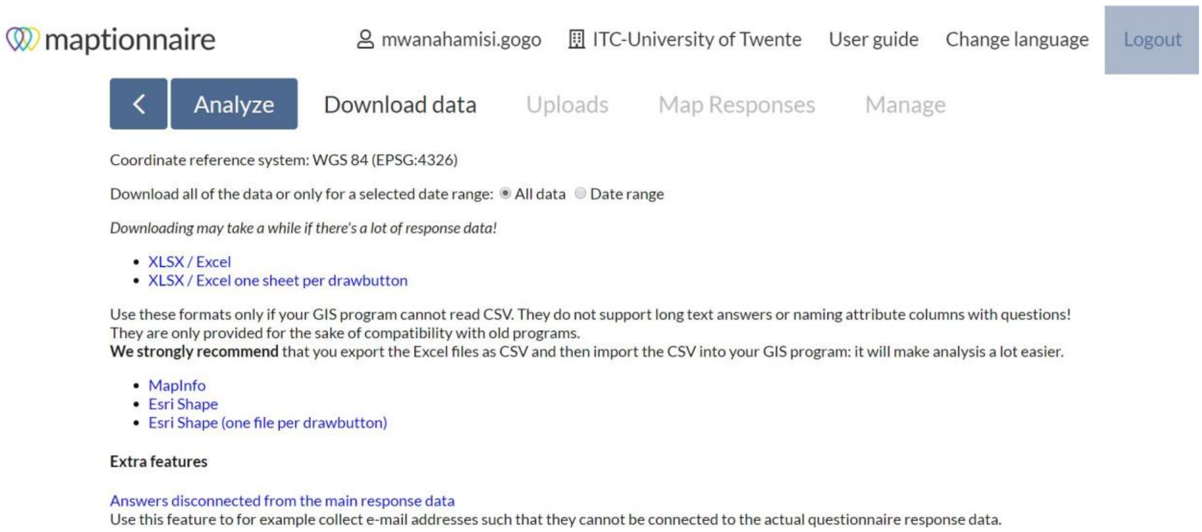


Appendix 4

Under this appendix it present maptionnaire questions and their answers.

Part 1: How maptionnaire was created and downloaded





Part 2: Maptionnaire questions

Name and Description

Questionnaire number: 5291

Vulnerability Assessment

Dear respondent,

This survey is done purposely to elicit information on drought vulnerability of semi-arid region (Dodoma) in Tanzania. It is for academic purpose only and the information provided will be treated with high-level of confidentiality. It takes maximum 5mins to answer the questions. Thank you

What is the name of your organization

- Prime Minister's Office (PMO)
- Vice President's Office (VPO)
- Ministry of agriculture
- Ministry of livestock and fisheries
- Ministry of water
- Ministry of works, transport and communication (Tanzania meteorological agency-TMA)
- National Burea of Statistics (NBS)
- World Food Program (WFP)
- Food and Agriculture Organisation (FAO)
- Research and academic Institutions
- Others

If others please specify

Can you weight the following factors which contribute to social vulnerability in a scale of 1 to 5. (1 very low, 2 low, 3 moderate, 4 high and 5 very high)	1	2	3	4	5
Livelihood	○	○	○	○	○
Age	○	○	○	○	○
Gender	○	○	○	○	○
Education level	○	○	○	○	○
Poverty level	○	○	○	○	○
Size of the family	○	○	○	○	○
Women head of the family	○	○	○	○	○
Special need groups (children, elderly and disabled)	○	○	○	○	○

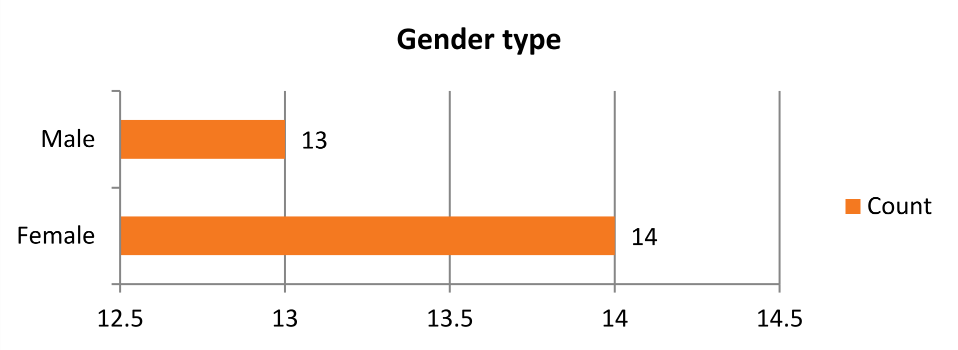
Drought prone	Yes	No	Not aware
Do you think that Dodoma is prone to a devastative drought in the near future?	○	○	○

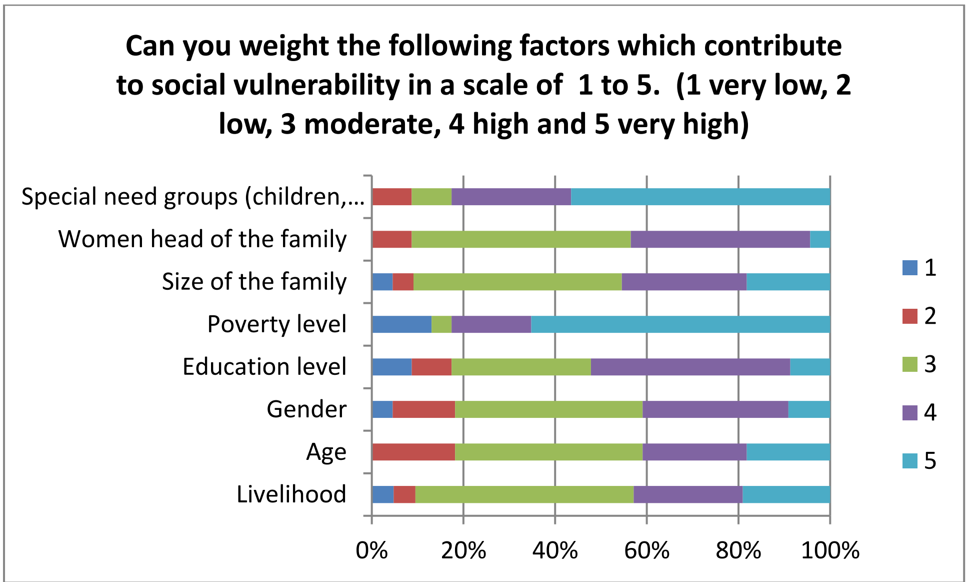
Awareness within the communities	Almost all	Many	Few	None	Not aware
If yes, in your opinion, how many Dodoma communities are concerned about a destructive drought?	○	○	○	○	○

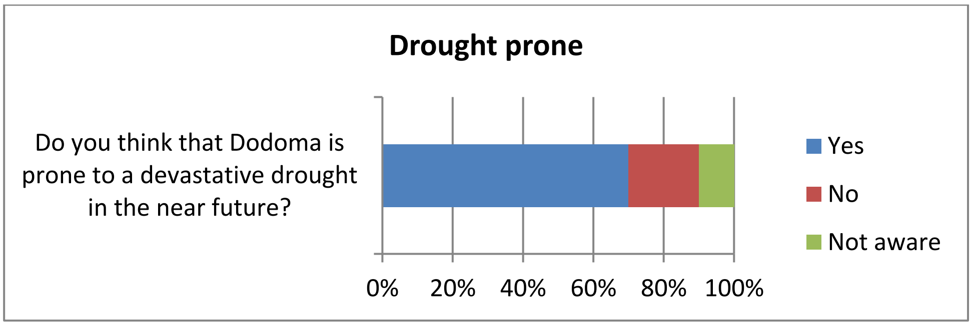
Awareness within Government sectors	Almost all	Many	Few	None	Not aware
If yes, in your opinion, how many Government sectors are concerned about a destructive drought?	○	○	○	○	○

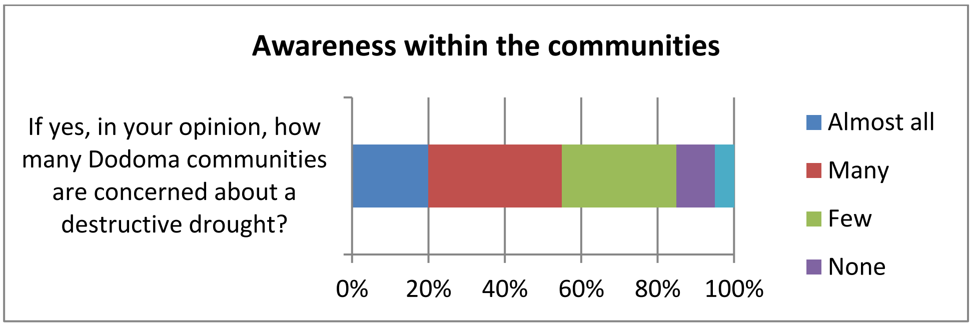
social capacity	Yes, many services exist	Yes, some services exist	Yes, few services exist	No services exist	Not aware
Are social assistance services like food and medical assistance available for vulnerable groups (e.g. children, elders, disabled)?	○	○	○	○	○
Are there services like education, early warning, agriculture incentives etc in place to build capacity for drought	○	○	○	○	○

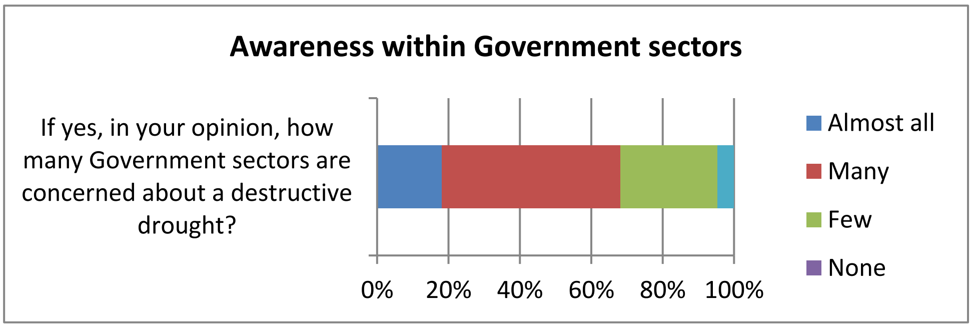
Part 3: Maptionnaire results

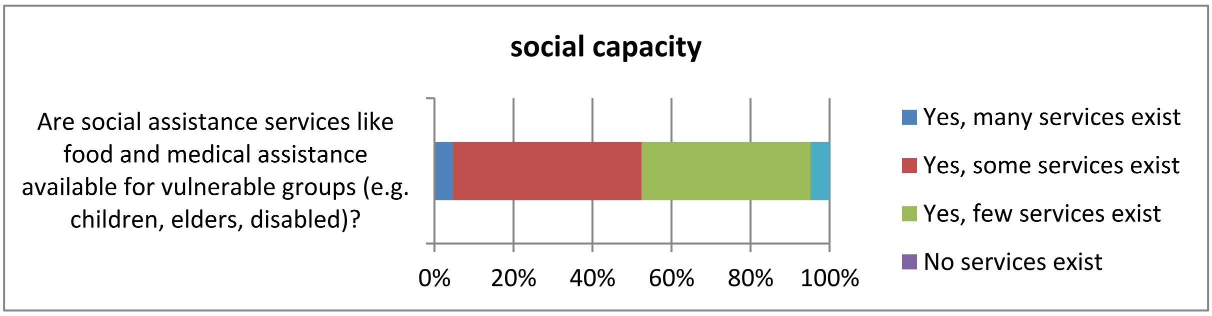





Drought prone
Do you think that Dodoma is prone to a devastative drought in the near future?
0%
20%
40%
60%
80%
100%
Yes
No
Not aware


Awareness within the communities
If yes, in your opinion, how many Dodoma communities are concerned about a destructive drought?
0%
20%
40%
60%
80%
100%
Almost all
Many
Few
None


Awareness within Government sectors
If yes, in your opinion, how many Government sectors are concerned about a destructive drought?
0%
20%
40%
60%
80%
100%
Almost all
Many
Few
None


social capacity
Are social assistance services like food and medical assistance available for vulnerable groups (e.g. children, elders, disabled)?
0%
20%
40%
60%
80%
100%
Yes, many services exist
Yes, some services exist
Yes, few services exist
No services exist