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Cattle Genetic Improvement for Adaptation, Conservation and Sustainable Utilization to Changing Climate in Ethiopia: A Review

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ABSTRACT

This paper reviewed cattle genetic improvement approaches for sustainable utilization, adaptation and conservation towards the changing climatic conditions. Livestock production is affected by climate change, which poses a greater threat to populations that rely on them for their overall food security. Climate change negatively affects the cattle production directly through impact on animal physiology, behavior and health and indirectly through affecting feed and water availability, quality and quantity of pasture, forage crops and rangeland as a result of increased temperature and droughts. Improvement of cattle genetic resources that are efficient and well adapted to extreme temperatures, low-quality diets and disease challenges is critical to deal with climate change. Changes in breeding strategies will facilitate to improve cattle breeds and increase their tolerance to dynamical climate. Breed replacement and unplanned crossbreeding with exotic cattle breeds without enough consideration of environmental conditions are the major factors contributing to the loss of locally adapted breeds and loss of certain adaptive traits. Maintenance of indigenous cattle genetic diversity, which underpins resistance to environmental stresses, is a valuable weapon for mitigating the possible effects of future climatic challenges. In contrast to traditional selection, genomic selection increases the accuracy of selection with the largest genetic gain, for the low heritability traits such as adaptability and reducing inbreeding. In conclusion, any breeding strategies should be precise and relevant in terms of breed suitability, performance and adaptability in the production environment and climatic stress to sustain cattle production.

Keywords: Adaptation; Cattle; Climate change; Conservation; Genetic improvement

INTRODUCTION

Livestock contributes significantly to global food security. Livestock production contributes 40 percent of global agricultural Gross Domestic Products (GDP) and supports the livelihoods of at least 1.3 billion people worldwide. They make a necessary and important contribution to global food security, provide 18% of global kilocalorie consumption and 34% of global protein supplies and provide essential micro-nutrients, such as vitamin B_{12}, iron and calcium. In marginal lands where livestock represents a unique source of energy, proteins and micronutrients their contribution is particularly significant [1]. Ethiopia is believed to have the largest livestock population in Africa, with nearly 65.35 million cattle,

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39.89 million sheep, 50.50 million goats, 2.11 million horses, 8.98 million donkeys, 0.38 million mules and 7.70 million camels in the country. The direct contribution of livestock to the country's economic growth is accounting for 39% of the country's agricultural GDP and 17% of its overall GDP.

Ethiopia is the 12th most populous country in the world, accounting for 1.47% of the global population. As a result of population growth, urbanization, rising economies and changes in dietary patterns, meeting food security needs remains a challenge, as demand for high-quality nutritious food from animal products increases [2]. To feed the ever-increasing demand for milk, milk products and beef genetic improvement of the Ethiopian indigenous cattle has been proposed as one of the options.

It is endowed with a variety of indigenous cattle genetic resources with millions of people depends on them. Despite their importance, cattle genetic diversity in Ethiopia is under threat due to information gaps on sustainable utilization and genetic improvement programs and little attention is given to conserve the diversity of the indigenous cattle breeds. Cattle genetic improvement programs have not yet adequately considered traits for adaptation and mitigation of current global climate change [3].

In addition to the shrinkage of grazing lands, scarcity of feed and water and inbreeding, climate change and increased focus to rely on few high-input exotic breeds is the main factor compromising productivity and the genetic integrity of indigenous cattle genetic resources in Ethiopia. Livestock production is also affected by climate change and its effects of competition for land and water, which poses a greater threat to the rural farming communities that, are dependent on livestock production for their overall food security. It impacts ecosystems and natural resources on which the livestock sector depends on and is considered as one of the most important challenges to sustainable development [4]. Climate change leads to reductions in cattle genetic diversity and productivity by depressing animals' adaptive response mechanisms, causing heat stress and diseases spreading. Climate change is already hampering and expected to be severe and lasting in many developing countries such as Ethiopia, necessitating a much broader view of the risk management approach.

Ethiopia is one of the most vulnerable countries to climate change induced disasters such as drought, floods and epidemics, that endangers farmers and pastoralists who depend on climate sensitive livelihoods and livestock production. These stimulate adaptive measures like altering breeding and management strategies and also changes in production technology and farming systems that could affect productivity. Sustainable intensification, adaptation to current and future production environments and competition for natural resources are key issues for the global animal protein production and as well as for the farmers and livelihoods dependent on livestock. Improvement of cattle genetic resources that are efficient and well adapted to extreme temperatures, low-quality feeds and disease challenges is crucial to deal with climate challenges. This paper presents an overview of the impact of current cattle genetic improvement approaches on adaptation and diversity conservation in response to climate change in Ethiopia [5].

LITERATURE REVIEW

Direct and Indirect Impacts of Climate Change on Cattle Production

Climate change has a direct influence on livestock due to rising temperature, variation in photoperiod as well as precipitation and indirectly due to the detrimental impacts on feed, increasing susceptibility to disease, as well as water and land use.

Effect of Climate Change on Animal Feeds

Livestock production depends on the availability to feed and water that animals need to survive, produce and reproduce. Climate change will negatively influence the quality and quantity of feed for cattle in a given area, which may result from the deterioration of the productivity, decline in quality and quantity of pastures and forage crops and rangeland as a consequence of increased temperature and droughts. A higher temperature as a result of climate change increase lignification and decreases the digestibility of feed resources. In Ethiopia about 87% of the overall animal feed *i.e.,* 59% green fodder (from grazing land) and 28% crop residues (from cropland) is highly climate-sensitive. Climate change affects the rangelands that have been turned into bare termite mounts and land that has been covered by unpalatable, poisonous plant species [6]. Similarly, direct effects of climate change on feed supplies, rangeland carrying capacity and grazing management may have a major impact on livestock production and their sustainability.

The Impact of Climate Change on Water Availability

Water and land resources are critical inputs in cattle production systems, especially in the production of feed crops. Agriculture uses 70% of freshwater resources globally, making it the world's largest consumer. The livestock sector consumes 8% of the world's water use and their water requirement increases with air temperature. The major issues in animal production affected by climate change are water scarcity and depletion are reported to seriously reduce livestock productivity. Climate change would affect water resources by decreasing river run-off, energy production, as well as increased floods and droughts [7]. According to, decreasing water levels in rivers and low level of water accumulation in community ponds has been observed in Ethiopia in recent years. Most pastoral regions in Ethiopia such as Loka Abaya and Boran pastoralists faced critical water shortages, more erratic and reduced amounts of rainfall, rise in temperature and prolonged and frequent period of drought as a result of climate change.

Effects Climate Change on Animal Production Performances

The possible effects of climate changes cause a wide range of detrimental impacts on the performance of cattle such as reduced growth rate, decreases animal health, lowered milk as well as meat production and impaired reproductive efficiency. Observations on the milk production of Holstein-Jersey dairy cattle in tropical and subtropical conditions may be 40% to 60% lower than in temperate conditions, raises serious concerns about resilience to future global warming. Collectively, these effects are expected to harm cattle production and productivity. Climate change is expected to results fall in livestock productivity maybe by 50% in 2050's compared to without change scenarios climate. Heat stress due to climate change is the most significant pressing factor that impacts cattle productivity. Heat stress directly impairs the performance of dairy cattle by suppressing appetite and feed intake, ultimately leading to reducing daily weight gain, feed conversion efficiency, milk yield and milk component, this causes significant economic losses to dairy cattle producers. Milk yield declined by 0.2 kg per unit increase temperature humidity index [8]. Lactating cows are especially sensitive to heat stress due to their high metabolism in the body associated with increased milk output. It has been identified as a decrease in body weight, growth rate and body total solids of cattle exposed to elevated temperature.

Impacts of Climate Changes on Reproduction of Animal

Many studies reported that the ambient temperature associated with climate change, will alter the physiology of livestock, reducing male and female fertility and increasing reproductive problems through alterations in the heat balance. Variability in temperatures and heat stress results reproductive inefficiency of cattle such as decreased fertility, increased age at first calving, conception rate and longevity. The conception rate of dairy cows may drop 20%-27% in summer and heat-stressed cows often have a poor expression of estrous due to impairment of ovarian functioning and embryo development. Heat stress compromises oocyte development by altering progesterone secretion. An increase in uterine temperature of 0.5°C above average causes decreased conception rates by 6.9% to 12.8% [9]. In general, the high-producing breeds from temperate regions, which provide the bulk of market production today, are not well adapted to heat stress. As a result, selection for improved meat and/or milk traits without considering adaptation extreme environmental conditions may increase animals' susceptibility to elevated temperatures. Therefore, selection and breed improvement strategies should not only be to exploit the production of animals, but also to increase adaptability, to curtail productivity losses and other health effects on animals.

Impacts of Climate Change on Cattle Health

A climatic impact affects livestock health mainly through variations in temperature and humidity. Climatic changes may have an indirect impact on animal health by increasing the incidence and distribution of climate sensitive infectious disease, increased survival and developments rates of pathogens in the environment, range and abundance of vector borne diseases and parasites and spreading of foodborne diseases during extreme weather events, which increases the potential for morbidity and heat related mortality. Livestock infectious diseases especially vector-bones are significantly affected by climate changes. In addition to the spread of diseases, climate change can have impacts, certain diseases are associated with water, which may be worsened by flooding and complicated by inadequate water access due to climate change [10]. Further indicated that diseases related factors that would be affected by climate change, including the molecular biology of pathogens, vectors, zoological factors, farming practices and the establishment of a new micro environment. For instance, variation in seasonal rainfall and specific weather conditions are causing the outbreaks of anthrax, bluetongue virus, facial eczema, rift valley fever and peste des petits ruminants.

Effect of Climate Change on Cattle Genetic Diversity

Climate change is thought to alter the pattern of genetic diversity of cattle, which may play an important role in adapting production systems, but this diversity may be in turn be threatened by climatic change effects. Climate change will accelerate the loss of cattle genetic and cultural diversity in agriculture already taking place as a result of globalization. Climate change has the potential to eliminate 15% to 37% of all species in the world. Climate changes may operate includes a significant number of animals may die as a result of disease epidemics, a large number of animals may be culled in disease control programs and climate change causes livestock keeping livelihoods unsustainable. Droughts in Ethiopia in the 1980's and 1990's resulted in 49% of herd losses under the communal land use, while drought of the 1990's, 57% of the cattle mortality under ranch management was attributed. According to Naod, et al. ecological reasons such as bush encroachment, frequent drought and population pressure lead to diminishing availability of good pasture and as well as factors related to herd management and civil reasons are among various reasons for the loss of genetic diversity. In addition, climate change impacts cattle genetic resources by catastrophic events, disease epidemics, productivity losses, physiological stress, agro-ecological changes and water and feed resources availability. Due to the impact of climate change in relation to maximum temperature and rainfall variation, the trends of livestock population/breed/species distribution pattern varied from year to year and from agro-ecology to agro-ecology [11].

Breeding Cattle for Improved Adaptation to the Changing Environment

Adaptation is defined as an action that people's and society's adjustment in response to actual or expected climatic effects, which moderates harm and optimize the positive impacts of climate change or exploits beneficial opportunities. Adapting climate change would increase the resilience of the system, assuming that future climate will push species to the limits of their tolerance range. Genetic adaptation essentially increases

productivity, efficiency and genetic diversity allowing more opportunities to match breeds to changing climates. An adaptation measure involves modification of production and management systems, breeding practices, structural and policy improvements, science and technology development. Reducing exposure to the risk of damage, improvement of the capacity to cope with unavoidable damages and take advantage of new opportunities are the three goals of adaptation. Communities improve livestock resilience by adopting appropriate technologies, using traditional skills and diversifying livelihoods to deal with climate stress. Identifying genes underlying adaptation phenotype is one way to get a better understand of adaptive capacity. This aim can be achieved by genetically characterizing livestock species and finding selection footprints in the animal genome.

Genetic improvement of cattle can involve a choice of appropriate breeds, selection of a suitable pure breeding or crossbreeding system and applying genetic enhancement within breed. In developed countries, the choice of suitable cattle breeds and breeding systems has been a significant contributor to improvements in productivity. Improvement of cattle genetic resources that are efficient and well adapted to extreme temperatures, low-quality diets and greater disease challenges is necessary to address the challenges of adapting to climate change and increasing productivity [12]. Changes in breeding strategies can help animals increase their tolerance to changing climate and improve their reproduction and growth development. The ability of cattle to adapt to environmental challenges is a valuable characteristic of a breed and becoming increasingly important in cost-effective animal production. This is especially important as the climate becomes warmer, conditions for diseases are more favorable and production costs are set to rise. An adaptive characteristic to climate change encompasses a wide range of physiological, behavioral and morphological features. Climate change adaptation strategies address not only livestock tolerance to heat, but also disease resistance, water scarcity tolerance and the ability to cope with poor quality feed are valuable characteristics of a breed and have importance when mitigating and adapting to environmental changes.

Many local breeds in tropical regions that have evolved over the centuries in diverse, stressful tropical climate have a range of unique adaptive traits, which enable them to be productive in harsh environments. According to, indigenous cattle breeds are better suited to high temperature, high solar radiation and dry conditions than exotic cattle breeds due to their skin pore density which allows them to successfully regulate their body temperature. These locally adapted cattle breeds possess genes that code for specific traits desired by the major breed owners and also have a greater capacity to grow and reproduce during unfavorable seasonal conditions with poor nutrition and higher disease and parasite pressures than high-performance breeds. They can also be expected to cope with the effects of climate change more easily than their exotic counterparts [13]. Currently, the dominant pattern of gene flow does not focus on the improvement of locally adapted breeds, but on the high-output breeds that need highly controlled production environments. Since exotic cattle breeds are not well suited to the local environment, they require controlled and intensive feeding and management systems, as well as some environmental modification to stay healthy and productive.

In many developing countries, including Ethiopia, are usually characterized by a lack of technology in livestock breeding programs that might help to speed up adaptation. Although the selection and crossbreeding of high-producing with indigenous cattle over many years has led to increased productivity, they are less adaptive to heat stress and susceptible to environmental challenges. According to many studies, the commercial and widespread breeds may show failings in some traits, such as insufficient resistance to diseases or tolerance to other environmental stress due to climatic changes. If climate change is faster than natural selection, the risk to the survival and adaptation, as well as vulnerability to the climate change of the commercial cattle breed is greater [14]. This highlights the need to understand the role of strategies such as breeding livestock for adaptability rather than exclusively focusing on high productivity. Such measures include identifying and strengthening local breeds adapted to local climatic stress and feed sources and improving local breeds through cross-breeding with heat and disease-tolerant breeds. According to, an efficient approach is the introgression of locally adaptive genes into commercial breeds through efficient breeding strategies that may be needed to bring better adapted to the rapidly changing environmental conditions. As a result, when attempting to establish a cattle improvement program for a challenging environment, selection of the stocks that are likely to be the most adaptable to local conditions is critical.

Adaptive traits of crossbred cattle usually deteriorate in comparison to local breeds. High levels of upgrading cattle have generally resulted to animals with less resistance to diseases and less resilient to environmental stress. Successful genetic improvement strategies require proper planning of pure breeding and crossbreeding or the development of synthetic breeds. According to well-considered breeding programs are needed to develop breeds with higher production while maintaining climate-adaptive qualities [15]. Breeding strategies must ensure the development of appropriate livestock breeds considering the future climatic conditions, which possess thermo-tolerance, drought tolerance and the ability to survive in limited pastures. Breeding programs should be seen in the context of long-term development strategies, somehow flexible and responsive to variable scenarios of climatic conditions for future needs of the programs.

In order to mitigate the negative effects of climate change and maximize any benefits, the best adaptation options must combine technological, behavioral, management and policy options. Genetic improvement programs should consider the environmental conditions, the future climatic conditions and livelihood security in addition to the objective of the national agriculture and livestock development. Therefore, breeding strategies given to farming communities should be accurate and relevant to the production system and consider traits

such as performance, adaptability and suitability of breeds as much as possible.

Breeding and Conservation of Cattle Genetic Diversity

Genetic diversity of domesticated animals is vital to the livestock sector. The diversity of farm animal species is the result of a long history of human practice; thus closely related to the diversity of production systems and socio-cultural values. The genetic diversity of Animal Genetic Resources (AnGRs) ensures the long-term viability of a breed or population as well as genetic improvement and adaptation to the changing environmental conditions. Conservation of genetic diversity of cattle population is not only important to meet present requirements of the society, but also important for meeting future challenges, supporting sustainable cattle production for food security, maintaining genetic variability for further use and conserving heritages. Increasing productivity and efficiency will be fundamental, but maintenance of genetic diversity will also be of importance [16]. Having broad genetic diversity would allow opportunities for genetic improvement by selection and mating strategies to maximize genetic response in the long run and adaptation to the changing environmental conditions, including not only those associated with climate but also to changes in the market, management and diseases challenges, as well as to develop new and improved breeds and to match breeds to a changing climate. In conservation, maintenance of both within and across-breed genetic diversity is the primary aim. The maintenance of cattle genetic diversity underlying resistance to harsh environmental conditions provides an important resource for combating the effects of possible future climatic challenges.

Livestock genetic diversity today is rapidly declining globally as specialization in animal breeding and the harmonizing effects of globalization advance. A very sizable number of animal breeds including cattle breeds have been created and disappeared globally in the history of animal farming [17]. Reports have been noted that in recent centuries there has been an inflated increase in the degree of extinction of livestock breeds relative to the rate of formation of new breeds. The cause for the loss of cattle genetic diversity and lowering of both productivity and population in Ethiopia are due to the increasing pattern of global reliance on a very limited number of modern commercialized livestock breed suited for the high input-output needs of industrial agriculture and genetic admixture and breeding schemes because of agricultural policies promoting rapid solutions to ensure food security or meeting the soaring demand for food. The loss of genetic diversity in domestic species has important economic, ecological and scientific implications as well as social considerations.

Loss of Genetic Diversity by Breed Replacement

Breed substitution occurs when improved breeds are directly replaced by other improved breeds or indigenous breeds upgraded to exotic breeds that are considered economically superior or when synthetic breeds are created by crossbreeding which eventually replaces existing breeds. It is often argued that with the use of improved breeds drastic advances in cattle production can be achieved. Even in areas where the exotic genotypes are ill-adapted, the introduction of exotic genetic material remains seen as a solution to the low productivity of local cattle breeds. According to Belew et al., the main cause for genetic erosion in developing countries is attributed to the fact that the farmers have a strong pressure to switch to commercialized cattle breeds and breeding schemes. Breed replacement without long-term breeding strategies has contributed to serious genetic erosion, including extinction of a number of locally adapted breeds. No one emphasized the merits of locally adapted animals to environmental conditions. However, often, complete replacement of local breeds by specialized, high productive breeds is not a sustainable strategy in the long run. Also indicated those gene introgressions together with an unsustainable selective pressure for adaptation to global climate change are the major challenges to the conservation of AnGRs. There are several well-documented cases of unrealistic livestock development projects based on importations of commercial breeds, these approaches lead to wrong breeding objectives and neglect the potential of indigenous livestock breeds [18]. However, newly introduced breeds and crossbreds need to be appropriate for the environment and fit within a production system that may be characterized by limited resources and climate changes. The use of misguided and uncontrolled introduction of exotic genes could have a drastic effect on cattle genetic diversity and may lead to the disappearance of indigenous cattle breed within few centuries.

Although the exotic breeds are considered as more productive, they lack adaptation to the environmental stress, disease and parasite resistance traits found in native breeds. Selection of highly productive breeds mainly focused on production characteristics and this underestimates functional and adaptive characteristics. According to, quick replacement of locally adapted breeds by indiscriminate crossbreeding should be avoided due to the loss of adaptive traits and lower economic benefits.

In contrast to exotic breeds, indigenous livestock breeds in Ethiopia are the hardiest breeds, well suited to the local climate and capable of coping and producing in harsh conditions due to physiological and genetic adaptations. It is clear that breeds that evolved in diverse, stressful, tropical environments possess unique adaptive traits. Although they have less production potential than specialized breeds, their level of production is relatively stable during testing conditions where high producing animals fail. On the contrary, the productivity evaluation of indigenous cattle breeds of Ethiopia demonstrates that they can outperform crossbreeds under improved conditions. Due to their smaller body size, indigenous cattle breeds maintain their reproductive potential during periods of extreme heat stress, water scarcity and reduced pasture availability, whereas the larger exotic cattle may experience reproductive impairments due to their higher energy requirements. Hence, better adoption approaches of the multipurpose functions of indigenous cattle breeds by

mapping suitability to the socio-cultural demand must be oriented. In this regard, suggested that realistic ways of improving local genetic resources should be selected and implemented in light of available tools, present and future environmental limitations and socio-cultural demands.

Maintenance of genetic diversity, which supports resistance to environmental stresses is a valuable weapon for mitigating the possible effects of future climatic challenges. From the long-term point of view, a concentration on environmentally sensitive breeds may create a serious problem for the sustainability of livestock production. Hence moving to a few breeds would eliminate a considerable amount of variation in the breeds, in addition to jeopardizing readily available gene combinations in other remaining gene resources. According to Okeyo, et al., several countries in the developed world have placed their local livestock populations at risk by exotic breed introduction and/or cross-breeding. Bringing cattle breeds that are more adapted to the changed conditions is one option of adapting the production system to the effects of climate change. Thus, any development agencies contemplating introducing a breed to a new area, it is essential to adequately consider the adaptation of breed to the new environment and climate change, properly consult livestock keepers and thorough assessment of the breed's suitability for use in the current and projected future production environment is critical.

Crossbreeding to the Loss of Cattle Genetic Diversity

Indeed, the introduction of exotic breeds and cross-breeding with improved breeds would bring a rapid genetic improvement than the time-consuming and wasteful selective breeding of native breeds. Crossbreeding has been most successful where it was followed by a rigorous selection program involving livestock owners' participation and substantial public sector investment in the form of technical support. Through crossbreeding strategies between local and exotic breeds, the productivity gap between both categories of breeds can be reduced in a short time by combining the high productivity of the former with adaptive attributes of the latter. Success has been limited due to the co-introduction of other unfavorable genetic characteristics of zebu cattle, particularly those associated with low productivity.

Crossbreeding may increase the overall genetic diversity by introducing new genes and genotypes (e.g. synthetic breeds) in the population. Cross-breeding can be considered as a necessary evil because it provides the much desired rapid increase in productivity of livestock and at the same time threatens indigenous breeds by replacing them. According to Chebo Alemayehu, indiscriminate crossbreeding or extensive use of exotic germplasm is the major cause of genetic erosion of locally adapted cattle breeds. Unplanned crossbreeding with exotic cattle breeds without enough consideration of environmental conditions is also a major factor contributing to the loss of locally adapted cattle breeds through replacement and loss of certain adaptive traits. This may results in inconsistent and rapid loss of genetic diversity by dilution of native-born genetic makeup.

Several ranches in Ethiopia, for example, Abernosa ranch which has been involved in the crossing of Boran cows with Holstein Friesian cattle, Gobe ranch which has been involved in the crossbreeding of Arsi with Holstein Fresian breeds and also with different grades of exotic cattle such as Jersey and Simmentals to produce F1 heifers for the distribution to the farmers and to increase the production of milk. These ranches have been distributed over thousands of heifers for use as dairy animals to cooperatives and private farmers over the last 30 years. In both cases, a vast range of exotic blood groups and genotypes are prevalent due to subsequent uncontrolled breeding at the level of the community herd, which harms the genetic diversity of the existing breeds through replacement and loss of some important adaptive traits.

Crossbreeding has often been performed indiscriminately in the past, resulting in the extinction of the local breeds that underpin the crossbreeding schemes, due to a lack of understanding by the authorities, companies and/or farmers concerned that certain pure breeds must be maintained to sustain the system. Therefore, any breeding strategies offered to the farming communities should be as accurate and relevant as possible in terms of breed suitability, performance and adaptability in the production environment climatic stress as possible [19]. The sustainability of crossbreeding strategy requires careful planning and long-term organization. Designing a breeding program also needs to take into consideration a mechanism that ensures the conservation of indigenous cattle genetic resources. More understanding of the match between livestock populations, breeds and genes with the physical, biological and economic landscape is required, as well as institutional and policy frameworks that encourage the sustainable use of conventional breeds and *in-situ* conservation.

Selective Breeding of Cattle to Mitigate Challenges of Climate Change

In many developing countries the existing animal genetic improvement method has been mainly relying on selective breeding by scoring animals based on their phenotypes to determine their breeding value. These conventional methods of selective breeding were mainly for higher productivity, which has limitations in terms of environmental adaptation such as climate change. Although selective breeding has significantly improved cattle breeds, several challenges remain such as low genetic progress in some important traits such as feed conversion efficiency, fertility and adaptation to warmer climatic conditions. Selection of cattle for increased output while ignoring traits correlated to traits of conservation interest such as adaptation, specific traits, genetic variants, can reduce breed distinctiveness and between-breed variation. As a result, the animals' flexible adaptable capacity to changing and divergent production has been replaced by inflexible, static and location-specific behavior. Selection of cattle for breeding should consider traits associated with heat-tolerance, fertility, feed conversion efficiency, relative adaptability to low-quality feed and disease resistance and given more consideration to the

genotype by environment interaction in addition to high productivity, to address climate change. Breeding for climate change adaptation or mitigation will not necessarily be different from prevailing programs. Recently emerged modern biotechnological tools have shown an indispensable promise for genetic improvement of beneficial traits and climate change adaptation and mitigation by improving intake, digestibility and nutritive value of low-quality forage, as well as improving animals health. To balance the mechanism of breeding and optimize the animal breeding program, the use of molecular genetics techniques in combination with conventional animal breeding tools is necessary.

Biotechnology for adaptive crossbreeding plays an important role to adopt and elucidate the problems resulted from climate changes through increasing disease resistance through genomic selection and genetic engineering. Moreover, the use of advanced modern biotechnology tools aids to solve the challenges of climate change and is applied to enhance genetic progress through increasing genetic variation. In contrast to the classical selection, genomic selection increases the accuracy of selection with the largest genetic gain for low heritability traits and reducing inbreeding. The genomic selection can be effective in the introgression of favorable alleles of a lowly heritable trait from a donor to a target population. Combination of crossbreeding and selection (including genomic selection) may allow the exploitation of both types of populations. Through repeated crossbreeding and backcrossing animals carrying the favorable disease resistance alleles and a more productive breed the animals, it is possible to combine the ability of disease resistance from indigenous cattle breeds and productivity from exotic breeds. It is also possible to produce genetically engineered animals that are healthier and have superior disease resistance ability to endemic diseases through the application of transgenic technology to the desired immune system. Strategies use genomic-based analysis breeding principles, which can accelerate the process of cattle breeding with higher and more productive as well as adapted to the changing environments as a result of climate change, taking epigenetic influence into account.

Genetic Improvement for Sustainability of Livestock Production

Sustainable use is described as the use of biological diversity components in a way and at a scale that does not result in long-term biodiversity loss, thereby maintaining its capacity to meet the needs of present and future generations. Sustainability is a holistic concept that jointly considers ecological, socio-cultural and economic dimensions of a system or intervention for long-lasting prosperity, meet the needs of the present without compromising the ability of the future. Sustainable use and genetic improvement of AnGRs are proposed as the best strategy for agriculture, food production, adaptation to possible future changes and maintaining their diversity. Any sustainable breeding program requires continued development and improvement of the breed to ensure its future competitiveness. Identification of effective breeding objectives and implementation of long-term breeding programs are necessary to achieve sustainable cattle genetic improvement which support livelihoods and minimize the long-term risk for the survival of cattle populations.

DISCUSSION

Any breeding program is dependent on environmental conditions, the production system and the culture for which the animals are bred. As a result, to sustain cattle production in an environment challenged by climate change, the animals must have the ability to survive and produce under harsh conditions. To be sustainable, the breeding program must be adaptable, market-driven, socially appropriate and considering animals' multi-purpose use, climate change and the long-term benefits to farmers. The degree to which the environment can be freed from constraints such as diseases, parasites, diet and climate is minimal. This provides a convincing case for using the best locally adapted, modified genotypes following environmental changes where possible and economical, as well as considering the advancement of suitable breeding programs. Sustainable use of cattle genetic resources depends on the continued use of between and within breed genetic diversity.

Sustaining livestock production in the changing climate scenario requires a paradigm shift in the use of existing technologies. To maintain the long-term horizon of cattle breeding, the definition of breeding objectives that includes determining the relative importance of the different traits of the breed in the context of a given production environment. Breeding objectives must be set at the national, regional or local level and not by outsiders to truly reflect the real needs of the area. Participation of farmer is essential that farmers influence the establishment of the breeding objectives and support the direction of change and validate the existing technologies with modifications for specific locations keeping in mind the requirement of an ultimate target group of farmers. Participation of farmers allows the application of feed and water conservation technologies that are simple to integrate indigenous expertise in advance of climate change-related problems and challenges [20]. Significant livestock research efforts are further needed to identify livestock genetic resources conservation measures through the development of national databases on existing genetic resources and to broaden adaptation for the future to develop resilient and more productive animals. Moreover, emphasis must be given to conducting research targeting the impact of multiple environmental stresses simultaneously is required rather than concentrating only on heat stress.

CONCLUSION

Cattle genetic improvement is necessary to development of livestock sector, to address the challenges of climate change adaption and to produce animals that are efficient and well adapted to extreme temperatures, low-quality diets and greater disease challenges. When attempting to establish a cattle genetic improvement program, the selection of stocks

that is likely to be the most adaptable to local conditions and considering the future climatic pressures, while ensuring the capacity for increased productivity is vital. Cattle genetic improvements are important for increased productivity of breeds, whereas conservation and, their sustainable use are also essential to secure important locally adapted indigenous breeds. The major causes for the erosion of genetic diversity are unplanned extensive use of exotic germplasm and replacing locally adapted cattle breed due to increased pattern of reliance on a very limited number of modern commercialized cattle breeds suited for high input-output breeds. The maintenance of cattle genetic diversity underlying resistance to harsh environmental conditions provides an important resource for combating the effects of possible future climatic challenges. Therefore, any breeding strategies should be relevant in terms of breed suitability, performance and adaptability in the production environment and climatic stress. Genetic improvement methods of cattle currently used in Ethiopia are focused on selective crossbreeding of high input-output commercialized and indigenous breeds based on their phenotypes, particularly for higher productivity, without considering adaptation of environmental stress such as climate change. Genomic selection of animals in combination with conversional methods considering traits associated with heat-tolerance, fertility, feed conversion efficiency, adaptability to low-quality feed and disease resistance in addition to high productivity is necessary.

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