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A Review on Causes of Climate Change: Challenges and Opportunities for Livestock Production in the Tropics

Girma Defar

Department of Animal & Range Sciences, College of Agriculture & Natural Resource, Madawalabu University, Bale-Robe, Ethiopia

Email address:
gdefaru@gmail.com, girmad16@yahoo.com

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Abstract: The growth in demand for livestock products will probably still play a dominant role over the next decades and lead to a net increase in the area dedicated to livestock, despite the intensification trend. It is estimated that the world food requirement by the year 2050 will be double that of 2010. A significant part of this requirement will emanate from the developing countries, on account of increased human populations, disposable incomes and urbanization. To the contrary, climate change poses the threat of serious social upheaval, population displacement; economic hardships and environmental degradation were it has been caused both by natural phenomenon and man-made activities. Livestock established their current geographic ranges through long-term adaptation to seasonal climate patterns. Anthropogenic climate change is likely to alter those seasonal patterns on a timescale far more rapid than has occurred naturally over past millennia. It is this rapid rate of climate change which challenges the natural adaptive capacity of livestock. The faster the changes, the greater will be the risk of damage exceeding ability to cope with the consequences. Significant negative consequences including loss of livestock through heat stress, loss of land to agricultural encroachment, an increase in frequency of flooding and the spread of human and livestock diseases were some the problems. Since, livestock are an irreplaceable source of livelihoods for the poor community and there is a chance to give attention for the sector. Because, it is the fastest growing sector and in some countries accounts for 80% of the GDP, in particular in dry lands. As to livestock products, about two-thirds of the increased demand needs to be met by improving the production efficiency of feeds (forages and concentrates). Balanced nutrition contributes to improve animal output as well as to reduce both the cost of production and the emission of greenhouse gases per animal. Ultimately large scale implementation of such programs can help to improve the productivity of livestock in developing countries. Therefore, livestock management system-efficient and affordable adaptation practices have to be developed for producers not able to buy expensive adaptation technologies.

Keywords: Climate Change, Challenges, Greenhouse gas, Livestock Production, Opportunities

1. Introduction

Evidence from the Intergovernmental Panel on Climate Change [1] is now overwhelmingly convincing that climate change is real, worse and the poor are vulnerable people. Climate change poses the threat of serious social upheaval, displacement, economic hardships and environmental degradation [2; 3]. The climatic factors include warmer temperatures, altered patterns of precipitation, increased frequency and severity of extreme climatic events and rising sea levels [1]. This is a limiting factor for animal and plant distribution [4]. Climate change has been the planet's biggest threat, affecting land and water availability, crop yields and periodically causing food crises [5]. Reports from [6] indicated climate change as one of the factors affecting rural poverty. While climate change is a global phenomenon, its negative impacts more severely felt by poor people in developing countries who rely on natural resource bases for their livelihood. Here, livestock keeping is amongst the most climate-sensitive economic sectors and rural poor communities are more exposed to the effects of climate change [1]. Thus, the ongoing damage to the environment is seriously affecting the economic sectors of food supplies like crop and livestock which are critical sources of livelihoods for the poor.

Livestock contribute 40% of the global value of

agricultural output and support the livelihoods food security of a billion people [7]. The livestock sector is one of the fastest growing parts of the agricultural economy, driven by population growth, urbanization and income growth in developing countries are fueling a massive global increase in demand for food of animal origin. The growth and transformation of the sector offer opportunities for agricultural development, poverty reduction and food security gains. The resulting demand comes from changes in the diets of billions of people and could provide income growth opportunities for many rural poor [8].

The natural greenhouse gas (GHG) effect results from the natural presence of GHGs such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) in the atmosphere. In addition to these ground GHG, human beings have been increasing GHG concentrations, principally in the form of CO_2, N_2O and CH_4 through industrial activity and agriculture. It is this enhanced GHG effect which is primarily responsible for anthropogenic climate change and a challenge to livestock production [9]. Study by [10] on the impact of climate change on future livestock agriculture examines how much agriculture in developing countries will be hurt by climate change scenarios. How developing countries badly affected depends on the climate change and can endure the impact. Therefore, the objective the paper is to review causes of climate change, its challenges and opportunities to livestock production system.

People's View of Climate Change: For a while, people did not believe the earth's temperature was rising, but now everyone accepts that climate change is real. The fourth assessment report of the [1] leaves no doubt that the Earth's climate is changing largely as a result of human activity and the last 60 years were the warmest in the last 1000 years. Many people think global warming means *human-induced* temperature change on the planet. However, global warming is just one aspect of climate change and global cooling is another. Climate change is caused both by natural phenomenon and man-made activity [11; 12].

Definition of Climate Change: Climate change is a change of climate that attributed directly or indirectly to human activity that alters the composition of the global atmosphere and in addition to natural climate variability observed over comparable time periods [13]. It refers to changes in the total of attributes that define climate (surface temperatures, precipitation patterns, winds, ocean currents) and other measures of the earth's climate [9]. The author viewed climate change as of two components, one is anthropogenic in origin that coincides with the past industrial periods and the other is natural.

2. Causes of Climate Change

There are different causes of climate change to the planet. Natural factors such as solar variability, volcanic dust levels, internal variability (geological changes); human factors (industry and agriculture); GHGs emissions (CO_2 from fossil fuels, CH_4 from farm animal dung and rice paddies, N_2O from vehicles); Aerosols, Ozone depletion and land use change [13] were the main contributors. The increase in atmospheric CO_2 concentrations together with emission of CO_2, volatile organic compounds, CH_4 and halogenated compounds by industries destroy the stratospheric ozone layer and increase the global warming [14]. Water vapor, CO_2, CH_4, N_2O and Ozone (O_3) are among others that partly trap the reflected radiation to warm the surface temperature.

Indicators of Climate Change

Climate change refers to statistical changes of weather over time and can include long-term changes in rainfall, wind, temperature and other patterns. Evidences indicated that global mean temperatures have increased by about 0.6°C over the 20th century [15]. A portion of solar radiation reaching earth's surface is scattered or reflected by clouds, aerosols, dust and other particles. Radiation reaching the planet is partly absorbed, causing the earth to emit thermal radiation and part of the radiation is reflected back to the atmosphere. Human activities have contributed to an increased accumulation of radioactively active gases [1]. Global surface temperature increased about 0.3-0.6°C during the 20th century [16; 2]. Between the late 18th century and 1994, CO_2 concentration has increased from 280 to 358 ppm, which is an increase of nearly 30%. During this period, concentration of N_2O has increased by 145% and CH_4 by 15%. The global air temperature from the pre-industrial era to the present time has increased by 0.76°C and the growth rate has progressively accelerated and where, 11 of the last 12 years rank among the warmest years since 1850 [17; 18].

Table 1. *Summary of changes in earth's atmosphere climate attributes and biophysical systems.*

	Indicators	Observed Changes
	Concentration indicators	
1	Atmospheric CO_2	280 ppm during (1000-1750) to 380 ppm in year 2000
2	Atmospheric CH_4	700 ppb during (1000-1750) to 1,750 ppb in year 2000
3	Atmospheric N_2O	270 ppb during (1000-1750) to 316 ppb in year 2000
4	Atmospheric HFC, PFC, SF6	Increased globally over the last 50 years
	Weather indicators	
1	Global mean surface temperature	Increased by 0.6±0.2°cover the 20th century
2	Northern hemisphere temperature	Increased over 20th century & 1990s were warmest decade
3	Cold or frost days	Decreased for nearly all land areas during 20th century
4	Heavy precipitation events	Increased at mid and high northern latitudes
5	Frequency & severity of drought	Increased summer drying & associated incidence of drought; in parts of Asia & Africa, frequency & intensity have been observed to increase in recent decades.
	Biological & physical indicators	

Indicators		Observed Changes
1	Global mean sea level	Increased at a rate of 1-2mm during 20th century
2	Arctic sea-ice extent & thickness	Thinned by 40% in recent decades
3	Snow cover	Decreased by 10% since global observations become available from satellites in the 1960s.
4	El Nino events	Become more frequent, persistent & intense during the last 20-30 years compared to the previous 100 years.
5	Growing season	Lengthened by about 1-4 days per decade during the last 40 years in the northern hemisphere.
6	Plant & animal ranges	Shifted poleward & up elevation for plants, birds, insects etc
7	Breeding, flowering & migration	Earlier flowering, earlier bird arrival, earlier date of breeding season & earlier emergency of insects.

Source: [19]

Climate changes due to anthropogenic impact on the earth's climate include warmer surface temperatures, shifting patterns of rainfall, prolonged drought, rising sea levels and extreme meteorological conditions including flooding and intense tropical cyclones. These changes are likely to have profound impacts on ecosystems, human health, water resources, livestock agriculture and others [9].

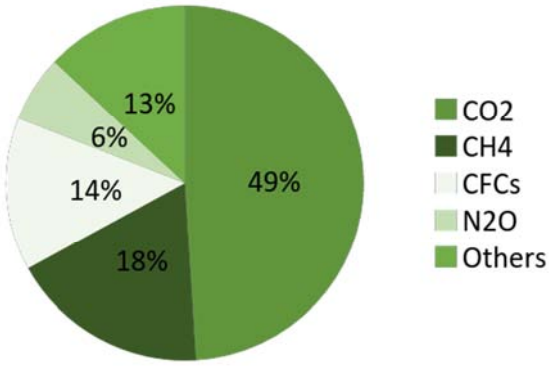
Source: [19]

Figure 1. *Climate change indicators.*

Contribution of Human Activities

Anthropogenic climate change has recently become a well-established fact and the resulting impact on the environment is already being observed. Recent projections suggest that average temperature could increase by1.4-5.8°C by 2100 [20]. Most climate scientists agree that the main cause of global warming is human activity. Driving your car, using electricity in your house and using aerosol products all contribute to GHGs. Trees help reduce GHGs and produce oxygen. However, right now, the forests were being destroyed at an unprecedented rate [21]. Every second we cut down one and a half acres of forest. It is estimated that given the current rate of destruction, all the rainforests will be gone within 40 years [11].

The [18] considered six gases: CO_2, CH_4, N_2O, hydro fluorocarbons (HFCs), per fluorocarbons (PFCs) and Sulphur hexafluoride (SF6) as having high global warming potential where CO_2, CH_4 and N_2O occur naturally in the atmosphere and are being added continuously. Therefore, their concentration is increasing due to human activities. The other three gases are added due to industrial activities in small quantities, and sufficient to increase global warming substantially as they have very high global warming potential in comparison to CO_2 [19].



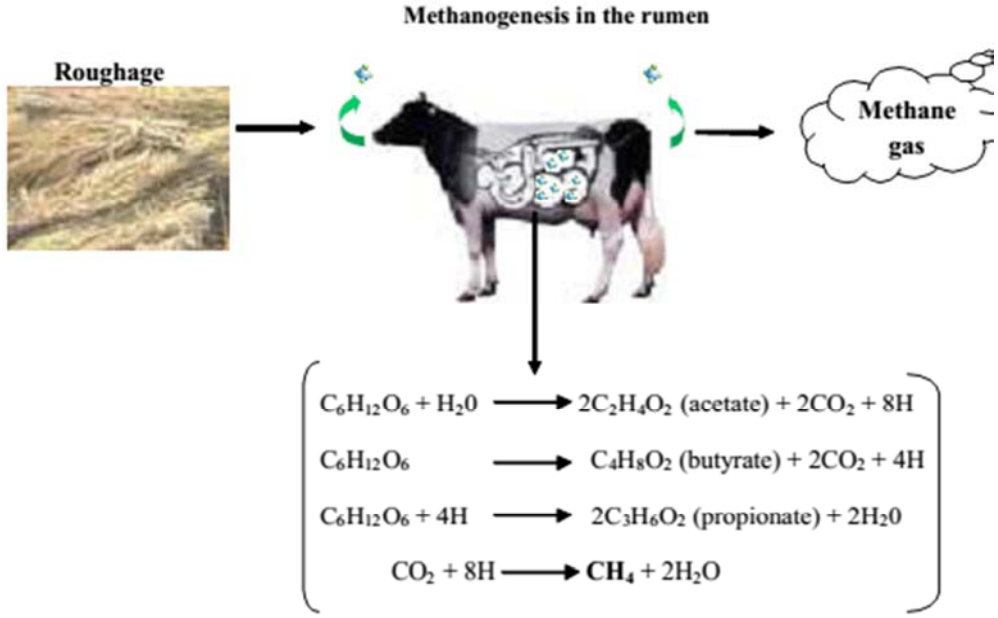
Source: [22]

Figure 2. *Contributions (%) of greenhouse gas to atmospheric warming.*

Livestock Contribution to Climate Change

The FAO predicts that between 2001 and 2050, global meat and milk consumption will approximately double. At present, nearly 60 billion animals a year are used globally to produce meat, milk and eggs and it becomes rise to 120 billion by 2050. Such a marked upsurge would have an overwhelming impact on climate change and the environment [23; 24]. Livestock production was responsible for 18% of global GHG emissions from all human activities, measured in CO_2-equivalent. This was a higher share than transport that accounts 14% of global GHG emissions [24; 6]. Animal agriculture emits GHG at various levels of the food chain: feed crops and pasture (N_2O and NH_3); enteric fermentation (CH_4); manure (CH_4, NH_3 and N_2O). Ruminants' enteric fermentation and emissions from manure represent the bulk of emissions; whereas manure management and feed production represent the bulk of emissions from monogastrics [25].

Livestock production is one of the main contributors to the emission of GHGs and thus has a potential impact on climate change. Recent estimates concerning animal agriculture's share of total global GHG emissions range mainly between 10-25% [24; 26; 27; 28]. According to [24] and [9], emissions from livestock constitute nearly 80% of all agricultural emissions. The livestock production system contributes to global climate change directly through production of GHGs emissions [28] and indirectly, through destruction of biodiversity and degradation of land. In livestock system, there are three main direct sources of the GHG emissions: enteric fermentation, manure and feed production [29]. While, indirect sources of GHGs are changes in land use and deforestation. Additionally, slaughtering, processing and transportation of products cause emissions related to use of fossil fuel and infrastructure development [9].

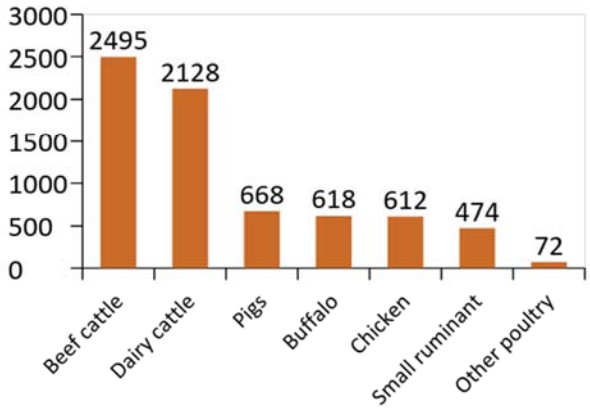


Source: [30]

Figure 3. *Ruminants GHG emission processes during digestion and metabolism.*

Relative to ruminants, monogastrics animals are minor emitters of GHG. The [31] assumes enteric CH_4 emission factors for pigs at about 1.2-2.8 % of the emission factors for cattle (1.5) vs 53 (beef or growing cattle) or 128 kg CH_4/head per year. Recent estimates place GHG emissions from pigs at about 9.5 % of the total emissions from livestock [32]. According to this author, contribution of poultry to the global livestock GHG emissions is around 9.7 % (Figure 4). Domestic non-ruminant herbivore animals (horses, donkeys, mules, hinnies) produce enteric CH_4 as a result of fermentation processes in their hindgut. However, hindgut fermenters do not produce as much CH_4 per unit of fermented feed as ruminants, perhaps as a result of availability of hydrogen sinks other than CH_4 [33]. Primary digestive microorganisms (bacteria, protozoa and fungi) hydrolyze proteins, starch and plant cell wall polymers into

amino acids and sugars. These simple products are then fermented to volatile fatty acids (VFA), hydrogen and CO_2. Acetate, propionate and butyrate, which are the major VFAs, are then absorbed and utilized by the host animal. Acetate and butyrate production results in CH_4 production, while propionate formation serves as a competitive pathway for hydrogen use in the rumen [30]. Livestock activities emit considerable amounts of these gases. Direct emissions from livestock come from the respiratory process of all animals in the form of CO_2. Animal manure also emits gases such as CH_4, N_2O, NH3 and CO_2, depending on the way they are produced (solid, liquid) and managed (collection, storage, spreading) [22; 34].



Source: [32]

Figure 4. *Emissions from the global livestock sector (in Metric ton CO_2-eq) during 2005.*

Most of the world's animal production is carried out in industrial systems that make very heavy demands on natural resources of land and water in order to grow feed-crops for farm animals. Industrial animal production causes widespread pollution from animal manure, use of fertilizer, pesticides and herbicides. The FAO reported, industrial animal production systems are increasing at six times the rate of traditional mixed farming systems and twice the rate of grazing system. Today, the livestock sector emerges as one of the top two or three most significant contributors to the serious environmental problems [24]. This includes deforestation, desertification, excretion of polluting nutrients, diverting food to feed and emission of GHGs [35]. The raising of livestock results in the emission of CH_4 from enteric fermentation and N_2O from excreted nitrogen and from chemical nitrogenous fertilizers used to produce feed for animals packed into “landless” Concentrated Animal Feeding Operations (CAFOs) [36; 35]. On the other hand, manure from livestock is important material to keep soil fertility sustainably for crop production [12].

Source: [37]

Figure 5. *Feedlots covered with accumulation of manure.*

3. Challenges of Climate Change on Livestock Production

Impact of Climate Change on Livestock Production

Livestock is one of the most important livelihood production systems worldwide particularly in developing countries. It has been shown that livestock productivity leads to a greater income factor particularly among poor households [38; 39] such as those in pastoral lands. Livestock established their current geographic ranges through long-term adaptation to seasonal climate patterns. However, anthropogenic climate changes likely to alter those seasonal patterns on a timescale far more rapid than has occurred naturally over past millennia. It is this rapid rate of climate change which challenges the natural adaptive capacity of livestock [40].

In pastoral, agro-pastoral and mixed systems, livestock are key assets for poor people, providing multiple economic, social and risk management functions in tropical countries. The impacts that climate change will bring about are expected to exacerbate the vulnerability of livestock systems and to reinforce existing factors that affects livestock production because of population and economic growth, increased demand for food livestock products [41] and increased conflict over scarce resources. For rural communities losing livestock assets might lead to the collapse into chronic poverty with long-term effects on their livelihood. The other direct effects from climate change is

higher temperatures and rainfall patterns changes, translating in an increased spread of existing vector-borne diseases and macro parasites of animals and the emergence and spread of new diseases [29; 42]. Additionally, extensive livestock systems are more susceptible to changes in the severity and distribution of diseases and parasites [20].

The indirect effects were brought by changes in feed resources linked to the carrying capacity, buffering abilities of ecosystems, increased desertification processes, increased scarcity of water resources and lower production. Further effects will be linked to the expected potential shortage of feed due to rapid increase in production competition between food, feed, fuel and land use systems [43].

Sources: [44; 45]

Figure 6. *Impact of drought and climate change on livestock production system.*

Recent changes in climate, especially warmer regional temperature have already had significant impacts on biodiversity and ecosystems, especially in dryland environments. Where, climate change is likely to have a significant impact on the environment. The faster the changes, the greater will be the risk of damage exceeding ability to cope with the consequences. As a result, many ecosystems decline or become fragmented and individual species could become extinct [19; 46; 25]. Significant negative consequences including loss of livestock and land to agricultural encroachment as the rise in rainfall raises the productive potential of arid areas, an increase in frequency of flooding and the spread of human and livestock diseases that thrive during the wet season [47].

Consequences of Climate Change on Livestock Production

Not only, livestock are contributors to global climate change, but also are victim of the situation. Typical migrations involve regular movement between dry and wet season grazing areas become sensitive to climate change. The impact of climate change on these systems is uncertain, but compromised by climate change in the presence of additional land use pressures [15]. There is a high probability that climate change will be accompanied by resource degradation due to increased drought and desertification. Coupled to the rapidly rising population growth in developing countries, this resource degradation could lead to increased competition for the scarce resources and heightened resource scarcity which then leads to declining livestock production, the mainstay of most economies of developing countries [15, 48]. Additionally, climate change will create new environmental conflict hotspot that leads to significant increase in national and international conflicts over shared resources, such as water and land [13].

The other issue is that, climate changes result in increased demand for H_2O and energy for livestock sector. However, under climate change scenarios, H_2O will become scarce and its availability less predictable. Consequently, heat stress adversely affects livestock by reducing appetite, production, fertility and increasing mortality rates. This is particularly concerning as in some cases long-term single-trait selection for yield has given rise to animals with lower heat tolerance [49]. Moreover, climate change will have far-reaching consequences for dairy, meat and wool production through impacts on grass and rangeland productivity. Heat stress on animals will reduce the rate of animal feed intake and causes poor growth performance [50]. Lack of H_2O and increased frequency of drought in certain countries cause a loss of resources. Consequently, it will exacerbate existing food insecurity and conflict over scarce resources [41].

Table 2. *Summaries of direct and indirect impacts of climate change on livestock.*

	Grazing system	**Non-grazing system**
Direct Impact	-Increased frequency of extreme weather events -Increased frequency & magnitude of drought & floods -Productivity losses due to temperature increase -Change in H_2O availability	-Change in H_2O availability (may increase or decrease, according to region) -Increased frequency of extreme weather events
Indirect Impact	Agro-ecological changes leading to: -Alteration of fodder quantity and quality -Changes in host–pathogen interactions & increased incidence -Disease epidemics (emerging)	-Increased resource prices (feed, H_2O and energy) -Disease epidemics (emerging) -Increased cost of animal housing

Source: [7]

Many of climate change predictions suggest that even small changes in temperature will be sufficient to have a relatively large effect on beef cattle operations that potentially lead to protein deficiency or other health issues. In contrast, small farmers who can switch to sheep and goats may not be as vulnerable to higher temperatures compared to large farmers that cannot make this switch. In these circumstances, small farmers in Africa are better to adapt to climate change more than their larger modern counterparts [6]. In terms of farm size, small farmers and large farmers responded to climate change differently. Small farmers are diversified, relying on dairy cattle, goats, sheep and chickens. Large farmers specialize in dairy and beef cattle. As a result of climate change, large farmers shift away from beef cattle and chickens in favor of dairy, sheep and goats. Owners of commercial livestock farms are better able to adapt to warming or precipitation increases by switching to heat tolerant animals and crops.

Sources: [1; 13]

Figure 7. *Cattle died from lack of feed and water.*

4. Opportunities for Livestock Production

Economic Contribution of Livestock

Livestock is a large contributor to agricultural GDP and many livelihoods depend on livestock worldwide and in particular in developing countries. Moreover, different livestock production systems have their specific environmental effects and not all systems contribute to the problems to the same extent. Therefore, in trying to address climate change, it is crucial to link technologies and policies to specific livestock production systems [51].

Growth in livestock sector has consistently exceeded that of the crop sector. The total demand for animal products in developing countries is expected to more than double by 2030 [52]. Additionally, livestock are an irreplaceable source of livelihoods for the poor and there is a chance to give attention for the sector. It is the fastest growing sector and accounts for 80% of the GDP in some countries, particularly in dry lands. The 70% of the 880 million rural poor people living below poverty standard are dependent on livestock for their livelihoods and subsequent food security [53]. Fueled by a growing population, rising income and urbanization; demand for animal products is burgeoning in the developing world: per capita consumption of meat rose from 15 kg in 1982 to 28 kg in 2002 and is expected to reach 37 kg by 2030 [52]. The pace of dietary change accelerates as countries become richer and populations become increasingly urbanized. Urbanization is accompanied by changes in habitual food consumption patterns and dramatic lifestyle changes. However, the livestock production is undergoing a complex process of technical and geographical change, which is shifting the balance of environmental problems that the sector causes [25].

Increasing international trade as well as the rise of large retailers and integrated food chains are other drivers of change in the livestock sector. More precisely, they influence the relative competitiveness of producers and production systems in supplying the rising demand for animal derived foods. Livestock production traded across international borders has increased from 4% in the early 1980s to approximately 10% at the present time. Developing countries are among the top 20 exporters and importers in value terms [23; 52].

Sources: [44]

Figure 8. *Increased herding of small ruminants.*

Per Capita Income

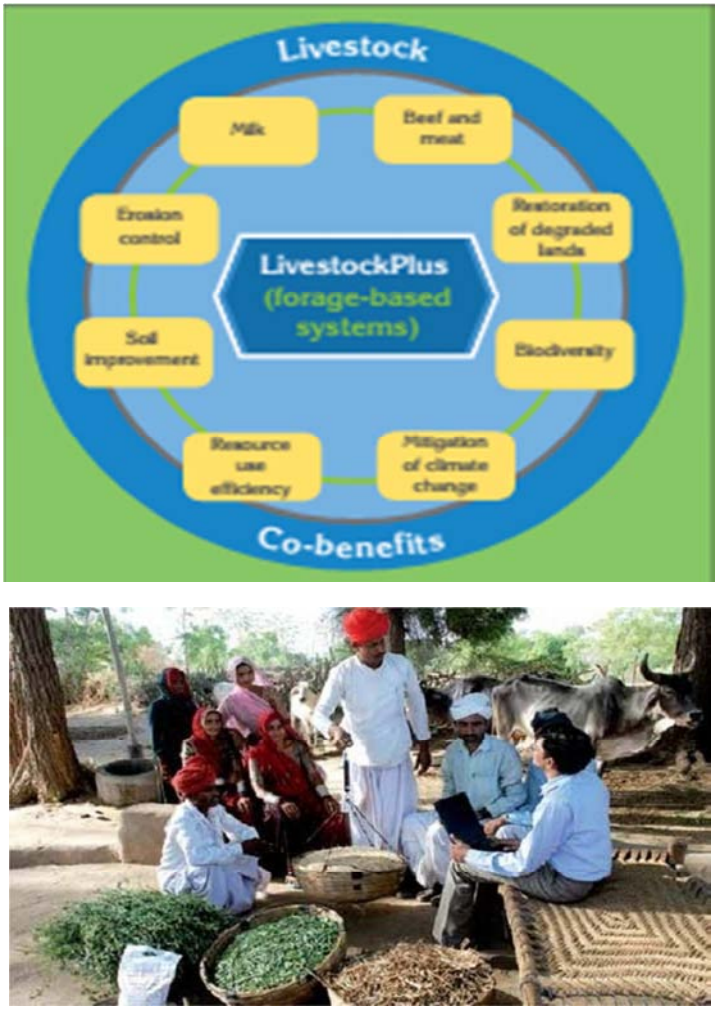
The projected growth in annual income, urbanization and growth of the human population in developing countries suggests the future demand for animal products will increase substantially. As per FAO's prediction, between 2001-2050 global meat and milk consumption will approximately double. At present, nearly 60 billion animals a year are used globally to produce meat, milk and eggs. This figure could rise to 120 billion by 2050 [23; 24]. By 2050 the global demand for dairy and meat is projected to increase by 74% and 58% respectively and large part of this demand will originate from developing countries [54]. Thus, following the increase in livestock population, annual demand for coarse

grains of animal feed also projected to increase by 553 million tones. This corresponds approximately to half of the total increase in demand [7] to meet the future demand for the production of milk and meat. Livestock is more resistant to climate change than crops because of its mobility and access to feed [6]. Beside these, there is more technological advancement to take disease preventative measures which include avoidance of areas known to be particularly susceptible to disease, migration and hygienic practices [55].

Livestock Feed Supplementation

The practices of supplementation of livestock grazing with other feeds were common during drought [56; 55]. The investigation by ILRI using improved fodder species to increase livestock product would improve productivity and therefore resilience of both livestock and pastoralists during vulnerable periods like floods or drought [47]. According to [54], feeding balanced rations was estimated to reduce enteric CH_4 emissions by 15-20% per kg of milk produced. Large scale implementation of such programs can help improve the productivity of livestock in developing countries. Similar approaches can be adopted for conserving hay to feed animals since no long-term climate change effect on hay quality [57]. Thus, it is advisable to take in to consideration the locally available feeds and their management conditions for production objectives. To bring sustainable changes, there are a number of ways to increase the adaptation capacity of livestock producers. These are production adjustments as diversification, intensification, integration and conservation of nature and ecosystems. These adaptation measures should be on extension of good development practices. They should include access to veterinary services and prevention measures to ensure the good health of the livestock and in some case the public to reduce vulnerability by promoting the health and diversification of economic activities.

Livestock management system-efficient and affordable adaptation practices have to be developed for rural poor not able to buy expensive adaptation technologies: 1) Provision of shade and water to reduce heat stress from increased temperature. 2) Reduction of livestock numbers; lower number of more productive animals will cause more efficient production and lesser emission of GHG from livestock production. 3) Change in livestock herd composition and 4) Improved management of water resources through the introduction of simple techniques for localized irrigation accompanied with infrastructure to harvest and store rain [5].



Sources: [54]

Figure 9. *Forage based system agriculture and the concept of balanced diet feeding.*

5. Conclusions and Recommendations

Evidence from the Intergovernmental Panel on Climate Change [1] is now overwhelmingly convincing that climate change is real, that it will become worse and the poor are vulnerable people. Developing countries in tropics are dominated by tropical weather patterns which makes highly variable climate attributes under current climate scenarios. A significant increase in temperature is projected for the entire tropical region and in most areas, accompanied by a decline in annual precipitation. In semi-arid and arid zones, increased temperatures coupled with decreased and more variable precipitation were resulted in reduced livestock productivity. Large parts of the region were vulnerable to natural hazards, such as droughts and floods. An overall decrease in precipitation was added additional stress to already scarce H_2O resources which resulted in a reduction of animal feed productivity. Since livestock contribute to and are a victim of climate change, the sector can play a key role in mitigating climate change. Adoption of improved technologies, encouraged by appropriate economic incentives, can lead to reduced emissions of GHGs by livestock. The CH_4 emissions from enteric fermentation change as production systems intensify and move toward the greater use of feed and increased productivity.

Taking immediate steps to curb climate change is critical to avoid locking ourselves into the worst-case climate outcome. If we don't act now, potential economic damage could be more than present in future. Estimates of future economic damages resulting from climate change have an important impact on policy decisions being made today. Even though, reducing GHG emissions and protecting ourselves from those impacts will be costly, a failure to act to address climate change would be even more expensive. Because of the substantial commitment to climate change that is already in action, much attention needs to be given to means of adapting to it so as to limit the damage. Thus, it should be given judicious policy and institutional reforms and significant public and private investments aimed at enhancing the ability of smallholders to take advantage of the opportunities offered by growth in the livestock sector. Measures to be taken are:

-Empower farming communities to influence policy and implementation at the regional level, including the planning of climate change adaptation strategies.

-Research by food and agricultural scientists to be put in place to provide appropriate or alternative technologies.

-Science and technology development should have better understanding of the causes and impacts of climate change on livestock development of new breeds and genetic types, improved animal health, water and soil management.

-Increasing awareness of global changes and improved capacity of livestock producers to understand and deal with climatic changes and provide training on agro-ecological technologies to practices production and conservation of animal feeds.

References

[1] IPCC (2007) Climate Change 2007: Impacts, Adaptation and Vulnerability. Summary for policy makers. Cambridge University Press, Cambridge, Fourth Assessment Report.

[2] Zell R (2004) Global climate change and the emergence/re-emergence of infectious diseases. International Journal of Medical Microbiology293: 16-26.

[3] Mihir K, Sarkar Md, Rajib R, Faysal A, Ringko K, ATM Jashim U, Ananya B, Md Humayan K (2014) Climate Change and Green Technology for Enduring Agriculture. *American Journal of Agriculture and Forestry.* Vol. 2, No. 1, 2014, pp. 7-14. doi: 10.11648/j.ajaf.20140201.12.

[4] Guisan A, Zimmerman NE (2000) Predictive habitat distribution models in ecology. Ecological Modeling 135: 147-186.

[5] Battisti DS, Naylor RL (2009) Science, Vol.323. no.5911, pp.240-244.

[6] FAD (www.ifad.org) Livestock and Climate Change; Livestock thematic papers.

[7] FAO (2009) Livestock in the balance; Food and Agriculture Organization of the United Nations, http://www.fao.org/catalog/inter-e.htm

[8] Christopher D, Mark R, Henning S, Simeon E Claude C (1999) Livestock to 2020, the Next Food Revolution. Food and Agriculture, and the Environment, Discussion Paper 28.

[9] Michael E M (2009) Do Global Warming and Climate Change Represent a Serious Threat to Our Welfare and Environment? Social Philosophy and Policy Foundation, Printed in the USA.

[10] FAO (2000) A developing country perspective. Economic & social development paper, 145.

[11] Sign of climate change (2012): Global warming and climate change.

[12] Haimanot B, Atinkut A, K Bedri, Assefa K Sentayehu, Dick W (2017) Farmers' Investment on Sustainable Agricultural Practices: Evidence from Amhara Region, Ethiopia. *American Journal of Life Sciences.* Vol. 5, No. 2, 2017, pp. 38-45. doi: 10.11648/j.ajls.20170502.11.

[13] ESAFF (2010) Sharing Experiences in Climate Change adaptation in Eastern and Southern Africa. Eastern and Southern African Small Scale Farmers Forum. Colline Hotel, Mukono, Uganda.

[14] WHO (World Health Organization) (2002) Reducing risks, promoting healthy life. Geneva, Switzerland: world health report, 192-197.

[15] Nkomo J C, Nyong A O, Kulindwa K (2006) The impact of climate change in Africa. The Stern Review on the Economics of Climate Change.

[16] IPCC (1996) Climate Change 1995; the Science of Climate Change. Houghton JT, Meira Filho LG, Callander BA, Harris N, Kattenberg A, Maskell K (Eds.), Contribution of Working Group I to the 2nd Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

[17] Stone DA (2008) Predicted climate changes for the years to come and implications for disease impact studies. In: De La Rocque S, Hendrickx G, Morand S (Eds.) Climate Change: Impact on the Epidemiology and Control of Animal Diseases. World Organization for Animal Health (OIE), Paris. Sci. Tech. Rev. 27 (2), 309-317.

[18] Epstein PR (2004) Climate change and public health emerging infectious diseases. In: Encyclopedia of Energy I: 381-392.

[19] IPCC (2001) Climate change synthesis report; Impacts, adaptation and vulnerability. IPCC 3rd Assessment Report Summery for Policy Makers. Cambridge University Press.

[20] UNFCCC (United Nation Framework Convention on Climate Change) (2005) Inventories of anthropogenic emissions by sources & removals by sinks of GHG gases. FCCC/SBI/2005/18/Add.2, 25.

[21] John H (2011) Global Warming, Climate Change and Sustainability: Challenge to Scientists, Policy Makers & Christians 4th edition, JRI Briefing Paper No 14.

[22] WRI (World Resources Institute) (2005) Navigating the numbers: Greenhouse Gas Data and International Climate Policy. World Resources Institute. http://pdf.wri.org/navigating_numbers

[23] FAO (2006) FAOSTAT: World Agriculture Information Centre, FAO, Rome. http://faostat.fao.org/default.aspx

[24] Steinfeld H (2006) Livestock's Long Shadow: Environmental issues and options. FAO, Rome. www.virtualcentre.org/en/library/key_pub/longshad/A0701E00.htm

[25] Gerber P, Wassenaar T, Rosales M, Castel V, Steinfeld H (2007) Environmental impacts of a changing livestock production: overview and discussion for a comparative assessment with other food production sectors. *FAO Fisheries Proceedings*. No. 10. Rome, pp. 37-54.

[26] Fiala N (2008) Meeting the Demand: An Estimation of Potential Future Greenhouse Gas Emissions from Meat Production. Ecological Economics 67, 412-419.

[27] UNEP (United Nations Environment Program) (2009) The environmental food crisis: The environment's role in averting future food crises. UNEP, Arendal.

[28] Gill M, Smith P, Wilkinson JM (2010) Mitigating climate change: the role of domestic livestock. Animal 4, 323-333.

[29] Dourmad J, Rigolot C, Hayo van der W (2008) Emission of Greenhouse Gas: Developing management and Animal farming systems to assist mitigation. Livestock and Global Change conference proceeding. May, 2008, Tunisia.

[30] Prasad CS (2013) Trainers' Training Programme (Skill Development). Feed Resources and Ration Balancing for Dairy Cattle. Department of Animal Husbandry, Dairying and Fisheries Ministry of Agriculture, Govt. of India, New Delhi. www.nianp.res.in

[31] IPCC (2006a) Emissions from Livestock and Manure Management. Chapter 10, In: 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4: Agriculture, Forestry and Other Land Use, pp. 10.1-10.87.

[32] Gerber P, MacLeod M, Opio C, Vellinga T, Falcucci A, Weiler V, Tempio G, Gianni G, Dietze K (2012) Greenhouse gas emissions from livestock food chains: a global assessment. Bratislava, EAAP.

[33] Jensen BB (1996) Methanogenesis in monogastrics animals. Environ. Mon. Assess. 42:99-112.

[34] NOAA (2006) National Oceanic & Atmospheric Administration. www.weather.gov

[35] Janzen H (2011) What place for livestock on a re-greening earth? Animal Feed Science and Technology, 166-167

[36] Herrero M, Gerber P, Vellinga T, Garnett T, Leip A, Opio C, Westhoek HJ, Thornton PK, Olesen J, Hutchings N, Montgomery H, Soussana JF, Steinfeld, H, McAllister TA (2011). Livestock and greenhouse gas emissions: The importance of getting the numbers right, Animal Feed Science and Technology, Vol 166-167, Pages 779-782.

[37] Country Research Development (CRD) (2011) Ethiopia: Methane Emissions from Agricultural Waste, Country Resource Assessment. Global Methane Initiative.

[38] Egeru A, MacOpiyo L, Majaliwa GJ (2012) Research Application Summary; The effect of climate variability and change on forage availability and productivity in Uganda's cattle corridor; a case study of Karamoja sub-region.

[39] Gelan A, Engida E, Carsia AS, Karugia J (2011) Integrating livestock into the CAADP framework: Policy analysis using a dynamic computable general equilibrium model for Ethiopia. Conference Paper: Increasing agricultural productivity and enhancing food security in Africa new challenges and opportunities. Addis Ababa, Ethiopia.

[40] Emanuel K (2005) Increasing Destructiveness of Tropical Cyclones over the Past 30 Years, Nature 436: 686-688.

[41] Cohen RD, Sykes CD, Wheaton EE, Stevens JP (2002) Evaluation of the effects of Climate Change on Forage and Livestock Production and Assessment of Adaptation Strategies on the Canadian Prairies. University of Saskatchewan, Saskatoon.

[42] FAO (2008) Climate-related Transboundary Pests and Diseases Including Relevant Aquatic Species. Expertise meeting, FAO. February, 2008.

[43] Thornton P, Herrero M (2008) Climate Change, Vulnerability, and Livestock Keepers: Challenges for Poverty Alleviation. In: Livestock and Global Climate Change conference proceeding, May 2008, Tunisia.

[44] Yohannes G, Wolfgang B, Ann W B (2010) Emerging responses to climate change in pastoral systems. www.agridea-international.ch/RDN

[45] Abebe T (2007) Climate Change National Adaptation Program of Action (Napa) of Ethiopia. National Meteorological Agency, Addis Ababa, Ethiopia.

[46] IPCC (2001a) Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the 3rd Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

[47] Oxfam (2008) Survival of the fittest; Pastoralism and climate change in East Africa. Oxfam Briefing Paper, Oxfam International, August, 2008.

[48] Homer T F (1994) Environmental Scarcities and violent conflict: Evidence from cases. International Security, 19(1):5-40.

[49] FAO (2011) Coping with Climate Change; the Importance of Genetic Resources for Food Security. Commission on genetic resources for food and agriculture. www.fao.org/nr/cgrfa

[50] Rowlinson P (2008) Adapting Livestock Production Systems to Climate Change Temperate Zones. Livestock and Global Change conference proceeding. May 2008, Tunisia.

[51] Jeannette van de S, Markos T (2012) Livestock and Climate Change in the Near East Region; Measures to adapt to and mitigate climate change. FAO, Regional Office for the Near East.

[52] FAO (2003) World agriculture: towards 2015/2030. FAO, Rome, Italy.

[53] Neely C, Bunning S (2008) Review of Evidence on Dry Land Pastoral Systems and Climate Change; Implications and opportunities for mitigation and adaptation. FAO-NRL Working Paper. Rome, Italy. Sally.Bunning@fao.org

[54] FAO (2012) Balanced feeding for improving livestock productivity: Increase in milk production and nutrient use efficiency and decrease in methane emission, by M.R. Garg. FAO Animal Production and Health Paper No. 173. Rome, Italy.

[55] Muhereza FE (2003) An Analysis of Factors Affecting Livestock Market Access in Nakasongola, Kotido and Sembabule Districts. A Report to Oxfam GB.

[56] WISP (World Initiative for Sustainable Pastoralism) (2006) A global initiative to promote sustainable pastoralism as an sustainable pastoralism as an effective and efficient land use and effective and production system for the dry lands the world. www.iucn.org/wisp

[57] Gihan M, Fabienne T, Guilhem B, Marina G, Didier T, François C (2016) A long-term data sequence (1960-2013) to Analyze the Sustainability of Hay Quality in Irrigated Permanent Grasslands Under Climate Change. American Journal of Agriculture & Forestry. Vol. 4, No. 6, pp.140-151. doi: 10.11648/j.ajaf.20160406.11