**CLIMATE CHANGE IMPACT AND VULNERABILITY OF ETHIOPIAN LIVESTOCK SECTOR: A REVIEW**

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**ABSTRACT**

*The most prominent climatic shocks are floods and recurrent drought, which affects crop and livestock productivity. These climatic shocks are the main causes of livestock loss, damage feed resources, crippling farm animal’s genetic potential and, also it severely affects the very foundation of ecosystem provisioning and support services. The scarcity of water is the main distinctive feature of drought-prone areas, hence, population migrates from drier environments to where water and its benefit (feed resources) are more prevalent. There are selective plant species from both C3 and C4 grasses that are adapted to drought condition. Adaptive capacity of forage species may increase their tolerance to withstand the changing climatic condition. There has been reported that a great milk production potential of some individual camel in different parts of the world, which shows that, there is a great genetic potential to increase camel milk productivity. The average surface temperature of Ethiopia is about 23℃ with minimum 6℃ during the coldest periods, while mean maximum rarely exceeds 26℃. In Lowland areas, the temperature variation is much greater, and the heat in the desert areas is extreme, occasionally as high as 60℃. Global warming may also influence livestock health through increasing disease causative vectors and survival of pathogens. Even it forms a condition of new disease emergence by creating favorable incubation temperature. As a result of climate change and global warming, camel became the hope of the future for food security in dryland and drought-prone areas. Thus, livestock scientific group and nutritionists should turn back to improve camel, milk production, health management and heat shock protein families to improve livelihoods of dryland and drought-prone community.*

**Key words:** *Climate change; drought; floods; climate shocks; camel*

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# **INTRODUCTION**

Climate is a dynamic state of the earth’s system. Vis-à-vis, climate change is not a new scenario of the current era. Starting from the creation of the earth, the climate has seen changing, there has been a succession of cold with warmer periods in the last million years. Thus, climate change is a natural condition, it has been changed in the past, changing at the current time and will change even in the future. However, the main headache of the current scientific and political group is a rapidly changing condition of the current climatic system than ever before. Past climate change is due to natural causes and changing rate is very slow while current climate change is mainly as a result of anthropogenic forcing and rapid changing rate (Houghton, 2009; El-Ramady *et al.,* 2012). Global warming became visualized since the industrial period of the last 150 years, ultimately over the last 60 years. That global warming has exacerbated changes to other earth’s climatic system. As a result of global warming, there has been changed in nature of atmosphere (increased average atmospheric temperature), Hydrosphere (sea level and ocean temperature rise), cryosphere (Ice sheet melts), lithosphere (ground surface and soil nature change) and biosphere (species composition change, species extinction and deforestation) are some of the consistent evidences of global warming (USGCRP, 2017; IPCC, 2014; El-Ramady *et al.,* 2012; UNFCCC, 1992).

Greenhouse gas emission from industry, energy and agricultural sectors are significantly increasing, which lead to increased toxic and heat-trapping gaseous composition in earth's atmosphere. Due to anthropogenic effects, emission of greenhouse gases is substantial since pre-industrial period. It is because of the most recent growth in technology, increased human population, extensive deforestation, changes in land use and land management practices, an appearance of these climate change forcing are now higher than ever. This led to increased carbon dioxide, methane and nitrous oxide concentration in the atmosphere. Those gases have been detected as likely dominant greenhouse gases that the reason for long-term global warming (IPCC, 2014; Pathak *et al.,* 2012; Gardiner, 2010).

Increasing magnitude and intensity of extreme weather events are already visible across all around the globe. Destructive climatic shocks like typhoons, hurricanes, droughts, and floods are affecting assets and millions of lives, holdback nation's economic growth and aggravating poverty in mainly low-income populations. Least developed countries are the most vulnerable groups, as they incapable to prepare and respond to these acute and chronic climatic shocks due to lack of resource and technological supports (UNFCCC, 2014). Impacts of climate change are more seen in the form of recurrent drought and erratic rainfall in arid and semi-arid regions of tropical areas. As a result of global warming, there would be increases in mean surface temperature and rainfall patterns, which intern affects agricultural productivity. In addition, intensity and frequency of extreme weather events adding destruction of the agricultural system of the planet on top of chronic climate change impacts. In addition to its contribution to food insecurity, climate change disrupts ecosystem support services, such as soil degradation and water scarcity (OECD, 2015). Most African populations depend on agriculture for their livelihoods and income, and it is the backbone of national economies for almost all countries in Africa. The sector employs 70-90% of the total labor forces across the continent. In Africa agricultural sector supports about 50% of feed demands and 50% of the income of the households. Among the agricultural sub-sectors, livestock rearing such as dairy, chicken, sheep, goat, beef, and camels provide substantial income and foods for the producers. Livestock would be the only asset of the poor in most pastoral and agro-pastoral communities. However, the sector is highly susceptible to extreme climatic events (Getachew, 2016). Climate extremes are having a significant impact on livestock productivity in East and West Africa. Increasing frequency and intensity of droughts are threatening the already vulnerable drought-prone areas livelihoods, and the existence of arid and semi-arid remote regions (IRDR, 2015). Climate change is exacerbating the challenges faced by the agricultural sector (OECD, 2015). Similarly, UNFCCC (2007) reported that climate change is threatening the productivity of agricultural land, with shortening growing periods and decreasing crop/pasture yields.

Ethiopia is suffering from the impacts of climate change such as an increase in average surface temperature, changes in rainfall patterns, recurrent drought, El Niño southern oscillation (ENSO), floods and La Nina. These effects are not equally distributed throughout the country by similar climatic disasters, but the effects are time-dependent and location specific, for example, one region of the country would be affecting by drought and the La Nina would be suffering the other location at the same time, and heavy rainfall and recurrent drought may suffer the same location at different time. In order to cope-up and adapt to the changing climatic condition, the country necessarily needs to switch to a new sustainable development strategy (OECD, 2015; FDRE, 2011). Agriculture is a backbone of the Ethiopian economy. Of the general farmer's livelihood activities, livestock production is an integral part of agricultural activity throughout the country. Climate change is affecting livestock productivity by altering ecosystem services like water availability, soil degradation, forage quality and quantity (Workneh, 2016). In the same way, Muleta (2016) concluded that climate change alters directly or indirectly livestock production and animal genetic resources in various aspects, such as influence in feed resources, water supply, diseases outbreak and animals stress due to heat shock. Increased surface temperature influences quality of forage production by lignification of plant tissue, which leads to poor feed utilization by altering digestibility and degradation rate. Climate change also impacting livestock species too, as a result, diminished livestock species diversities were observed in response to climate change. Producers left with a certain species whose cope up and adapt to the changing climatic condition and recurrent disasters (Zelalem *et al.*, 2016).

Keeping livestock is the main livelihoods for near to 15 million people in Ethiopia (Virtanen *et al.,* 2011). In southern (Borana, Kereyou and South Omo), Eastern (Afar and Somali) and western (some parts of Gambella) parts of Ethiopia primarily depend on pastoral and agro-pastoral production systems for their income and foods. Pastoralist depends on livestock production for almost all of their livelihoods sources, no crop production at all. However, agro-pastoralist cultivates crops to certain extents, but their livelihoods still largely depend on livestock keeping (Tegegne *et al.,* 2013). In pastoral systems, species diversities have various production qualities and functions. Among pastoral livestock species, camels are a complete multipurpose farm animal, it provides milk, meat and draft power attributes, and also its social prestige is remarkable among the pastoral societies along with cattle. Goat and cattle also provide meat and milk, above all goat rapidly recovered from drought than cattle. Thus, camel and goat are the preferred livestock species in arid, semi-arid and drought-prone areas (Sanfo *et al*., 2015). Large populations of pastoral livestock species are highly threatening by climatic disasters and inhospitable production environment. The livelihoods of pastoralists basically build on livestock asset, which is a disposable income source for households, that's why pastoralists are considered as the poorest of poor. Development and poverty rates are worse among the pastoralist than non-pastoralists in Ethiopia (Virtanen *et al.,* 2011). Climate change increases environmental inhospitality and livestock vulnerability to changing condition, and also exacerbate the existing livestock production bottlenecks (Getachew, 2016). This review was made to point out the major impacts and vulnerability of livestock to extreme events that imbedded the productivity of livestock and developed adaption mechanism to climate shock.

## **Animal Production in the Face of Climate Shocks**

### Drought impacts and Animal production

In times of drought, lack of water can often cause a decline in crop and animal yields, and thus, farmer’s loss their regular income. According to the report of Briney (2017), Plant and animal species can suffer tremendously due to long-term droughts and overtime desertification can happen with an extreme lack of moisture. UNCEIF (2015) identified, approximately 655,000 droughts affected pastoral community members in Ethiopian Somali and Afar regions. Further drought is associated with a substantial decline in livestock population due to increased mortality and forced off-take (Workneh, 2016). Similarly, Zelalem *et al.* (2016) decline in the number of livestock species namely cattle, goats, sheep and donkey kept by pastoralists was remarkable due to climate change. Most of the animals were reported to have died during severe droughts, which occurred in 2005 and 2008. In addition, it was revealed that both daily and lactation cattle milk yields were declined steadily and dramatically, the reduction was estimated at about 89% between 1981/82 and 2009. The impact of the 2017 Indian Ocean Dipole-induced drought, exacerbated by poor/failed rains in the southern drought belt, which is likely to lead to a sharper deterioration in livestock body conditions, and impacting milk production and nutrition status of the families that depend on livestock for their food and income (OCHA, 2017).

### Drought subjects livestock not only to the scarcity of water and poor pasture but also to high air temperature and strong solar radiation. Animals must, therefore, deal with an increased heat load at the same time as their supply of water shrinks (Kay, 1997). Cattle, goat, and camels are the most important livestock species in drier parts of Africa. Sab-Saharan livestock producers remain jammed by several effects of recurrent drought economically and biologically, which deplete available livestock feed resources and reduced water supply for plants and animals. The scarcity of water is the main distinctive feature of drought-prone areas, hence, population migrates from drier environments to where water and its benefit (feed resources) are more prevalent (Briney, 2017). In 2018 more than 2 million cattle are at risk and in need for feed aids in Bale and Guji zones of Oromia regional state in Ethiopia, due to constitute of recurrent drought in the last successive three years (Oromia Disaster Risk Management Commission, 2018). The World Bank Group (2015) was reported that the decreasing rate of affected people due to drought from year to year in Ethiopia. There was more than 12.6 million in 2000, 6.2 million in 2003 and 3.2 million in 2005 peoples were affected. This report showed that decreasing trends of affected people due to recurrent drought. However, it is not mean that recurrent drought incidence is decreasing. Simply it is due to significant impacts of disaster management efforts of the national and international organization.

### Flooding shock and Animal Loss

Global warming enhances evaporation rate of water from the surface and water bodies, which lead to greater concentration of water vapor in the lower atmosphere. Increased water vapor concentration in the atmosphere capable of absorbing longwave radiation and strengthen the greenhouse effects through re-emitting it downward to the surface of the earth, which furtherly, raises surface temperature, cause more atmospheric water vapor and extreme rainfall (Hansen et al, 1997; Houghton, 1995; Haigh, 2002). The intensity and frequency of climatic extreme events, like floods and drought are more prevalent in lowland regions. Several studies reported that climatic shock related drought incidence, intensities, and frequency in many parts of sub-Saharan Africa in general and in various regions, particularly in Ethiopia. However, the intensity and frequency of floods missing from several scientific investigations, while floods cause severe and increasing risk to dwellers in the river basin and lowland areas. Floods are expected from year to year in some areas, particularly in the vicinity of large rivers in Afar and Somali regions (UNCEIF, 2015; Alemseged *et al.,* 2013).

Flooding can be dangerous for livestock keepers, who’re their livelihood are mostly affected as a result of this shock. Flooding is the most common and costly damage the physical asset including livestock in most areas of under flood risk. Especially for livestock keepers it damage live animals and livestock feed, additionally it also crippling farm animals genetic potential (UCDAVIS and WIFSS, 2015). Floods were mainly caused by heavy rainfall in and upstream areas. Cultivated crops and cattle were severely damaged due to extreme floods in Gambella, Ethiopia in 2007. It was reported that about 77.3% cultivated crops were severely damaged and 73.2% of live cattle were lost at that moment (Alemseged *et al.,* 2013 & FDRE, 2016). In the year of 2016 in Ethiopia, the incidence of the flood was affected low elevated areas of Amhara, Somali, Afar, and Oromia as a result of natural drainage systems of heavy rain in the highland mountain to the lowland plains (FDRE, 2016 & WFP, 2006). The main livelihood of the peoples in these flood-prone areas depends on their livestock and have characteristics of the pastoral production system.



Figure 2. Map of flood-prone areas (Source FDRE, 2016)

In the year of 2006 more than 70 thousand in Diredawa, 34 thousand in Amhara and 8 thousand in south Omo peoples have been affected due to intense and extensive flooding occurred and have been damaged lives and assets in different parts of Ethiopia. As a result, more than 2700 head of cattle and an unconfirmed number of small ruminant (Maybe 3 to 5 thousand) have been died (WFP, 2006; IFRC, 2006). Similarly, in the year of 2016, there was the incidence of flooding in different parts of the country and near to half million peoples have been affected in different ways, they lost their crops and livestock (Salem, 2016; FAO, 2016). According to FAO (2016) about 80% of small ruminants, 40% of cattle and over 55, 000 hectares of the main pastureland have been lost in the lowland regions of Ethiopia, due to flash flooding accompanied by heavy rainfall in the upper plain areas. Flood hazard assessment and mapping areas of Awash River basin in Ethiopia illustrates that the arid and semi-arid areas of Afar region fall within high to very high flood hazard zone (Yitea and Gebre, 2015). Which affects pastoral and agro-pastoral communities who survive in this geographical location and their livestock population is at risk. Loss of livestock is a disaster for the predominant pastoralists since livestock is their main source of livelihoods. Furthermore, whenever the livestock have been survived in the face of such climatic shocks, low animal body condition is another challenge for the owners because it diminishes terms of livestock trade.

## **Impacts of climate change on livestock Feed production**

Lowland areas are most affected by climate change shocks interchangeably, like floods and recurrent drought. Drought affected pastoralist may within the recovery process as a result of the last shock, but then again they face another shock like floods. These both shocks affect quality and quantity of available livestock feeds resources (FAO, 2016; Denbela and Guyo, 2017).

Rapid environmental change is occurring due to combined effects of climate change. For most plants, these changes are so rapid and they become powerless to respond with the extant genetic diversity. However, some species extant genetic diversity may develop adaptive capacity in response to such rapidly changing condition (Donald and Elizabeth, 2012). Thus, those plant species with poor genetic diversity are being affected by rapid environmental changes. Raising atmospheric carbon dioxide concentration may be positive effects on plant growth due to CO2 fertilization effects (Midgley, 2017; Forster *et al*, 2007). Higher atmospheric CO2 concentration has been positively stimulated photosynthetic carbon uptake rates in many plants. As elevated CO2 concentration improve forage and grassland aboveground biomass, root biomass and depth, leafing rate significantly increased yields (reviewed in Gray and Brady, 2016; Rust and Rust, 2013). However, since CO2 is a major greenhouse gas, its concentration increment lead to further near-surface warming, which intern increase evapotranspiration from plants and hinder plant productivity. Nevertheless, most plants are developing a wide variety of physiological changes in responding to climate and environmental change by less opening of stomatal aperture under higher CO2 Concentration, which minimize the flux of moisture from plants to atmosphere through transpiration (Forster *et al*, 2007). In general, higher plants physiologically well resistant to increased near-surface atmospheric temperature.

Drought plague regions are experiencing water stress as a result of climate change. The typical characteristics of drought are water stress, resulting in substantial effects on plant growth and productivity since water availability is the most governing factor affecting plant growth and development (Kurade, 2017; Gray and Brady, 2016; Valtorta, 2002). This trend deteriorates livestock forage and pasture availability, and quality (Rust and Rust, 2013). Pasture may be less productive under drier and hotter atmospheric condition since its high productivity is recorded in moistening and cooler condition. Thus, it is advised to shift to drought-resistant forage species and verities to overcome water stress challenges in drought-prone areas (Kurade, 2017). Livestock feed resources like forage and rangeland productivity are directly affected by drought. Above all prolonged drought as a result of climate change partakes remarkable impacts on quality of feed resources and lead to change habitat species composition, and modify the species of livestock that feed on them (Rust and Rust, 2013).

Photosynthesis is the process by which plants produce sugar through CO2 and H2O bonding in the presence of sunlight (Whitmarsh and Govindjee, 1995; Asimov, 1968). As solar radiation is the primary source of energy for the system of the earth, plants are the ultimate source of food and feed for the earth’s life. Based on their adaptation and carbon assimilation mechanism, plants could be classified into C3, C4, and CAM. C3 plants are well adapted under moist and cold environmental condition while C4 and CAM plants are a good producer under hot and drier condition (Lara and Andreo, 2011; Gregory, 1977). In tropical regions, the effects of global warming are more visible in the form of recurrent drought. In drought and water stress condition the productivity and survivability of C3 plant capacity are very less and they forced to replaced by plants which are able to produce under the warming condition. Thus, the area is left with C4 and CAM plants. Such plants are the plant species which preferred for livestock feed under the categories of grasses.

In C3 photosynthesis CO2 fixed into organic compound essentially in the mesophyll cells. Basically, the plant takes CO2 through the open leaf structure called stomata. Rubisco originates in the stomata of C3 plant species and stomata kept open to fix CO2 and O2 depending up on CO2 and the O2 ratio of atmospheric condition. Rubisco can fix CO2 or O2. In the primary step, Rubisco combines CO2 with 5 carbon molecules (ribulose bisphosphate) to form two carbon three molecules (phosphoglycerate). At lower atmospheric CO2 concentration (CO2: O2 ratio) Rubisco forced to uptake atmospheric O2 as a substrate and forms phosphoglycolate instead of phosphoglycerate and vice-versa (**Vogan, and Sage**, 2011; Lara and Andreo, 2011; Ehleringer and Cerling, 2002; Gregory, 1977). Vis-à-vis atmospheric CO2 concentration is low, a fixation of atmospheric O2 and release of CO2 to atmosphere became more pronounced through photorespiration process. Under such environmental condition, C3 plant stomata remain open to uptake CO2 or O2 from the atmosphere, which increases photorespiration and exacerbate water stresses in drought condition. Because of its special carbon fixation mechanism, C4 plants safely survive under dry and warm condition. C4 plants fix four carbon molecule in the form of CO2 and concentrate it around Rubisco so that Rubisco has no chance to react with oxygen. C4 plants also keep their stomata less openly, they open their stomata narrowly, uptake CO2 very quickly and close then after. Thus, this adaptive mechanism helps to improve water utilization efficiency under drought and water stress condition. Unlike C3, C4 plants have an alternate carbon-fixing enzyme called phosphoenolpyruvate (PEP) carboxylase. This enzyme has a high affinity for CO2 and has no oxygenizing activity(**Sage** *et al*, 2011; **Vogan, and Sage**, 2011; Lara and Andreo, 2011; **von Caemmerer and Furbank**, 2003; **Bolton and Brown**, 1980).

Cooler and moist is more suitable for most of pasture and grasses. In this regard productivity of livestock feed have been affected by warming and water stress condition. However, C4 plant species are more productive under high temperature, low moisture and high light intensity condition (Rust and Rust, 2013; Warne *et al*, 2010). C4 plant species are more desirable under global warming effects in tropical and subtropical regions (Barker and Caradus, 2001). However, the higher vegetative productivity of C4 plants under such harsh conditions are at the expense of livestock feed quality and quantity too (EPA, 2017; Valtorta, 2002). Due to water stress and higher temperature C4 forage species like tall fescue, kangaroo grass, Lucerne, red grass, chicory and wire grass constituents lower N and crude protein concentrations than C3 forage species. Vis-à-vis, the digestibility of cellulose, hemicellulose, and lignin are poorly utilized by livestock digestive system, which makes C4 forage species lower in quality than C3 forage plants (Sejian *et al.*, 2016; Kashun, 2016; Nkondze, 2013; DaMatta *et al*, 2009; Barker and Caradus, 2001). Taylor *et al* (2010) exposed selected species of C3 and C4 grasses to the drought condition to identify their adaptive capacity. Thus, the finding revealed that there are selective species from both C3 and C4 grasses are adapted to drought condition. The result clearly tells us C4 plants are not arbitrarily adapted to drought condition and C3 species are not generally unable to grow under water stress condition. Adaptive capacity of forage species may increase their tolerance to withstand the changing condition like surface warming and recurrent drought (Barker and Caradus, 2001).

The natural habitat of the camel is basically arid and semi-arid areas where high ambient temperature and scarcity of water is more evident. The plant grew in these areas undergone various adaptation mechanism to withstand such harsh environmental condition (Donald and Elizabeth, 2012). Reduction in leaf size, replacements of the leaf with thrones to reduce surface evaporation, and sparse distribution of plants to minimize soil water competition are some of the plant's adaptation mechanism under drought condition. Slightly lengthier and sparse distributions of pasture species (shrub/bushes) in lowland (arid desert) areas are more prominent (UNDP, 2007; Alemayehu, 1987). Camels are considered as habitat responsible animals because of they take few bites from a given shrub/Bushes and move on, thus they are not destroying their feed resource by chewing to the root like goat particularly (Muli *et al*, 2008).

## **Climate Change Effects on Milk Production and Composition in Camel**

Vulnerability of livestock to global warming and recurrent drought varies from species to species based on their adaptive mechanism (Getachew, 2016). Of the pastoral livestock species, cattle and sheep are the most vulnerable species in drier and hot environmental condition. It was reported that cattle and sheep death is the most prominent during 2011 drought period in Borana zone while the death of goat is eventually low and loss of camel is not recorded at all in the year (Galma *et al*, 2017). Loss of animals are not only attached to drought but also due to cumulative impacts of global warming like lack of rainfall, high temperature and lack of drinking water. Which lead to the altered growth potential of plants, deterioration of livestock feed resources and altered physiological response of an animal to high temperature. Under higher temperature and poor feed resources productivity of grazing livestock species (cattle and Sheep) are dramatically declined, whereas, browser species (Goat and Camels) are less affected. This is due to the fact that deterioration leads to poor grassland serving capacity and the areas left with browse feed resources (Getachew, 2016; Zelalem *et al*, 2009). Even though the productivity of most livestock species are affected by global warming and drought, milk productivity of camel remains increased with long lactation period under such harsh environmental condition than any other dairy animals in the same area (Sisay *et al,* 2015; Eisa and Mustafa, 2011).

Camel herder has bright future in the face of climate change because they increase their milk yield under increased aridity and water stress condition. For camel producers, camel milk is not the only source of food but also provide their main income (Odongo, 2016; Muli *et al*, 2008). Camels are the most milk productive animal than any other milk producing livestock species in an inhospitable production environment and thus, they are the fittest livestock species for semi-arid and arid desert areas (Fayed, 2001). As a result, a camel can produce a larger volume of milk than other milk producing farm animals, more than four times milk per day than that of cattle and much more than goat under similar lactation and environmental condition. In general as aridity increases, daily milk yield of the camel is increased simultaneously. Unlike other livestock species, water contents of camels milk become increased when water deficit face to the animal (Sisay and Awoke, 2015; Richard and Gerard, 1985). Above all, average lactation periods of dairy camels range from 12 to 18 months under the harsh environmental condition, whereas, it is limited to 6 to 9 months under a favorable condition in dairy cattle (Simenew *et al*, 2013; Gerard, 1985).

There is a great potential in increasing camel milk yield through successive selection and proper breeding programs. It was reported that some individual camel can produce up to 40 liters/ day, Pakistani and Afghanistan camel can produce up to 30 liters/day and Maghrebi she-camels can produce up to 25.5 liters/day under intensive management (Abdalla *et al,* 2015; Gauthier-Pilters & Dagg, 1981). Therefore, there is a great genetic potential to produce high yielding specialized camel milk breeds. In this regard, camel is the hope the future of food security under longer drought condition in dryland areas. To meet protein requirement of increasing human population, a camel can be the potential source of animal protein and owner livelihood in arid and hostile environmental condition (Yagil *et al*, 1994). However, the genetic potential with great hardiness who withstand drought condition and produce some amounts of milk is needed under some circumstances.

## **Climate Change and Camel Diseases**

One of the impacts of global warming is recurrent drought so that increased rate of livestock disease prevalence was common during the periods (Galma *et al*, 2017; Zelalem *et al*, 2009). As a result of climate change, dormant disease-causing vectors have activated and even new diseases may emerge and will continue to spread (Simenew, 2016). The prevalence and abundance of endemic parasites especially helminths are increased as a result of global warming through altering free-living larval stage on grazing and browse pasture and drinking water, which directly lead to high risk of disease outbreak and impacts livestock health (Van Dijk *et al*, 2010; Fassi-Fehri, 1987).

Global warming may also influence livestock health through increasing disease causative vectors and survival of pathogens (Nejash and Kula, 2016). Even it forms a condition of new disease emergence by creating favorable incubation temperature. Lack of suitable feeds may also increase the susceptibility of animals to disease. Almost all diseases causative agents and reservoirs have different temperature and moisture related vital rates to survive, develop pathogenicity and widespread in the environment. Though, global warming provide them a conducive environment to survive and abandoned, which increases vulnerability of animal to diseases as a result of increased pathogenicity and distributions of livestock diseases causative agents in dryland areas (EPA, 2017; Zelalem *et al.*, 2016; Kasahun, 2016; Lubroth, 2013; Morand *et al,* 2013; van Dijk, 2009).

Alternating temperature, drought, rainfall and soil moisture all affect successful activation outbreak of a given livestock disease. Some disease-causing agents are more active and able to cause disease at a higher temperature while some other became well established under cold condition (UNICEF, 2015). Anthrax is the infectious disease of all homoeothermic animals including human beings. This disease-causing agent is associated with the effects of global warming like increased surface temperature, relative humidity, and soil moisture. Thus the outbreak of disease and successful activation of anthrax spores has linked to high temperature and heavy rainfall. Anthrax spore activated in a temperature range of 25 to 60℃ (Turnbull *et al*, 2007; Davies, 1960). High temperature following heavy rainfall exacerbates Anthrax outbreak. The other disease increased as a result of global warming is camelpox. Camelpox is a viral disease and it is a host-specific disease. It does not affect other livestock species. It is species specific and contagious skin disease. The favorable temperature for incubation of camelpox ranges 34 to 39℃ (Hadeel, 2009; Buchnev *et al*, 1987; Fassi-Fehri, 1987). This ranges of temperature are very common in arid and semi-arid areas of tropical environments where large populations of livestock live on.

Table 1: Effects of global warming on the outbreaks of several camel diseases

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| --- | --- | --- | --- | --- |
| No | Disease types | Agents/transmission | Climate factors | References |
| 1 | Anthrax | Bacteria | Outbreak-associated to heavy rainfall following to high temperature | Turnbull *et al*, 2007; Davies, 1960 |
| 2 | Camelpox | Virus | Hot and dry period helps survival and spread of the virus | Hadeel, 2009 |
| 3 | Trypanosomiasis | Protozoa (tsetse flies vector) | Hot and dry condition favors survival and prevalence of tsetse flies vector | Enwezor and Sackey, 2005; Röttcher *et al*, 1987 |
| 4 | Tick infestation | External Parasite | Outbreak-associated with high temperature and drought. | Rodriguez *et al*, 2015 |
| 5 | Rift Valley fever | Virus, transmitted  by *Aedes* and *Culex*  mosquitoes | Associated with Heavy rainfall following with recurrent drought the El Niño Southern Oscillation (ENSO) | Himeidan *et al*, 2014 |
| 6 | Foot and mouth disease | Virus | Elevated Temperature, the seasonal occurrence of dry and cold season | Habiela *et al*., 2010 |
| 7 | Bluetongue | Virus | Related to cold temperatures due to La-Nina | Jiménez-Clavero, 2012 |
| 8 | Respiratory diseases | May Bacteria, viral, protozoa and others | Associated with flooding, drought, high temperature and air dust concentration in drought-prone areas | Yusa, *et al*, 2015; Fassi-Fehri, 1987 |
| 9 | Sudden death syndrome | Unknown | Emerging disease as a result of Higher temperature and recurrent drought condition | Simenew, 2016 |
| 10 | Haemonchosis | Nematodes | Associated with prolonged drought and higher temperature | Van Dijk *et al*, 2010 |

# **CONCLUSION AND RECOMMENDATION**

Climate change is characterized by water stress and flooding in sub-Saharan Africa, which deplete available livestock feed resources and reduced water supply for plants and animals. The most prominent climatic shocks are floods and recurrent drought, which affects crop and livestock productivity. These climatic shocks are the main causes of livestock and crop losses. Floods damage live animals and livestock feed, and also crippling farm animal’s genetic potential. Drought and floods affects not only livestock production but also it severely affects its very foundation of ecosystem like provisioning and support services. The scarcity of water is the main distinctive feature of drought-prone areas, hence, population migrates from drier environments to where water and its benefit (feed resources) are more prevalent. There are selective plant species from both C3 and C4 grasses are adapted to drought condition. Adaptive capacity of forage species may increase their tolerance to withstand the changing condition like surface warming and recurrent drought. Prolonged drought as a result of climate change partakes remarkable impacts on quality of feed resources and lead to change habitat species composition, and modify the species of livestock that feed on them. Camel is well adapted and more productive animal under drought and water stress condition.

* Thus, when the environment thought to be under the risk of drought, it is preferred to produce camel for sustainable household food production and income in the face of drought and water stress condition.

Global warming may also influence livestock health through increasing disease causative vectors and survival of pathogens. Even it forms a condition of new disease emergence by creating favorable incubation temperature. Lack of suitable feeds may also increase the susceptibility of animals to disease. Almost all diseases causative agents and reservoirs have different temperature and moisture related vital rates to survive, develop pathogenicity and widespread in the environment. Thus,

* Veterinary support services such as medical prophylaxes and curative treatments should be provided regularly or periodically, when the diseases supposed to be occurs.
* Scientific investigations, renovating and strengthening of ethno-veterinary perspective of pastoralists against some camel diseases should be attentive.

# **REFERENCES**

Abdalla, E.B, A.E.A. Ashmawy,M.H. Farouk, O.A.E. Salama, F.A. Khalil, A.F. Seioudy, 2015. Milk production potential in Maghrebi she-camels. Small Ruminant Research. Vol 123 (1), pp (129-135). ELSEVER publisher

Adolph, E.F, 1964. *Desert Animals: physiological problems of heat and water*. Knut Schmidt-Nielsen. The University of Chicago Press. 277 pp.

AGRA (Alliance for a Green Revolution in Africa), 2016. Africa Agriculture Status Report 2016. Progress towards Agricultural Transformation in Africa. Pp (300)

Alemayehu Mengistu, 1987. Feed resources in Ethiopia. Proceedings of the second Pastures Network for Eastern and Southern Africa (PANESA) workshop, held at the International Laboratory for Research on Animal Diseases, Kabete, Nairobi, Kenya, 11-15 November 1985

Alemseged, H.T., Kusters, K. and Negash Wagesho, 2013. Loss and damage from flooding in the Gambela region, Ethiopia. *Int. J. Global Warming*, Vol. 5 (4) pp.483–497.

Aleme Asres and Negassie Amha, 2014. Physiological Adaptation of Animals to the Change of Environment: A Review. Journal of Biology, Agriculture and Healthcare, Vol.4 (25), pp. (146-151)

Al-Jassim, R. and V. Sejian, 2015. Review paper: climate change and camel production: impact and contribution. *Journal of Camelid Science*, Vol.8, pp. (1-17).

Asimov, I., 1968. Photosynthesis. New York, NY: Basic books.

Archana, P.R, J. Aleena, P. Pragna, M.K Vidya, A.P.A. Niyas, M. Bagath, G. Krishnan, A. Manimaran, V. Beena, E.K. Kurien, V. Sejian and R. Bhatta, 2017. Role of Heat Shock Proteins in Livestock Adaptation to Heat Stress. *J Dairy Vet Anim Res* Vol 5(1): 00127. DOI:[10.15406/jdvar.2017.05.00127](http://dx.doi.org/10.15406/jdvar.2017.05.00127" \t "_blank)

Baidar, B.K, A. Iqbal and M. Riaz, 2003. Production and Management of Camels. Text book Part II, University of Agriculture, Faisalabad, Pakistan.

Barker, D.J and J.R. Caradus, 2001. Adaptation of Forage Species to Drought. AgResearch - Grasslands, Private Bag 11008, Palmerston North, New Zealand.

Barnesa, A, D. Beattya, E. Taylora, C. Stockmana, S. Maloneyb and M. McCarthy, 2004. Physiology of heat stress in cattle and sheep. A project report for MLA and LiveCorp, Meat & Livestock Australia Limited.

Briney, E, 2017. Drought: Its Causes, Stages, and Problems. An Overview of Drought. [**https://www.thoughtco.com/drought-causes-stages-and-problems-1434940**](https://www.thoughtco.com/drought-causes-stages-and-problems-1434940)

**Bolton J.K and R.H. Brown,** 1980. Photosynthesis of grass species differing in carbon dioxide fixation pathways. V. Response of Panicum maximum, Panicum milioides, and tall fescue (Festuca arundinacea) to nitrogen nutrition. Plant Physiol **66**: 97-100

Buchnev, K.N, T, S.ZH. Tulepbaev and A.R. Sansyzbaev, 1987. Infectious diseases of camels in the USSR. Rev. sci. tech. Off. int. Epiz, Vol 6 (2), pp (487-495).

Cao Y, N. Ohwatari, T. Matsumoto, M. Kosaka, A. Ohtsuru and S. Yamashita, 1999. TGF-beta1 mediates 70-kDa heat shock protein induction due to ultraviolet irradiation in human skin fibroblasts. *Pflügers Archiv*. Vol-**438**(3): pp (239–44). [doi](https://en.wikipedia.org/wiki/Digital_object_identifier):[10.1007/s004240050905](https://doi.org/10.1007%2Fs004240050905).

Coffey, S., 2008. A Systems Approach to Climate Change Impacts on Livestock Production. Paper prepared for presentation at the “Agriculture in A Changing Climate: The New International Research Frontier” conference conducted by the Crawford Fund for *International Agricultural Research*, Parliament House, Canberra, Australia, September 3:39-48.

CSA (Central Statistics Agency), 2015. Agricultural sample survey volume II. Report on livestock and livestock characteristics (private peasant holdings). Addis Ababa, Ethiopia.

DaMatta, F.M, A. Grandis, B.C. Arenque and M.S. Buckeridge, 2009. Impacts of climate changes on crop physiology and food quality. *Food Research International*. Vol 43 pp (1814–1823). Elsevier Ltd

Davies, D.G, 1960. The Influence of Temperature and Humidity on Spore Formation and Germination in Bacillus anthracis. *The Journal of Hygiene*, Vol. 58 (2), pp. (177-186).  Cambridge University Press

Denbela Hidosa and M. Guyo, 2017. Climate Change Effects on Livestock Feed Resources: A Review. *J Fisheries Livest Prod*. Vol-5: 259. doi: 10.4172/2332- 2608.1000259

DeShazer, J.A, (ed), 2009. Livestock Energetics and Thermal Environment management Agricultural 1–22. St. Joseph, MI: ASABE, 2009. Iowa State University.

Donald, O.R. and A. Elizabeth, 2012. Focus on Climate Change. *Journal of plant physiology. Vol 160 (4).* pp (1675-1676). Publisher: American Society of Plant Biologists

Ehleringer, J.R and T.E. Cerling, 2002. C3 and C4 Photosynthesis. The Earth system: biological and ecological dimensions of global environmental change. Vol. 2. Pp (186–190). John Wiley & Sons, Ltd, Chichester

Eisa, M.O and A.B. Mustafa, 2011. Production Systems and Dairy Production of Sudan Camel (Camelus dromedarius): A Review. *Middle-East Journal of Scientific Research*, Vol. 7 (2): pp (132-135). IDOSI Publications.

El-Ramady, H.R*.,* A.A, Belal and S.M. El-Marsafawy, 2012. Climate Change: A Blessing or a Curse for Agriculture? *Contemporary Environmental Readings.* Vol. 1 PP (301)

Enwezor, F.N.C and A.K.B. Sackey, 2005. Camel trypanosomosis - a review. *Veterinarski Arhiv*, Vol 75 (5), pp (439-452).

EPA (Environmental protection Agency), 2017. Climate Impacts on Agriculture and Food Supply. US EPA. <https://19january2017snapshot.epa.gov/climate-impacts>

FAO, 2016. Livestock-dependent households face massive challenges following El Niño-induced drought and flooding in Ethiopia. Food and Agriculture Organization of the United Nations Report, July, 2016. [www.reliefweb.int/organization/fao](http://www.reliefweb.int/organization/fao)

Fassi-Fehri, M.M, 1987. Diseases of camels. Rev. sci. tech. Off. int. Epiz., Vol 6 (2), pp (337-354).

Fayed, R.H, 2001.  Adaptation of the Camel to Desert Environment. Proceedings of the ESARF 11th Annual Conference. <http://esarf2.tripod.com/conf2001proc>

FDRE, 2011. Ethiopia’s Climate-Resilient Green Economy. Green economy strategy. Addis Ababa, November 2011, Ethiopia.

FDRE, 2016. Flood Alert. National Disaster Risk Management Commission. Early Warning and Response Directorate. April, 2016. Ethiopia.

Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland, 2007, Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Galma Wako, Menfese Tadesse and Ayana Angassa, 2017. Camel management as an adaptive strategy to climate change by pastoralists in southern Ethiopia. Ecological Processes Vol 6:26. Springer open publisher. DOI 10.1186/s13717-017-0093-5

Gardiner, D.A, 2010. Past, Present and Future Mean Temperatures for Earth’s Global Climate. A Study of Global Temperatures and their Trends. Worcester Polytechnic Institute.

Gauthier-Pilters, H and A.I. Dagg, 1981. *The Camel: Its Evolution, Ecology, Behavior, and Relationship to Man.* University of Chicago Press; First Edition.

Getachew Bekele, 2016. The Impacts of Climate Change on Livestock Production and Productivities in Developing Countries: A Review. *International Journal of Research - Granthaalayah*, Vol. 4 (8): 181-187.

GORDON, C. J, 2008. Thermoregulation in homeothermic and poikilothermic organisms. Presented at Hypothermia-From Threat to Cure, sponsored by NY Academy of Sciences, Manhattan, NY.

Gray, S.B and S.M. Brady, 2016. Plant developmental responses to climate change. Developmental Biology 419 (2016) 64–77. Published by Elsevier Inc.

Gregory, R. P., 1977. Biochemistry of photosynthesis. London: Wiley.

Habiela, M, M.A.G. Alamin, Y.A. Raouf and Y.H. Ali, 2010. Epizootiological study of foot and mouth disease in the Sudan: the situation after two decades. *VETERINARSKI ARHIV*, Vol 80 (1), pp (11-26).

Hadeel, G, 2009. Effects of Temperature and pH on the growth of Camelpox virus in Cell Culture. An MSc thesis submitted to department of microbiology, faculty of Veterinary Medicine, University of Khartoum.

Haigh, J.D, 2002. Radiative forcing of climate change. Weather Vol. 57 (8). Pages 278–283

Hansen, J., M. Sato and R. Ruedy, 1997. *Radiative forcing and climate response*. J. Geophys. Res., 102(D6), 6831–6864, doi:[10.1029/96JD03436](http://dx.doi.org/10.1029/96JD03436" \t "_blank" \o "Link to external resource: 10.1029/96JD03436).

Himeidan, Y. E., E.J. Kweka, M.M. Mahgoub, E.A. El Rayah and J.O. Ouma, 2014. Recent Outbreaks of Rift Valley Fever in East Africa and the Middle East. *Frontiers in Public Health*, Vol *2*, 169. http://doi.org/10.3389/fpubh.2014.00169

Houghton, J.T, 2009. Global warming: The Complete Briefing. 4th Edition. Cambridge University Press, the Edinburgh Building, Cambridge, UK.

Houghton, J.T, 1995. *Climate Change 1994: Radiative Forcing of Climate Change and an Evaluation of the IPCC 1992 IS92 Emission Scenarios.* IPCC WG I and III. Cambridge University Press, 1995. 339 pages

Hsu, W.L and T. Yoshioka, 2015. Role of TRP channels in the induction of heat shock proteins (Hsps) by heating skin. *Biophysics,* Vol. 11, pp. 25–32. doi: 10.2142/biophysics.11.25

IFRC (International Federation of Red Cross Societies), 2006. Ethiopia: Floods. Appeal no. MDRET003 (revised). Glide no. FL-2006-000122-ETH, 6 September 2006. [www.ifrc.org](http://www.ifrc.org)

Ignaciuk A, Mason-D'Croz D (2014), Modelling Adaptation to Climate Change in Agriculture. OECD Food, Agriculture and Fisheries Papers 70: 58.

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.). IPCC, Geneva, Switzerland, 151 pp.

IRDR (Integrated Research on Disaster Risk), 2015. Building resilience to climate shocks and stresses: addressing the knowledge gap. Beijing, China 100094. <http://www.irdrinternational.org>

Jiao, L, 2012. Climate change a mixed blessing for wheat, say experts. Bringing science & development together through news & analysis. SciDev.Net

Jiménez-Clavero, M. Á. (2012). Animal viral diseases and global change: bluetongue and West Nile fever as paradigms. *Frontiers in Genetics*, Vol *3*(105). <http://doi.org/10.3389/fgene.2012.00105>.

Kassahun Desalegn, 2016. The Climate Change Impacts on Livestock Production: A Review. *Global Veterinaria* Vol 16 (2). © IDOSI Publications.

Kay, R.N.B, 1997. Responses of African livestock and wild herbivores to drought. *Journal of Arid Environments*. Vol. 37: pp (683–694)

Kerr, S, 2015. Livestock Heat Stress: Recognition, Response, and Prevention. Washington State University Extension fact sheet.

Kiros Abebe, 2017. Effect of Climate Change on Nutritional Supply to Livestock Production. *Acad. Res. J. Agri. Sci. Res*. Vol 5(2): 98-106.

Kurade N.P., B. Sajjanar, A.V. Nirmale, S.S. Pawar, K.T. Sampath, 2017. Nutritional Management: Key to Sustain Livestock in Drought-Prone Areas. In: Minhas P., Rane J., Pasala R. (eds) Abiotic Stress Management for Resilient Agriculture. Springer, Singapore

Lara, M.V and C.S. Andreo, 2011. C4 Plants Adaptation to High Levels of CO2 and to Drought Environments. A book chapter of Abiotic Stress in Plants - Mechanisms and Adaptations. InTech publishing. doi 10.5772/24936

Lienhard V, J.H and J.H. Lienhard IV, 2001. A heat Transfer Text Book. 3rd ed. Cambridge, Massachusetts, U.S.A. pages (688)

Lubroth, J, 2013. *Climate change and animal health. Animal Health Service*, FAO, Rome.

Martin, N., 2010. North African crops to be hit hardest by climate change. Bringing science & development together through news & analysis. SciDev.Net

Marek-Trzonkowska, N, P. Trzonkowski and J. Siebert, 2016. Heat shock proteins (HSPs) in the homeostasis of regulatory T cells (Tregs). The abstract by PubMed Central

Midgley. G.F., 2017. Plant Physiological Responses to Climate and Environmental Change. In: eLS. John Wiley & Sons Ltd, Chichester. doi: 10.1002/9780470015902.a0003205.pub2. [www.els.net](http://www.els.net)

Mulata Hayelom, 2016. Review on the Impact of Climate Change on Livestock Production and Genetic Diversity. *International Journal of Engineering Development and Research*, Vol. 4 (2). PP (4).

Muli, M, D. Kimenye and P. Kivolonzi, 2008. The Camel Milk Industry in Kenya. Results of a study commissioned by SNV to explore the potential of Camel Milk from Isiolo District to access sustainable formal markets. Final Report, SNV.

Mulu Gebreselassie, Gebreyohanes and Awol Mohammed Assen, 2017. Adaptation Mechanisms of Camels (*Camelus dromedarius*) for Desert Environment: A Review. *Journal of Veterinary Science & Technology*, Vol 8 6), pp (486-4890). DOI: 10.4172/2157-7579.1000486

Morand, S, K. A. Owers, A. Waret-Szkuta, K.M. McIntyre & M. Baylis, 2013. Climate variability and outbreaks of infectious diseases in Europe. SCIENTIFIC REPORTS: 3:1774 |DOI:10.1038/srep01774. [www.nature.com/scientificreports](http://www.nature.com/scientificreports)

National Research Council, 1981. Effect of Environment on Nutrient Requirements of Domestic Animals. Washington, DC: The National Academies Press. <https://doi.org/10.17226/4963>.

Nejash Abdela and Kula Jilo, 2016. Impact of Climate Change on Livestock Health: A Review. *Global Veterinaria* 16 (5): 419-424, 2016. © IDOSI Publications.

Nkondze, M.S., M.B. Masuku, A. M. Manyatsi, 2014. The Impact of Climate Change on Livestock Production in Swaziland: The case of Mpolonjeni Area Development Programme. *Journal of Agricultural Studies*. Vol. 2 (1). [www.macrothink.org/jas](http://www.macrothink.org/jas)

NOAA, 2018. National Centers for Environmental Information, State of the Climate: Global Climate. A Report. Online February 2018, <https://www.ncdc.noaa.gov/sotc/global/201801>

OCHA, 2017. United Nation Office of the Coordination Humanitarian Affairs. Crisis Overview, Ethiopia. <http://www.unocha.org/ethiopia>

Odongo, N.O, 2016. Quality, Safety, Andpost-Harvest Losses of Camel Milk along the Camel Milk Value Chain in Isiolo County. Kenya. MSc Dissertation. Department of Food Science, Nutrition and Technology, Faculty of Agriculture, University of Nairobi, Kenya

OECD, 2014. Green Growth Indicators for Agriculture: A Preliminary Assessment, OECD Green Growth Studies, DOI: http://dx.doi.org/10.1787/9789264223202-en

OECD, 2015. Agriculture and Climate Change. Trade and Agriculture Directorate. http://www.oecd.org/tad/sustainable-agriculture/ agriculture-and-climate-change.htm

Ornas, A.H.A, 1988 (ed). Camels in Development: Sustainable production in African dryland. Scandinavian Institute of African Studies. Pages- 164. Sweden

Oromia Disaster Risk Management Commission, 2018. Risk and disaster management and Control Report. Fana Broadcasting Corporation (FBC) news, Afan Oromo Version. 28 February 2018, Ethiopia.

Oyhantçabal, W, E, Vitale, P, Lagarmilla, 2010. Climate Change and Links to Animal Diseases and Animal Production. Agricultura y Pesca, Constituyente 1476 – 2º Piso, CP 11200 Montevideo, Uruguay. Conf. OIE 2010, 179-186

Pathak H, P.K. Aggarwal and S.D. Singh (Editors), 2012. Climate Change Impact, Adaptation and Mitigation in Agriculture: Methodology for Assessment and Applications. Indian Agricultural Research Institute, New Delhi. pp xix + 302.

Peters, R.H, 1986. *The Ecological Implications of Body Size.* Cambridge University Press, Science - 329 pages

Pockley, G., 2001. Heat shock proteins in health and disease. *Expert Reviews in Molecular Medicine*. Cambridge University Press. <http://www.open.edu/openlearn/nature-environment>

Richard D. and D. Gerard, 1985. Milk production potential of dromedary’s camel in Dankali (Ethiopia). in Conference international ensures productions animals in zones arides. 1985/09/07 –12, Damas (Syrie), Maisons- Alfort, CIRAD-EMVT, 16 p.

Ritossa, F, 1962. A new puffing pattern induced by temperature shock and DNP in drosophila. *Experientia*. Vol 18 (12): pp (571–573). doi:10.1007/BF02172188.

Robinson S, K. Strzepek, R. Cervigni, 2013. The Cost of Adapting to Climate Change in Ethiopia: Sector-Wise and Macro-Economic Estimates. ESSP working paper 53. 1-23.

Rodriguez, I.A, E. Rasoazanabary, L.R. Godfrey, 2015. Seasonal variation in the abundance and distribution of ticks that parasitize *Microcebus griseorufus* at the Bezà Mahafaly Special Reserve, Madagascar. International Journal for Parasitology: Parasites and Wildlife, Vol 4 (3), pp (408-413). The ELSEVEIR

Romanucci, M., T. Bastow, & L. Della Salda, 2008. Heat shock proteins in animal neoplasms and human tumours a comparison. *Cell Stress & Chaperones*, Vol-13(3), pp (253–262). <http://doi.org/10.1007/s12192-008-0030-8>

Röttcher, D, D. Schillinger and E. Zweygarth, 1987. Trypanosomiasis in the camel (Camelus dromedarius). Rev. sci. tech. Off. int. Epiz., Vol 6 (2), pp (463-470).

Rust, J.M. and T. Rust, 2013. Climate change and livestock production: A review with emphasis on Africa. *South African Journal of Animal Science*, Vol-43 (3)

**Sage, R.F, P.A. Christin, E.J. Edwards**, 2011. The C4 plant lineages of planet Earth. J Exp Bot **62,** 3155-3169

Sanfo A, Sawadogo I, Kulo EA, Zampaligre N. 2015 Perceptions and Adaptation Measures of Crop Farmers and AgroPastoralists in the Eastern and Plateau Central Regions of Burkina Faso, West Africa. *FIRE Journal of Science and Technology* 3: 286-298.

Sejian, V, Gaughan, J. B., Bhatta, R and Naqvi, S. M. K., 2016. Impact of Climate Change on Livestock Productivity. Broadening Horizons. Feedipedia. [www.feedipedia.org](http://www.feedipedia.org)

Salem Selomon, 2016. Drought, Then Floods Hit Ethiopia's Economy. The New York Times, Poynter.org

Simenew Kaskis, T. Dejen, Tesfaye Sisay, Fekadu Regassa, Tesfu Kassa and Fufa Abuna, 2013. Characterization of Camel Production System in Afar Pastoralists, North East Ethiopia. Asian Journal of Agricultural Sciences, Vol 5(2): pp (16-24). Maxwell Scientific Organization

Simenew Keskes, 2014. Characterization of *Camelus dromedaries* in Ethiopia: Production Systems, Reproductive Performances and Infertility Problems. A PhD Dissertation, College of Veterinary Medicine and Agriculture, Addis Ababa University.

Sisay Fikru and Awoke Kassa, 2015. Review on Production, Quality and Use of Camel Milk in Ethiopia. J Fisheries Livest Prod 3:145. doi:10.4172/2332-2608.1000145

Sisay Kebede, Getachew Animut and Lemma Zemedu, 2015. The contribution of camel milk to pastoralist livelihoods in Ethiopia An economic assessment in Somali Regional State. International Institute for Environment and Development. Country Report.

Sivan, A, A. N. Shriram, N. Muruganandam and R. Thamizhmani, 2017. Expression of heat shock proteins (HSPs) in *Aedes aegypti (L) and Aedes albopictus (Skuse) (Diptera: Culicidae*) larvae in response to thermal stress. *Journal of Acta Tropica*, Vol 167, pp (121–127). The ELSEVIER

Tariq, A and T. Hussain, M. M. Ali and M. E. Babar, 2014. Camels Adaptation to Desert Biome. *Global Veterinaria,* Vol 12 (3): pp (307-313). IDOSI Publications

Taylor, S. H, B. S. Ripley, F. I. Woodward & C. P. Osborne, 2011. Drought limitation of photosynthesis differs between C3 and C4 grass species in a comparative experiment. Plant, Cell and Environment. Vol 34, pp (65–75). Blackwell Publishing Ltd. doi: 10.1111/j.1365-3040.2010.02226.x.

Tegegne, A., Gebremedhin, B., Hoekstra, D., Belay, B., and Mekasha, Y. 2013. Smallholder dairy production and marketing systems in Ethiopia: IPMS experiences and opportunities for market-oriented development. Working Paper No. 31. ILRI: Addis, Ababa, Ethiopia.

Thornton, P. K. (2010). Livestock Production: Recent Trends, Future Prospects. CGIAR/ESSP Program on Climate Change, Agriculture and Food Security (CCAFS), *International Livestock Research Institute* (ILRS) 365, 2853-2867.

Tolson J.K and S. M. Roberts, 2005. Manipulating heat shock protein expression in laboratory animals. *Methods***,** Vol 35 (2), pp (149-157). The ELSEVIER publishing ltd

Turnbull, PC, D.A. Frawley, and R.L. Bull, 2007. Heat activation/shock temperatures for Bacillus anthracis spores and the issue of spore plate counts versus true numbers of spores. Journal of Microbiol Methods. Vol 68(2): pp (353-537), ELSEVIER publisher

UNDP (United Nations Development Programme), 2007. Tiviski: A Camel Milk Dairy Improving Livelihoods for Semi-Nomadic Herders in Mauritania. A Case Study. Growing inclusive market. [www.growinginclusivemarkets.org](http://www.growinginclusivemarkets.org)

UNFCCC, 2014. Building Resilience to the Shocks and Stresses of Climate Change**.** [www.rockefellerfoundation.org](http://www.rockefellerfoundation.org)

UNFCCC (United Nations Framework Convention on Climate Change*), 1992.* New York: United Nations, General Assembly.

UNFCCC, 2007. Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries. © 2007 UNFCCC United Nations Framework Convention on Climate Change. [www.unfccc.int](http://www.unfccc.int)

UNICEF, 2015. Ethiopia: Drought Crisis, Immediate Needs Overview.

USGCRP, 2017: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 470 pp., doi: 10.7930/J0J964J6.

UCDAVIS and WIFSS, 2015. Flooding & Livestock Owners. Preparing, Responding, and Recovering. Newsletter. <http://www.prep4agthreats.org/Natural-Disasters/>

Valtorta, S.E, 2002. Animal production in a changing climate: impacts and mitigation. A Santa Fe National Council for Scientific and Technical Research, National Institute of Agricultural Technology, Rafaela Experimental Station.

Van Dijk. J, N.D. Sargison, F. Kenyon, P.J. Skuce, 2010. Climate change and infectious disease: helminthological challenges to farmed ruminants in temperate regions. Journal of Animal, Vol 4(3), pp (377-392). DOI: 10.1017/S1751731109990991.

Vining, K.C, 2007. Effects of weather on agricultural crops and livestock: an overview. International journal of environmental studies. Vol 36 (1-2). [doi.org/10.1080/00207239008710581](https://doi.org/10.1080/00207239008710581)

Virtanen, P, K. Palmujoki and Dereje Terefe, 2011. Global Climate Policies, Local Institutions and Food Security in a Pastoral Society in Ethiopia. Consilience: The *Journal of Sustainable Development* Vol. 5, Iss. 1 (2011), Pp. 96-118.

**Vogan, P.J and R.F. Sage**, 2011. Water-use efficiency and nitrogen-use efficiency of C3-C4 intermediate species of Flaveria. Plant Cell Environ. Vol- **34**: 1415–1430.

**von Caemmerer, S and R.T. Furbank**, 2003. The C4 pathway: an efficient CO2 pump. Photosyn Res **77**: 191–207

Warne, W.R, A.D. Pershall and B.O. Wolf, 2010. Linking precipitation and C3–C4 plant production to resource dynamics in higher-trophic-level consumers. *Ecology*, Vol 91(6), pp. (1628–1638). The Ecological Society of America.

WFP (World Food Program), 2006. Extensive flooding in Ethiopia: WFP update. 18 August 2006, World food Program. [**www.wfp.org/stories/extensive-flooding-ethiopia-wfp-update**](http://www.wfp.org/stories/extensive-flooding-ethiopia-wfp-update)

Whitmarsh, J. and Govindjee, 1995. The photosynthetic process. Published in Encyclopedia of Applied Physics (Vol. 13, pp. 513-532) by VCH Publishers

Workneh Abebe Wodajo, 2016. Effect of Climate Change on Livestock Production in Ethiopia. *International Conference on Environmental Sustainability for Food Security*, 22-24 Sept 2016 , T A Mi Ln Ad U , India.

World Bank Group, 2015. Climate Change Knowledge Portal for Development practitioners and policy makers. <http://sdwebx.worldbank.org/climateportal/>

Yagil, R., O. Zagorski, C. van Creveld, and A. Saran, 1994. Science and camel’s milk production. *Science and camel’s milk production.* Ed. Saint Marin, G. Expansion Scientifique Francais, Paris, 75-89

Yitea Sineshaw and Gebre SL 2015. Flood Hazard Assessment and Mapping of Flood Inundation Area of the Awash River Basin in Ethiopia using GIS and HEC-GeoRAS/HEC-RAS Model. J Civil Environ Eng 5: 179. doi:10.4172/2165-784X.1000179

Yusa, A., P. Berry, J.J. Cheng, N. Ogden, B. Bonsal, R. Stewart, and R. Waldick, 2015. Climate Change, Drought and Human Health in Canada. *International Journal of Environmental Research and Public Health*, *12*(7), 8359–8412. <http://doi.org/10.3390/ijerph120708359>

Zelalem Yilma, Aynalem Haile and E. Guerne-Bleich, 2009. Effects of climate change on livestock production and livelihood of pastoralists in selected pastoral areas of Borana, Ethiopia, Food and Agriculture Organization of the United Nations, Sub Regional Office for Eastern Africa (FAO/SFE), Addis Ababa, Ethiopia, 32 p.