Chapter 13
Sustaining Livestock Production Under the Changing Climate: Africa Scenario for Nigeria Resilience and Adaptation Actions

Akeem Babatunde Sikiru, Silpa Mullakkalparambil Velayyudhan, Mini R. Reshma Nair, Sejian Veerasamy, and John Olayinka Makinde

Abstract Climate change is a global millennial challenge affecting humans in all facets of life. In Africa, livestock production is one of the sectors most affected by climate change because livestock production is extensive, smallholders operated, and low external input operation. The paper gives an insight for sustaining Africa's livestock production in resilience to climate change. The study obtained secondary meteorological and livestock production data for the continent over forty years, and the data were analysed for the understanding of changes over the years and prediction of future scenario. The result revealed that by the year 2050, the average surface temperature in Africa will rise by 2.2 °C, while the livestock population will continue to grow. The result also indicated that the scenario revealed in the study is an Africa-wide condition, but the West Africa subregion of Africa could be the most vulnerable to the climate change impact of temperature rise. The study also indicated that small ruminant animals including sheep and goats could be more

A. B. Sikiru (✉)
Department of Animal Production, Federal University of Technology, Minna, Niger 920211, Nigeria
e-mail: akeembaba01@gmail.com

S. M. Velayyudhan · M. R. R. Nair · S. Veerasamy
ICAR-National Institute of Animal Nutrition and Physiology, Adugodi, Hosur Road, Bangalore, Karnataka 560030, India

S. M. Velayyudhan
Institute of Animal Breeding and Genetics, Justus-Liebig-Universität Gießen, 35390 Giessen, Germany

M. R. R. Nair
Academy of Climate Change Education and Research, Kerala Agricultural University, Vellanikkara, Thrissur, Kerala 680656, India

A. B. Sikiru
Federal University of Agriculture, Zuru 872101, Kebbi, Nigeria

J. O. Makinde
Federal University Gashua, Gashua 671105, Yobe, Nigeria

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tolerant to the future changing climate scenarios in Africa compared with other livestock because their population keeps increasing over the years despite the climate change threats. Finally, future projections of climate conditions indicated that Africa could be a hub of future livestock production, but climate conditions would affect optimal animal performances and production. Therefore, several strategies to sustain livestock production were suggested as resilient means for adapting to the changing climate conditions.

Keywords Adaptation · Africa · Amelioration · Climate · Heat stress · Livestock · Resilience

Introduction

The rising human population has led to an increase in global demand for livestock and agricultural products (Naqvi and Sejian 2011). However, erratic climatic conditions have posed a threat across the world—a situation which necessitated the convocation of the Intergovernmental Panel on Climate Change (IPCC), which reported that the mean global surface temperature in 2100 could increase between 0.3 and 4.8 °C higher (IPCC 2014a). This rising temperature is a matter of concern, especially in Africa, which has been identified as the most vulnerable region to climate change in the world (IPCC 2014b). There are varying risk factors of climate which have been assessed and found to have a potential negative impact on the Africa, such as the reduction in water resources, reduced crop productivity, and increased incidence of vector-borne and waterborne diseases; these are critical to livestock production and its consequence on the environment (IPCC 2014b).

Livestock production contributes immensely to the Africa economy and contributing to the standard of living of poor and marginal farmers while ensuring food security (AU-IBAR 2015). The sector was also reported to be contributing between 30 and 80% to the entire agricultural gross domestic product (GDP) of most countries in the sub-Saharan Africa region (AU-IBAR 2015). Therefore, the livestock production sector could be confidently described as a high potential for delivering sustainable development goals and socio-economic transformation in Africa, according to the release of the African Union (AU) since about a decade ago (AU 2014). This has placed African policymakers and stakeholders in the increasing awareness creation about livestock production as well as exploiting the livestock production to meet up the rising demand for protein and promotion of economic growth (AU-IBAR 2015).

In attestation of the foregoing facts, Pica-Ciamarra et al. (2013) stated that the demand for livestock and their products are expected to increase two to eightfold by 2050 in Africa. Meanwhile, based on the current issues in the livestock sector in Africa coupled with low investment and growth, meeting up with the projected demand is nearly impossible (Herrero et al. 2014). This is reflected in the yearly increase in the import of animal products to the continent, leading to a drastic increase in livestock product import bills and loss of foreign exchange (AU-IBAR 2015). These are ancillary factors to a series of negative effects on the economy, exacerbation of food insecurity, unemployment, and poor trading (Akokpari 2007).

Although Africa is a blessed continent in terms of extensive range land, water resources, and others that can boost livestock production, the climatic change challenges have always threatened the livestock production sector directly or indirectly with severe consequence on animals growth, production, and resistance to diseases (Otte et al. 2012; Yaméogo et al. 2014; AU-IBAR 2015). Therefore, overcoming the constraint of climate change is highly desirable for the Africa livestock production sector because it would help the livestock farmers to sustain production of animals to produce animal proteins for feeding the teeming growing population in the continent. Hence, in this chapter, data on climate and livestock production in Africa were analysed, and relevant information on various adverse effects of climate change on the African livestock population and production in future under climate change scenarios was reported. Furthermore, the chapter also suggested various mitigation strategies for sustainable livestock production in the face of changing climate conditions and a specific framework for resilience and adaptation in Nigeria.

Methodology

Sources of the Data

Climate Data

The monthly surface temperature data for the periods between the year 1980 and 2019 in Africa were retrieved from the database of the National Oceanic and Atmospheric Administration (NOAA) of the USA (https://www.climate.gov). While data on relative humidity were retrieved from the public datasets of the Copernicus Climate Data Store (https://cds.climate.copernicus.eu/#!/home) and the United Nations (UN) data explorer platform (http://data.un.org/Explorer.aspx?d=CLINO).

Livestock Production Data

There was a retrieval of livestock production data for Africa between 1980 and 2019 from the Food and Agriculture data (FAOSTAT 2019). The data obtained include populations of goat, sheep, and cattle; milk and meat production output from cattle and the small ruminant, respectively.

Data Analyses

The data retrieved for both the climate and livestock production were organized into ten year groups, including 1980–1989, 1990–1999, 2000–2009, and 2010–2019; and in each ten years group, a year was divided into four quarters (3 months units) giving a total of 16 quarters in the 40 year period which represented the unit time used in the analysis. The data were then subjected to descriptive statistical analysis and time series modelling using Microsoft Excel with the aim of understanding patterns of changes over the years and to identify contributions of seasonal, irregular, and trend components to the livestock production The time series model used for the study simple time series model is described by Sikiru et al. (2020). The model takes y (t) as the time series value of a parameter over a given period of time, S (t) is the seasonal component associated with the parameter changes over a given period of time, I (t) is the irregular component associated with the parameter changes over a given period of time, and T (t) is the trend component associated with the parameter changes over a given period of time (Pollock et al. 1999).

Results and Discussion

The average increase in the surface temperature recorded between 1980 and 2019 was 1.3 °C, but by the year 2050, the increase in surface temperature of Africa could increase up to 2.2 °C and this indicates that temperature increase in Africa is real and almost impossible (Fig. 13.1a–c). The relationship between increase in temperature changes, temperature-humidity index (THI), and population of livestock and products, outputs indicated an inverse relationships whereby, as the temperature and temperature-humidity index (THI) increases, there is decrease in population of the livestock in a perfect inverse relationship of $P < 0.01$ and $R^2 = 0.72$ (Fig. 13.1).

The temperature-humidity index follows similar patterns as the surface temperature changes which indicated that there could be a future increase in the THI and consequential non-favourable climate conditions for livestock production in Africa. Meanwhile, for both the temperature and THI increases, West Africa subregion is the major driver as the bulk of the increase may be found in the West Africa and these may lead to reduced livestock products supply compared with the Africa-wide average (Fig. 13.1). Finally, the projections indicated potential livestock population and production increase, West Africa could be the hub of the future production except for milk, and the climate conditions in the region are the least suitable for optimal animal performances (Fig. 13.1).

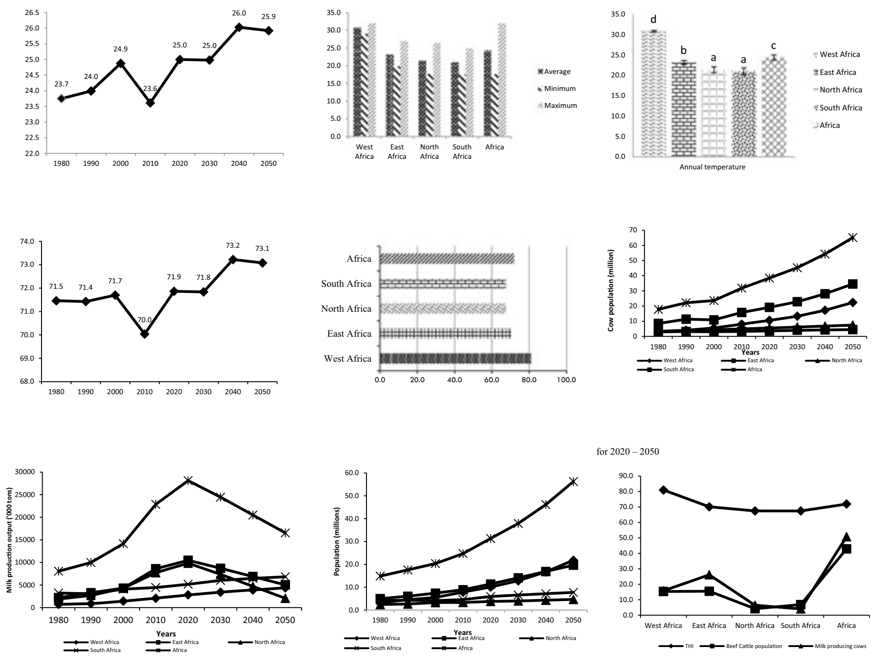

Fig. 13.1 Various consequences of climate change on African continent with specific emphasis on livestock production across the sub region. **a** Average annual recorded and projected temperature for Africa (°C), **b** Minimum and maximum projected temperature (°C) for Africa by regions 2020–2050, **c** Projected variations in regional annual temperatures (°C) for Africa 2020 to 2050, **d** Average annual calculated and projected temperature-humidity-index for Africa (°C), **e** Regional projected Temperature-Humidity-Index for Africa 2020–2050, **f** Regional populations and trends of milk producing cows distribution in Africa, **g** Regional past and future trends of milk production output ('000 tons) for Africa, **h** Regional populations and trends of cattle slaughtered for beef production in Africa, **i** Relationships between temperature-humidity-index and regional population trends of beef and milk producing cattle in Africa for 2020–2050

Discussion

Significance of Livestock Production to the African Continent

The benefits of livestock production in Africa are huge and as such, the analysed continental climate data of Africa concerning livestock population as demonstrated in this study established and increasing trend which could be hampered by climate variable specifically surface temperature and relative humidity (Fig. 13.1). These outcomes described possible consequences of climate change on livestock production in Africa and how it could compromise the significance of livestock production in Africa. In Africa, livestock production is a principal component of human survival, and it is a vital source of livelihood of people, especially in the rural areas (Raheem et al. 2019). This is because livestock farming provides multiple benefits to the farmer as a source of foods in forms of milk and meat, as a source of agricultural power where animals are used as draught in land cultivation, as a source of manure used as alternative to chemical fertilizers in crop production, and the promotion of human welfare via supply of incomes (Meltzer 1995).

In Africa, livestock production remains a source of livelihood and promotion of human well-being because animals represent reliable and affordable sources of food and resources for work and livelihood support such as transportation (Mapiye et al. 2020). In a survey data collected on 1624 households across Africa, it was reported that there is a positive correlation between livestock ownership and the nutritional status and well-being of children (Ruel et al. 2017). Similarly, investigations across Africa, spanning Nigeria in the west to Malawi in Southeast, it was revealed that livestock production could serve as an avenue for alleviating child malnutrition (Hetherington et al. 2017). Apart from benefits accrued to smallholders, livestock production also promotes commercial investment in Africa because it is a growing viable agricultural enterprise in the continent. This is driven majorly by the increasing demand for animal products, urban development, increasing population, increasing income, middle-class population growth, and changing lifestyles of young working professionals (Roessler et al. 2016).

Climate Change and Economic Consequences in the African Livestock Sector

In an economy and economic development terms, climate change could have strong negative implications for the economy of the African livestock sector; this was earlier opined in a report by Hendrix (2017). The direct impacts of climate change on animals such as heat stress, production decline, impaired reproductive efficiency, and increased incidence of animal diseases could severely affect the continent's economy since huge incomes are associated with livestock productivity (Ogenga et al. 2018). Climate change could also pose several indirect consequences like animal feed and fodder shortage, water scarcity, alarming multiplication, and spread of vectors transmitting diseases, all of which can contribute directly and indirectly to unemployment and hamper economic growth in Africa (Hopkins and Prado 2007; Thornton et al. 2009). For instance, climate change has been reported affected Sudan, a country in the Northeast Africa and projection of economic loss if unabated, could result in an approximate loss of up to 105.5 billion USD by the year 2050 (Borgomeo et al. 2018; Siddig et al. 2020).

Another indirect consequence of climate change that could negatively affect the economy is the reduction in forage yield and insufficient availability of water for animal (Escarcha et al. 2018a, b). Although these could be indirectly, it could be confounded with a reduction in revenue generation from animal sales as well as directly aggravating competition for land resources and land uses between crop farmers and livestock herders (Thornton and Herrero 2010a). This situation is the leading factor continually forcing livestock keepers to migrate in search of greener pasture and, in recent years, has created economic and security challenges. This is a concern in countries such as Nigeria, where food security is presently at the risk of food security promoted by ethnoreligious cynicism (Sikiru 2016, 2020).

The economic implications were simulated in a climate-livestock model which indicated that higher atmospheric temperature corresponds to the lower profit maximization in a livestock enterprise (Seo and Mendelsohn 2008a). In application of this model to the African scenario, it revealed that increasing temperature in Africa will continuously be a leading factor responsible for reducing production and population of cattle and chicken in Africa. However, the model proposed the possibility of sustainable production of sheep and goats despite the temperature increase. Taking all factors into account, and looking at the simulated model, climate change could cause between $9 and $12 billion loss in Africa by 2030 if current conditions are left unabated (Seo and Mendelsohn 2008b).

Climate Impacts on Livestock Production Performances and Management

The impact of climate change on livestock performances and management cannot be overlooked, and some of the possible scenarios in Africa and their potential impacts were presented in this study following an elucidation of the relationships between the increasing surface temperature, high temperature-humidity index, and livestock performances (Fig. 13.2). Changes in these climatic parameters to the high extreme levels can negatively affect livestock production and management as well as increase the risk of the vulnerability of livestock rearing communities to natural disasters such as drought (Zougmoré et al. 2016). The extreme frequencies of these parameters and their interaction with other factors have changed the livestock production systems among African livestock producers which has consequently led to loss of productivity (IPCC 2014b; Zougmoré et al. 2016).

Changing climate conditions could also affect livestock production at both the species and breed levels and in addition could differently hamper production performances in different animals and breeds (Hoffmann 2010). For example, it has been established through prediction modelling that the demand for beef and cattle and dairy compared with goats and sheep will decrease significantly because of temperature rises (Kurukulasuriya et al. 2006; Rust and Rust 2013). Meanwhile, goats and chicken as well as sheep preferred wetter agro-climatic zones over beef and dairy cattle (Seo and Mendelsohn 2006). Furthermore, livestock net revenues in Africa are observed to be highly sensitive to climate, in areas with moderate climate conditions, livestock keepers were reported to generate higher revenue and vice versa compared with livestock keepers in the harsh climates (Kurukulasuriya et al. 2006).

The direct and indirect impacts of climate change on livestock could also impair their reproductive efficiency and hence have been identified to significantly reduce the

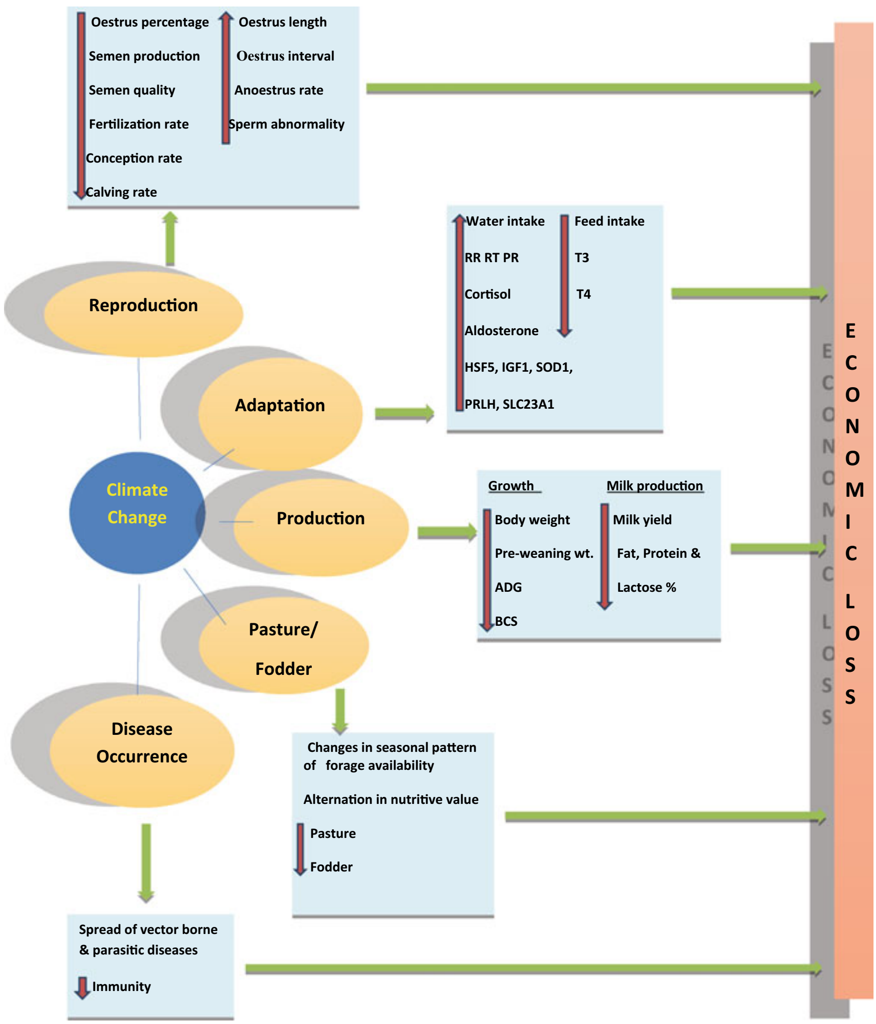

Fig. 13.2 Impacts of climate change variabilities on livestock production and management in relation to economic loss arising from poor performance characteristics of animals in Africa. The figure indicated negative effects of climate variations on decreasing reproductive performances, reducing growth, milk production and increased spread of diseases due to decreased immune competence

animal production performances in terms of fertility and reproduction outcomes (Rust and Rust 2013). The indigenous African cattle constitute the highest percentage of the meat-producing animals in Africa, and they are mainly reared on natural pastures, with their finishing custom feedlots. These animals could be severely affected by the negative effects of varying climatic conditions, and as a result, production management could be affected, leading to low animal productivity (Scholtz and Theunissen 2010; Rust and Rust 2013). This was also reported by Furstenberg and Scholtz (2008), who anticipated that global warming can lead to a 30% decline in land productivity in Africa, a situation which was identified as a consequence of the reduction in the rangelands and forests in Africa since the production of animals will become more difficult and less profitable.

In a confirmation of these possibilities, Scholtz et al. (2018) reported that the effect of climate on pre- and post-weaning performances of different breeds of cattle in South Africa was reduced due to increased summer temperature. It was also reported in the same study that there was a reduction in the average daily weight gain of the calves as a result of the heat waves increase during summer season. Similarly, Okouruwa (2015) studied the effects of heat stress on the live weight of West African Dwarf (WAD) goats in Nigeria in a study where goats were grouped into three types of housing production systems: T1 (confined to their pens throughout the day), T2 (allowed in the open yard from 8.00 am and 1.00 pm), and T3 (allowed in the open yard from 1.00 and 6.00 pm). The body weights records of the animals were obtained before and after the exposure of the animals to different housing confinement. The analysis of variance of the obtained records of weight changes of the goats indicated a significant reduction in the average body weight of the animals subjected to the open yard grazing from 1.00 and 6.00 pm which was attributed to the negative impacts of heat stress on the growth and production of the animals.

Milk production is another economic activity of livestock sector that could be adversely affected by heat stress occasioned by climate change as posited by Kekana et al. (2018). These researchers evaluated the effect of high thermal stress on milk production traits in lactating Jersey cattle reared in two communal regions of South Africa. The summer thermal-humidity index (THI) of the two regions was THI-1 (72–83: extreme caution) and THI-2 (75–87: danger). It was observed that there was a significant reduction in milk yield, urea nitrogen, fat, and protein and lactose percentage of lactating Jersey cows subjected to higher thermal stress (THI-2). In another study, Salem and Bouraoui (2009) also reported a 10% reduction in the milk yield per cow during summer heat stress conditions in Tunisia which is also within the continent of Africa. The foregoing paragraphs and projected increase in temperature and THI in Africa submitted that climatic changes could negatively affect production performances and management of animals in Africa. Also, the health of the animals could get compromised due to climate change since favourable environment for the survival of pathogens could be created to enhance the spread of vector-borne and parasitic diseases as well as reducing immunity as the underlying promoters of reduced animal productivity (Rust and Rust 2013).

Impact of Climate Change on Livestock Reproduction and Fertility

In addition to the direct and or indirect impacts of harsh climate on livestock production performances, climate change can also impact livestock reproduction and fertility. This is possible through the exertion of heat stress, which could have serious implications on animal reproduction (Sikiru et al. 2020). Changing climatic conditions could modulate the hypothalamus-hypophyseal-pituitary-ovarian axis of the animals, which could reduce the secretion of gonadotropin-releasing hormones. This could lead to complex malfunctioning of the primary reproductive hormones oestrogen, testosterone, follicle-stimulating hormone, and luteinizing hormone, thereby making the animal unproductive (Kebede 2016).

In female animals, climate change-related stress shortens the duration of receptivity for mating (Ekesbo and Gunnarsson 2018); in assisted reproductive technology practices such as artificial insemination, heat stress could induce conception failures in animals (Hansen 2014). Furthermore, elevated temperatures due to climate change could induce oestrogen malfunction and non-viability of mature follicles via modulation of the PGF-2α secretion. In addition to conception losses, heat stress could also prevent or extend an animal's returning to breeding after the lactation (Bilby et al. 2008). In male animals, when elevated temperatures cause heat stress, there is an increase in intra-testicular temperature, which could result in the production of poor quality semen, reduced secretion of reproductive hormones, and overall reproductive failures (Bhakat et al. 2014).

Being a tropical continent, Africa is more vulnerable to heat stress and exposure of livestock to extended nutritional crisis as an indirect impact of heat stress can impair endocrine functions which could cumulatively lead to reduced reproductive output (Habeeb et al. 2018). According to Gwazdauskas (1985), climate change modifies seasonal features regulating the animal's reproductive performances, and this could be linked with differences in feeds available based on season.

Impact of Climate Change on Pasture/Fodder Availability in Africa

Livestock production in Africa is primarily an extensive system wherein the animals are left in the open grasslands for grazing. It is smallholders operated especially the nomadic smallholders who actively engage in this system of rearing. These nomads often move from one location to another along with their herd in search of green pasture (McIntire et al. 1992). However, the pattern is changing in the recent years from pure nomadic pastoralism to agro-pastoralism because of the reduced availability of forages and fodder which could be attributed reduced rainfall due to climate change. This changing pattern of rainfall negatively affects pastoralists movement and migration search for greener pastures (Palmer and Bennett 2013; Hoffman and Vogel 2008).

Therefore, while responding to climate change-induced forage shortages and poor rangeland productivity, livestock keepers now engage in the production of food crops and other arable plants as a coping strategy. This has led to what could be described as a crop-livestock integration commonly found across different parts of Africa. In

Nigeria, for example, smallholders livestock keepers in the Southern and Northern Guinea Savannah agro-ecological zones are now agro-pastoralists instead of being purely pastoral nomads because they are now engaged in the cultivation of common staple crops in addition to the rearing of animals (Baiyeri et al. 2019). This practice seems to benefit principles of sustainable agriculture, but it must be stated that it has an indirect implication on food security because it shifts the focus of livestock keepers away from animal production. In relation to the feed shortage, climate change also harms soil quality, thereby affecting fodder production and yield (Swanepoel and Tshuma 2017).

Since climate change causes reduced pasture and rangeland productivity through shortage of water or precipitation, drought remains one of the greatest limitations affecting animal production within the complex of the rangeland productivity. For instance, it was reported that in South Africa, even years after a ravaging drought, which caused huge loss of pasture on extensive rangeland, close to half and quarter populations of cattle and goats were, respectively, lost in KwaZulu Natal which is a major livestock production hub in the country as results of the cumulative consequences of drought (Vetter et al. 2020).

Similarly, it was reported that in Burkina Faso which is a landlocked country where almost half of its population depends on traditional livestock production, extreme drought once led to the loss of 87% of the livestock population. This loss was attributed to the non-availability of feed resources from both the natural rangelands and non-availability of residues from crop processing (Traore and Owiyo 2013). The implications of this type of climate effect usually extend beyond livestock production systems as it usually affects economic conditions of the people who depend on the animals for food supply and income generation. Furthermore, while describing climate change impact on forage and fodder crop production in Nigeria, Shiawoya and Tsado (2011) identified rainfall instability as a major cause of forage and fodder shortage in Nigeria. Hence, it was concluded that to overcome the problem of climate change effects of rainfall on grassland productivity, deliberate efforts are required for the promotion of better feed resource utilization.

It could be deduced from the foregoing submissions that livestock production in Africa is climate dependent because predominant animal keepers are smallholders who solely depend on natural grassland, but unfortunately, the productivity of the natural grassland has reduced in recent years. Therefore, it becomes necessary to investigate the extent of climate impacts on feed resources used by smallholders with the adaptation of the animals as this could give a better understanding of ways to promote the optimum use of scarce available pasture/fodders.

Climate Change Effects on Livestock Disease Outbreaks in Africa

The protection of livestock against climate vulnerabilities in Africa requires evaluation of climate change impacts on the livestock disease occurrence, distribution, outbreak, and or biology of some disease vectors and related pathogenic organisms (Grace et al. 2015). This becomes highly important because livestock diseases of economic importance are threats to the sector, even in other parts of the world with stable climatic conditions and production management compared with Africa. It was reported that flooding increased prevalence and transmission of pathogenic organisms through faecal-oral routes in Great Britain (Gale et al. 2009).

Meanwhile, flooding is almost one of the most common climate change consequences ravaging African countries, and most of these locations have livestock production as their economic mainstay. A specific example of these scenarios is the Jigawa state of Nigeria, which faces huge economic losses annually due to the inevitable flood occurrence along the flood plain of the Hadejia–Nguru Wetland, where livestock production and other agricultural activities are negatively affected virtually every year (Kaugama and Ahmed 2014).

Climate change has been implicated in the outbreak of some livestock and human diseases of economic importance across Africa. In East Africa, the outbreak of the Rift Valley Fever virus has been linked with increasing temperature, which enhanced transmission of the diseases by many biting insects found in the area (Freeman et al. 2007). Similarly, climate change has been identified as a major factor promoting the existence and occurrence of trypanosomiasis in Africa. Unfortunately, the tsetse fly, which transmits the protozoa, adapts to every changing climate condition in Africa from riverside to savannah grassland (McDermott et al. 2002). This further aggravates the transmission of diseases across regions in Africa.

Furthermore, increasing temperature and relative humidity promotes the occurrence and spread of other diseases allied to livestock production such as helminthiasis caused by roundworms, tapeworms, and trematodes. Apart from these, human diseases related to livestock production are also influenced by climate change results of the change in animal and crop production practices, notable among these diseases include malaria, schistosomiasis, and lymphatic filariasis (Patz et al. 2005).

Ameliorative Strategies for Livestock Production in Response to Climate Change in Africa

Improved Livestock Management Practices for Reducing the Animal's Response to Heat Stress

The management practices for reducing heat stress in animals involve multiple approaches aimed at reducing most metabolic losses that the animal would have incurred in response to climate pressures (Sarangi 2018; Sejian et al. 2018). Therefore, the management strategies that can be adopted for livestock management should primarily aim at looking into the modification of housing and feeding practices of the animals. Designing and redesigning of the animal shelter to provide proper ventilation and enabling cooling facilities for the amelioration of the heat load on the livestock are important (Sejian et al. 2018). The provision of shade is one of the easiest and cheapest methods suitable for decreasing the adverse effect of solar radiation (Sarangi 2018). Studies conducted by Muller et al. (1994a, b) also revealed that animals subjected to heat stress and reared in dry lots containing shade showed lower signs of distress compared to those reared without shade.

In pasture-based animal production systems, the provision of shade for animals on rangeland and increasing proximity to water resources for the alleviation of heat stress are significant strategies that can be employed by local pastoralists in protecting grazing cattle. Farmers can also graze their cattle near dams thereby giving them access to ad libitum drinking water (Katiyatiya et al. 2014). These are because animals having better access to shade have been reported to have higher weight gain, milk production, and reproductive performance (Berger et al. 2004; Al-Dawood 2017). Furthermore, according to Hammadi et al. (2012), it was observed that there was a reduction in rectal temperature and respiration rate in goats that were provided shade during grazing periods.

Feeding and nutritional management could also play a crucial role in livestock physiological modulation in response to the amelioration of heat stress (Al-Dawood 2017). Feeding animals during cooler periods of the day and also at more frequent intervals is advised during the summer. This maintains normal feed intake of the animal and prevents the co-occurrence of peak metabolic and climatic heat load (Mader and Davis 2004). Also, increasing the frequency helps in minimizing the diurnal fluctuation in rumen metabolites and increases feed utilization efficiency in the gut (Soto-Navarro et al. 2000).

Deliberate exposure of livestock to changing climate conditions without hampering the performances of the animals is the main aim of production management (Seré et al. 2007). Although several attempts and strategies of management have been reported from different parts of the world, there is a scarcity of experimented production management strategies reported from Africa. However, there is indigenous knowledge of livestock production management existing among the pastoralists and agro-pastoralists in different parts of Africa. Indigenous knowledge comprises a wide variety of traditional and innovative technologies such as rainwater harvesting systems whereby water harvested during the wet season is kept for animals' consumption during the dry season (Ajani et al. 2013).

Implementation of Strategic Nutritional Intervention

Animals depend on an adequate supply of nutrients for their normal functioning and production performances. Impacts of climate change on animal nutrition have been documented and reported to include poor intake of feed and poor digestibility due to heat stress (Rojas-Downing et al. 2017a). These reports have opened up the potential application of nutritional manipulation for adaptation of livestock to changing climate scenarios. Management of feeding practices has been suggested as a strategy for improving livestock production and protecting climate change. According to earlier reports and recommendations for hot climate areas as is found in Africa, feeding management practices including manipulation of animal dietary composition in such a way that animals derive maximum benefits of nutrients per quantity of feeds provided without generation of obnoxious gases was recommended by Renaudeau et al. (2012). In a different view by Thornton and Herrero (2010b), since livestock production in the tropics, including Africa, is predominantly extensive grazing, it was recommended that livestock producers inculcate agro-forestry as part of their activities and plant species from such practices should be incorporated into the formulation of the animals' diets.

Nutritional strategy for adapting to changing climate scenarios could also be in the form of manipulating the animals' digestive physiology for the utilization of lesser use animal feed resources (Makkar 2016). For example, the ruminant animals could be supplemented with crop residues in addition to their extensive grazing during the dry season when natural rangelands become non-productive (Alphonce 2017). This has been demonstrated from studies and reports across African countries where animals were supplemented with both rich concentrate and poor feed residue to cushion the negative effects of climate impacts on rangeland productivity.

According to reports of Mengesha (2016), supplementation of protein-rich leaves as strategic feed resources in Ethiopian highland sheep led to an improvement of dry matter intakes, body weight changes, and nutrient digestibility. The study concluded that such a protein supplement improved the low quality of the sheep feed during the dry season, which led to improved performance of the sheep. Similarly, it was also reported by Sikiru et al. (2018) that cassava bran and fish processing waste are potential dry season feed resources suitable for growing lambs since it has no negative impact on the health of the animals and it promotes growth and performance of the animals. Furthermore, Sikiru and Makinde (2018) reported that low-cost supplemental feeding practices in lactating goats under extension production have significant impacts on the improvement of pruning weight gain of goat kids. Similarly, it was reported that an indigenous Nigerian goat (Red Sokoto) made appreciable weight gains in the long dry season when supplemented with crop residue-based diets (Malau-Aduli et al. 2003).

Finally, while conducting a survey on livestock production and management in the Republic of South Africa, Mapiye et al. (2009) recommended that nutritional management should be considered as a major factor in the management of pedo-climatic conditions threatening the productivity of indigenous livestock in the country. It could be inferred from the above submissions that nutritional manipulations stand as potential ameliorative strategies for improving animal efficiencies in Africa under climate conditions. This strategy mainly focuses on two thematic areas vis-a-vis strategic supplemental feeding for inhibiting the negative effects of forage and fodder shortages as well as manipulation of functional digestive physiology of the ruminant animals.

Adaptation Strategies for Livestock Production in Response to Climate Change

This present study and similar other previous studies suggested that African countries could be most affected by climate change due to limited skills and equipment for disaster management, inadequate financial resources for climate management, weak institutional capacity, and high dependence on rain-fed agriculture (Bagamba et al. 2012). Therefore, implementing breeding of thermo-tolerant animal breeds, developing early warning systems, improved pasture management, better use of water resources, empowering women towards livestock rearing, and upgrading capacity building programmes for professionals working with farmers and conducting research on livestock production are the main strategies for sustainable livestock production in the African continent. In Fig. 13.3 of this chapter, some of these strategies for sustaining African livestock production in the changing climate scenario were presented.

Breeding Policy for Thermo-Tolerance Breeds of Livestock

Africans host many indigenous species of animals that tolerate heat stress and disease; hence, preparing breeding policies for exploitation of the traits in these indigenous breeds would aid in combating the losses incurred through climate change in livestock production (Dzama 2016). Although these breeds may have lower production rates when compared to the exotic breeds, their ability to thrive in harsh environmental conditions with low feed intake provides a basis for adaptation to climate change. Also, the cost of expenditure on maintenance and treatment of such adapted breeds would be lower than the high producing exotic breeds. Thus, preparing suitable breeding policies that would encourage the use of the indigenous germplasm and also their crosses with exotic animal breed may be considered.

However, it is necessary to understand the agro-climatic condition prevailing in a region before introducing any specific breed into the breeding policy of the area (Zougmoré et al. 2016). Meanwhile, there are a few projects and policies on the use of indigenous livestock of Africa, and most breeding project focus on conservation rather than utilization of the beneficial traits (Katiyatiya et al. 2014; Dzama 2016). Hence, there arises a need to scrutinize the existing policies and amend them as well as encouraging of governmental intervention such as subsidies and tax incentives to indigenous animal breeders and breeding companies to promote the use of indigenous germplasm in animal breeding.

The adoption of suitable breed-species mix with indigenous African livestock breeds known for their thermo-tolerance and disease resistance should be the primary objective in the livestock agriculture policies (Dzama 2016). According to Katiyatiya et al. (2014) who surveyed the farmers of Eastern Cape Province of South Africa, to evaluate their perceptions and knowledge on heat stress and tick resistance in cattle. They observed that most of the farmers in this region preferred rearing indigenous

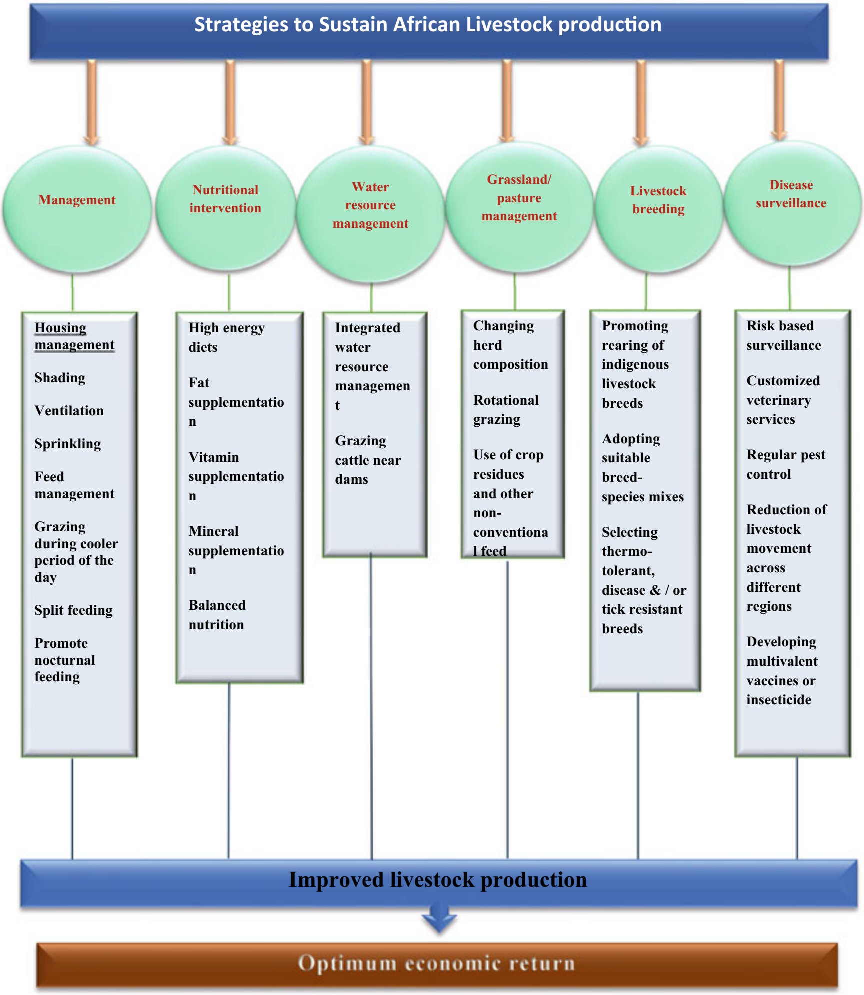

Fig. 13.3 Different strategies to sustain African livestock production in the changing climate scenario

Ngumi cattle and other non-descript cattle, which are again crossed with Ngumi and exotic cattle breeds. This is because the Ngumi cattle are known for their adaptability in low grazing areas and also for possessing good heat and tick tolerance (Musemwa et al. 2010). Despite having comparatively lower productivity than the other exotic cattle breeds, the farmers in this region preferred rearing Ngumi cattle as they provided sustainable farming. Similar trends of farmers shifting towards indigenous Sanga breeds of cattle like Nguni, Tuli, and Tswana were also reported among the commercial and smallholder sector in South Africa (Dzama 2016).

Furthermore, a significant rise in poultry rearing also projects in this region due to the increasing demand for chicken. This sector is again reported to be dominated by small-scale farmers who engaged in the rearing of indigenous flocks that are well adapted to produce well and survive under harsh environmental conditions (Dzama 2016). These indicated that enhancing livestock rearing using indigenous breeds can guarantee the farmers with a sustained production and income (Zougmoré et al. 2016).

In an effort to promote the use of indigenous animals breeding as adaptation to climate change, Onzima et al. (2018) conducted a genome-wide characterization study on six Ugandan goat breeds and identified several thermo-tolerance-related genes. Some of the genes are HOXC12, HOXC13, PPP1R36, HSPA2, DNAJC24, DNAJC13, KPNA4, MTOR, SH2B1, MAPK3, and IGF1, which are involved either directly or indirectly in molecular responses to heat stress highlighting the significance of indigenous goat breeds. Meanwhile, across each country in Africa, there are indigenous breeds which are well adapted to the environmental conditions persisting in Africa such as the N'Dama, Boran, Ogaden, Kenana, Ankole, East African shorthorn Zebu, Fogera breeds of cattle; WAD goats, Kigezi, Mubende, Small East African breeds of the goat; WAD sheep, Horro sheep, Red Maasai, and Nguni sheep (Adedeji 2012; Okourwa 2015; Taye et al. 2017; Onzima et al. 2018). Also, Srikanth et al. (2019) reported some differentially expressed heat stress-related genes in indigenous breeds of Kenyan chicken reared in both the lowland and highland agro-climatic zones of the country, and some of the genes include CCNB2, Crb2, CHST9, SESN1, NR4A3, COMMD4, TTC32, H1F0, ACYP1, and RPS28. The potential biomarkers generated across these studies may serve to develop appropriate future breeding strategies for chicken in Africa.

Implementation of Early Warning Systems for Climate Change Preparedness and Response

Timely forecasting of future weather events in a relevant manner could improve the planning and preparedness against undesirable climatic conditions (Nhamo et al. 2019). Such early warning systems can play a role in disseminating information on droughts, floods, and also on disease outbreaks to farmers. Though Africa has numerous early warning systems (EWSs), limited reports are available on their effectiveness. Lumbroso (2018) stated that EWSs in Uganda and the rest of Africa have to build a strong scientific and technical basis to aid people at risk. Also, sufficient funding should be provided to enable better response and interventions.

Improved Management of Water and Water Resources

Climate change adaptation practices at the farm level in Africa can have significant development outcomes in addition to reducing exposure to weather risks (Rojas-Downing et al. 2017b). It was projected that by the year 2025, about 64% of the world may be living under water stress conditions due to water scarcity and depletion of water sources; Africa is no exception in this projection (Rosegrant et al. 2002). The implication on livestock production is that there will be less water for animal consumption; hence, there is the need for livestock systems requiring less water use and development of livestock adaptation capacity to water shortage as an ameliorative coping strategy. Research investigating the effects of water shortage in livestock production, however, is scanty. Therefore, it is important to consider it as an appropriate mitigation strategy for sustainable livestock production (Thornton et al. 2009).

Water consumption is the most limiting resource for grazing animals, whether during drought or not in the tropics and subtropical countries of Africa because during the dry season, there is always a water shortage coupled with high temperature which puts livestock under stress conditions (Gaughan 2012). Therefore, assessment of animal endurance capacity under water shortage without limiting physiological and productive performance is worthy of exploration to ameliorate climate change effects on livestock production in Africa (Casamassima et al. 2008). Water availability and quality are the main challenges climate change posed on animal production, especially in an extensive livestock system. Therefore, the integrative adaptive approach is a very crucial part of climate change mitigation needs (Sejian et al, 2015). Livestock adaptation to water shortage could serve the entire world, including African countries as a climate resilience strategy for fighting food insecurity (Belay et al. 2017).

Improved Management of Grazing/Pasture Land Management

Changing the pattern of grazing management, such as reducing the number of animals per pasture land area, the use of crop residues and feeding of animals with fodder crops which are usually in abundance compared with the grasses and legumes for animals' consumption are leading adaptation strategies employed by smallholder agro-pastoralists in Africa. In confirmation of these strategies as farmers-driven adaptation approaches, Woldeamlak et al. (2015) stated that smallholder farmers across Africa have made adjustments in livestock production in response to climate change that includes feeding crop residues and feeding fodder crops known as kinchib (*Euphorbia tirucalli*), cactus (Ficus carica) to goats, and camels. In a similar report, Ducrotoy et al. (2017) stated that changing of herd size by reducing the animal population in a particular place for a given time at a prominent livestock production centre in Nigeria significantly contributed to better grazing land management and improved animal performances.

Therefore, since these are farmer-driven strategies, their acceptance by farmers as adaptation strategies could be easier when they become institutionalized by governments and other relevant organizations involved in livestock production in Africa. These forms of adaptive measures could be easily adopted across the continent through the engagement of community-based organizations and farmers' cooperatives in grazing management (Escarcha et al. 2018a, b). This will involve educating and informing their fellow community members about the need to contribute to climate change adaptation through reduction of grazing animals per time within a given area of land to encourage pasture land conservation, increasing forage growth and development as well as the establishment of community fodder banks (Davies et al. 2020).

Continuous Surveillance of Livestock Disease Occurrences and Vector Migration Patterns

Disease surveillance—an information-based activity—involves the collection and analysis of information on disease occurrence. Well-functioning surveillance systems along with timely responses are predicted to reduce the cost of outbreaks by 95% (Grace 2014). The very first step towards this would be to reduce the knowledge gaps on pests and diseases to enrich the data on epidemiological diseases (Bett et al. 2017). This would also help in developing risk maps to assess the climatic influence on such diseases. Risk-based (targeted) surveillance must be encouraged which focuses on diseases prevalent across different sectors, subpopulations, and areas (Grace 2014).

Participatory disease surveillance involving local communities has helped early detection and reporting of diseases such as rinderpest and avian influenza in Africa (Grace et al. 2015). Such surveillances have wider coverage and are cost effective when compared to the traditional surveillance measures which follow the assumption that the probability of disease occurrence is constant throughout the reference population (Grace et al. 2015). Having such a relevant and informative data will then aid in planning customized veterinary services, like vaccination and deworming schedules, for every region. Pest protection is also an important disease surveillance measure as vectors transmit infectious livestock diseases (Bett et al. 2017). Practising regular pest control measures will help to keep check on the vectors.

The movement of livestock across different regions and national boundaries, for the trade of nomadic pastoralism, can further aggravate the spread of disease, which led to a coordinated approach and the establishment of the Intergovernmental Authority on Development, in Africa. This was aimed at harmonizing the surveillance and control of livestock diseases by developing standard methods and procedures (Bett et al. 2017). Technological advancements aiming towards quicker detection, response, and effective management are being practised. The development of safer vaccines for Rift Valley Fever by Warimwe et al. (2016) is one such example. As some of the climate-sensitive infectious diseases co-occur in the same ecology, future researches are targeted towards tackling multiple diseases together. Developing multivalent vaccines or insecticides to control multiple diseases and vectors would be cost effective and useful (Bett et al. 2017).

Implementation of Livestock Production with an Emphasis on Women Empowerment

Women are more capable of managing ecosystem services and food security than men; they possess immense leadership qualities and play a potent role in handling various issues like energy consumption, deforestation, population growth, economic growth, and management, developing scientific research and technologies, contributing towards policy making, and many more. Thus, it should be of prime importance to involve them actively in livestock rearing (Sejian et al. 2015). Several activities associated with livestock production such as fodder collection, feeding, watering, and health care, management, milking, and household-level processing, value addition, and marketing are performed by women (Patel et al. 2016). Therefore, implementation of livestock production systems with an emphasis on women empowerment can be an adaptation strategy to climate change in Africa.

Implementation of Livestock Extension, Education, and Capacity Building Programmes

Farmers across Africa adopt various measures to combat the deleterious effects of climate change within the scope of their agricultural knowledge. However, they are ignorant of the other possible adaptive strategies available in other parts of the world such as India, where a capacity building programme referred to as the *Krishi Vigyan Kendra* (KVK) is bringing out entrepreneurship prowess in dairy keepers following training on knowledge gained via capacity building cum livestock extension programme for dairy development (Kumar et al. 2011). Adaptation strategies would be successful only when the knowledge and inputs are transferred down to the ultimate target groups who are the poor farmers.

Developing a suitable capacity building programme (CBP) to enhance the knowledge and understanding of livestock owners and local, commercial market stakeholders towards the impact of climate change on livestock production would increase their awareness of the global changes in climate and its effects on livestock production. For a successful implementation of adaptation strategies, CBP should focus on the basic understanding of climate change, its impacts on biodiversity and ecosystems, and its role towards conservation and sustenance of eco-services and also strategies for assessing vulnerability and adaptation (Sejian et al. 2015). This will stimulate active participation by all sectors including governmental, non-governmental, private sector, and volunteers to support livestock farmers and besides support timely upgrading of technologies, policies, and frameworks which has to be made to ensure effective use of feasible adaptation strategies.

Conclusion and Recommendations

Nigeria can be regarded as the centre point of animal products consumption and production in West Africa. The population of the country also keeps growing while serving as the flourishing market for neighbouring Sahel countries that raise livestock in the region. The country also drives beef consumption in the West Africa region because 50% of beef consumption in the ECOWAS region are from Nigeria (Bénard et al. 2010). Unfortunately, livestock production in Nigeria could be at the risk of climate change because it is largely pasture-based and extensive grazing management (Ducrotoy et al. 2018).

Meanwhile, available data, records, and submissions on livestock production in Africa and its concerns with climate change examined in this present study considered West Africa as the driver of the future demand for livestock products as well as the most vulnerable region to climate change consequences in Africa. Hence, since Nigeria is the nerve cord of livestock production in West Africa, a working hypothesis for action as follows proposed for livestock production under climate change for the promotion of food security and human well-being in Africa, West Africa, and Nigeria is as follows:

> In Africa, increasing ambient temperature, relative humidity, damaging wind speed, extreme thermal radiation and reducing precipitation are environmental stressors that could arise from climate change and they could have negative impacts on livestock production, which could serve as potential hindrances affecting animals' health, growth, productivity, and reproduction; and these can increase the risks of poverty and food insecurity in the continent.

Therefore, this study suggests the need for scientific and institutional experimental testing of the hypothesis stated above for generating empirical data that can be used for developing models that can provide resilience and adaptation measures as critical need for sustainable livestock production in Africa for promotion of food security and human well-being under changing climate conditions.

Climate changes have severe impacts on the livestock production system in many parts of the tropical and subtropical countries of Africa; but despite the importance of the livestock production sector to African farmers and the magnitude of climate change consequences, they may likely face in future, little or no hope exists to overcome these challenges. This is because the intersections between climate change and livestock production are a relatively neglected area of research in Africa.

There is need for carrying out empirical data generated from experimental studies focusing on biological, productive, and other climate change effects on animal production and performances. This is because the trends of climate change variables (especially temperature increase) generated in this study indicated that among the various subregions of Africa, the West African subregion could be highly vulnerable to the devastating climate consequences concerning livestock production.

Furthermore, available reports via socio-economic assessment revealed that climate change has led to serious repercussions affecting animal production and reproductive efficiency as well as disease outbreaks. These climate change consequences indirectly affected animal production in Africa as a result of accompanying reduced fodder and water resources. Therefore, several solutions, as well as adaptation strategies proposed in this chapter if implemented, could sustain livestock production in the face of changing climatic conditions in the Africa.

Africa is undoubtedly in need of researchers working in the areas of livestock production and climate change to sustain the continents' livestock production and promotion of global food security, considering the cofounding effects of Africa population growth and migration on other parts of the world. Future research efforts are needed to develop cost-effective, easy-to-use technologies catering to the needs of African livestock farmers to mitigate and adapt to climate change realities as it affects their production systems. Apart from scientific research investigations, there is a need for institutional policies that can enhance farmers' adaptation to climate change, and this includes but not limited to refinements of existing animal breeding policies for the development of more climate-resilient livestock breeds specific to different agro-ecological zones of Africa. Finally, special initiatives are required for the development of more adaptation and coping strategies in future through international collaborations of governmental, non-governmental, and developmental agencies for conservation of water resources and pasture land management to ensure optimum livestock production in Africa.

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