ASSESSING THE IMPACT OF WATER SCARCITY ON
AGRICULTURE PRODUCTIVITY:
A CASE STUDY OF GABILEY DISTRICT, SOMALIA

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In Partial Fulfillment of the Requirements for the award of Msc Degree
in Environmental Management

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Declaration A

“I declare that this thesis has not been presented at any Higher educational learning Institute for the award of academic degree”

__________________________________________________________

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Declaration B

“I confirmed this thesis has been prepared under my supervision”

___________________________________________
Name and Signature of the Supervisor

___________________________________________
Date
Dedication
I dedicate this work to my mother Khadiija Awale Mohamed for her relentless support throughout my academic journey, and most importantly nurturing me with love, respect and God fearing.
Acknowledgement

I owe gratitude to Allah for the support and assistance throughout my life, letting me to reach at this point. Without him, I would not reach at this lightening threshold. I would like to thank my Mother Khadiija Awale for her overwhelming support in various aspects in my Life. I would also like to thank my biological Brother Ahmed Abdi Musse, sister Rooda and Khadra for their financial and moral support throughout my academic journey.

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### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Deyr</td>
<td>Somali short rain season</td>
</tr>
<tr>
<td>Gu</td>
<td>Somali plenty rain season</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agricultural Organization</td>
</tr>
<tr>
<td>FSNAU</td>
<td>Food Security and Nutrition Analysis Unit</td>
</tr>
<tr>
<td>UN</td>
<td>United Nation</td>
</tr>
<tr>
<td>UNDP</td>
<td>United Nation Development Program</td>
</tr>
<tr>
<td>USAID</td>
<td>United States Assistance for International Development</td>
</tr>
<tr>
<td>CLHE</td>
<td>Candlelight for Health, Education and Environment</td>
</tr>
<tr>
<td>SWALIM</td>
<td>Somalia Water and Land Information Management</td>
</tr>
<tr>
<td>Barkad</td>
<td>a small water reservoir that is constructed with cement and rocks</td>
</tr>
<tr>
<td>Somaliland</td>
<td>Self-autonomy region in northern part of Somalia, that declared its succession from rest of Somalia.</td>
</tr>
</tbody>
</table>
Abstract

Apparently Gabiley District undergoes water crisis where the demand of water outstrips the available water. This has resulted in number of consequences in various aspects in the life of the people, but most importantly hindering their agricultural productivity despite the agriculture contributes 70% of the economy of the county as the people predominantly graze animals (goat, sheep, camel, cattle). However, the major purpose of this study was to examine the Impact of prevailing water crisis in Gabiley has had on Agricultural productions in Gabiley District Somalia. The study assessed the major factors that are responsible water scarcity; and the adaptation measures that people are currently resorting to acclimatize with growing water menace. Both Quantitative and qualitative data analysis were used in the study to analyze different primary data obtained from the field and from the Ministry of Agriculture particularly rainfall distributions data and cereal production trends. Pearson Coefficient Correlation was employed to determine whether there is significant relationship between water shortage particularly precariousness of rainfall performance and crop yields. Sorghum (Sorghum bicolor) and Maize (Zea mays) were selected as benchmark crops due to availability of statistical data trends. Rainfall data for the last 10 years was obtained from there is strong, positive significant correlation between rainfall variability and Produced yields in Gabiley over the last 7years (2010-2016), (r=0.53, and p=0.05). The study finds rainfall distribution in Gabiley District that in turn results in frequent droughts as critical factor that affects water availability in Gabiley District. Disparity of water supply, local climate change, poor harvesting of rainwater, and overstocking are all found as important factors that cause water scarcity in Gabiley District, and it has resulted in reduction of surface water, changes of water table, as well as changes of quality and quantity of yields and formation of hardpans in the soil. Meanwhile, the study has found important adaptation measures being used in the area by local people to acclimatize with prevailing water crisis in Gabiley. This study emphasizes bold measures against prevailing micro-climatic changes in the study area, halt deforestation, regulate on climate and efficiently utilize rainwater, and provide water governance policies and rights to ensure the harmonization of different needs on water resources. These measures will complement to one another, and ultimately counteract the severe water shortage in Gabiley District, Somalia.
CHAPTER ONE
INTRODUCTION

1.1 Background of the study

Water resources are finite, and due to climate change, the growing demand for water in various development aspects. The irrational interactions of man with the environment have caused water to become scarce. Water scarcity is among the contemporary critical problems in this world, and thus has been ensuing intricate in humanity, nature functions, agricultural and socio-economic development at large throughout the globe (Musse et al, 2016).

About 40 percent of the world’s population lives in areas with moderate-to-high water stress. Moderate stress is defined by U.N Assessment of Freshwater Resources as human consumption of more than 20 percent of all accessible renewable freshwater resources, whereas severe stress donates consumption greater than 40 percent (Tietenberg & Lewis et al, 2012). By 2025, it is estimated that about two-thirds of world’s population — about 5.5 billion people will live in areas facing either moderate or severe water stresses (Tietenberg & Lewis et al, 2012).

In China, United States, Mexico and India, groundwater is being consumed faster than it’s being replenished, and aquifer levels are steadily falling. Some river, such as the Colorado in the western United States and the Yellow river in China, often run dry before they reach the sea. Formerly, enormous lakes, such as the Aral Sea and Lake Chad, are now a fraction of their once-historic sizes. Glaciers that feed many Asian rivers are shrinking (Tietenberg & Lynne, 2012).

Africa and Asia suffer the most from lack of access to safe and sufficient water for their societal needs. Up to 50 percent of Africa’s urban residents and 75 percents of Asians lack adequate water (U.N Assessment of Freshwater Resources, 2008).
Global consumption of water is doubling every decade; more than twice the rate of population growth. By 2025 the demand for fresh water is expected to rise by 56 percent more than what currently available, (UN-Water, 2007).

However, the issue of water stress or scarcity is an international contemporary problem which comes after Climate Change and Biodiversity loss. In Arab countries, water scarcity remains the most serious threat to Arab security, as virtually all Arab countries are well below the line of “water poverty. The World Bank has classified 15 Arab Countries under Water poverty line (when per capita water availability cubic meters/year is below 1,000), and nine of them in the Middle East (Muawya et al, 2011).

The global enormity of water stress/scarcity has been affecting on agriculture and food security at large, though the extent of water stresses varies in one place to another, in one country to another, the fact is that we all of us have felt the sear of water stresses in one way or another.

Since the 1960s, global food production has at least kept pace with world population growth, providing more food per capita at generally declining prices, but at a cost to water resources. At the close of the 20th and 21st centuries, agriculture used a global average of 70% of all water withdrawals, and FAO estimates that global abstractions for irrigation will grow by some 14% by 2030. While this is a much slower rate than experienced in the 1990's, water stress is projected to grow locally and, in some cases, regionally, constraining local food production (Elizabeth et al, 2008).

Water shortages will depress agricultural yields, thus posing a severe threat to the global food security. This adds pressure on food prices and imports. In developing and emerging economies, food prices have been rising significantly due to population growth and a growing demand for
more resource intensive food. The index of food prices in Russia almost doubled from 449 in 2004 to 831 in 2009. Rising food prices will weigh on people’s disposable income, thus impacting consumption and economic growth, (Hodgson et al, 2010).

According to World Bank (2013), Agriculture employs 65 percentages of African labour forces, and 32 percent of Growth Domestic products. Agriculture has profound impact on economic development of Africa. However, there has been slight reduction of food production in Africa. The level of production of rice dropped as the annual growth rate was -0.5 percent. In contrast RAF recorded a reduction in rice production from 2010 to 2011 due to the decrease of production in East Africa, Southern Africa and West Africa. Only Central Africa recorded a slight increase between 2010 and 2011 (FAO Yearbook, 2013).

A research conducted by Water Systems Analysis Group at the Institute for the Study of Earth, Oceans, and Space at the University of New Hampshire revealed that there is urgent need for sustainable agricultural development in Africa; they discovered that about 64 percent of Africans rely on water that is limited and highly variable negatively affects agriculture.

In Somaliland and Somalia at large, the cereal importations have significantly increased as result of water scarcity and drought related issues. The commercial imports of cereal requirement in Berbera, Bosaso and Moqdisho ports have increased by 36% in 2011 (FSNAU, 2011). Despite worsening conditions reported in the press, commercial imports through the 3 ports are noted to have increased. The purpose of this study is therefore to establish the main causes of water scarcity in Gabiley District and its effect on agriculture.
1.2 Problem Statement

Dramatic water scarcity has been observed across the northern regions of Somalia. The rural community has been experiencing serious poverty due to water scarcity which cannot fully support their agricultural productions. Hundreds of livestock herds died in western and northeastern parts of the region due to the absence of enough water and extreme weather conditions.

Gabiley is one of the water scarce Districts in Somalia. The growing water scarcity in Gabiley poses challenges to agricultural sectors. Areas which were predominantly livestock based are gradually shifting into a mixed livestock-crop production system in an attempt of trying to have dual production purpose in order to have alternative livelihoods which can sustain incomes (CLHE, 2010).

In 2011, around 408,000 tonnes of cereal equivalents of rice and wheat were registered as imported between January and July through Bossasso, Berbera and Mogadishu of which a substantial proportion has been coming through Berbera (FNSAU, 2011). The productions of sorghum, maize, mango, and tomato have decreased in Gabiley and across the country at large. The rain distribution is precarious, erratic and uneven. At times the entire country does not receive rain in 2 consecutive years, apart from a few areas which receive small amounts of rain. In Gabiley rainfall is uneven and unreliable, and thus has affected the agricultural productions, because most of the agriculture is rain-fed. Pasture has been fading. Hundreds of acres of rangelands with no pasture have been observed, hereby, hindering farmers to keep their livestock there. The urban residents in the District have been suffering economically from the expensiveness of agriculture products and water fetched by the trucks.
Apart from shortage and uneven rainfall, the groundwater has been reported at deep level. Abdirahman Mohamed who has farms in Gabiley has reported to me that about 6 men are needed to fetch a small amount of water from the bottom line of the well, because the water table has shrunk considerably, and most of this water is not safe at all.

The continuous use of modest water by households in Gabiley District and it’s sub-counties for their daily household activities has led them to suffer from sanitation and hygiene related diseases. WHO has asserted that resorting to drinking unsafe water from the polluted and shrunk wells or boreholes has exacerbated the health conditions of people in Somaliland particularly rural people. Several diseases have been cited in the area of study. Areas that suffer from water stress serve as catalysts for the spread of diseases. When the farmer gets affected by sanitation and hygiene related diseases stemmed from water scarcity, s/he won’t be able to laboriously mechanize and irrigate his farm, and this impedes agricultural productivity. However, this study tries to find out the main causes of the water scarcity in Gabiley, and it examines it tenable effects on Agricultural productivity.

1.3 Operational definitions of Key terms

Water scarcity; it is the lack of sufficient available water resources to meet the demands of water usage within a region or a specific area.

Agricultural Productions; it is the production of crops and animal products.

Deforestation; it is the clearing of trees and transforming forest into cleared land. This is mainly done in an attempt of getting fuel wood, charcoal and wood or in order to make the land available for other uses.

Hydrological cycle; it is a conceptual model that describes the storage and movement of water between the biosphere, atmosphere, lithosphere, and the hydrosphere.
Micro Climate change: it is the change of climatic condition in certain restricted area or region.

Climate Change: it is the statistical change of weather conditions for quite long period of time, mainly decade or decades.

Food insecurity: it is the state of being without reliable access to a sufficient quantity of affordable, nutritious food.

1.4 Objectives of the Study

1.4.1 General Objective
The overall objective of this study was to examine the impact of water scarcity on agricultural productivity in Gabiley District, Somalia

1.4.2 Specific Objectives
i) To establish the causes of water scarcity in Gabiley District.

ii) To examine the effects of water scarcity on crop and animal productions in Gabiley District.

iii) To establish adaptation measures which have been put in place by farmers for dealing with water scarcity in Gabiley District.

1.5 Research Questions
1. What are the causes of water scarcity in Gabiley District?

2. What are the effects of water scarcity on agricultural productions in Gabiley District?

3. What are the adaptation measures which have been resorted to by farmers to deal with water scarce phenomenon in Gabiley District?

1.6 Hypothesis
Ho: There is no significant relationship between water scarcity and Agricultural productivity in Gabiley District.
1.7 Scope of the study

1.7.1 Geographical scope
This study was conducted in Gabiley which is located in the western part of Somaliland, about 32 km due west of Hargeisa. Arbsiyoyo, Abaarso, Xidhmo are the sub-counties under Gabiley District in which the study was be carried out. Latitude: 9° 43' 59.99" N, Longitude: 43° 37' 59.99" E

Source: Google map, 2017

1.7.2 Content scope
The independent variable of this study was Water scarcity whereas Agriculture production is dependent variable. The study evolved on determining causes of water scarcity in Gabiley, how it affects agricultural productions, what has been done by farmers to adopt to it, and what could be done in the near future to counteract the severity of water scarcity in Agricultural sectors in Gabiley District.

1.7.3 Time scope
The study was conducted within a limited period of one year (from May, 2016 to May, 2017). The period has been chosen by the researcher because it fits right into the schedule of the researcher; and with concentration and curiosity, the researcher was able to produce the work within that period.
Water scarcity (Independent variable) is usually caused by nature and anthropogenic activities. Sometimes water scarcity in certain areas can be attributed to its geological structure such as terrain, landscape, the kind of vegetation belt, and the soil structure. However, there are other...
human induced factors which cause water scarcity and they are deforestation and low technology. Poor technology usually causes inefficient utilization of ground water, oceans and the runoffs. With the absence of substantive amounts of water impinging on agricultural productions, because without or inadequacy of water, agricultural production will be tricky. Low agricultural production (dependent variable) is often caused by the absence of substantive amounts of water; however, there are other technical and natural factors which have significant impacts on agricultural production, most importantly is water scarcity. The incorporation of technical, technological, indigenous knowledge and Government action can draw up a platform of efficient management and use of water resources in agriculture.

1.9 Significance of the study
The Government of Somaliland especially Ministries of Agriculture, Environment and Water will realize the main factors which have spawned water scarcity in this study area as well as the entire country at large. This study will be a fueling tool to Government for solving or at least counteracting the water scarcity across the country.

This study will also impart adaptation measures to farmers in order to adopt the water stresses as well as climate change so as to be in a position of pursuing their agricultural practices, to feed their community. Also, this study imparts agronomic methods/schemes to farmers to be able to efficiently manage the finite water resources. And it will contribute to the existing literatures and propagations in field of water and agriculture and their interrelatedness; and eventually it will be an eye opener to other researchers in making more analyses and critique the problem in the future.

This study will inform the public about the causes of water stresses/scarcity in Gabiley District and across the country, and their individual roles to counteract this menace.
1.10 Limitations of the study
There were financial limitations in travelling and conducting this research due to absence of financial support from Government and International Environment, Agriculture and Water Organizations moreover the study is vital to the whole country. The accessibility of some farmers was difficult due to terrain, poor infrastructure and remoteness of the area. Meanwhile, some of the respondents used to ask researcher hospitality in terms of finance during primary data collection, which is far beyond the financial capacity of researcher to deal with it.
CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction
This Chapter looks at related studies about the causes of water scarcity in different areas, the effects that water scarcity results to agriculture sectors, and the adaptation measures that can be used to adopt with vista where water is scarce.

2.1 Causes of water scarcity
Freshwater scarcity has been cited as the major crisis of the 21st century, but it is surprisingly hard to describe the nature of the global water crisis. According to the work of Fabriz et al, (2008) causes of water scarcity include groundwater depletion, ecological destruction, drought-driven conflicts, unmet subsistence needs, resource capture by elite, and water reallocation to nature. Water scarcity is categorized as: (1) un sustainability decline in the water stock or ecosystem function that could result in a long-term steep decline in future human wellbeing; (2) vulnerability high variability in water resource availability combined with inadequate coping capacity, leading to temporary drops in human wellbeing; (3) chronic scarcity — persistent inadequate access and hence low conditions of human wellbeing. All syndromes could be explained by a limited set of causal factors that fall into four categories: demand changes, supply changes, governance systems, and infrastructure/technology. By considering basins as members of syndrome classes and tracing common causal pathways of water crises, water resource analysts and planners might develop improved water policies aimed at reducing vulnerability, inequity, and un sustainability of freshwater systems.

Drought: Draught is defined as a prolonged period of unusually dry weather in an area; low rainfall leads to low water in aquifers and the pattern may lead to water shortages even for the households. Southeast England for example, experienced shortages of water since 2004. The water levels in several catchments dropped due to rainfall that was below average (Fabriz et al.,
A balance must be maintained between the water supplied and the surface run-off to replace it.

According to Zhang (2007), Climate change is the cause of change in the distribution of worlds’ water. This conclusion stems from the fact that water availability is also dependent on climatic conditions. Scarcity of water for domestic use may further be linked to low flow periods during summer. High temperatures during these periods call for more water for agricultural purposes (Schula and Wike, 2001).

Climate change is drastically affecting Yemen’s water availability. The summary of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (2008) came to the conclusion that the climate in the Middle East and North African region will become even hotter and drier. As detailed in van der Gun (2009), this will increase the occurrence of droughts, potentially destroy agriculture, reduce tourism and cause rising sea levels and flooding in coastal regions.

It is salient that scarcity of water may also be linked to the rising heat or hot temperatures. Water shortage for household use will obviously lack unless there are other interventions. Similarly, (Eriksen, O”brien and Rosentrater 2008) concur that, the increasing droughts in Southern African dry land will further increase due to high temperatures and decreased rainfall. According to (Niekerk and Versfeld 2009) the planning of water resources need to be done considering many factors including rainfall and run off. This shows that climate change adds to water supply uncertainties.

Uitto and Biswas (2000) theorized that, surface runoff is also a course for drinkable water shortage. This is due to the fact that, flood carries different objects from the ground into the drinkable water sources. The rivers, fountains and dams that normally provide water to the households may be rendered undrinkable during heavy floods and also for some days or weeks
after the flood. At times, a river which may be a sole source of clean water for the community may also become a source for flood. This may lead to a situation whereby the community is left without water for household use.

Similarly, Twort, Ratnayaka and Brandt (2008) agree that, the peak runoffs are difficult to estimate as a result of the damage occasioned by the debris and sediment brought down by the floods. These objects render the water unusable for some household activities including drinking. Runoff has according to Wallace (2000) been shown as a major loss of water. When rainfall is high and infiltration rate is low because of steep slopes, runoff becomes high and a high quantity of water is lost.

Earthquakes may cause water shortage in that, they may destroy a variety of infrastructures including those of water supply. The water service may be destroyed for days, weeks, months or even for longer periods depending on the seriousness of the damage (Uitto and Biswas, et al 2000).

Evaporation and Transpiration: Evaporation is the key part of hydrological cycle as seventy five percent of the annual precipitation returns to the atmosphere due to evaporation and transpiration (Twort, Ratnayaka and Brandt 2000). According to this source a lot of water goes back to the atmosphere as a result of “evapotranspiration” which is a combination of the two processes, namely, evaporation and transpiration. It is difficult to measure the loss of water through these processes with certainty. Through these processes water is lost from any open water source, e.g. dams, reservoirs, rivers and the vegetation (Twort, Ratnayaka and Brandt 2000).

Disparity in water supply Research conducted by Mainganye (2006) discovered that, there was a disparity in the way the villages received water.
Over-development of hydraulic infrastructure is a main cause of constructed water scarcity (Molle et al., 2008). In many river basins, the expansion of irrigated areas has boosted demand beyond the capacity of catchments, stretched available resources and progressively generated water scarcity. In years with low rainfall, the water demand that has been allowed to build up during wet years cannot be satisfied, leading to a general perception of water scarcity and generating calls for additional investments in water saving technologies. Wet years, instead, are seen as lost opportunities, when ‘excess’ water flows to the sea, and this too often translates into new water development. Research has shown that over-development of infrastructure and growing artificial scarcity often results from an alliance of financial and political interests rather than from any legitimate ‘need’ (Molle et al., 2008). The pressure to ‘save’ any single drop of water from ‘running to the sea’ is often politically stronger than any carefully conducted hydrological assessment that would take into account the economic, environmental and social dimensions of water resources development.

2.2 The Effects Of Water Scarcity With Crop And Animal Production
Agriculture is accountable for the largest extraction of water and thus considered the chief ‘culprit’ under conditions of local absolute scarceness (COAG, 2007). Water is vital for all socio-economic development and for maintaining healthy ecosystems. As the population increases the utilization of groundwater and surface water for the domestic, industrial sectors and agriculture exaggerate, leading to tensions, conflicts between users, and extreme pressure on the environment (UN-WATER, 2006).

Bindi and Olesen (2011) found that predicted warmer temperatures that impedes in precipitation would affect European agriculture both positively and negatively depending on the crops and varieties and the adaptation measures undertaken. But studies indicate that
African agriculture would be mostly negatively affected by climate change (Tessema et al., 2013; Bryan et al., 2009; Deressa et al., 2009).

Food policy must not lose sight of surging water scarcity. Water is a key element of agricultural production. Water scarcity can cut production and badly impact on food security worldwide. The brutality of the water crisis has prompted the United Nations (UNDP, 2007), to conclude that it is water scarcity, not to be deficient in arable land that will be the most important limitation to increased food production over the next few decades. For example, Australia is one of the major food producing and land copious countries, but recent drought minimized its food and agricultural production substantially (Goesch et al., 2007 cited in Hanjra, and Qureshi, 2010). Irrigation has helped enhance agricultural yields and outputs in arid and semi-arid environments and stabilized food production and cost (Hanjra et al. 2009a, 2009b; Rosegrant and Cline et al., 2003; Sampath, 1992; Hanjra and Qureshi, 2010).

Globally, increased agricultural production is required for dropping rural poverty and more economic growth (Hanjra and Gichuki, 2008). New investments in irrigation infrastructure and enhanced water management can reduce the impact of water scarcity (Falkenmark and Molden, 2008 cited in Hanjra and Qureshi, 2010).

The water scarcity scenario according to FAO (Food and Agriculture Organization) in 2007 argues that most countries in the Near East and North Africa experience acute water scarcity. Others such as Pakistan, Mexico, South Africa, and huge parts of China and India also have chronic water problems. Irrigated agriculture requires larger demand for water in these countries. To mitigate the water problems, these countries have to focus on the efficient use of all water sources (surface water, ground water and rainfall) and on water allocation plans that maximize the economic and social returns to limited water resources and at the same time increase the
water productivity of all sectors. During this endeavor, there needs to be a particular focus on issues relating to equity in access to water and on the social impacts of water allocation policies (UN-WATER, 2007).

Kasinof (2009) wrote that Yemen’s water crisis has the potential to contribute to the country’s instability and potential trajectory toward failure. According to Kasin (2009) as he reported from Abdulrahman Al Eryani, Yemen’s Minister of Water and Environment, much of the country’s rising militancy is a conflict overran sources. They manifest themselves in very different ways: tribal conflicts, sectarian conflicts, political conflicts. Really they are all about sharing and participating in the resources of the country, either oil, or water and land. Current conflicts include a widening armed rebellion in the north and a violent separatist movement in the south. These are intensified by the water crisis, and further prevent the government from entering the regions to try to solve the crisis in an organized manner. Many regions are too dangerous for government engineers or hydrologists to go to.

A study by Sana’a University researchers found that between 70-80 percent of all rural conflicts in Yemen are related to water. A geology professor at the university estimates that Sana’a wells – one of its primary water sources – will run dry by 2015, based on the current water-usage rates. In Taiz, Yemen’s third-largest city, residents are only allowed to access public water tanks once every 45 days. In Sana’a, there were 180 wells ten years ago. Today there are only 80. “We have a water shortage that reflects itself in fighting between the people,” Deputy Planning Minister Hisham Sharaf said. According to Lyon (2009), on August 24, 2009, one person was shot dead and three were wounded during water protests in the southern city of Aden. People fear that if the crisis is not solved, more serious conflicts could break out in Yemen to add to the ones that already exist.
The most immediate consequence of drought is a fall in crop production, due to inadequate and poorly distributed rainfall. Farmers are faced with harvests that are too small to both feed their families and fulfill their other commitments. Livestock sales act as a buffer in times of hardship, farmers disinvesting in these assets to buy food. The first animals to be sold are usually those which make the least contribution to farm production, such as sheep and goats. However, as the period of drought-induced food deficit lengthens, farmers will have to start selling transport and draft animals, such as oxen and donkeys, as well as breeding stock, which constitute the basis of the household's wealth. In the Ethiopian highlands, stock are usually disposed of in the following order: sheep and goats, then younger cattle, with horses, donkeys and work oxen being sold as a last resort (Wood et al., 2012), since the latter are essential for land preparation.

Where crops have been badly affected by drought, pasture production is also likely to be reduced although output from natural pastures tends to be less vulnerable to drought than crop production. Low rainfall causes poor pasture growth and may also lead to a decline in fodder supplies from crop residues. Insufficient levels of fodder around the village lead to weight loss and increased deaths among livestock, especially where immigrant herds put further pressure on limited local pastures. While the response of most pastoral groups to fodder shortage is to move themselves and their herds elsewhere, this is not an option so easily followed by livestock-owning farmers. Typically, farmers own fewer animals and have less familiarity with regular transhumant than pastoralists, both of which act as constraints on migration. In addition, few farm households will have sufficient labour to both take their animals to other grazing areas and continue with necessary farming operations. Thus, sedentary herds can be particularly badly hit in times of drought. A recent survey of deaths among draft animals in the Niono area of northwest Mali found losses of between 50 and 70% over the period 1983-84 (FAO, 2000). These high losses were caused by pasture shortages exacerbated by herds from further north on their
way to southern pastures, by the sedentary character of livestock holdings amongst farmers in this area and by the normal dependence of horses (and to some extent donkeys) on a daily grain ration to supplement natural grazing, a supplement which is no longer given because of poor harvests.

The overall effect of a fall in fodder and crop production is to reduce the draft capacity of the farming sector, leading to lower crop output in the subsequent farming season. Loss of livestock around the farming settlement also reduces the household's access to dung, a product of considerable importance both as a fuel where firewood is scarce and as a means to retain fertility on regularly cropped soils (Wood et al., 2012).

Although they could not be considered as a loss to the national economy, to the individual farmer drought-induced distress sales of work oxen are as much of a loss as are animal deaths. In addition, since distress sales are associated with reduced prices offered, farmers also incur a substantial financial loss compared to sales under more normal circumstances. The distribution of work oxen losses between deaths and distress sales will vary according to the circumstances in which drought has taken place and the constraints faced by different producers. A report by the Relief and Rehabilitation Commission of Ethiopia for the province of Wollo in 1974 presents data showing almost all losses to have been due to deaths rather than sales: 71% dead from starvation, as opposed to 19% sold, leaving 2% disposed of by other means and 8% remaining (Wolde Mariam, 2009). By contrast, Wood's survey of farmers in the northern highlands of Ethiopia in 1974 found that most livestock losses were the result of distress sales in order to raise cash rather than deaths due to inadequate fodder (Wood, 1976). As will be discussed later, the circumstances in which oxen are lost have differing implications for the action that governments or agencies should take in moderating the effects of drought.
One means by which farm households try to make ends meet in times of crop failure is to release labour to earn income elsewhere; at the same time, this reduces the burden on household food reserves. The net effect on farm productivity depends on whether this migration continues into the next farming season, thereby reducing the household's labour supply. This will be the case where shortage of food is so acute that the household must depend on the earnings of some of its members to feed the rest of the family until the next harvest.

Changes in the distribution of wealth usually accompany drought. The experience of farm households will differ according to their ownership of assets, their access to incomes from other sources and the extent to which these assets and incomes are less affected by drought than are harvests. The most vulnerable amongst those hit by drought will be those with few assets to sell, those who most need to purchase grain due to an absence of their own household reserves and those who cannot pin access to food through other means, such as borrowing, coercion or theft. The richest members of the community may even be in a position to benefit during drought, as they can acquire land and other assets at low prices from distress sales by poorer neighbours. The differential impact of drought on the incomes and assets of rich and poor is formalised by Sen in his essay on "Poverty and Famines" (1999).

In times of drought, not only is there a direct shortfall of food production but also relative price movements of grain versus other commodities may drastically reduce the purchasing power of groups. Despite is seen in the case of pastoralists who face rising grain prices but failing livestock prices as drought intensifies. Pastoralists face a major decision problem related to the timing of sales which minimize unfavourable grain/livestock ratios. Many farmers may be in a similar situation, needing to sell livestock, labour or land in markets where an excess supply of these commodities has reduced their value.
2.3 The Adaptation Measures Against Water Crisis/Shortage
Maddison (2007) noted perception and adoption of adaptation strategies with water crisis and Climate variability are two key components which are to be perceived and then acclimatize with. This means that farmers need to perceive a change in the climatic conditions and then implement a set of strategies to address them. Agricultural adaptation can vary depending on the agro-ecological and climatic conditions, farm types and socio-political and institutional arrangements. These include a wide range of forms, scales, timing and agents (Khorshed et al., 2015).

Adaptation can take place both on-farm and off-farm. Planned adaptation requires government intervention, whereas autonomous adaptation occurs through private agents (Seo, 2011). A planned approach is seen as more efficient and more effective than a reactive approach for addressing climate variability (IPCC, 2001, cited in Khorshed 2015). In the case of reactive adaptation, farmers react to the water crisis and climate event once the impact is observed. An anticipatory adaptation, however, needs good forecasting and, often, government incentives (Khorshed at al., 2015).

Pereira et al., (2002) assessed on-farm irrigation management, including the use of treated wastewater and saline waters. Other farm level adaptation practices include crop diversification, and land and water management (Wall and Smit et al, 2005). Jones and Boyd (2011) defined adaptation as ex post and ex ante strategies in coping with drought in times of shock and stress. Ex post strategies include wild food harvesting, reduction in food intake, trade of livestock, temporary migration and seeking aid assistance (both food and finance). Additionally, on-farm strategies include changes in the timing of planting, use of new crop varieties and working as agricultural laborers. Ex ante measures include the storage of food stocks and dissemination of drought-related early warning information.
These include *ex post* strategies (e.g., crop diversification, changing cropping intensity, crop mix, crop type and location) and *ex ante* strategies (e.g., crop insurance, pricing reform, opening up of trade and investment, extension services, income diversification, food reserve and storage, migration, improving weather forecasting, land-use change, and the development and adoption of new technologies). Mwinjaka *et al* (2010) noted that both *ex ante* and *ex post* adaptation measures can be implemented at the local level through to the global level and can be assessed and incorporated into micro-level strategies (Jones and Boyd, 2011; cited in Khorsheed’s work, 2015). Trinh *et al* (2013) found the recovery and reuse of wastewater as an option to cope with water scarcity for 16% of rice-cultivated area for three rice seasons in Can Tho City, Vietnam.

Pereira *et al*, (2002) emphasized the demand management strategies to reduce irrigation at the farm level include supplemental irrigation, deficit irrigation, improved irrigation methods and performance, distribution uniformity, and various soil and water conservation practices; defining demand management for irrigation to be practices and management decisions of a multiple nature, including agronomic, economic and technical.

For Ethiopian highland rain-fed crop agriculture, Gebrehiwot and van der Veen (2013) considered crop diversification, changing planting dates, soil conservation, increasing rainwater capture and planting trees as key adaptation measures. Adaptation measures can be implemented in isolation or in combination with other policies or strategies. Dealing with water scarcity requires a complementary approach of supply and demand management as well as on-farm and off-farm measures. Importantly, adaptation strategies can be framed and implemented not only at temporal scales, but can also have a range of spatial scales, from local to regional and to national (Bonsal *et al*., 2011 ). Appropriate adaptations foster
resilience and decrease vulnerability to multiple threats (Khorsheed et al, 2015). Supply management strategies include the use of wastewater and inferior quality water for irrigation, increased storage capacity, improved conveyance and distribution systems, enhanced operation and maintenance, and the development of new sources of water supplies such as treated wastewater and saline groundwater (Pereira et al, 2002; cited in Khorhsed’s work 2015).

2.4 RESEARCH GAP

The researcher did not come across a study that looks at the prevailing water scarcity in Gabiley District and how this menace has impacted in agriculture and socio-economic wellbeing of the people at large.
CHAPTER THREE
METHODOLOGY

3.1 Research Design
This study employed exploratory survey design to explore and describe the characteristics of the prevailing conditions of water scarcity in Gabiley District and its effects on agriculture. Both qualitative and quantitative approaches were employed in the study. The qualitative approach was used to analyze the descriptive answers obtained especially from the interview guide questions while the quantitative was used to analyze the quantified and measurable responses especially from the questionnaire.

3.2 Research population
The research target population and sample size often determine the time and financial aspects of conducting the research; therefore as factor of this, the target population of this study was 201 - encompassing farmers, community leaders, Government officials and environmental activists; And this was obtained through survey of each category or respondents group that the researched expected to gain in dept information about the water scarcity situation in Gabiley District and effects on Agriculture. These groups were targeted since they have substantial information about trends of water scarcity in the area of study, its effects on agriculture, and available adaptation strategies that have always been resorted to by community.

3.3 Sample Size
Out of the selected target population of 201, the sample size of 120 was selected using Slovene’s formula. In according to Roscoe 1975, sample sizes of between 30 and 500 are appropriate for most studies. Therefore, this sample size has been used by the researcher. Most importantly, information was given to respondents about the topic of research because if respondents are less informed, inadequate information might have been obtained.

\[ n = \frac{N}{1 + N(e)^2} \]

\[ n = \frac{201}{1 + 201(0.05)^2} \]
\[ n = \frac{201}{1 + 0.6675} = 120.43 \approx 120 \text{ respondents} \]

N=number of targeted population

e=(0.06675) which stands on allowed probability of committing an error in selecting a small representative of population.

n= obtained sample size/respondents.

**Table 3.1 Target Population and Sample Size summary**

<table>
<thead>
<tr>
<th>Respondent Category</th>
<th>Population</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmers</td>
<td>70</td>
<td>42</td>
</tr>
<tr>
<td>Environmental Practitioners/Activists</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td>Community leaders</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>Government Officials</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td>Academicians</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>201</strong></td>
<td><strong>120</strong></td>
</tr>
</tbody>
</table>

In order to get specific sample size from each respondent group, the researcher used a mathematical term to calculate the specific sample size from each respondent group. The number of each respondent group is multiplied to overall sample size, and then divided total number of target population.

e.g. 70 X 120=8400

\[
\frac{8400}{201}
\]

= 42

39
3.4 Sampling Technique and procedure
Stratified random sampling was employed in this study to determine the prioritized respondent categories from the target population (Farmers, Environmental activists, Community leaders, and Government officials). The determined respondents were consulted and prior information had to be given to them, seeking their consent before they are fully involved in the research.

Purposive sampling was also employed to select high profile respondents from Government officials and Environment activists whom could have eminent information on the research topic.

3.5 Research Instruments
The following data collection instruments will be used:

(i) Questionnaire
This was designed in line with the objectives of the study. The questionnaires contained closed-ended questions. This instrument is selected because closed ended questions are easier to analyze since they are an immediate usable form, they are easier to administer because each item is followed by alternative answer, and ultimately they are economical in terms of time and money as long as this research is not funded by the Government and International Environment and Water Organizations.

(ii) Focus Group Discussions
Focus group discussion has been employed in the study, and it was chosen because the respondents give instant answers and the data collected can easily be edited since the researcher will have heard when the respondent is communicating (answering) the question. The researcher was in position to save him-self from misinterpretation of questions since he can rephrase the question if not fully heard or answered so that he can get the relevant information needed.

(iii) Documentary Review
The researcher reviewed existing documentaries about the study topic. The tool is selected because it gives accurate, correct and historical data, which may be used for future aspects. The
sources of the information here were libraries, data banks of media, news papers, and reports from International Organizations and any other published document that could readily be available for use as regards the topic of research.

(iv) Interviews

This involved face to face interactions between the researcher and the participants through discussion. Babbie (2003) argues that interviews can be in two ways, namely structured and unstructured:

The researcher used unstructured interviews where the responses were long, elaborated and not specific in order to get adequate information and ideas which would have been stagnant at the upstage of the mind of respondent if structured interview were employed. The interviews were conducted both group level and individual level. Interviews with the selected respondents were carried out using the interview guide because it is the most appropriate method which could be used to study the attitudes, views, ideas, and experiences of the people. It also has an element of flexibility.

(v) Observation

Observation surveys were done across the study area particularly where the scar of water scarcity are encountered by the agropostralists. Some pictures were taken during observation.

3.6 Source of data collection

The researcher collected the data from two sources, primary and secondary sources.

i. Primary Data
It is the data that was collected by the researcher from the field through interviewing of different respondents from different categories (Farmers, Environmentalists, Community leaders, Government officials), Observations, questionnaires, and Focus Group discussions.

ii. Secondary data

This data were mainly trends of rainfall distribution and yields harvested over the last 10 years (2006-2016). This data was collected from Ministries of Agriculture, Livestock, water and Environment. The collected data from these sources are articulated with the raw primary data to make sound the study.

3.7 Data Processing and Analysis

Data processing is concerned with classifying response into meaningful categories called codes.” Data processing started by editing the schedules and coding the responses. Editing, Coding and Tabulation techniques were used. SPSS (IBM 20) is used to process, code and analyze the data.

3.8 Validity and Reliability of The Research Instruments

3.8.1 Validity

The content validity addresses the degree to which the test items represented the domain of the traits or property being measured(amin2005). Thus, the researcher tested the validity of the content of the questionnaires after collecting responses from the respondents. The researcher then compiled the responses from rates and compute. The content validity index (CVI) validity was determined at alpha coefficient value of 0.70, the following formula had been used to determine the content validity index (CVI).

\[ CVI = \frac{\text{no of items declared valid}}{\text{total no of items}} \]
3.8.2 Reliability
Reliability is a measure of the degree to which a research instrument yields consistent results or data after repeated trials (Muganda & Mugenda, 2003). Reliability of the instrument was established through a test-retest technique. The researcher exercised a pre-test of the instrument on group of subjects and waited one week then administer the same test to the same subjects a second time.

3.9 Ethical Considerations
To ensure ethical observance in the study, the researcher got an introductory letter from the School of Engineering and Applied Science (SEAS) at Kampala International University, and he introduced himself to Government Officials, Environmental activists, community leaders, Farmers, and other bodies such as policemen.

The researcher recognized guidance from academicians, policemen during the period of conducting this research.

Saliently, the researcher gave concentration into the privacy and confidentiality of respondents.
CHAPTER FOUR
RESULTS AND DISCUSSIONS

4.1 DEMOGRAPHIC CHARACTERISTIC OF THE RESPONDENTS

Table 4.1

The below table is the demographic characteristic of the respondents who were involved in the study.

<table>
<thead>
<tr>
<th>Demographic Characteristic</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>A) Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>72</td>
<td>60.0</td>
</tr>
<tr>
<td>Female</td>
<td>48</td>
<td>40.0</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>100.0</td>
</tr>
</tbody>
</table>

B) MARITAL STATUS

<table>
<thead>
<tr>
<th>Marital Status</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>32</td>
<td>26.7</td>
</tr>
<tr>
<td>Married</td>
<td>81</td>
<td>67.5</td>
</tr>
<tr>
<td>Divorced</td>
<td>4</td>
<td>3.3</td>
</tr>
<tr>
<td>Widow</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>-------</td>
<td>---</td>
<td>-----</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### C) AGE

<table>
<thead>
<tr>
<th>Category</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>under25</td>
<td>29</td>
<td>24.2</td>
</tr>
<tr>
<td>26-35</td>
<td>37</td>
<td>30.8</td>
</tr>
<tr>
<td>36-45</td>
<td>32</td>
<td>26.7</td>
</tr>
<tr>
<td>over45</td>
<td>22</td>
<td>18.3</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### D) EDUCATIONAL LEVEL

<table>
<thead>
<tr>
<th>Level</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>37</td>
<td>30.8</td>
</tr>
<tr>
<td>Secondary</td>
<td>35</td>
<td>29.2</td>
</tr>
<tr>
<td>University Level</td>
<td>12</td>
<td>10.0</td>
</tr>
<tr>
<td>Nothing</td>
<td>36</td>
<td>30.0</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### E) OCCUPATION

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmer</td>
<td>59</td>
<td>49.2</td>
</tr>
<tr>
<td>Environment</td>
<td>16</td>
<td>13.3</td>
</tr>
<tr>
<td>Practioner/Activist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community leaders</td>
<td>18</td>
<td>15.0</td>
</tr>
<tr>
<td>-------------------</td>
<td>----</td>
<td>------</td>
</tr>
<tr>
<td>Public servant</td>
<td>15</td>
<td>12.5</td>
</tr>
<tr>
<td>Researcher/University Lecturer</td>
<td>12</td>
<td>10.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>120</td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Source: Primary data

The findings of this table show that 60% of the respondents who got involved in this study were males, whereas 40% were females. This shows that males are predominant in the study than females. About 68% of the respondents are married, 26.7 single, and 5.8% are widowed/divorced. Most of the respondents are married, because contemporary Somali rural life and traditions succumbs to youths to marry early. In some areas you are going to find a girl at age of 13 who has already been married by a man who is slightly older or far beyond her age. This kind of traditional norm violates basic human rights. The girl needs to grow both physically and mentally. A Child Wives Foundation in Ethiopia stressed out that early marriage is one of the most harmful practices as it usually denies girls educational opportunities, leads to poverty and economic insecurity and has a serious negative impact on their health and decision-making capacities. It also reinforces other forms of gender-based violence and problems.

In terms of Age, about 55% of the respondents were under 35 years old, where as the 45% are over 36 years old. In that figure, 18% out of the 45% are over 45 years old. This shows that the major people who work at Agricultural sector are youth ranging (0-36 years old), and this shows a potential for future drive of Agricultural Production despite having meteorological and technical challenges.

On Education, 30% of the respondents were illiterate, about 30% were able to attend primary schools despite not successfully finishing these foundation, and about 39% are at secondary and
University level. For those who studied at Universities, are Environmental Practitioners and Researchers/Academicians at Universities and Colleges whom the researcher purposively selected during conducting this study to ensure that the relevant insights and views for this topic to be gained.

In terms of occupation, about 49% of the respondents were agro-pastoralists who reside in Gabiley, Arabsio, Abaarso and nearby valleys; and 15% were community leaders, 12.5% are Public servants/Government officials, and 23% are Academicians and Environment activist who were selected for their insights about the growing water scarcity in the area, variability of rainfall, and Agro-pastoral production.

4.1.1 Rainfall
Gabiley has a bimodal rainfall distribution (Gu and Deyr). The first main rainy season (Gu) occurs between April and June, when around 60 percent of rain falls, and the second rainy season (Deyr) from August to November. The months of highest rainfall within these seasons are generally from April–June and October–November. The two dry seasons in the country are Jilaal and Hagga, which occur between December -March and July- August, respectively.

Rainfall is low and erratic. The amount of rainfall received annually is different from the next preceding year as shown in (figure 4.1). Awale et al (2016) argue that the growing variability and shortage of rainfall distribution in Gabiley and across Somaliland is due to substantial reduction of forest cover.
Figure 4.1 Mean Annual rainfall received in Gabiley (2006-2016), combination of both Deyr and Gu rainfall performance

Source: Ministry of Agriculture
Figure 4.2. Gu rainfall Performance in Somaliland, 2016
The arrow pinpoints to Gabiley District and amount of Gu’ rainfall it received last year.

According to the Figure 2, Gabiley received last year appropriately 310 mm of rainwater.

Source: FAO/SWALIM, 2016

Figure 4.3. Deyr Rainfall Performance in Somaliland, 2016
The above graph shows Deyr Rainfall Performance in Somaliland 2016, as the arrow directs,

Gabiley District received approximately 130 mm of rainwater in that year.

Source: FAO/SWALIM, 2016
This conspicuously brings out the erectness and tininess of the rainwater in the area which potential post perilous impact on food productivity.

4.1.2 Land Use
By laws all land belongs to the State. In the past the rangelands were held either under a system based on customary water rights in the traditional clan-based land ownership system in which land was considered to ‘belong’ to families although there was no formal title deed.

Land is mainly used for livestock production/rearing or mix farming (crop and livestock production). The use of different zones at different seasons is greatly influenced by fodder/pasture and water availability and by the seasonal activity of biting flies and ticks. However, Government has been trying to develop Comprehensive land use plan, but this is under draft due to technical issues that concern harmonization of different needs from various categories in the community, and varying interest of different Government institutions particularly Ministry of Agriculture, Ministry of Water and Energy, Ministry of Livestock and Ministry of Environment and Rural Development.
4.1.3 Situation of the Farmers in the Area

Figure 4.4 Agricultural Involvement Period
Source: Primary data

From the study, 48% of the respondents have been involved in agricultural sectors for 11-15 years; whereas 16% of the respondents have been involved in farming for 6-10 years. About 6% of the respondents been involved in agriculture for over 16 years, whereas 19% have involved in farming for 5 years. However, these people particularly for those farmers who have been involved in the agricultural sector are predominantly agro-pastoralists, experiencing water stresses and other technical constraints over the last decades. In Focus Group discussion, some people pointed out that their livelihoods depend on the extraction of some mineral ores and clearing forests for charcoal production. They stated that, in the face of growing challenges in agriculture with limited intervention from the Government, we had to opt into production of charcoal and extraction of mineral ores from mountains to sustain the income of their families. However, the
growing charcoal production market in the Gabiley, and the region at large have profoundly impacted on the forest cover and the hydrology of the area.

![Experience of Water scarcity](image)

**Figure 4.5 Experience of Water scarcity**

Source: Primary data

Majority of the respondents that is 90% of the respondents were experiencing water scarcity which was potentially masterminded by erratic, uneven and enormous variability of rainfall distribution.

The most important and prime rainy seasons are Gu and Deyr. Gu which starts either the end of February or early week of March, and it lasts up to May, whereas the Deyr rainy season get outset at end of September or early weeks of October. However, in the normal course of event, period that is expected by the people to receive rain could at times get muddled by the natural factors. In the Interview and focus group discussion, farmers stressed out that unreliability of rain season hinders their schedule of seasonal crop growing. At times some areas fail to receive rain in two consecutive years.
Figure 4.6. Dekadal Rainfall (mm) in 2011 vs Long term averages (LTA) in Gabiley
Source: FSNAU/FAO, 2011

From figure 4.6 April and May is a period that Gu rain is received. The end of August, rainy season restarts (Deyr), and it lasts up to October. However much the rainy season get outset, but amount of rain which is received is uncertain, and ubiquitously erratic and uneven.

4.1.4 Water Source and Distance
The major water source that people get water from is Barkado (Constructed water reservoirs/dams) as shown in figure 4.7. About 48% of the respondents do fetch water from these water reservoirs. These water reservoirs are constructed in a bid to harvest rainwater. Most of them are not covered, and the sunrays heats them up whereby it increases evaporation hence
depletion of surface water. However much they try to harvest runoffs and rainwater droplets, the strapping sun radiations normally dry up these water in the reservoir in a short time of period roughly 3 weeks upto 2 months before it gets replenished by next proceeding rainy season. This depends on the number of people who are using the Barkad, livestock population, and intensity of sunrays.

Despite this, about 30% of the respondents obtain water from boreholes, whereas the 25% get from wells; and around 6% of the respondents can access tap water, and these respondents are either in Gabiley District, or not far away from the District.

![Bar Chart](image)

**Figure 4.7. People’s responses on different water sources in Gabiley**

Source: Primary data

About 61.7% of respondents normally move less than 1 km during fetching water, 28.3% 1-2 km, and 10% of the respondents perilously move over 3 km in order to find water. The demographic changes and pastoral lifestyle which entitles nomads to move around in search of pasture, water and favorable environment, ensues these people to move away from the constructed water reservoirs and boreholes by the Government and International Organization.
This in turn, lets them to perpetuate their culture that evolves on moving around, shifting from one place to another, and fetching water from far distance.

During focus Group discussion, some respondents were arguing that what makes certain groups to move from borehole/Barkada and others to move 1-3 km to reach at these water sources, is improper prior assessment of borehole construction before it was constructed. Some people do consider these disparities due to alienation of certain clan/group, however this has always been resulting in water conflict, despite the conflict arising as result of precariousness of water.

4.2 Causes of Water scarcity
Water scarcity in Gabiley was established to be caused by prevailing droughts(28%) and Climate Change(17%), Overstocking of livestock(10%), Poor technology(18%) which ensues poor harvesting of rainwater, deforestation(7%), Disparity of water use(4%), Overpopulation(10%), Geological factors(7%) and Limited Government intervention(4%) in providing water facility that let to utilize potential ground water recharges.
1. **Drought/Climate Change**

About 45% of the respondents believe that prevailing drought severity and Climate change are major factors that affect water scarcity. However, drought and climate change are two causal features that normally go hand in hand, and they reinforce one another despite the fact that most scientists believe that drought is the byproduct/result of climate change. At times drought can take natural course events. The prevailing climate change in Somaliland has changed the vegetation, affected on hydrology particularly rainfall, and most importantly it has escalated evaporation of surface water, as the temperature in the area increases.
However, drought and climate change which overlap one another are believed to be the end result of removal of vegetation cover by human induced activities. This was early emphasized by the Hemming (1966, cited by German Agro-Action, 2005) who stated that Somaliland has been in a state of ecological change for many decades if not hundreds of years, and practically all the changes have been towards a reduction in the vegetation cover. This assessment suggests that the most recent process of climatic change has been one of decreasing rainfall and that desertification has proceeded considerably in the last 500 years. Butzer (1961) has constructed a map indicating the percentage rainfall decrease during the period 1911-1940 and he places most of Somaliland between 20 and 25% reduction (SWALIM Report, 2012).

Awale (2016), has corroborated the remarkable increase of the temperature in the study area and country (Somaliland) at large which is an evidence of the prevailing climate change that has resulted in a decrease in the mist forest areas. The decline in the use and sale of second hand cold weather clothes- Locally known as Huu-Dhaydh due to increase of temperature, can be a throttle that bear an evidence of the presence of climate change in the study area and country at large.

In turn, the relationship between climate change and water is significant \( (P=0.005) \), as the temperature continuous to rise, it will have a significant impact on freshwater supply with potential devastation on these resources.

However, about 45% of the respondents unsubtly emphasized the issue of climate change in combination with drought as the most important factor that lets these water resources to decrease and to be unevenly distributed. Also, surface water including constructed water reservoirs, natural water reservoirs and other water body sources decrease in amount as a result of evaporation, hence water scarcity.

2. Poor Technology/ Rainwater harvesting
About 18% of the respondents do believe that the prevailing water scarcity among agro-pastoral community in Gabiley, and urban dwellers as well is due to poor rainwater harvesting owing to poor technology. The harvested rainfall is limited due to number of technical and financial constraints that have led agro-pastoral communities to fail to efficiently utilize rainwater. Despite the Barkado(s) taking an important role in harvesting rainwater, these Barkado(s) were not built in accordance with needed standards. Also some strong sun radiations significantly increase the evaporation of these water reservoirs, hence the issue of water scarcity.

The observation method revealed that there are some water and soil conservation methods practiced by the local people on their own will, despite the technical constraints. The stressed out in the interview, that these people are lacking the necessary skills and financial supports in improving their capacity to efficiently harvest rainwater. However, due to poverty people will not able to adopt good technology for resource utilization. This agrees with Chitereka 2008. Meanwhile, communal grazing also brings a danger to maintenance and sustainability of any devised rainwater harvesting idea, or soil and water conservation techniques as the land get used by different people- having different interests and attitudes.

3. Overstocking of Livestock

Ten percentage (10%) of responses said that livestock is the leading economic throttle in Somaliland. Livestock production accounts for 60-65% of the country’s gross domestic product (GDP). As director of animal health (Ahmed Haybe, 2017) at Ministry of Livestock confirmed to me, that livestock in Somaliland (northern region in Somalia) are estimated approximately 25 million herd. Among pastoralists, especially those classified as poor, 50-80% of income is derived from the sale of livestock, and 25-30% of food comes from livestock products. Sheep and goats account for 91% of all animal exports, and in 2010 a total of 2.352 million sheep and goats were exported through the Berbera Port. Assuming an average export price of $70, the
estimated total value would be over $160 million. With government taxes at around $3.60 per head, this means tax revenue of around $8.5 million, or 30% of the Somaliland government’s total revenue (USAID, 2013), (cited in Somaliland Figures Report, 2014).

Therefore, the rural community in Gabiley and Somaliland at large normally graze multitude numbers of animal herds, including camels, cattle, goats, and sheep for both economic and traditional wealthy purposes. Hundreds of Thousands of livestock herds are grazed in Gabiley to sell them to exporters so as to export to Saudi Arabia, Yemen, Egypt and Kuwait markets, or just keep them around for traditional superiority. Also others graze these multitude livestock herds for dairy production; however, the extensive livestock grazing with multitude numbers increases water withdrawal for livestock irrigation, hence scarcity takes its toll. During the Discussion and Interview with different Academicians and Environment activists it was mentioned that overstocking of animals was a critical contributor to the prevailing water scarcity in Gabiley.

All of these millions of livestock herds need water to drink so as to survive in the harsh environment conditions before being exported to Gulf States. Since Camels and cattle normally drink hundreds of gallons of water, this puts pressure on water resource availability and sustainability, due to water being finite resources. Gabiley and the country at large is now experiencing water scarcity.

Furthermore, the millions of livestock grazed in Gabiley and the country at large have been releasing large volumes of methane gas into the atmosphere resulting in atmospheric warming or increase of temperature which has caused pasture to disappear, and thus pushed the rural community to rely on trees as a source of fodder, and this has been accelerating the rate of deforestation in Gabiley, and ultimately hydrological cycle perturbation.
4. Increase in Population

About 10% of the respondents indicated that there is substantial increase in population which outstrips the food, and this forces many farmers to grow more crops, to clear more land for agriculture, and graze tremendous livestock in a bid to produce sufficient dairy products that are adjusted with quantity demanded. In Gabiley, more than 60,000 people have registered in 2017 election. The issue of population increase was further backed by group discussion member where about 30% said population increase is a critical menace on freshwater and thereby posting water scarcity as the demand for water by human, industries, and agriculture rises dangerously. People who are living in Gabiley and its villages/counties may be approximately 60,000 as it was mentioned in the Presidential Voter registration reports (2017), but harmonization of their interests on water use from wells, springs and constructed water reservoirs is intricate, and it has resulted in water shortage due to failures by governing and harmonizing these needs. Obviously, resources get rippled and depleted when strong and inclusive sustainability measures are not put on place.

Mortmore et al, (1972), assert that in many areas increasing population threatens to upset the balance of population and resources. Marla et al, (1984), observes that, with the growing pressure of population on the land, farms become smaller and farms are divided and sub-divided into tiny strips and plots that are less productive, but exerts more pressure on freshwater.

5. Deforestation

About 7% of the respondents, backed by 29% of the interviewed respondents and Focus Group Discussion have agreed that deforestation is a critical subject that causes shortage of precipitation in Gabiley. In Gabiley and the country at large, the majority of people use charcoal and firewood as their source of energy. This traditional biomass energy is the major source of
their energy. There is no other alternative energy source in the study area apart from clearing and burning of trees to make firewood and charcoal, and this has disrupted the water cycle whereby precipitation tended to be precarious resulting in perturbation in the hydrological cycle. The massive ongoing deforestation in Gabiley has engraved the study area to lose a lot of plant diversity which used to take part in the formation of rainfall, and sustainability of the ecosystem. From 1990 to 2010, Somalia has lost 1,535,000 ha of forests, (FAO Report, 2010); this shows that there is massive ongoing deforestation in Somalia. Ali who is one of the farmers who was interviewed said that he collects a bunch of firewood daily or two days at once. He said that now he moves 1 to 3 km to get good and potential trees such as (Acacia bussei, Acacia millifera aff, Acacia misera, Azadirachta indica, Azima tetracentha, Acacia nilotica, and good tree of acacia tortilis) that are all good for charcoal production. The entire trees which used to be around his home have been cleared by himself and his neighboring households. However, massive and blindly clearing of forests has changed the micro climatic state of the study area. This has resulted into shortness and irregularity of rainfall distribution in the study area, hence water stress. Thus, deforestation has had a profound impact on freshwater due to population increase in Gabiley. Same thing supported by Davidson et al., (1992) as he argues that high population growth accelerates problems of land degradation through cultivation of marginal lands, soil erosion, overgrazing( that has impact on water availability) and most importantly deforestation. Morgan et al., (1980) also states that the nature of plant cover and the slope of the land have a great influence on erosion and freshwater availability.
Plate 1: Mother that moves out with camel in deforested area
Source: Photo taken during field

6. Disparity in water supply; About 4% of the respondents and substantial number of arguments in the focus group discussions, believe that water scarcity in their area is due to inequality in water supply and resource use. The numbers of needed boreholes were not made by the Government, and at times the places that were established as communal water reservoir (Barkad) were not allocated properly basing on accessibility of different users. Some people are close to water body which is either Borehole or Barkad made by Government, whereas the rest of community members remain far from them. Also as stated in the focus group discussion, projects that concern exploration and utilization of potential groundwater, in most cases are taken to different areas/District in the country for political interest.
7. **Poor Government Intervention.** About 4% of the respondents and substantial number of group discussion members emphasized the prevailing water scarcity due to limited Government intervention in empowering people with needed capacity (Technical and Financial support) to efficiently harvest rainwater and potential groundwater resources. The respondents said that the absence of political will from Government in extending water supply and capacitating local people with different rainwater harvesting techniques/technologies is profoundly contributing to growing water scarcity in study area.

8. **Geology of the area** (about 7% of responses); from focus group discussions, interview and questionnaire responses, some respondents said that geology of the area such as landscape, soil structure and available forest species contribute water stress. The entire horn of Africa, and particularly Somalia is almost equidistant from the equator and the Tropic of Cancer. It consists chiefly of mountains uplifted through the formation of the Great East Africa Rift Valley. In Somalia, there is not much seasonal variation in its climate. Hot conditions prevail year-round along with periodic monsoon winds and irregular rainfall (Hadden Report Lee, 2007). In Gabiley and Somalia at large there are no tropical forests which could take magnificent role in formation of rainfall. The soil structure in Gabiley and North regions of Somalia (Somaliland) at large does not act as spongy permeable and water gets a challenge to infiltrate into the soil. Also the periodic monsoon winds normally erode the humus soil which acts as a spongy and helps water to infiltrate into the ground; Thus, the geological structure of Gabiley and natural climatic conditions in Somalia and horn of Africa at large has a call on water stresses and chronically occurrence of droughts.
4.3 EFFECTS OF WATER SCARCITY ON AGRICULTURAL PRODUCTION IN GABILEY
There are several commonly known consequences/effects of water scarcity on agricultural production, but hereunder, in this study, the researcher has established these following effects basing on people’s responses and awareness.

Figure 4.9 Peoples responses on effects of Water scarcity on their Agriculture constituent
1. Less surface water

About 36% of the respondents’ attributed reduction of surface water as the most important effects resulting from water scarcity. As we know, availability of water and fertile soil are major elements that enable people to grow crops or rear animals. Having said that, the absence of one of these elements has an affect on the productivity of the farm, and hence very important in
peoples livelihood. However, in focus group discussions and interviews, the majority of the participants highlighted a decline of surface water particularly Constructed water reservoir (Barkado) and other small scale dams within the study area. These water bodies get declined as the precipitation tends to be more erratic, precarious, and uneven.

2. Changes in the Quantity of the harvested yields. About 22 % of the respondents and substantial number of groups in focus group discussions stressed out the changes of the quantity and quality of the harvested yields from agriculture as utmost effects that has been caused by water scarcity in the study area. The yields from both animals and crops have been subject to gradual changes and fluctuation. This comes as a result of the changes of precipitation and failures to efficiently utilize rainwater.

Table 4.2. summary of cereal production in Gabiley(2012-2016).

<table>
<thead>
<tr>
<th>District</th>
<th>Sorghum</th>
<th>Maize</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gabiley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>Area cult.(ha)</td>
<td>Harvested area(ha)</td>
</tr>
<tr>
<td>------</td>
<td>---------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>2012</td>
<td>21,056</td>
<td>20,523</td>
</tr>
<tr>
<td>2013</td>
<td>23,000</td>
<td>19,500</td>
</tr>
<tr>
<td>2014</td>
<td>26,500</td>
<td>20,000</td>
</tr>
<tr>
<td>2015</td>
<td>25000</td>
<td>9000</td>
</tr>
<tr>
<td>2016</td>
<td>30,000</td>
<td>23,000</td>
</tr>
</tbody>
</table>

Source: secondary data from Ministry Of Agriculture, 2017

In the above table, The statistical trends of sorghum and Maize production in Gabiley over the last 5 years (2012-2016) has been subject to changes. In table 4.2, the area cultivated is bigger than the area harvested; this means that some areas failed to produce yields. However, the yields produced have been gradually waning in numbers, and this has made in the country to experience food insecurity, thereby increase of food importation.

In 2015, the country experienced severe droughts with no rainfall except some few locations were able to obtain little rain, leading to a reduction in expected yields. As is observed in the table 4.2.

*Food Imports:*
Imports constitute the main source of food supply for Somaliland (Table 4.3). The country imports substantial amounts of sugar, rice, wheat, cooking oil and dates consumed. This is due to the absence of favorable climatic and soil conditions required for growing these commodities.

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>140,688</td>
<td>157355</td>
<td>143555</td>
<td>35</td>
<td>4765</td>
<td>93</td>
<td>NA</td>
<td>21137</td>
<td>4161</td>
<td>20978</td>
<td>4424</td>
<td>4,782,500 ltrs</td>
</tr>
<tr>
<td>2009</td>
<td>155965</td>
<td>59645</td>
<td>53475</td>
<td>115712</td>
<td>NA</td>
<td>NA</td>
<td>17210</td>
<td>18776</td>
<td>3015</td>
<td>4232</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2008</td>
<td>194523</td>
<td>61288</td>
<td>51596</td>
<td>11509</td>
<td>NA</td>
<td>NA</td>
<td>31506</td>
<td>18903</td>
<td>3474</td>
<td>5575</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2007</td>
<td>174076</td>
<td>89762</td>
<td>46817</td>
<td>3411</td>
<td>NA</td>
<td>NA</td>
<td>33388</td>
<td>19033</td>
<td>3866</td>
<td>3548</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

Source: Berbera Port Authority, Customs, Ministry of Finance, Customs Department, 2010

Table 4.3 Food imported through Berbera Port (2007-2010)

The above table shows us the food items that have been imported through Berbera port since 2007. There has been gradual increase in importation of foods, and this is resulted in by the changes and fluctuations of agricultural productivity within the country.
The above figure (4.12), shows how the yields are steadily declining or increasing as the rainfall distribution changes in Gabiley, Somaliland.

3. **Formation of hardpans;** twelve percent (12%) of respondents together with focus group discussions have indicated Formation of hardpans as a major impacts that water scarcity has caused. They stressed out that they normally get challenges in mechanizing their farms as the soil gets changed in terms of structure and permeability. However, on the basis of scientific judgment, formation of hardpans is normally caused by the increase in temperature that makes the soil moisture to evaporate, thus the soil eventually cannot keep water for a long time. Also changes in microclimatic in Gabiley, poor soil mechanization as well as limited capacity in soil and water conservation mastermind the escalation of these hardpans in the soil. However, it is crystal clear that these growing hardpans in the soil do impede agricultural productivity, as is evidenced in table 4.3 where the area harvested is substantially less than the previously cultivated, giving a depiction that some areas failed to produce yields.
Plate 2. A cereal grower who is trying to mechanize the cultivation

4. Weight Loss and Increase of Animal death; Eight percent (8%) of respondents indicated that weight loss and increase of animal death are the results of water scarcity. This was confirmed in the focus group discussion and interview.

Livestock do need water on a daily basis as the human beings need except camel that takes several days without water. However, the prevailing water scarcity in the study area resulted in a multitude of livestock to lose weight due to absence of sufficient water and pasture, and thus making them more vulnerable to diseases, eventually susceptible to death. To note, if the livestock keepers sell off their herds, the price gets low due to weight that they have lost.

Also farmers spend a lot of time in fetching water for their livestock due to slight remoteness of the water source, thus has reduced time that would have spend on cultivation, hence reduction in yield.

Plate 3: Animals taking fetched water

5. Increase of Livestock sale as buffer; Eleven percent (11%) of the respondents and number of groups in the focus group discussions indicated that the growing water scarcity in the study
area, unreliability of rainfall and failures to utilize rainwater have triggered the selling of livestock. Despite for economic interest in Livestock selling/exportation, some interviewers stressed out that if there was adequate water, they would have kept their livestock because they have value for the purpose of traditional superiority.

Table 4.4. Number Of Exported Livestock To Arabian Gulf States (2004-2012)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>GOAT</th>
<th>CATTLE</th>
<th>CAMEL</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>866,571</td>
<td>131,884</td>
<td>3,888</td>
<td>1,002,343</td>
</tr>
<tr>
<td>2005</td>
<td>1,021,399</td>
<td>145,945</td>
<td>4745</td>
<td>1,172,089</td>
</tr>
<tr>
<td>2006</td>
<td>1,200,289</td>
<td>97,333</td>
<td>23,512</td>
<td>1,321,134</td>
</tr>
<tr>
<td>2007</td>
<td>115061</td>
<td>83978</td>
<td>19626</td>
<td>218,665</td>
</tr>
<tr>
<td>2008</td>
<td>1,223,095</td>
<td>81,668</td>
<td>26,090</td>
<td>1,330,853</td>
</tr>
<tr>
<td>2009</td>
<td>1,554,237</td>
<td>88,048</td>
<td>20,414</td>
<td>1,662,699</td>
</tr>
<tr>
<td>2010</td>
<td>2,584,810</td>
<td>133,021</td>
<td>92651</td>
<td>2,810,482</td>
</tr>
<tr>
<td>2011</td>
<td>2,867,642</td>
<td>120,111</td>
<td>96,097</td>
<td>3,083,850</td>
</tr>
</tbody>
</table>
The gradual increase in export of livestock products to Arabian countries has tremendously increased since 2012 as shown in table 4.3 above; with goat/sheep being exported in high quantities compared to cattle and camel.

6. Soil erosion; soil erosion in the area was confirmed by direct observation where huge areas are being eroded. These are wind erosions spawned by the moving winds in the region. The sun radiation reduces soil moisture, and turns it drier, thereby making wind to easily erode top soil. This was confirmed by 8% of the questionnaire respondents and focus group discussions. However, there are also several factors that have led the study area to encounter soil erosion including runoffs that come due to failures in rainwater harvesting, and poor grazing system.

4.4 Adaptation measures against water scarcity in Gabiley District

<table>
<thead>
<tr>
<th>Adaptation measure</th>
<th>Frequency</th>
<th>Percent</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tried Infrastructural Investment</td>
<td>17</td>
<td>14.2</td>
<td>4</td>
</tr>
<tr>
<td>Tried to build Awareness on rainwater harvesting</td>
<td>27</td>
<td>22.5</td>
<td>2</td>
</tr>
<tr>
<td>Changing Irrigational scheme</td>
<td>4</td>
<td>3.3</td>
<td>5</td>
</tr>
<tr>
<td>Used Soil and water conservation methods</td>
<td>26</td>
<td>21.7</td>
<td>3</td>
</tr>
<tr>
<td>Built Water reservoirs</td>
<td>46</td>
<td>38.3</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Somaliland Ministry of Livestock
Thirty Eight percent (38%) of the respondents stressed out that constructed small scale water reservoirs (Bakads) and earth dams are a major technique that people resort to in order to adopt with prevailing water stress in the study area. This was also confirmed by observation where the researcher observed roughly 32 Barkads and earth dams in study area. However, these Barkads do have different widths and depths, depending on the economic and technical capacity of the household in constructing these Barkads. This was intended in a bid to harvest rainwater particularly raindrops and runoffs. Also the water in these Barkads gets used up within a short period of time due to sun’s radiations and hot temperature in the study area that increase more evaporation, hence shrinkage of water table in the Barkads.

Twenty two percent (22%) of the respondents and from the focus group discussion have indicated the presence of awareness on rain water harvesting, but they are lacking technical and financial support from Government and relevant bodies. They are willing to efficiently utilize rainwater with zero runoff, but there are economic and technical constraints owing to absence of strong political will and commitment from central Government, and Local Authority.

Despite the technical and financial constraints, some people have willingly tried to establish some methods of soil and water conservation (about 21% of the responses). However, to some extent, this has helped them to harvest substantial amount of water, and conserve top soil, but most of the precipitation ends up as runoffs, and end up into sea.

About 14% of the respondents, and in the focus group discussion, numerous respondents believe that Government has tried its best in improving water infrastructure, establishing boreholes, and
communal water dams, but these do not meet the water demand for domestic and Agricultural purposes.

More so, about 3% of the respondents indicated that they have made some changes about the way they used to irrigate their farms, adopting drip irrigation that minimizes water lost during watering in the farm, and this has helped them to demand less water in their farms, and conserve water in their Barkads.

4.5. Testing Hypothesis
In order to establish whether there is significant relationship between Water scarcity and Agricultural Productivity, the researcher has correlated rainfall data and trend of cereal production over the last 7 years (2010-2017).

Rain is the utmost source of all water on earth, therefore, any change in the precipitation directly affects all source of water whether it is surface water, ground water, constructed water reservoirs, etc.

There is significant relationship between water scarcity (taking rainfall performance as research model) with harvested yields throughout 2010-2016 in Gabiley, \( r=0.32 \), at \( P \geq 0.05 \).

The null hypothesis was rejected and the alternative one accepted that annual rainfall performance in Gabiley throughout 2010-2016, and cereal yields produced within that same period, do have significant positive correlation, strong( \( r=0.32 \), at \( P \geq 0.05 \))
CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion
With regard to findings, the prevailing water scarcity in Gabiley is a result of anthropogenic activities that people normally done on disrupting some important ecological elements including forests and soil. The massive deforestation has reduced forest cover, and in turn caused the precipitation to get erratic, precarious and irregular moreover the trees play a critical role in hydrological cycle and ecosystems. This massive deforestation contributes to the dry micro-climatic change in the study area, and drought occurrences. Additionally, the limited capacity in rainwater harvesting and overstocking of livestock profoundly contribute to the escalation of water scarcity in the study area and Somaliland region at large.

Strong Political will and Commitment from Government in Providing technical and financial backups to the farmers were not observed during the research period, and this unsubtly made people to lack the needed technical and financial support that could help them to some extent to efficiently utilize rainwater, and provide adequate water into their crops grown fields and herds as well. Also there was lack of capacity in the government to desalinate seawater which is potential water source as long as the country is adjacent to the red sea and Gulf of Aden peninsula. Meanwhile, the semi-aridness of the Somaliland environment and region at large, has made the study area to be susceptible to any negative changes in the climate particularly variability of rainfall, hence water stress.

Despite this, the utmost effect that water scarcity has brought is the reduction of surface water which is either earth dams or water reservoirs (both manmade and natural) that are intended to provide water for livestock and crops, thereby food insecurity. Meanwhile, the reduction of yields, weight loss and death of some animals as well as formed hardpans in the soil do arise.
The weight loss of the animals profoundly impacted on the income of the livestock keepers, also the hardpans in soil made the runoff not to effectively infiltrate into the ground. The roots of crops get intricate to unfold across the soil and uptake some nutrients and water as the soil structure has been changed, thereby reduction of yields. This can also be evidenced in the table where the area harvested is less than the area that was cultivated by the farmers thereby giving a depiction that some areas fail to produce yields.

There are a few adaptation strategies to the prevailing water scarcity in Gabiley as well as the country at large. Some reservoirs are built by the local people, but these reservoirs (Barkads) are temporary solutions to the problem. At the same time, water evaporation from the barkads by the sun radiation is so intense. Despite having soil and water conservation techniques by the local people, boreholes, the demand of water keeps on increasing due to increasing populations, increasing livestock and increasing cultivated area.

5.2 Recommendation
From the findings of this research, I recommend that Government halts massive deforestation activities taking place in Gabiley and Somaliland at large due to disruption of the natural regularity of the hydrological cycle and micro-climate. Deforestation can be halted by imposing strict laws and regulations on people. Forest products should be licensed and enforced to sustainably utilize forest resources.

Selective logging and certified forest products measures should be put in place. Developing alternative renewable energy sources is needed to ward off people from barely relying on fuel wood and charcoal.

People should be trained with different rainwater harvesting techniques, and provide the needed financial and material elements for them to be able to utilize rainwater efficiently. Also,
sustainable irrigational methods that minimize water should be trained with people such as drip and trickle irrigation, at the same time provide them with materials they need to be able to adopt to these irrigational methods.

Water reservoirs (both earth dams and Barkads) should be covered, so that water will not be able to evaporate from them. Different agro-forestry practices have to be introduced to people, and provide different tree seedlings as this will regulate climate and moderate rainfall variability, as well as provide people woody materials they need.

Government and the relevant civil and international organizations should construct surfeit number of water reservoirs to efficiently utilize rainwater. Construction of water retention ditches and infiltration ditches are needed in order to catch and retain the runoffs and hold it until it seeps into the ground so as to regenerate underground water. Also farmers should be trained on how to mulch their farms to promote greater infiltration of runoffs and rain drops into the ground.

Also Government should regulate number of livestock kept to reduce the number of livestock herds that they are rearing as this reduces the amounts of methane emissions into the atmosphere, and subsequently it conserves water because the regulated herds of livestock use water sustainably.

Government and the relevant civil and international organizations such as Food and Agricultural Organization (FAO) should encourage farmers to plant xerophytes, fast growing crops, and drought resistance crops. Farmer should irrigate their farms during night to reduce water lost during evaporation.
Government should put in place Family planning policies and incentives to reduce rapidly growing population.

There is also high need to ensure policy alignment and government projects that enhance food-water and energy nexus to be sustainable within Somalia. Decisions outside the water domain, such as those determining energy prices, trade agreements, agricultural subsidies and poverty reduction strategies, can all have a major impact on water supply and demand, and therefore on water scarcity. Alignment of the many policies, legislation and fiscal measures that influence water management, service delivery and level of demand is crucial. Agriculture and food security policies have to be strongly connected to water policies and that degree of connection needs to be appreciated to ensure overall coherence.

Nevertheless, by doing all of these, the menace of water scarcity in Gabiley will be counteracted, water availability and supply to agricultural sectors will also be improved, and ultimately agricultural productivity will be boosted up, hence better amelioration of the livelihood of rural community in Gabiley.
THE CONTRIBUTION OF THE STUDY IN THE EXISTING KNOWLEDGE

There are no studies carried in Gabiley District about prevailing water scarcity and the waning of crops/harvested yields. Thus, this study will create bedrock information about the water scarcity menace in Gabiley, the resulting effects, and the potential adaptation measures that can be resorted to by farmers in any water stress location to acclimatize to water scarcity which is now a global problem. The study has validated the scholarly ideas and studies that determined the relationship between water scarcity and agricultural production.
APPENDIX I: QUESTIONNAIRES

ID:0001

QUESTIONNAIRE FOR RESPONDENTS IN GABILEY DISTRICT, SOMALIA

Dear respondent

I am Sharmarke Abdi Musse, a student from Kampala International University who want to conduct a research study on Impact of water scarcity on agricultural production using Gabiley as the case study. I kindly request you to spare some time and fill this questionnaire. The information given will be used for academic purposes only and will be treated with utmost confidentiality. Your cooperation will be highly appreciated.

SECTION A: BACKGROUND INFORMATION

Please tick the most suitable answer.

1. What is your job/occupation? .................................................................

2. Gender
   (a) Male  
   (b) Female  

3. Age bracket
   (a) 20-25  
   (b) 26-35  
   (c) 36-40  
   (d) 41 and above  

4. Highest level of education.
   (a) Primary  
   (b) Secondary  
   (c) Diploma  
   (d) University education  
   (e) Nothing  
   (f) Others specify).................................
6. What is your marital status?
   (a) Single
   (b) Married
   (c) Widowed
   (d) Divorced

7. For how long have you been involved in agriculture production?
   (a) Less than 3 years
   (b) 3-8 years
   (c) 8-13 years
   (d) More than 13 years

8. Do you experience any water scarcity in this area?
   a) Yes
   b) No
   c) Not sure

9. How do the rainy seasons come?
   a) Once in each two years
   b) Once in year
   c) Twice in year
   D) There times in year
   E) Uneven

10. What is the distance between your home and water points?
    a) Less than 1 kilometres
    b) 1-2 kilometres
    c) 3-5 kilometres
    d) More than 5 kilometres

11. What is your source of water?
    a) Tap water
    b) Borehole
    c) wells
d) Spring

e) Constructed Water reservoirs (Barkad)

f) Others…………………… (specify)
SECTION B: CAUSES OF WATER SCARCITY IN GABILEY

Evaluate the following statements by ticking the appropriate alternative of your choice.

<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Agree</th>
<th>Not sure</th>
<th>Disagree</th>
<th>Strongly disagree</th>
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<td>1. Drought causes water scarcity in Gabiley District as the aridity increases</td>
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<td>2. The growing micro climatic change in Gabiley and across the region contributes to water scarcity in District.</td>
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<td>3. Poor rainwater harvesting can also be a course for water shortage.</td>
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<td>4. Geology and nature of the terrain in the region contribute to water stresses in Gabiley District.</td>
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<td>5. The Massive Deforestation activities in Gabiley District have caused water scarcity as it impedes precipitation and hydrology at large.</td>
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<td>6. Disparity in the way the villages received water in Gabiley District causes water scarcity</td>
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<tr>
<td>7. Limited technical and financial support of the Farmers in harvesting rainwater contributes to the water scarcity in Gabiley District.</td>
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<td>8. Flood irrigation method that often used farmers in Gabiley District during irrigation causes water scarcity as it increases water abstraction.</td>
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<td>9. The increase in Population in Gabiley District causes water scarcity due to different competing uses.</td>
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SECTION C: THE EFFECTS OF WATER SCARCITY ON AGRICULTURAL PRODUCTION IN GABILEY

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<tr>
<td>1 Reduction of yields both animal and crop.</td>
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<td>2 Less surface water</td>
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<tr>
<td>3 Livestock sales act as a buffer in the face of water scarcity and droughts, hence reduction of livestock industry</td>
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<td>4 weight loss and increased deaths among livestock</td>
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<td>5 Changes in the distribution of wealth usually due to scarcity of water</td>
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<tr>
<td>6 Formation of hardpans</td>
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SECTION C: THE ADAPTATION MEASURES WHICH HAVE BEEN RESORTED TO BY FARMERS FOR ADOPTING WITH WATER SCARCITY PHENOMENON

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<td>1 Tried to do Infrastructure investment</td>
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<td>2 Tried to build awareness and knowledge on rainwater and runoff water harvesting</td>
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<tr>
<td>3 Water reservoir/Barkads and earth dams are constructed</td>
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<td>4 Soil and water Conservation techniques are in place</td>
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<td>5 Tried to change irrigational methods, and adopt sustainable irrigational methods</td>
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Thank you very much for your cooperation
APPENDIX II

INTERVIEW GUIDE

AN INTERVIEW FOR THE KEY INFORMANTS IN GABILEY DISTRICT, SOMALIA

Dear respondent

I am Sharmarke Abdi Musse, a student at Kampala International University, Uganda conducting a research study on the impact of water scarcity on agriculture production using Gabiley as the case study as a requirement for the award of a Masters Degree in Environmental management, I kindly request you to spare some time and fill this questionnaire. The information given will be used for academic purposes only and will be treated with utmost confidentiality. Your cooperation will be highly appreciated.

1. What is your job? .................................................................

2. Gender( Male, Female)________

3. Age____________________

4. Highest level of education?________________________

5. What is your marital status?_____________________

6. For how long have you been in agriculture production?

7. What do you think is the utmost factor that causes inadequacy of water in your Farm?_______________

8. How do you irrigate your farm?_____________________

9. What are the effects that growing water scarcity posted on your farm?

10. As farmer, how do you adopt with growing water stresses in Gabiley and the country?________________________________________________________

11. Do you normally get adequate financial and technical support from Government and relevant bodies for you to be able to acclimatize with growing water stresses in the region?________________________________________________________
### APPENDIX III: Spearman’s rank table on rainfall and yields harvested data (2010-2016)

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<tr>
<th>X</th>
<th>Rx</th>
<th>Y</th>
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\[ D^2 = 38 \]

\[ = 1 - \frac{6ed^2}{n(n^2 - 1)} \]

\[ = 1 - \frac{6(38)}{7(49 - 1)} \]

\[ = 1 - \frac{228}{336} \]

\[ = 1 - 0.67 \]

1-0.67
r=0.32
Appendix IV: THE SPSS PACKAGE USED BY THE RESEARCHER TO ANALYZE PRIMARY DATA

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