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Impact of Drought on Tomato Production in Bal'ad, Somalia

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Abstract

This study investigated the impact of drought on tomato production, the three major objectives of the research were to evaluate the causes of drought on tomato production, to assess the constraints of drought on tomato farmers, to suggest possible solutions to manage drought on tomato production. The study found that drought has negative impact on farmers, pastoralists, and other communities that depend on these two sectors, the data was collected from BALCAD by using questionnaire and analyzed statistical package for social science (SPSS) version 16.0 After analyzing answers of the respondents from the questions asked in the questionnaire, The study found that drought on tomato production is caused by factors like precipitation deficiency, climate change, and human activities, leading to negative impacts on farmers and ranchers, reduced crop production, and unemployment among agricultural laborers, with suggested solutions including early warning systems and government support. The study concludes that drought, driven by factors like precipitation deficiency, climate change, and human activities, has significant adverse effects on tomato production, leading to reduced yields, unemployment, and migration among farmers in the Middle Shabelle region of Somalia. The study recommends establishing early warning systems, promoting water harvesting techniques, distributing drought-resistant seeds, improving irrigation infrastructure, conducting farmer awareness programs, providing alternative livelihood skills training, and increasing budgetary allocations for drought relief measures to enhance tomato producers' climate resilience and food security in BALCAD.

Keywords: *Drought, Tomato Production, Agricultural,* Bal'ad, Somalia

1.0 Introduction

Research indicates that a universal definition of drought is neither possible nor advisable due to the multifaceted nature of drought (Wilhite and Glantz 1985; Heim 2002; Redmond 2002; Boken et al. 2005). Instead, drought should encompass multiple definitions, each emphasizing a specific aspect. Drought definitions are categorized as either conceptual or operational (NDMC 2006a). Conceptual definitions are broad and are commonly employed for establishing drought policies. For instance, drought might be conceptually defined as "an extended period of insufficient precipitation leading to extensive crop damage and yield losses" (NDMC 2006a). Operational definitions typically designate the temporal extent and severity of a drought, are more specific, and are unique to each drought event. Wilhite and Glantz (1985) identified four primary drought definitions: meteorological drought, agricultural drought, hydrologic drought, and socio-economic drought. A meteorological drought definition depends on the degree of dryness and the absence of rainfall over a designated period. The definition typically varies from place to place due to the diversity of climates. An agricultural drought definition often entails a blend of meteorological drought characteristics and agricultural repercussions. For example, various meteorological factors, such as evapotranspiration, are considered in an agricultural drought definition. The onset of an agricultural drought often trails behind a meteorological drought. A hydrologic drought definition centers on alterations in surface or subsurface hydrology, stream flow, and runoff. A hydrologic drought may not necessarily coincide with a meteorological drought or an agricultural drought. A socio-economic drought definition incorporates water supply and demand concerns and addresses conflicts between water users. Socio-economic drought typically manifests after the other drought types as water supplies decline and water demand rises. Each of the aforementioned definitions reflects some of the impacts caused by droughts and unveils the intricate nature of drought development. Drought is an extended period when a region experiences a deficiency in its water supply, whether atmospheric, surface, or subsurface water.

Droughts can extend for months or years, or they may be declared after as few as 15 days. This typically occurs when a region experiences consistently below average precipitation. Droughts can have a substantial impact on the ecosystem and agriculture of the affected region. While droughts may persist for several years, even a short, intense drought can cause significant damage and harm to the local economy. Periods of droughts can have far-reaching environmental, agricultural, health, economic, and social consequences. The effect varies depending on the level of vulnerability. For example, subsistence farmers are more likely to migrate during droughts as they lack alternative food sources. Areas with populations that rely on agriculture as a major food source are more vulnerable to famine. Somalia is heavily reliant on its natural resources and the provision of ecosystem services. Due to this dependency, the country's vulnerability to climate change is projected to increase. This, along with the man-made degradation of natural resources from charcoal production and overgrazing, has heightened Somalia's vulnerability to drought and desertification, leading to a significant decline in food security. Natural hazards and disasters are prevalent in Somalia. The increasing spatial and temporal variability of rainy and dry seasons, as well as floods and droughts, contribute to these serious natural disasters. El Niño-induced changes in weather patterns continue to impact the region. Historical trends indicate that droughts regularly occur at intervals of 2-3 years during the Deyr (October-December) season and 8-10 years in consecutive Deyr and Gu (April-June) seasons, exacerbating seasonal hardships. An estimated 3.2 million people are severely food insecure. This situation is anticipated to persist throughout 2017 given the high likelihood of a third consecutive poor harvest in July. Access to food is relatively better than previously anticipated due to large-scale humanitarian assistance. Nonetheless, the overall food security situation remains critical.

Since January, 102,263 individuals have received treatment for Severe Acute Malnutrition (SAM), with SAM admissions showing an increase of more than 50% since 2016. The Food Security and Nutrition Analysis Unit's (FSNAU) post-Jilaal 2017 survey reveals a high prevalence of Global Acute Malnutrition (15% to 30%) in several regions, including Bay, Bakool, Sool, Sanaag, Bari, Nugal, Baidoa, and Mogadishu IDP camps. The severe impact of the 2015-2016 El Niño phenomenon exacerbated an already widespread drought in Puntland and Somaliland, leading to food insecurity, cash shortages, out-migration, and livestock losses. These effects are now spreading to other parts of the country, particularly Jubaland in the south. Somaliland and Puntland have experienced below-average rains for up to four seasons over two years, affecting nearly 1.4 million people. The listed drought names include Lafcad, Cadhoole, Siigacase, Cadaabhoomey, Dhaxanweyn, Dabadheer, Gaatama, Liiga, Gacmadheer, Sima, Isdeber, Anaakaadaran, and Igusawir, all of which have impacted Somalia.

1.1 Problem Statement

Somalia is a drought-prone country primarily due to its unique climatic conditions. Arid and semi-arid lands cover 80% of the country, where annual rainfall varies from 200 to 500mm. Periodical droughts are a natural part of the climate system in these regions (Kandji, 2006). Drought conditions essentially arise from a deficit of water supply over time and/or space. This deficit can occur in precipitation, stream flow, accumulated water in storage reservoirs, groundwater aquifers, and soil moisture reserves. When describing a drought situation, it's crucial to understand its duration, spatial extent, severity, initiation, and termination. Based on the areal extent, a drought can be classified as a point drought, small-area drought, or a continental drought. However, in Somalia, the impact of the drought is affecting most parts of the country, leading to water scarcity, resulting in deficits in agricultural production and livestock loss, and increasing food and water prices. These factors are making it increasingly difficult for poor families to feed themselves (SWALIM, 2011). In Balcad, farmers rely on river water for irrigating their crops. However, the river water dries up between December and April, leaving farmers with a water shortage that affects their high-value crops, particularly those sensitive to water stress, such as tomatoes. Drought is the absence of sufficient rainfall or supplemental irrigation for a period of time that depletes soil moisture and damages plants. Water is essential for life, as it constitutes the major component of plant cells and is the medium in which growth processes occur. Without adequate water, biological processes like photosynthesis are severely reduced. Reduced photosynthesis translates to reduced plant growth, including root growth.

1.1 Objectives of the Study

i. To evaluate the causes of drought on tomato production
ii. To assess the constraints of drought on tomato farmers
iii. To suggest possible solutions to manage the impact of drought on tomato production

1.3 Research Questions

i. What are the causes of drought on tomato production?
ii. What are the constraints of drought on tomato farmers?
iii. What are possible solutions to manage the impact of drought on tomato production?

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2.1 Types of Drought

There are several types of drought which include; meteorological, agricultural, hydrological and socioeconomic drought.

2.1.1 Meteorological drought

Meteorological drought is typically defined based on the degree of dryness compared to a "normal" or average amount of precipitation and the duration of the dry period. These definitions vary by region because the atmospheric conditions causing precipitation deficiencies differ greatly. For example, in regions with year-round precipitation like tropical rainforests, humid subtropical climates, or humid mid-latitude climates (e.g., Manaus, Brazil; New Orleans, Louisiana, USA; London, England), some definitions identify drought based on the number of days with precipitation below a specified threshold. However, in areas with seasonal rainfall patterns, like the central United States, northeast Brazil, West Africa, and northern Australia (e.g., Omaha, Nebraska, USA; Fortaleza, Ceará, Brazil; Darwin, Northwest Territory, Australia), extended periods without rainfall are common, making such a definition unrealistic. Other definitions may consider actual precipitation departures from average amounts on monthly, seasonal, or annual time scales.

2.1.2 Agricultural drought

Agricultural drought connects various aspects of meteorological or hydrological drought to their impact on agriculture, focusing on factors like precipitation shortages, disparities between actual and potential evapotranspiration, soil water deficits, reduced groundwater or reservoir levels, and more. The definition of agricultural drought should consider factors such as plant water demand, prevailing weather conditions, specific plant characteristics, growth stages, and soil properties. An effective definition should also account for varying crop susceptibility during different stages of development, from emergence to maturity. For instance, insufficient topsoil moisture during planting can hinder germination, resulting in lower plant populations per hectare and reduced final yield. However, if topsoil moisture is adequate for early growth needs, deficiencies in subsoil moisture at this stage may not impact final yield as long as subsoil moisture is replenished during the growing season or rainfall meets plant water requirements.

2.1.3 Hydrological Drought

Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (i.e., stream-flow, reservoir and lake levels, groundwater). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system. Hydrological droughts are usually out of phase with or lag the occurrence of meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, stream-flow, and groundwater and reservoir levels. As a result, these impacts are out of phase with impacts in other economic sectors. For example, a precipitation deficiency may result in a rapid depletion of soil moisture that is almost immediately discernible to agriculturalists, but the impact of this deficiency on reservoir levels may not affect hydroelectric power production or recreational uses for many months. Also, water in hydrologic storage systems (e.g., reservoirs, rivers) is often used for multiple and competing purposes (e.g., flood control, irrigation, recreation, navigation, hydropower, wildlife habitat), further complicating the sequence and quantification of impacts. Competition for water in these storage systems escalates during drought and conflicts between water users increase significantly.

2.1.4 Socioeconomic Definitions of Drought

It associates the supply and demand of some economic good with elements of meteorological, hydrological, and agricultural drought. It differs from the aforementioned types of drought because its occurrence depends on the time and space processes of supply and demand to identify or classify droughts. The supply of many economic goods, such as water, forage, food grains, fish, and hydroelectric power, depends on weather. Because of the natural variability of climate, water supply is ample in some years but unable to meet human and environmental needs in other years. Socioeconomic drought occurs when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply. For example, in Uruguay in 1988–89, drought resulted in significantly reduced hydroelectric power production because power plants were dependent on-stream flow rather than storage for power generation. Reducing hydroelectric power production required the government to convert to more expensive (imported) petroleum and implement stringent energy conservation measures to meet the nation’s power needs. In most instances, the demand for economic goods is increasing as a result of increasing population and per capita consumption. Supply may also increase because of improved production efficiency, technology, or the construction of reservoirs that increase surface water storage capacity. If both supply and demand are increasing, the critical factor is the relative rate of change. Is demand increasing more rapidly than supply? If so, vulnerability and the incidence of drought may increase in the future as supply and demand trends converge. Wilhite, D.A.; and M.H. Glantz. 1985. Understanding the Drought Phenomenon: The Role of Definitions. Water International 10(3):111–120.

2.2 Major Causes of Drought

Precipitation deficiency, the dry season, El Niño, erosion and human activities, climatic changes, drying out of surface water flow, and global warming are the main causes of drought. Mechanisms of producing precipitation include convective, stratiform, and orographic rainfall. Convective processes involve strong vertical motions that can cause the overturning of the atmosphere in that location within an hour and cause heavy precipitation, while stratiform processes involve weaker upward motions and less intense precipitation over a longer duration. Precipitation can be divided into three categories, based on whether it falls as liquid water, liquid water that freezes on contact with the surface, or ice. Droughts occur mainly in areas where normal levels of rainfall are, in themselves, low. If these factors do not support precipitation volumes sufficiently to reach the surface over a sufficient time, the result is a drought. Drought can be triggered by a high level of reflected sunlight and above average prevalence of high-pressure systems, winds carrying continental, rather than oceanic air masses, and ridges of high-pressure areas aloft can prevent or restrict the developing of thunderstorm activity or rainfall over one certain region. Once a region is within drought, feedback mechanisms such as local arid air, hot conditions which can promote warm core ridging, and minimal evapotranspiration can worsen drought conditions.

Within the tropics, the presence of distinct wet and dry seasons is influenced by the movement of the Intertropical Convergence Zone or Monsoon trough. The dry season is associated with increased drought occurrence and is characterized by low humidity, leading to the drying up of watering holes and rivers. This scarcity of water resources compels many grazing animals to migrate in search of more fertile lands where water is available. Examples of such animals are zebras, elephants, and wildebeest. Because of the lack of water in the plants, bushfires are common. Since water vapour becomes more energetic with increasing temperature, more water vapour is required to increase relative humidity values to 100% at higher temperatures (or to get the temperature to fall to the dew point). Periods of warmth quicken the pace of fruit and vegetable production, increase evaporation and transpiration from plants, and worsen drought conditions.

Drier and hotter weather occurs in parts of the Amazon River Basin, Colombia, and Central America during El Niño events. Winters during the El Niño are warmer and drier than average conditions in the Northwest, northern Midwest, and northern Mideast United States, so those regions experience reduced snowfalls. Conditions are also drier than normal from December to February in south-central Africa, mainly in Zambia, Zimbabwe, Mozambique, and Botswana. Direct effects of El Niño resulting in drier conditions occur in parts of Southeast Asia and Northern Australia, increasing bush fires, worsening haze, and decreasing air quality dramatically. Drier-than-normal conditions are also in general observed in Queensland, inland Victoria, inland New South Wales, and eastern Tasmania from June to August. As warm water spreads from the west Pacific and the Indian Ocean to the east Pacific, it causes extensive drought in the western Pacific. Singapore experienced the driest February in 2014 since records began in 1869, with only 6.3 mm of rain falling in the month and temperatures hitting as high as 35 °C on 26 February. The years 1968 and 2005 had the next driest Februaries, when 8.4 mm of rain fell.

Human activity can directly trigger exacerbating factors such as over farming, excessive irrigation, deforestation, and erosion adversely impact the ability of the land to capture and hold water. In arid climates, the main source of erosion is wind. Erosion can be the result of material movement by the wind. The wind can cause small particles to be lifted and therefore moved to another region (deflation). Suspended particles within the wind may impact on solid objects causing erosion by abrasion (ecological succession). Wind erosion generally occurs in areas with little or no vegetation, often in areas where there is insufficient rainfall to support vegetation. Loess is a homogeneous, typically no stratified, porous, friable, slightly coherent, often calcareous, fine-grained, silt, pale yellow or buff, windblown (Aeolian) sediment. It generally occurs as a widespread blanket deposit that covers areas of hundreds of square kilometres and tens of meters thick. Loess often stands in either steep or vertical faces. Loess tends to develop into highly rich soils. Under appropriate climatic conditions, areas with loess are among the most agriculturally productive in the world. Loess deposits are geologically unstable by nature, and will erode very readily. Therefore, windbreaks (such as big trees and bushes) are often planted by farmers to reduce the wind erosion of loess. Wind erosion is much more severe in arid areas and during times of drought. For example, in the Great Plains, it is estimated that soil loss due to wind erosion can be as much as 6100 times greater in drought years than in wet years.

Activities that contribute to global climate change are expected to induce droughts with significant agricultural impacts worldwide, particularly in developing nations. While global warming can lead to increased rainfall globally, it also brings about challenges such as droughts, floods, and erosion in different regions. Paradoxically, certain proposed solutions to global warming, like solar radiation management through space sunshades, may inadvertently raise the risk of drought. Lakes, rivers, and streams serve as primary sources of downstream surface waters in various regions, and during extremely hot seasons or due to human activities, these surface water flows may dwindle downstream, exacerbating drought conditions as water demand exceeds supply. Human activities, including greenhouse gas emissions, have contributed to rising global temperatures, leading to increased evaporation, evapotranspiration, wildfires, and prolonged dry spells. This exacerbates

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drought conditions, and some of the most severe droughts in sub-Saharan Africa have been linked to global warming and climate change.

2.3 Impacts of Drought

Impacts are commonly referred to as direct and indirect. Direct impacts include reduced crop, rangeland, and forest productivity, increased fire hazard, reduced water levels, increased livestock and wildlife mortality rates, and damage to wildlife and fish habitat. The consequences of these direct impacts illustrate indirect impacts. For example, a reduction in crop, rangeland, and forest productivity may result in reduced income for farmers and agribusiness, increased prices for food and timber, unemployment, reduced tax revenues because of reduced expenditures, foreclosures on bank loans to farmers and businesses, migration, and disaster relief programs the impacts of drought are related to how severe the drought is, and how long it lasts. If a drought is fairly mild, it may go unnoticed by the majority of people, even though the drought may have negative environmental impacts. Some drought impacts may be easily quantified, such as the decrease in water levels in reservoirs or lakes. Other impacts, such as the effect of drought on the stress levels of farmers, may be more difficult to quantify. Generally, the impacts of drought are negative. There are a few exceptions, though. For example, a long drought may result in increased awareness of water issues and more efficient water use.

2.3.1 Types of Drought Impacts

The types of drought impacts are categorized as environmental impacts of drought such as habitat damage, environmental degradation, and increased wildfires, social impacts of drought including public health threats, conflicts over resources, reduced quality of life, and loss of human life, as well as economic impacts of drought consisting of costs for drought relief programs, loss of revenues, reduced agricultural and industrial production, and higher costs for commodities.

2.3.2 Environmental Impacts of Drought

Drought directly impacts the environment, affecting water sources, land, fish, wildlife, and plant communities. It can lead to lower water levels in reservoirs, lakes, and ponds, as well as reduced river stream flow. This decrease in available water can also result in the shrinkage of wetlands, groundwater depletion, and potentially deteriorate water quality, with increased salt concentrations. Inadequate water supply can diminish soil's capacity to support crops, leading to increased dustiness, erosion, and a higher risk of wildfires due to dry conditions. The scarcity of water and reduced soil quality can have repercussions on fish, animals, and plant life. Wildlife habitat may deteriorate due to poor soil quality and insufficient water for plant growth, potentially leading to water shortages for animals. Additionally, endangered species may experience added stress, and there may be a loss of biodiversity in the affected areas.

2.3.3 Common consequences of environmental impacts

There are several common consequences of the environmental impacts of drought. Losses or destruction of fish and wildlife habitat occur, leading to a lack of food and drinking water for wild animals. This can increase disease in wild animals because of reduced food and water supplies, resulting in migration of wildlife. There is also increased stress on endangered species which can potentially cause extinction. In addition, lower water levels occur in reservoirs, lakes, and ponds due to drought. Loss of wetlands and more wildfires also commonly result. Wind and water erosion of soils transpires, worsening soil quality. Overall, drought substantially degrades habitats and

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ecosystems through interlinked environmental consequences across flora and fauna. Mitigation through sustainable water resource management and wildlife conservation practices is necessary to counter such wide-ranging impacts over the short and long term.

2.3.4 Social Impacts of Drought

Drought becomes most apparent when it impacts our daily lives. The social impacts of drought are usually indirect, that is, they are a consequence of direct impacts of drought, such as low water levels in drinking water reservoirs and increased dust. Drought can affect human health, result in conflicts and impact our quality of life. Drought may possibly affect physical and mental human health. Increased dust levels could be detrimental to people with respiratory problems, and wildfires caused from the dryness may become a public safety issue. Farmers and those whose livelihoods are directly connected to land and water may have high stress levels or experience anxiety or depression. Drought can also result in conflict. Demand for water will likely remain the same during a drought, but because of reduced supply, certain demands may not be met. For example, people may be asked to reduce their domestic water use, or to stop watering their lawns. Conflicts between water users may occur because some may feel that their needs are a lower priority. Drought might also impact quality of life. For instance, the aesthetics of a community may change. Small bodies of water may dry up and plants might die. Drought can also affect recreation and there may be less recreation opportunities (e.g. water sports might be limited).

2.3.5 Common consequences of social impacts

Drought can have numerous social consequences for affected populations. At the individual level, economic anxieties can lead to psychological issues such as increased rates of depression due to income losses among farming communities. Additionally, low water flows and poor water quality during droughts can directly contribute to heightened health problems for people reliant on affected water sources. Prolonged exposure to dust particles may also result in additional health issues. Ultimately, droughts can lead to loss of human life and pose a broader threat to public safety through more frequent wildfires in degraded forest and range areas.

At the community level, drought causes economic migration and displacement as many farmers are forced to move from affected rural areas to cities in search of alternative livelihoods due to reduced farm-based incomes. Drought-induced water scarcity also impacts incomes and jobs in supporting industries, exacerbating economic distress. The cumulative social costs underscore how droughts severely undermine the well-being, quality of life, and community cohesion of vulnerable groups, particularly in rural areas heavily reliant on climate-sensitive primary sectors like agriculture.

2.3.6 Economic Impacts of Drought

Drought can cost people, businesses and government’s money. These impacts may be local, and only affect those in the drought-stricken area, or they may be widespread and impact people living outside the drought affected area. Drought also has an adverse impact on different sectors, such as agriculture, energy production, tourism, and recreation. In the agricultural industry, dry conditions and lack of precipitation can damage or kill crops, negatively impacting farmers’ income. Crop loss also impacts consumers through increased food prices and the economic impacts of drought can be felt in other provinces and even countries. A lack of food and water, or increase in the price of food and water, can lead to ranchers selling or slaughtering more animals from their herd. An increase in animals slaughtered early in a drought year may cause an initial decrease in meat prices due to overabundance of meat. However, this is often followed by an increase in meat prices as a drought persists, as there are less animals and the price to feed and water the animals has increased. Drought can also hurt the recreation and tourism industry. Businesses, such as water sport rental shops, maybe financially impacted during a drought. Small businesses near a waterfront or in a vacation town that rely on a steady stream of tourists for business may also lose money. As climate variability increases in the future, the economic impacts of drought may be more prominent. Droughts can be expensive for consumers with increased food and energy prices, as well as cost the municipality, province and country where they occur. If a drought is severe enough, it may also have an impact on the overall GDP of a nation.

2.3.7 Common consequences of economic impacts include

Common consequences of economic impacts include farmers facing financial losses when their crops are destroyed by drought, while ranchers find themselves incurring higher expenses for feed and water for their livestock. Businesses closely tied to agriculture, such as tractor manufacturers and food producers, may experience reduced profitability due to drought-related damage to crops and livestock. Additionally, companies specializing in boat and fishing equipment sales might see a decline in sales as droughts lead to the drying up of lakes and water sources. Further, power companies relying on hydroelectric power may be compelled to allocate increased funds toward alternative fuel sources if droughts significantly diminish the water supply. Lastly, water companies may be required to invest in new or additional water supplies to address the challenges posed by drought conditions.

2.4 Effects of Drought on Tomato Production

2.4.1 Germination

Seed germination is very sensitive to environmental factors such as soil moisture, oxygen and light. According to Hsiao (1973), entire stages from seed germination to harvesting are very susceptible to drought stress in tomato. In seed germination of tomato water absorption is most important process, in which three phases occur. First phase is imbibition in which seed surface absorbs water, in second phase, hydration of cotyledons takes place, in third phase, radical emergence takes place followed by subsequent growth of seedling. Lower water potential reduces the water uptake and moisture content in first phase, increases the length of second phase and seed cannot enter in third phase (Bradford 1986). Low availability of soil moisture decreases seed germination and seedling growth (Gamze et al. 2005). According to Dodd and Donavan (1999), lower water potential during drought stress decreases germination percentage. Related research shows reduction or delay in germination of seed during low water availability at germination stage (Turk et al. 2004). In tomato seeds, most favorable germination is found at 50-57% of field capacity. Drought stress is also associated with increased salinity level which reduces seed germination in tomato. Foolad and Lin (1997) experimented with tomato seed germination and found reduction in seed germination due to the osmotic stress.

2.4.2 Water and mineral uptake

Solubilization and translocation of minerals are reduced in soil solution due to drought stress. According to Subramanian et al. (2006), nitrogen and phosphorous content decreases in root and shoot of tomato during water stress. Root nutrient uptake reduces due to less transpiration rate, stomatal closer and lower energy input (Baligar et al. 2001). Plant has many anatomical and physiological changes to reduce the effect of stress. Increase in root length and biomass are the good characteristics of drought tolerance. According to Wu and Cosgrove (2000), root: shoot ratio increases during water deficit condition. It facilitates increased capacity of plant to absorb more water and mineral. There are many changes in plant anatomy during drought stress such as lignifications, suberization and development of casparian bands (North and Nobel 2000, Aroca 2012).

2.4.3 Proline accumulation

Proline accumulation is a significant response of plant under drought stress. According to Shtereva et al. (2008), PEG induced drought stress increases endogenous proline concentration in tomato calli. According to Anjum et al. (2000), proline is a scavenger of OH^{-} radical and plays an important role in osmotic adjustment during oxidative stress. It reduces the damaging effect of ROS to the membrane lipid and protein, enzymes and DNA. Proline has an important role to sustain root growth under water stress condition. It accumulates in root growing zone and increases the activity of enzyme such as xyloglucan endotransglycosylase (XET) and the expansions which accelerate cell elongation by loosening of cell wall (Hartung et al. 1999).

2.4.4 Plant Growth and development

Drought stress is the combination of various types of stress so it shows very complex effect on plant growth and development process (Zlatev and Lidon, 2012). Due to drought stress, there is inhibition of cell division and enlargement leading to reduction in vegetative and reproductive growth. Leaf area and stem length get reduced due to decrease in cell size. Low level of soil water disturbs water relation in plant, which is directly related to uptake of water and mineral. It influences biochemical and metabolic changes in cellular organization, such as turgor pressure, membrane stability, reduction in cell size (Yordanov et al. 2003). Plant growth under stress condition depends on water availability, its use efficiency and the severity of stress level. Along with dehydration, influences of other related stress such as temperature, salt, oxidative stress and transpiration rate are also the main components which affect plant growth. Water use efficiency is affected by Leaf area ratio (LAR) and net assimilation rate (NAR), which are the main components of relative growth rate (RGR) (Van den Boogaard et al. 1997). Water loss by transpiration per unit time is also the main factor which influences water use efficiency and growth rate. Decreased leaf area ratio reduces the photosynthesizing area and finally growth rate. In the initial stages of water stress, root growth is accelerated. According to Hamblin et al. (1991) and Gorai et al. (2010), the relative biomass allocation to root system increases as compared to shoot. Reproductive stages in tomato such as flower and fruit setting are most sensitive to drought stress (Salter 1954). Water deficit condition decreases tomato growth cycle by accelerating different growth and development stages. According to Desclaux and Roumet (1996), plant developmental phase is stimulated to turn from vegetative to reproductive phase by the indication of drought stress.

2.4.5 Genetic responses

During drought stress several genes are activated in plants, leading to physiological and metabolic changes against the stress condition. According to Zhu et al. (1997), many plant genes and physiological mechanisms are concerned with response to water stress in plant system. Plant has specific quality to reduce the effect of drought stress by adaptation and escaping mechanism. Many scientists have observed that drought tolerance is complex mechanism in which several genes are involved; it is a polygenic trait. Stress induced genes regulate synthesis of plant hormone (ABA, ethelene), amino acids (proline) and accumulation of different types of protein (LEA, HSPs), osmolytes (mannitol, sorbitol, quercitol, pinitol, proline, glycine betaine, etc.) (Cushman and Bohnert, 2000). Drought induced genes are regulated by a specific signal transduction pathway which activates transcription factors. Activated genes during drought stress are involved in protection with creation of efficient antioxidant system by synthesis of enzyme i.e. superoxide dismutase, catalase, ascorbate reductase, glutathione reductase, etc. Drought stress alters gene expression and, therefore, the production of new proteins i.e., late embryogenesis abundant (LEA) and mRNAs. LEA proteins are strongly hydrophilic in nature and have a specific quality to retain water in tissue during water stress. These proteins also protect cell membrane.

2.4.6 Osmotic Adjustment

According to Boyer et al. (2008), plant accumulates osmotically active solutes inside the cell during drought stress which causes reduction in cell water potential. Plants maintain water absorption and cellular turgor pressure during water stress by osmotic adjustment. According to Cattivelli et al. (2008), this process keeps up higher photosynthetic rate and increased growth during water scarcity. An experiment done by Nahar et al. (2011) with five tomato genotypes to evaluate osmotic adjustment and fruit quality under drought stress showed that concentration of proline, glucose, fructose, sucrose, malic acid, ascorbic acid and citric acid increased significantly. Compatible solutes such as fructose, sucrose, glucose, glycerol, mannitol, sorbitol, quercitol, pinitol, proline and glycine betaine are synthesized and accumulated by plants and these organic solutes play an important role in osmotic adjustment. Proline reduces proteolytic damage of folded protein organization by reducing the denaturation and increases cell membrane stability. Acording to Claussen (2005), proline has a specific role in osmotic adjustment and scavenging of hydroxyl radical during stress environment. These intracellular solutes maintain turgor pressure and decrease water potential as compared to surrounding environment thereby increasing water uptake.

2.4.7 Senescence

The senescence program is expedited by both biotic and abiotic stressors. The presence of reactive oxygen species (ROS) triggers oxidative breakdown in lipids, proteins, and DNA, leading to the acceleration of ageing and a decrease in the lifespan of plants. Water stress in tomatoes enhances the development of proteases, which promote senescence by breaking down proteins into amino acids. Zhu (2001) found that drought stress leads to a decrease in protein content in plants due to the detrimental impact of reactive oxygen species (ROS) on amino acids. During periods of drought stress in tomato plants, the synthesis of growth retardants such as abscisic acid (ABA) and ethylene increases. This increase in growth retardants leads to senescence, abscission, and programmed cell death in response to both biotic and abiotic stress.

2.4.8 Photosynthesis

Water is the important component in cellular structure and has very significant role in all metabolic processes. Photosynthesis, pigments and plastids are affected by less water condition; it damages cell membrane structure (Levitt 1980). Drought stress causes reduction in photosynthetic process; it leads to deterioration of thylakoid membranes and substantial damage to photosynthetic pigments (Huseynova et al. 2009, Anjum et al. 2011). Chlorophyll content also decreases under drought stress, it may be because of reduction in activity of the enzymes involved in chlorophyll synthesis (Ashraf and Karim 1991), or may be due to increase in chlorophyll break down (Kaewsuksaeng, 2011). Drought stress leads to dehydration of mesophyll cell and reduction in water use

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2.4.9 Dry matter production

Water availability is the key factor for dry matter production in plant. Low water availability decreases water and nutrient uptake, photosynthetic rate and translocation of photo assimilates. An experiment done by Nahar et al. (2011) with four tomato genotype showed reduction in dry matter production under water deficit condition, similar to those reported by Aragon (1988).

2.4.10 Lycopene content

Lycopene is a key quality parameter in tomato which plays an important role in biosynthesis of carotenoids. It is responsible for red color in tomato fruit and processing product. Lycopene acts as an antioxidant. It has a specific role in defense mechanism against environmental stress by scavenging peroxyl radicals and quenching singlet oxygen. An experiment done by Giannakoulaet al. (2013) estimated quality parameter in tomato genotypes under drought stress condition and there was a significant increase in lycopene content during water and salinity stress.

2.4.11 Yield

Drought stress is a serious environmental stress which affects agriculture productivity and yield. It is an important factor, which harms more than 50% of crop yield worldwide (Bray et al. 2000; Wang et al. 2003). According to Kramer (1969), drought stress affects physiological process of plant at different stages and reduces the quality and quantity of yield. Uptake of mineral nutrition also reduces under low soil water condition i.e., nitrogen, sodium, sulphur, potassium, magnesium and calcium (Nahar and Gretzmacher, 2002). According to Giardini et al. (1988), under low water condition, tomato plant has reduced yield and fruit size. Many scientific studies have revealed that low water availability decreases number of leaves, branches, flowers and fruits in tomato cultivars. Fruit quality, shape, diameter and weight decreases under drought stress as compared to the normal condition. Experimental studies show significant reduction in number of seeds per tomato fruit under water stress condition. According to Simiciklas et al. (1989) drought stress during seed formation or seed filling reduces seedling vigour and germination in next generation.

2.5 Conceptual Framework

Figure 1 shows the conceptual framework.

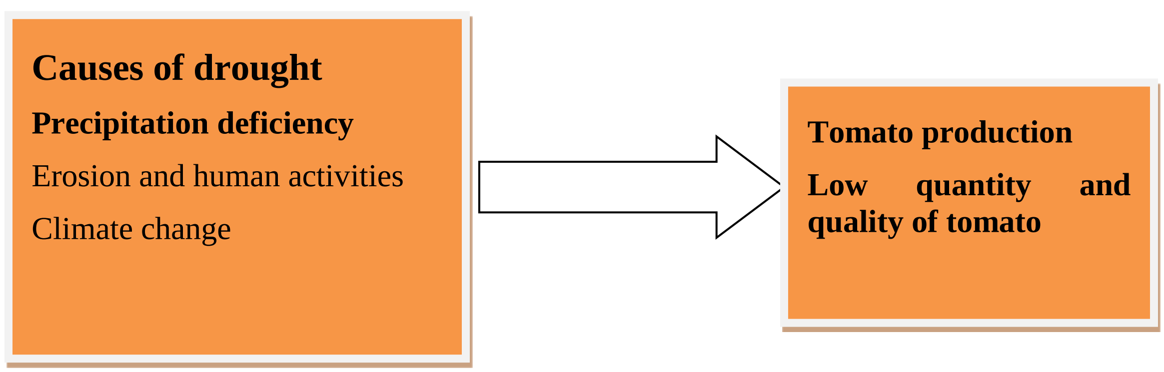

Figure 1: Conceptual Framework

3.0 Research Methodology

This study followed a descriptive research design that is cross-sectional and quantitative in nature. The target population was 52 people, comprising farmers in the BALCAD district. The sample consisted of 46 participants selected from farmers in BALCAD using purposive sampling to choose respondents believed to have information concerning this study. The questionnaire for the study was developed by the researchers and pilot tested before final data collection in order to establish reliability and validity. Data were collected from the study area through this questionnaire and then analyzed using SPSS statistical computer software.

4.0 Findings and Discussion

For the first objective, the study looked at how drought affects tomato production. It found that most respondents agreed or strongly agreed, indicating that drought is caused by a lack of precipitation, climate change, and human activities like overgrazing and deforestation. These factors also negatively affect farmers and ranchers. The drying up of surface water, such as lakes and rivers, comes next, causing disputes between water users and waterborne illnesses like malaria and cholera in areas close to riverbanks.

Researchers observed that most respondents agreed or strongly agreed that agricultural labourers lose their jobs when drought affects their region when it comes to the second objective, which was the constraints of drought on tomato farmers. Reduced crop productivity as a result of insufficient and uneven rainfall is the most obvious effect of drought. Inadequate precipitation results in stunted pasture development and can also lower crop residue feed supply. Due to the ensuing decreases in agricultural output, farm labourers experience unemployment during dry spells. After that, they leave their fields to live in camps as refugees and stop receiving assistance when needed.

The third objective was to identify potential ways to control tomato production during a drought. Researchers discovered that the majority of respondents highly agreed or agreed that the first step in ending drought is providing early warning systems to populations that are vulnerable to drought, like farmers, rangeland managers, and other people that depend on these industries. Early warning helps farmers plant drought-tolerant crops in drought-prone seasons, create water catchments, capture water during droughts, and even store seeds for the next season's seeding as well as grains for consumption. In order to help farmers, reduce drought, local governments must also provide drought-resistant seed varieties, build water-harvesting dams and reservoirs, and provide farmers and pastoralists with timely weather forecast information that enables them to anticipate potential droughts and devise mitigation strategies. The government provides early response, money, and technical assistance to farmers.

6.0 Conclusion of the Study

The study concludes that in the Middle Shabelle region of Somalia, specifically in BALCAD, drought significantly negatively affects tomato production and farmers. It identifies key causes of drought as precipitation deficiency, climate change, deforestation, and human activities like overgrazing, leading to surface water depletion, conflicts over water use, and disease outbreaks. Drought imposes severe constraints on tomato farmers through crop failures and yield reductions due to inadequate rainfall, resulting in the loss of on-farm employment and income for agricultural laborers. Many farmers and workers are forced to migrate from drought-affected farms to urban areas or refugee camps. Urgent measures required include early drought warning systems and improved water management through dams and reservoirs to enhance preparedness among vulnerable farming communities. Recommendations also include the distribution of climate-resilient seeds, better access to weather advisories, and government support for drought relief, based on the study's findings.

7.0 Recommendations

The study recommends establishing robust early warning systems by local governments for timely forecasts of droughts to facilitate advanced preparation by vulnerable agricultural communities as well as promoting various water harvesting techniques like building small check dams, ponds and trenches to store water for irrigation purposes during dry periods while also distributing drought resilient tomato seed varieties that can withstand moisture stress through agriculture departments along with constructing critical irrigation infrastructure projects involving community borewells, sprinklers and canal systems to combat water scarcity in drought prone areas as well as creating mass farmer awareness programs by extension services regarding sustainable farming practices like mulching, zero tilling and crop diversification that can significantly reduce drought vulnerability over the long run in addition to providing vital alternative livelihood skills training to drought hit tomato farmers to enable income generation during harsh weather events compounded by increasing budgetary allocations towards drought relief measures by concerned authorities in order to deliver emergency assistance and subsidized inputs to distressed farmers based on the recommendations outlined in this study for strengthening the climate resilience and food security of tomato producers in BALCAD.

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