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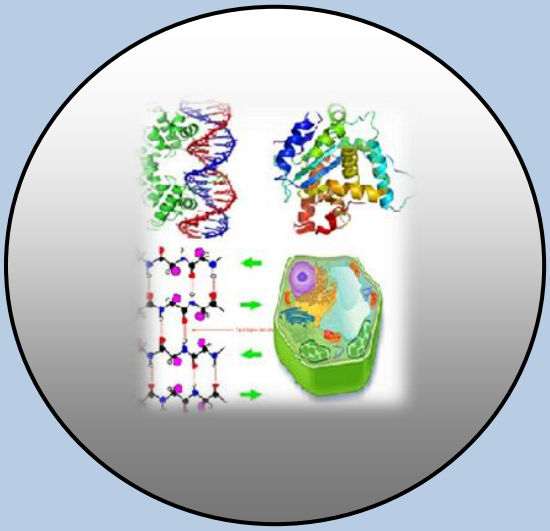
ISSN 2319-3077 Online/Electronic
ISSN 0970-4973 Print

Global Impact factor of Journal: 0.756
Scientific Journals Impact Factor: 3.285
InfoBase Impact Factor: 2.93
Index Copernicus International Value
IC Value of Journal 6.01 Poland, Europe

J. Biol. Chem. Research
Volume 32 (2) 2015 Pages No. 755-764



Journal of Biological and Chemical Research

(An International Refereed/Peer Reviewed Journal of Life Sciences and Chemistry)

Indexed Abstracted and Cited in about 25 different Scientific Databases around the World

Published by Society for Advancement of Sciences®

J. Biol. Chem. Research. Vol. 32, No. 2: 755-764, 2015
(An International Refereed/Peer Reviewed Journal of Life Sciences and Chemistry)
Ms 32/2/65/2015

ISSN 0970-4973 (Print)
ISSN 2319-3077 (Online/Electronic)

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REVIEW ARTICLE

Received: 15/07/2015 Revised: 01/09/2015 Accepted: 05/09/2015

Impact of Climate Change on Production Systems in Semi-arid Regions of Ethiopia

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ABSTRACT

Climate change is one of development challenges that affect the livelihoods of communities of the world including communities in Ethiopian. Majority of the Ethiopian economy depends on agriculture which is the most vulnerable economic sector to the impacts of climate change. The impacts of climate change on the life of developing countries are tremendously increasing. This is because of overexploitation of natural resources that leads to extreme temperature and flooding, increasing of diseases prevalence's in semi-arid regions, loss of soil fertility and low agricultural productions. Communities whose livelihood depends on agricultural activities are directly affected by climatic change events mainly by extreme low or high precipitation and temperature. Various natural and anthropogenic activities lead to climate change. Climate change has a number of negative impacts on natural environment in general and biodiversity in particular. The intimate interaction between human and environment also shows the dependence of communities' livelihoods on environmental resources. Therefore, human activities disturb natural environment which lead to emissions of green house gases to the atmosphere. This in turn has led to the change of climate parameters and thereby brought climate change. Climate change is mainly threatening the rain-fed agricultural sector by affecting the livelihood of the rural communities, particularly in technologically and economically less developed/developing countries in Asia, Africa including Ethiopia. Semi-arid areas are even more vulnerable to the negative effect of climate change as they are suffering of erratic rainfall and rising temperatures. The shortage of rainwater and high temperature are not suitable for crop and livestock production as it affects the soil moisture, forage production and enhances diseases. In order to overcome the negative impacts of climate change, the communities can adapt these climatic hazards by using mechanisms such as developing rainwater-harvesting technologies, using improved crop varieties, agro forestry practices and locally feasible adaptation and mitigation options.
Keywords: Climate, Climate change, Impacts, Adaptation and Mitigation.

INTRODUCTION

Climate change affects ecosystems and production systems at different scales. It is also expected to affect agricultural and livestock production, water balances, input supplies and other components of agricultural systems (Aydinalp and Cresser, 2008). Climate change can retard development efforts and achievements by years (Adem and Bewket, 2011). The devastating effects of global climate change are increasing and most damages are predicted to occur in developing countries. This is because of their over reliance rain fed agricultural production and their low adaptive capacity (Bruckner, 2012). Majority of the rural population in the developing countries depends on crop and livestock production for their livelihoods (Musemwa et al., 2008). Livestock took a lion's share in semi-arid areas. However, the livestock sector is highly vulnerable to climate change. Many climate change predictions suggest that the African livestock sector will be negatively affected by 2020 unless the current negative trend is reversed through adaption and mitigation mechanisms (Calvosa et al., 2009). The Inter Governmental Panel of Climate Change (IPCC) predicted that by 2100 the increase in global average surface temperature may be between 1.8 and 4.0°c. With global average temperature increases of 1.5-2.5°c, approximately 20-30% of plant and animal species are expected to be at risk of extinction (FAO, 2007). In African countries agriculture is main components of their economy with livestock production a key contributor to the agricultural sector. It is estimated to employee 70 to 90% of the total labor force as well as supplying up to 50% of household food requirements and household incomes (FAO, 2007). Africa covers about 30 million kilometer square and livestock production takes place on about 54% of the total area or 16 million kilometer square, where nearly 80% of the population lives. Livestock production accounts for about 30% of the gross value of the agricultural production, within 92% of that coming from the production of beef, cattle, dairy cattle, goats, sheep and chickens (IFAD, 2009). According to Thornton et al., (2008) there are direct and indirect impacts of climate change on livestock and livestock systems. Among the direct effects of climate change are higher temperatures and changes in rainfall patterns, translating in an increased spread of existing vector-borne diseases and macro parasites of animals as well as the emergence and spread of new diseases. In some areas, climate change may also cause new transmission models. These effects will be felt by both developed and developing countries, but developing countries will be most impacted because of their lack of appropriate technologies and prediction capacities. Some of the indirect effects are changes in feed resources linked to the carrying capacity of rangelands, the buffering abilities of ecosystems, increased desertification processes, increased scarcity of water resource and lower production of grain. Other indirect effects will be the potential shortage of feed due to a rapid increase in production competition between food, feed, fuel and land use systems (FAO, 2008). Therefore, this article is aimed to assess the impacts of climate change on production systems by emphasizing on semiarid production systems in Ethiopia.

Climate change and production systems in Ethiopia

Ethiopia is the second most populous country in Africa with population growth rate of 2.6% (World Bank, 2015). Majority of the Ethiopian population depends on agriculture and live in rural areas. Agriculture contributes about 44% to the country's gross domestic product (GDP). About 84% of the national population is living in rural deriving livelihoods from agriculture and natural resources (Adem and Bewket, 2011).

Rainfall dependent agriculture is the most commonly practices across the country and this situation makes the country vulnerable to climate related shocks, which in turn has a potential to threaten food security unless appropriate adaption and mitigation mechanisms are in palace (Conway and Schipper, 2011).

Effect of climate change on livestock population

Livestock production contributes to GHG such as methane and is affected by climate change. Livestock production systems may be affected in various ways by climate change. In general terms, climate change affects livestock and crop production directly through increase in temperature and shifts in rainfall amounts patterns and through ecosystem changes, changes in crop yield, quality and types, alter the distribution of animal diseases, and increased competition for resources indirectly (IPCC 2007 and Thornton et al., 2007). This effect is more severe in semiarid ecosystems. Therefore, climate change is likely to exert observable problems on production systems where resource endowments are poorest and where the ability of livestock owners to respond and adapt is most limited (FAO, 2007). The impact of climate change is expected to heighten the vulnerability of livestock systems and reinforce existing factors that are affecting livestock production systems, such as rapid population and economic growth, rising demand for food and products, conflict over scarce resources such as land tenure, water and energy especially bio-fuels. Losing livestock assets could trigger a collapse into chronic poverty and have a lasting effect on the livelihoods of rural communities (IFAD, 2009). Livestock production is increasing throughout Africa, driven by growth of human population, living standards and urbanization (World Bank, 2004). The same source indicated that, total human population in Africa continued to grow at about 2.5% per year and will double in 16 years while GDP is increasing at 3.2%. Seventy percent of the rural poor own livestock and over 200 million people rely on livestock for income. In small-scale mixed crop-livestock farming, livestock provide animal power, transportation and manure for fertilizing croplands. Apart from economic importance, livestock is socially and culturally important in Africa, for payment of dowry, celebrations and gifts to family members, and as a source of savings: safer, despite diseases and drought, than the banking system and easier to manage for remote farmers. Climate change will have far-reaching consequences for dairy and meat production, especially in vulnerable parts of the world where it is vital for nutrition and livelihoods. The impact of climate change on livestock systems could exacerbate existing stresses upon communities through climate change events such as drought. The inevitable susceptibility of agriculture to climate change emanates from its inherent link to climatic factors, which are sensitive to changes in climate variables (Anwar et al., 2013). Therefore, climate change is posing unprecedented challenges to crop cultivation and livestock production in semiarid regions including Ethiopia. The prevailing smallholder livestock production in the region, such as pastoralists are more vulnerable to changing climatic factors given the high dependency of the sector on scarce natural resources and a low adaptive capacity of the developing countries' economies (Kassie et al., 2013).

Rangeland livestock production

Rangelands occupy majority of the African continent and in West and Central Africa, they account for 30% of cattle and 50% of small ruminant production supplying 60% of beef, 40% of sheep and goat meat and 70% of milk World Initiative for Sustainable Pastoralism (WISP, 2010).

Animal production in the Ethiopian rangelands depends essentially on the use of natural vegetation (pasture and shrubs) that is grazed or browsed predominantly by mixed herds of ruminants and equines. Rangelands are estimated to store up to 30% of the world's soil carbon in addition to the substantial amount of aboveground carbon stored in trees, bushes, shrubs and grasses. In view of the vast extent of grasslands and rangelands and the degraded nature of large areas of these systems, the potential to sequester carbon through improved management is significant. Such management practices include restoring organic matter to soils, reducing erosion, and decreasing losses resulting from burning and overgrazing (White, *et al*., 2000 and Grace, *et al*., 2006).

Forage quality and quantity

Research reports indicated that, grassland productivity under elevated atmospheric CO_2 concentrations and the interaction with temperature have the likelihood of a number of outcomes of climate change globally (Topp and Doyle, 1996; IGER, 2003 and Hopkins, 2004). The report indicated that it applies to grasslands globally and are not specific to Africa. Modeling study of Hanson et al., (1993) indicated that mean forage digestibility decreased under all scenarios considered. The models simulated an increase in standing biomass but a considerable reduction in the nitrogen concentration of plants during the summer grazing months, large enough to bring about considerable decreases in animal performance. Higher temperature increases the growth rate and lignifications of grazed plants. Other studies have shown that an increase in the legume content of swards may partially compensate for the decline in protein content of the non-fixing plant species. The decline of C4 grasses which are less nutritious than C3 plants may compensate for the reduced protein content under elevated CO_2. However, the opposite effect is expected under associated temperature increases (IPCC, 2007).

Water resources

Water is essential input in all production systems. However, water scarcity has become globally significant over the last 40 years and is an accelerating condition for 1-2 billion people worldwide (IIRR, 2004). Population growth, economic development and climate change impacts will undoubtedly have a substantial effect on global water availability in the future. Globally, freshwater resources are relatively scarce; amounting to only 2.5% of all water resources and of this, not quite 70% is locked up in glaciers and permanent ice (MA, 2005). Estimates of the renewable global water supply are very imprecise, but lie between 33,500 and 47,000 cubic km per year, about one-third of which is accessible to humans, once its physical proximity to human population and year-to-year variability are taken into account (Postel et al., 1996). Groundwater also plays an important role in water supply between 1.5 and 3 billion people depend on groundwater for drinking (MA, 2005). There is considerable uncertainty associated with estimating available groundwater resources and their recharge rates and this makes assessments of water use particularly challenging. The comprehensive assessment (Behnke, 2007) indicted that if today's food production and environmental trends continue into the future, they will lead to crises in many parts of the world. The impact of increased temperatures on water demand by livestock is predicted to be negative. The impacts of climate change on water supply changes in livestock systems are not well studied for specific regions. Studies in Southeastern pastoral areas of Ethiopia indicated that there is critical shortage of rainfall (unreliable, less intensity and duration), and hence ponds do not fill to their capacity and dry out fast, streams and rivers disappeared and boreholes dried out (ESAP, 2009).

The key contribution of groundwater to extensive grazing systems will probably become even more important in the future in the face of climate change (Masike, 2007).

Livestock diseases and climate change

Increased temperature may have effect on some pathogens and parasites. It causes increased development on their life cycle outside their hosts. This may reduce their reproduction time and hence have more reproduction per year resulting into higher number of pathogens/parasites which predicts more infections. However, some pathogens/parasites are sensitive to higher temperature and will affect their survival (Harvell et al., 2002).

Temperature and moisture frequently impose limits on vectors distribution. Low temperatures limit vector distribution because of high winter mortality and a relatively slow rate of population recovery during warmer seasons. This is different with high temperatures as limiting occurs when there is excessive moisture loss. Therefore, cooler and high altitude regions, which are too cold, for certain vectors may begin to allow them to flourish with climate change. Warmer regions could become even warmer and yet remain permissive for vectors if there is also increased precipitation or humidity. These regions may become less conducive to vectors if moisture levels remain unchanged or decrease with concomitant increase in moisture stress. Changes to temperature and moisture will also lead to increases or decreases in the abundance of many disease vectors (Anyamba et al., 2002 and Gagnon et al., 2002).

Pastoral livelihood and climate change

Pastoralists in Ethiopia are mainly found in five lowland regions: Afar, Oromiya, Somali and the Southern Nations Nationalities and People's (SNNP) and Gambella regional states. The main livelihoods of pastoralists include pastoralism, farming and ex-pastoralism (ex-pastoralists later engaged in petty income-earning activities) (Behnke et al., 2007). In Ethiopia livestock in pastoral regions accounts for an estimated 40% of the country's total livestock population (PFE, 2006). According to Amaha (2006) the dry lands of Ethiopia are dominated by rangeland based livestock production systems known as pastoralism and agro-pastoralist i.e. partly involved in opportunistic cropping and represents a significant sector of the national agriculture in the country. The livestock sector contributes about 40% of agricultural Gross Domestic Product (GDP) or more than 20% of the total GDP. However, this important livelihood is threatened by climatic events (Roy et al., 2007 and Amaha, 2006). Degradations in biological and physical rangeland resources have become serious challenges, bearing negative impacts on the pastoral ecosystems, livestock production and livelihoods. As a result, there are high livestock mortalities in most pastoral areas. Simultaneous outbreaks of livestock diseases are also common and spread along the drought fronts, aggravating the number of animal mortalities. Climate change and variability are said to be serious environmental issues for the sustainability of pastoral lands over the next thirty years (Vetter, 2005). The climate of the pastoral lands in Ethiopia is characterized by scarce rainfall which falls unreliably and within short rainy seasons and often limited availability for human, crop and livestock use. High temperatures during rainy seasons lead to the loss of much of the rainwater through evaporation, and intensive rainfall results in floods. Therefore, arid and semi-arid areas that serve as the source basis for the livestock production system known as pastoral production system in Ethiopia are facing enormous threat (Kassahun et al., 2008).

Climate change on livestock market and exports

The value of cattle and livestock specifically stock small may decrease during drought due to increased supply and deteriorating conditions of the animals and the response of herders to these market conditions is highly varied with some producers selling their animals before the value becomes unacceptably low while others reserve higher value stock as long as possible as a backup. Livestock market often declines and their price increases immediately after drought when farmers are rebuilding their herds and more likely to withhold animals from sale (Davies, 2006). All regions in Ethiopia are not equally affected by drought. For instance, Deressa et al., (2008) reported that Afar, Somali, Tigray regions and Borena area in Oromia Regional States are the most susceptible to the impacts of climate change. The frequency of drought and flooding also varies from region to region. There is evidence of marginal downward pressure on domestic livestock prices during times of drought and a slight upward pressure on livestock prices in periods immediately after droughts. While prices did not fluctuate much over the years, farmers receive lower total value for their cattle and small stock because of the lower average grades arising from the poor conditions of the animals (UNDP, 2008). According to Aklilu and Catley (2011) livestock marketing and commercial involvement in certain countries in the Horn of Africa and Southern Africa are greatly contributing to national economies of their countries. The same report indicated that, in the Horn, pastoralist generates impressive amounts of foreign exchange and a significant contribution to GDP. Despite constraints, pastoral households in Ethiopia are also increasingly involved in commercial livestock production for sale, with results that taken together are impressive both in terms of the volume and value of international trade and foreign exchange earnings. Despite their remoteness and their participation in weak national economies, these are pastoral production systems oriented to commercial production.

Relationship between Land use change, Climate Change and Livestock

Developing countries like Ethiopia are facing and will face changes in rainfall patterns and extreme events, such as severe water shortages, droughts and flooding. These events will increase the risk of land degradation and biodiversity loss. Climate change also will affect the length of growing seasons and crop and livestock yields and bring about increased risk of food shortages, insecurity and pest and disease incidence, putting populations at greater health and livelihood risks (IPCC, 2007). The same report indicated that agriculture, which includes crop and livestock production, is responsible for some 14% of CO_2 equivalent emissions (IPPC, 2007a) while land-use change including land degradation and deforestation which are linked to agriculture accounts for another 18%. Conversion of rangelands to cropland is a major cause of emissions, resulting in 95% loss of aboveground carbon and up to 60 % loss of belowground carbon (Guo and Gifford, 2002). Degradation of aboveground vegetation can cause an estimated loss of six tons of carbon per ha and soil degradation processes lead to a loss of 13 tons of carbon per ha (Woomer et al., 2004). The impacts of climate change are likely to be highly spatially variable, but developing countries, like Ethiopia, generally are considered more vulnerable than developed countries due to their lower capacity to adapt (Thomas and Twyman, 2005). People in these countries are particularly vulnerable and population growth is an added challenge that exacerbates pressures on natural resources and poverty. Africa's population has been projected to more than double from 0.9 to 2 billion from 2005 to 2050.

Climate change and variability will have serious implications, affecting ecosystem goods and services upon which people and livestock keepers depend, thus exacerbating current development challenges (UNDP, 2008).

The Role of Livestock in Adapting to Climate Change

Changing climate and increasing climate variability are clearly going to have considerable impacts through a wide range of mechanisms on people whose livelihoods depend at least in part on livestock. Livestock are one of the key coping mechanisms in variable environments and as this variability increases they will become more important. There is a growing body of literature on the role of livestock in providing pathways out of poverty for poor households. For many poor people, the loss of livestock assets means collapsing into chronic poverty with long-term effects on their livelihoods or ability to climb up the poverty ladder. Furthermore, other studies showed that diversification of income sources through livestock farming can be a key strategy for escaping poverty (Krishna et al., 2004; and Kristjanson et al., 2004). The role that livestock have been shown to play in coping with risk and providing livelihood options are generally very essential and will continue to be a key sector. However there is an imbalance between the crop and livestock sector research. This is an imbalance that needs to be verified by research evidences and some of the CGIAR centers are already addressing this imbalance. For instance, ILRI and CIAT are undertaking work to identify much more specifically those areas of Africa where changing climate and climate variability are likely to make any crop production increasingly difficult. In such places, livestock keeping is likely to be one viable option for maintaining household food security in the face of increasing climate variability.

SUMMARY AND CONCLUSION

The reviewed literatures evidences that, climate change and variability are long-term environmental issues and pose serious threats to vulnerable and impoverished people worldwide. In this context, governments, the scientific community, development organizations and the private sector need to increasingly recognize that the ecosystems such as dry lands, grasslands and rangelands deserve appropriate attention, not only for their large extent, widespread degradation and limited resilience to drought and desertification, but also for their potential capacity to sequester and store carbon in soils while supporting sustainable pastoral and agropastoral livelihoods for millions of people. Furthermore, grassland management is becoming among most important agricultural sustainability activities for climate change adaptation and mitigation. Ethiopia's economy is highly dependent on agriculture. Livestock constitutes one of the largest components of the agricultural sector. Ethiopia is the primary producer and export of livestock products in Africa. However, climate change has far reaching consequences on livestock production potential of the country and it is a huge treat for many people's who are directly depending on livestock production. It is also a treat for the export capacity of the country. Therefore, technology supported livestock management practices should be implemented in order to minimize its effects on livestock production of the country. There is a also a need to harness the full potential contribution of livestock in countries development that will satisfy current and future human needs while conserving the natural resource of the country. Several and diversified opportunities exist to mitigate environmental damage and to utilize the huge potential that livestock contribute. Hence, the role of livestock in semiarid ecosystems towards the efforts to ensure food security and food self sufficiency in the production system is essential.

Therefore, this need be supported by demand devein action research to enhance the adaption and mitigation capacity of the semiarid ecosystems of the country. The implementation of the enabling policy of the country towards mitigation such as watershed systems conservation activities need be sustained in coming years in a better and enhanced way. This has cascading effects towards crop production, forage availability in semiarid lowlands and enhance carbon sequestration of grasslands. Policies must recognize the diverse benefits, including the environmental benefits of keeping livestock and the dynamic nature of semi-arid ecosystems thereby its impact on agricultural production in general and livestock sector specifically.

ACKNOWLEDGEMENTS

The authors acknowledge Jimma University, College of Agriculture and Veterinary medicine for availing the ICT facilities. The authors of the reviewed articles and cited in this review article are also dully acknowledged for their valuable resources and information in published materials.

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