The State of Conservation of Animal Genetic Resources in Developing Countries: A Review

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***Abstract*—Animal genetic resources are playing a vital role in ensuring food security and maintaining genetic diversity. The efforts of conservation of animal genetic resources in developing countries are minimal. Even the different animal genetic conservation programs in developing countries are not effective confounded by different challenges. Different factors are responsible for the loss of animal genetic resources. As a matter of facts, the issue of animal genetic resources in developing countries reflects the theory of the chicken –the egg paradox in the sense that conservation programs usually started without the advent of full spectrum of conservation strategies. Besides, the importance of animal genetic resources is viewed from their direct merit and their conservation is solely depending on their direct merits neglecting the other outstanding merits. Overall, animal genetic resource conservation is becoming under question for defined newly emerging and existing constraints and there is a pressing need to curb this scenario. This review therefore, summarizes the issues of conservation of animal genetic resources in developing countries.**

***Index Terms*—animal, conservation, developing countries, diversity, genetic resources**

I. Introduction

AnGR comprises all animal species, breeds and strains that have economic, scientific and cultural value to mankind in terms of food and agricultural production for the present and the posterity [1]-[6]. For the last dozen thousand years, about 40 animal species have been tamed or semi-tamed worldwide [7]. Though reports in literature vary, within these species, there are globally about 7616 livestock breeds of which about 30% of them are at risk of extinction [8], [9]. The majority of these breeds are found in developing countries characterised by marginalized production environments. The predominant species include cattle, sheep, goats, pigs, chickens, horses and buffalo [10]. Several other domesticated animals like camels, donkeys, elephants, reindeer and rabbits are also valuable to different regions of the world [11]. Cattle, sheep, chickens, are predominantly found all over the world, while goats and pigs are less uniformly distributed.

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In developing countries, animal genetic resources (AnGR) are a very crucial component of biodiversity [12] nourishing 70% of the world's rural poor. These comprised of 194 million pastoralists, 686 million mixed farmers, and 107 million landless livestock keepers [13]. The effort to improve food security in developing countries lies in wise use of genetic diversity [14]. The values of AnGR conservation are mentioned in enormous literatures. All of them entirely appraise the past and present contribution of animal genetic resources to people under different environmental conditions [14], [15]. However, animal genetic resources are depleting for various defined reasons in developing countries [16] and [17]. The great concerns are the inflated loss of indigenous breeds impacting the livelihood options for the poor owing to utilization and management of these genetic resources [18]. This review therefore, explores the states of conservation of animal genetic resources in developing countries.

II. Drivers for the Loss of Animal Genetic Resources

In developing countries, the genetic diversity of livestock populations is dwindling for a multitude of threatening factors that lead to extinction. Analyses of the different scholars' report almost mention a similar threat reviewed below for this disappearance [17] and [18].

A. Pressure to Adopt Improved Animal Breeds

In the history of animal breeding, a very sizable number of breeds have been created and disappeared globally. In the last centuries, reports noted that there has been an inflated increase in the degree of extinction of livestock breeds than the rate of formation of new breeds. The main cause of genetic erosion in developing countries is attributed to the fact that farmers have a strong pressure to switch to commercialized livestock production and breeding schemes [12] because of agricultural policies promoting rapid solutions to ensure food security or meeting the soaring demand for food. With the advent and development of artificial insemination during the last 50 years, only a few males were involved in breeding schemes and consequently commercial breeds decline in their effective population

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size. Surprisingly, the Holstein cattle is known to have an effective population size of about 50 leading unavoidably to genetic drift and loss of alleles[2].

Cross-breeding and subsequently the replacement of locally adapted breeds by a narrow range of high-yielding international trans-boundary breeds is becoming an area of concern affecting animal genetic diversity in developing countries [19], [20]. This type of breed replacement without any long-term breeding plans, has contributed to severe genetic erosion, including extinction of a number of locally adapted (both within and across) breeds in the last few decades [19 and 14].The devastating effects to date are that dilution and in turn disappearance of important adaptive traits (resistance to diseases, adaptation to poor nutrition, and gregarious behaviour) by poorly designed crossbreeding [12]. These traits would otherwise been very crucial for the survival and management of herds in extensive farming and harsh environments. Several practical examples illustrate this genetic introgression threat, where indiscriminate repeated crossbreeding considerably disturbed their adaptation to harsh environments [14]. For instance, in Ethiopia, indiscriminate crossbreeding using the semen from exotic cattle breeds is resulting in enormous levels of dilution of the indigenous genetic makeup [21] for the last four decades. Artificial insemination has, in most cases, been and is still being executed on indigenous breeds that have not been evaluated and/or not characterized. Needless to say, simultaneous efforts to conserve the gene pool of the indigenous breeds are non-existent and genetic diversity is threatened by introduction of exotic genetic materials, droughts, and drought associated indiscriminate restocking schemes, and delicate development interventions.

In developing countries, within-breed genetic diversity is also under question adhered to the use of few highly popular sires for breeding purposes [22]. Most importantly about 50% of the total variation at the quantitative level is between breeds and thus utilizing just a few breeds would eliminate a considerable amount of variation in the species, apart from the loss of unique genes existing in those breeds [12]. In several animal breeding and improvement programs of developing countries economic decisions are mainly based solely on only the direct use values of indigenous genetic resources. The indigenous breeds are regarded to have low absolute production figures which otherwise would have been high if the production environment and the level of input are taken into consideration [3]. For these reasons, the value of conservation of AnGR has generally been underestimated. For instance, it estimated that 80% of the values of livestock in low-input developing country systems are attributed to non-market values, while only 20% is attributable to direct production outputs [21]. In other words, breeds are evaluated based on their individual performance considering only a single product [3].

Mention worthy, indigenous breeds produce and reproduce even under very harsh environmental conditions, and are considered as a very crucial asset since they have developed valuable adaptive traits over time. This productivity in harsh environments is critically important since only few types of livestock production systems sustain high input-high output systems. Therefore, it is advised that value of AnGR should be analysed at different levels (livestock keeper, community, national, global) and should consider a wide range of functions of livestock [4] to sketch out sound conservation and breed improvement programs.

B. Paradigm Shift in Production System

The livestock production systems have been changed enormously in the past and are projected to change significantly in the coming 50 years as well [23]. According to [24], these profound changes in agriculture in developing countries have caused severe and adverse impacts on the environment. Specifically, livestock production systems have changed in ways that have had a major impact on the use, exchange and conservation of farm animal genetic diversity [13] and in turn lead to the loss of livestock genetic diversity. This loss of genetic diversity is closely adhered to the alteration of small-scale (often largely subsistence) to large-scale commercialized or semi-commercialized modes of agriculture [4].

Production systems that are more intensive in their utilization of external inputs, more specialized and often larger in scale are now expanding rapidly in several developing countries. This is be-cause it has often been assumed that intensification requires the importation of exotic breeds. In practice however, it is highly likely that, given improved management, the native breeds will be perfectly satisfactory [25]. In effect, the paradigm shift in production system has led to increased use of exotic genetic resources, often at the expense of indigenous livestock breeds [26]. For in-stance, in Ethiopia, the overall paradigm shift in production system and land fragmentation situation forced transformation of transhumance way of cattle management to sedentary farming and in turn a decline in population size and admixture of a recognized breeds. The declining in population size and deteriorating in its genetic merit situation of Fogera cattle breed in the belt of Lake Tana due to a paradigm shift in the production system mainly from transhumance based livestock dominant crop livestock production to crop dominant crop livestock production [27]. This phenomenon has left the breed with an extinction probability of 0.47 [28] and [29]. Pastoralists in semi-arid areas are also losing their livelihoods as their grazing areas are being used for other purposes like irrigated cropping, rain-fed farming, nature reserves and wildlife parks [14].

C. Population Pressure, Globalization and the Livestock Revolution

Population increase [32], globalization and the livestock revolution [30] are regarded as the critical drivers propelling the erosion of animal genetic resources. Population pressure and increasing in income levels are putting pressure on livestock owners in developing

countries to increase production by urging to depend only on a limited range of genotypes [22] and [25] to meet the escalated demand for high quality livestock food products. Between 1993 and 2020, population growth, urbanisation and increased income levels are projected to be more than double than meat and milk consumption in developing countries [30]. This will surge an increasing trend in the share of developing countries in livestock production and consumption [31]. For example, 80% of production increase in dairy is also believed to come from smallholders [32].

"Ref. [19]" stated that globalization is also expected to bring a massive use of fewer live-stock breeds which may adversely affect smallholder competitiveness and threaten the sustainable use of indigenous livestock breeds. Among other things, the livestock revolution in developing countries is also expected to exacerbate further the declining trend of animal genetic resources [14]. The changing pattern in consumer demand and preference because of income levels is another threat for animal genetic resources that failed to supply the desired products. For example, consumer preference for leaner meat has led to a decline in pig breeds with a higher fat content [18]. Besides, colonization was also reported in contributing the replacement of indigenous animal genetic resources by improved livestock breeds [4] in developing countries. As a result, several animal genetic resources are endangered and minimal attention is paid to conserve them which retained several breeds to disappear before they are characterized and documented [6].

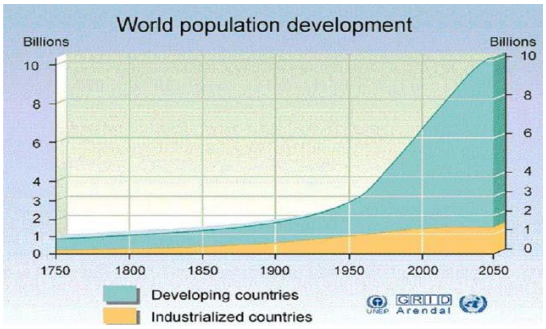

Figure 1. Population growth in developing and industrialized countries [32]

D. *Climate Change, Biotechnology and Development Policies*

Climate change is also an emerging hotspot issue of the globe that drives the state of animal genetic resources by distressing the already established systems of animal husbandry [10] and [30]. In the tropics and subtropics, in particular, increasing heat stress is expected to cause daunt challenges in livestock production by retarding production and fertility, increasing mortality rates; elevated water requirements and deterring feed intakes[14] and [33]. Particularly, high-output breeds from temperate regions are not well adapted to the effects of extreme temperatures and suffer from heat stress. If animals are introduced into a very hot climate characterised by higher humidity and poor-quality and quantity forage, they suffer from heat stress and do not produce to their full potential unless their management can be acclimatized.

Climate change also affects rainfall patterns especially in semi-arid areas leading them to experience erratic rainfall in the coming decades [33]. In connection with this, extreme temperatures projected to deteriorate feed quality and quantity by intensifying the degree of lignifications of forages and thereby causing animals to suffer from chronic nutritional deficiency. The spatial and temporal distributions of many infectious diseases especially that are transmitted by vectors can also be affected by climate change and new threats to animal health are likely to emerge [10]. For instance, the spread of bluetongue virus in Europe is suggested to have a linkage with climate change [33]. The effects of climate change also interferes with changes in land use, trade, human traffic and animal populations, disease control measures, socio-cultural, economical and political factors[10].

Advancements in biotechnology [30] are also projected to boost the on-going livestock revolution by affecting the exchange, use and conservation of AnGR [4]. It facilitates the use of superior genotypes across the globe, which may negatively affect conservation of global farm animal genetic diversity. Furthermore, rapid developments in biotechnology are providing new opportunities to enhance genetic progress by increasing genetic variation, increasing accuracy of selection, reduce the generation interval and increasing the selection intensity. Biotechnology is having an increasing impact on the animal breeding and genetics sector by facilitating the exchange of genetic material between countries and regions of the world thereby diverting the local attention to improved livestock breeds [30]. Besides, wrongly, planned policies and development programmes often trigger the threats to AnGRs by promoting superior genetic resources particularly if cross-breeding takes place in unsupervised condition [22]. Land use policies, direct and indirect subsidies tend to favour intensive livestock production at the expense of the small holder live-stock producers.

III. Why Worry about Loss of Animal Genetic Resources?

The loss of animal genetic resources is not only linked with the extinction of indigenous breeds but also the loss of best bet genetic diversity within breeds which the genes and gene complexes they carry may be useful to agriculture in the future. "Ref. [18]" indicated that genetic diversity is necessary for genetic change within a biological population for the sustainability of a breed to respond to selection to increase productivity and for adaptation to changing environmental conditions that are associated with climate, changes in markets, management and husbandry practices, and disease challenges. Livestock genetic diversity allows the existence of livestock in very marginal environments sustainably that are unsuitable for cultivation which account for two-thirds of the world's land surface [3]. For example, cattle breeds that are resistant to trypanosomosis are one of the

few ways to produce meat and milk in large swathes of the tropics. N'dama cattle breeds of West and Central Africa and Sheko cattle breed of Southern Ethiopia can be a good example for adapting to tsetse infested marginal environments of Africa. Besides, in marginal environments, local livestock breeds are crucial for sustaining rural livelihoods by producing a wide range of products with relatively low levels of input. Thus, if the traditional stock has become extinct adaptive traits may be rapidly lost by poorly designed crossbreeding leading to dilution of important adaptive loci of traditional breeds. The key traits for the survival and the management of herds in extensive farming like resistance to local infectious and parasitic diseases, adaptation to poor forage, homing and gregarious behaviour can be rapidly lost and difficult to rescue [5].

The disappearance or reduction of these locally adapted animal genetic resources force rural human populations to migrate to already overcrowd urban areas, increasing food insecurity and provoking irreversible social disintegration of rural communities [12]. Since there is a large interdependence between the livestock and the crop components in low-input production systems, the loss of local breeds will also have negative effects on the yield of local crops. Animal Genetic Resources are also important form of insurance that enables responses to as-yet-unknown future challenges [3]. Relying on a small number of livestock breeds is risky because it results in the loss of genes and gene combinations that although they are not relevant at present, may become relevant in the future. For example, breeds may differ in their level of resistance to newly emerging diseases triggered by climate change.

Apart from its importance in maintaining genetic diversity, animal genetic resources play a crucial role in the livelihood and well-being of the poor in the developing world [1]. Worldwide, there have been noticeable increases in hunger [22] and 842 million people were estimated to suffer from severe hunger in 2011-13 [22] leaving malnourished 30 or more percent of children under 5 years of age in sub-Saharan Africa and South and East Asia [22] and [14]. The livestock revolution is expected to meet these nutritional requirements [31] by improving the livelihood 1.96 billion people who depend on it [11]. The projected global population increase by some 90 million people per annum and the current international food and financial crises will also excel the expectation from the livestock revolution [30]. The implication is that the livestock producers are expected to increase their production by 50% to feed about 2 billion people in the next 35 years. For instance, by 2020, the share of developing countries in total world meat consumption is projected to increase from 52% to 63% [31].

Livestock genetic diversity allows farmers to develop new breeds in response to changing and very unpredictable conditions [10] and [12], including climate, diseases, knowledge of human nutritional requirements, and changing market conditions or societal needs. Besides, they yield important non-monetary benefits by enabling poor and landless people to access and utilize communally grazing lands, by producing dung fertilizer for cropping, serving for rituals, religious and social exchange systems, and by offering a mobile bank account that can be cashed when the need arises [18]. Over all, the diversified use of livestock on average contributes to between 10% and 50% of the gross domestic product of countries in the tropical developing world [14]. Nevertheless, numerous breeds have been lost and several are at risk of extinction [17].

Moreover, animal genetic resources have been integral parts of the livelihoods and traditions of several communities over years [13]. In essence, loss of a defined breed is a loss of cultural identity for that community, and a loss of part of the heritage of humanity. However, among other factors, economic condition as well as political backing for crossbreeding with exotic breeds, have already resulted in the disappearance of huge number of indigenous livestock breeds in particular [3] and biodiversity in general. This is because usually the economic merits of these breeds are judged without considering the overall qualities of the breed. Hence, it is usually recommended that the total economic value assessment of a given animal genetic resource should consider the entire direct and indirect merits of the animals when compared to its counter parts.

Animal genetic resources are also very essential in research and training activities like research in immunology, nutrition, reproduction, genetics and adaptation to climatic and other environmental changes [34]. Having a wide range of breeds available can help in the precise localization of mutations responsible for particular characteristics and livestock can serve as animal models for the study of genetic diseases in humans. Other users of AnGR in the conservation sector are also indispensible as it helps us to manage vegetation in nature reserves or to maintain culturally significant landscapes through grazing [22].

IV. Current State of Animal Genetic Resources in Developing Countries

It is reported that the status of AnGR is poorly understood and loss of genetic diversity is difficult to quantify [4]. But, still there are salient facts that animal genetic resources are disappearing rapidly worldwide. For instance, from the existing 7,616 animal breeds, the status of 36% of breeds is neither known nor comprehensive genetic characterization is yet done [22]. Few reports also showed that from the existing breeds about 1000 breeds have extinct (Table I) during the last 100 years [3]. Currently, about one-fifth of the world's domestic livestock are at risk [35] and 10% are already extinct [24]. Most of these breeds are from developing countries [29] and it is also anticipated that the hotspots of breed loss and genetic erosion in the coming years will be in developing countries [25]. For instance, Ref. [28] and Ref. [29] reported higher extinction probability for some selected cattle breeds of cattle (Table II).

TABLE I. NUMBER OF EXTINCT LIVESTOCK BREEDS [7]

Species	Africa	Asia	Europe and caucasus	Latin America and carbean	Near and Middle east	North America	Southwest pacific	International trans boundary breeds	World
Ass	1	0	3	0	1	0	0	0	5
Buffalo	0	0	1	0	0	0	0	0	1
Cattle	20	18	120	19	1	1	2	1	182
Goat	0	2	15	0	0	1	0	0	18
Horse	6	1	72	0	0	8	1	0	88
pig	0	15	91	2	0	0	1	0	109
Rabbit	0	0	0	0	2	0	0	0	2
Sheep	5	6	144	0	1	1	2	0	159
Chicken	0	5	51	0	0	1	0	0	57
Total	32	47	497	21	5	12	6	1	621

TABLE II. EXTINCTION PROBABILITY OF SOME SELECTED CATTLE BREEDS OF ETHIOPIA

No.	Breed	Extinction probability	References
1	Sheko	0.77	Resit-Marti et al., 2003
2	Highland zebu	0.77	Resit-Marti et al., 2003
3	Begait	0.67	Zerabruk et al., 2007
4	Abergelle	0.53	Zerabruk et al., 2007
5	Bale	0.57	Resit-Marti et al., 2003
6	Irob	0.57	Zerabruk et al., 2007
7	Arsi	0.53	Resit-Marti et al., 2003
8	Arado	0.50	Resit-Marti et al., 2003
9	Ethiopia Boran	0.48	Resit-Marti et al., 2003
10	Abigar	0.47	Resit-Marti et al., 2003
11	Fogera	0.43, 0.47	Resit-Marti et al., 2003; Zerabruk et al., 2007
12	Afar	0.43, 0.47	Resit-Marti et al., 2003; Zerabruk et al., 2007
13	Raya	0.47	Zerabruk et al., 2007
14	Arado	0.37	Zerabruk et al., 2007

Many countries have never surveyed their breeds systematically and many breeds may still be un-recognized – and some will become extinct even before they have been documented [13]. Breed inventories, and particularly surveys of population size and structure at breed level, are inadequate in many parts of the world. A case in point is India where two distinct breeds (the Malvi camel, and the Nari cattle) were threatened and escaped the attention of scientists [22]. "Ref. [7]" Reported the risk status of mammalian and avian breeds in the different regions of the world (Table III and Table IV).

TABLE III. RISK STATUS OF MAMMALIAN BREEDS JUN 2012[7]

Species	Africa	Asia	Europe and Caucasus	Latin America and Caribbean	Near and Middle east	North America	Southwest pacific	International trans-boundary breeds	World
Unknown	388	445	383	341	109	52	93	36	1847
Critical	13	19	305	10	0	7	14	4	372
Critical-maintained	1	9	44	4	0	2	0	0	60
Endangered	25	45	357	20	5	23	15	20	510
Endangered-maintained	5	8	178	8	0	12	1	0	212
Not at risk	220	780	861	93	84	13	17	328	2396
Extinct	32	42	446	21	5	11	6	1	564
Total	684	1348	2574	497	203	120	146	389	5961

TABLE IV. RISK STATUS OF AVIAN BREEDS JUNE 2012[7]

Species	Africa	Asia	Europe and Caucasus	Latin America and Caribbean	Near and Middle east	North America	Southwest pacific	International trans-boundary breeds	World
Unknown	132	228	334	126	33	3	42	32	930
Critical	7	8	180	1	0	27	6	10	233
Critical-maintained	1	8	17	2	0	0	0	0	28
Endangered	10	21	229	5	6	8	4	18	301
Endangered-maintained	2	5	155	3	0	0	0	0	165
Not at risk	69	206	164	14	15	4	7	101	580
Extinct	2	5	56	0	0	1	0	0	64
Total	223	481	1135	151	54	43	59	161	2301

V. The Status of Animal Genetic Resource Conservation Programs

Ex situ and in situ conservation programs are the two methods employed in conservation pro-grams of animal genetic resources. Ex situ conservation means conservation of animal genetic re-sources away from its original production systems where they were developed or are now normally found and bred [7] and [36]. This is maintenance of live animals in a zoo (ex situ in vivo) and cryopreservation of genetic material like semen, oocytes, embryos and DNA [Ibid]. In situ conservation involves production of animals in their original production environment either on-farm or community based and includes both actual farms and pastoral production systems.

In practice, ex situ in vivo conservation program suffers from disadvantages of variation of herd management on the farms from management of the herd in the field. Unlike herds under farmers' management, animals in the station may be spared migration, drought, and diseases and subjected to a different pattern of evolutionary processes. This means natural selection is usually no longer effective in its role of ensuring the adaptation of the population [36]. At times numbers of animals in the zoo/ranch may be too few to represent the full diversity of the breed and the animals may become secluded from the wider gene pool. Furthermore, they are subjected to gradually change their characteristics in adaptation to their new environment. Similarly, the limitation of conservation of animal genetic resources in a gene bank is that it does not possess the breed's socioeconomic role, nor does it save its cultural, historical and ecological values. Besides, ex situ conservation requires appropriate infrastructure and organisation, technical capacity, legal arrangements and sustained funding [37]. These days, the issue of budget is also becoming critical to run conservation programs in developing countries. The other question is this kind of conservation programs requires sufficient grazing land to sustain the existing animals. Nonetheless, to date land scarcity is becoming a pronounced challenge in many developing countries. Here, Ethiopia can be a very good example where many ranch grazing lands are allotted for other farming enterprises in Metekel and Adamitulu cattle breeding and multiplication centres. To maintain animal genetic resources sustainably, it is usually recommended to make use of complementary approaches of conservation involving both ex situ and in situ at national, regional and/or global levels [4].

In developing countries, few breeds of cattle, sheep, goat, buffalo and pig are covered by conservation programmes (Table V), and programmes are of variable quality [13]. For several reasons, developing countries do not put conservation of animal genetic resources as a priority, mainly be-cause their main goals are increased production and competitiveness in the global market in the short term. Unfortunately, there are very few prospective efforts directed towards thinking about the future of genetic resources and breeding programs. Kenya has better experience than the other countries with improvement schemes (livestock recording and genetic evaluations) for all exotic dairy breeds and for some local beef or dual-purpose breeds like the Boran and Sahiwal cattle breeds. Beef cattle breeding programmes limited to a small part of the country's commercial beef producers are also in place in Botswana. Whereas, conservation programmes are to some extent available for indigenous ruminant breeds, as for the Tswana cattle breed. In Mozambique breed-ing stations are used for conservation of indigenous cattle and small ruminant breeds, such as Nguni, Angoni and Landim cattle breeds. In Ethiopia, from the 1950s to 1970s, conservation pro-grams were established in the form of ranches and multiplications centres for the conservation of Fogera, Boran, Horro and Arsi cattle breeds and Menz sheep [13] and [38]. These include Metekel cattle ranch, Andassa cattle ranch, Wolaita cattle ranch, Jigjiga ogaden cattle ranch, Dida Tuyura Boran cattle and Abernossa Boran cattle ranch, Bako sheep ranch and Menz sheep ranch. However, most of them, including sheep ranches (Horro sheep ranch at Bako, Menz sheep ranch at Sheno and Amed-Guya menze sheep multiplication centre) are closed with a disappearance of thousands of animals. Besides, semen of both exotic and indigenous cattle breeds is stored in se-men banks, but not regularly used. In Tanzania breeding programmes exist for Mpwapwa and Boran cattle breeds at research stations and for goats, breeding strategies exist for pure breeding of Blended, Newala, Ujiji and Gogo breeds. In Uganda, breeding schemes are practised within research and development programmes for Ankole cattle as well as for some other cattle, goat and sheep breeds. In Zambia, characterization and conservation programmes are undertaken for some indigenous cattle, like Angoni, Barotse, Tonga and Baila breeds. Indigenous cattle breeds are being conserved in vivo at government stations.

TABLE V. Number of Countries with Conservation Programs [13]

Region	No. of countries with in vivo conservation	No. of countries with in vitro conservation
Africa	18	9
Asia	13	12
Europe and Caucasus	33	12
Latin America and the Caribbean	8	6
Near and middle east	1	0
North America	2	2
South west pacific	2	1
World	77	42

10 countries in Latin America have genetic resource conservation programs for indigenous breeds. Nine countries claimed that they have a program for bovine, seven for sheep, four for goats, four for camelids, three for pigs and three for horse breeds. Besides, programs for the conservation of donkey breeds, buffaloes, rabbits, Guinea Pigs and Capybaras were mentioned. Gene banks for honeybees were also established in Argentina. Similarly, conservation programmes for breeds of ruminant livestock, are also being undertaken or are planned in the south East Asian countries-Bangladesh, Bhutan, India, Nepal, Pakistan and Srilanka for several cattle, Buffalo, goat and sheep breeds [15].

Over all, no fully functioning breeding and conservation programmes with active farmer participation are available in any of these countries. Usually nucleus herds at research stations are used for multiplication of indigenous breeds that are considered threatened and vulnerable to inbreeding. In general, institutional and organizational frameworks are too weak to support sustainable breeding programmes. According to the reports of [39], shortage of trained and skilled personnel in animal breeding is the single biggest constraint to development and implementation of AnGR improvement programmes in developing countries. Besides, lack of facilities, breeding policies, and definitions of breeding objectives, weak interactions and linkages between and within different institutions were also reported as key constraints in developing countries. Insufficient funding for breeding activities is also an important constraint in conservation and improvement of animal genetic resource conservation. Most countries in Africa and Asia lack functioning breeding programmes, whereas some Latin American countries developed commercially viable breeding programmes for indigenous breeds and crosses. Common reasons for the failures are lack of involvement and engagement of farmers and other stakeholders. The majority of people in the live-stock sector are not aware of the current policy debate that may significantly influence the ex-change, conservation and use of AnGR. So far, government representatives, non-governmental or civil society organizations and a number of scientists have dominated the issues [4]. In general, reports agreed that there is a gap between the perceptions of policy makers and those farmers, breeding organizations and pastoralists who actually work with AnGR in practice.

VI. Ideal Scenarios for Maintaining Animal Genetic Resources in Developing Countries

There is limited awareness about the importance of the conservation and sustainable use of AnGR among policy makers and major stakeholders in the livestock sector [4]. The first step toward an efficient conservation strategy for animal genetic resources is the proper characterization of the conservation value of the different breeds and wild relatives [14]. However, the implementation of the subsequent steps is more complex, as conservation strategies for farm animal genetic resources must integrate technical, economical, sociological, and political parameters [20]. According to [3] and [8], effective management of farm animal genetic resources requires comprehensive knowledge of the breeds' characteristics, including data on population size and structure, geographical distribution, the production environment, and within- and between-breed genetic diversity.

In AnGR conservation, the relative importance of AnGR from the livestock keepers' perspective should be appraised [11] as livestock keepers are the main custodians of AnGR diversity [22]. "Ref. [11]" advises that the awareness of shrinking diversity and the challenge to increase future food production must be translated into efficient long-term strategies and operational breeding schemes. This requires good knowledge of both the actual production and market systems, including socio-economic and cultural values, and the characteristics of the breeds in order to formulate adequate breeding objectives. "Ref. [6]" emphasizes that it is not through the keeping of animals per se, but rather the combination of rural peoples' knowledge of their environment and the way that they manage their livestock that maintains domestic animal diversity. This knowledge includes the recognition and evaluation of livestock characteristics and breeds or 'types'; the management of animal and plant genetic resources and how these interact in the production system and ethno-veterinary knowledge. Nevertheless, this rather extensive and complex knowledge system has not been adequately characterised and documented as experts often do not appreciate the value of this knowledge. "Ref. [22]" pointed out that ignoring such wealth of knowledge could partly be the reason why livestock genetic improvement programs that are solely based on western designs and structures have generally failed in many developing tropical countries.

Several practical examples ascertain the importance of considering indigenous knowledge in animal genetic resource conservation programs. For instance, livestock keepers have bred the trypanotolerant N'Dama cattle of West Africa and the helminth resistant Red Maasai sheep of East Africa for centuries [3]. Similarly, the indigenous cattle, goat, pig, camel and buffalo breeders of developing countries understand the concept of maintaining domestic animal diversity under harsh environments since time of livestock domestication and use. They identify and select their animals for a wide variety of characteristics, such as drought tolerance, longevity, diseases resistance, ability to survive on low quality feeds etc. This knowledge system is crucial to under-stand the history and nature of existing diversity in animal populations and a basis for developing strategies for its continued maintenance and sustainable exploitation.

The most promising option for maintaining animal genetic resources is to support and provide incentives for local communities to continue herding and managing their animal genetic resources in their respective ecological contexts. According to Ref. [39], in this a win-win approach, conservation of domestic animal diversity is expected to go hand-in-hand with the creation or

maintenance of rural income opportunities. Another critical issue for conservation and genetic improvement programmes is the availability of supportive infrastructure [40]. In order for breeding programmes to succeed, infrastructure such as physical facilities, functioning recording and genetic evaluation systems, are required. In low to medium input systems functioning infrastructure is often lacking or is underdeveloped to support breeding activities.

"Ref. [41]" also stated that maintenance of livestock genetic diversity requires a wide range of general policy changes as well as a full spectrum of strategies. A strategy to conserve the diversity of animal genetic resources developed by farmers, nomads and indigenous communities is very crucial to maintain the existing farm animal genetic diversity. Such a strategy developed should also include- promotion and support of the marketing of products from local breeds; better access to veterinary services for local livestock; awareness-raising among consumers about the value of national-level genetic resources and better description and documentation of particularly valuable characteristics of local breeds. Besides, a strategy on security land use rights for farmers and pastoralists, effective prohibition of land measures against encroachment on traditional pasture land and promotion and documentation of traditional knowledge. A strategy for controlling imports of exotic breeds and provision of information on the potential consequences is also need-ed. A strategy for capacity building among farmers and local communities, through education and training, awareness raising, information-sharing and the dissemination of case studies is also very important. Supportive policies, efficient organizations and institutions, competent staff, long-term financial support and strong links between these components are also needed.

The world has about 7616 livestock breeds and conservation of all of them is not technically and financial feasible. A wide number of factors potentially contribute to the decision regarding the priority of breeds for conservation. These include degree of endangered-ness, breed divergence, specific adaptations, and risk of breed extinction, breed merit, unique traits, and cultural value, and genetic uniqueness, traits of economic importance and within breed variation [26] and [19]. Policy choices must be made to prescribe which and how many breeds to conserve, along with the management strategies to implement [24]. Most importantly, [41]-[45] suggested that conservation of farm animal genetic resources should be designed with a long term perspective, using a planning horizon of at least 50 years as the required genetic management to maintain diversity over a given time horizon differs between species.

VII. Conclusions

In conclusion, from this review it can be noted that the issue of conservation of animal genetic re-sources in developing countries is interwoven by different multifaceted constraints. In other words, the issue of conservation of animal genetic resources reminds the theory of the chicken- the egg paradox in the sense that conservation programs usually started without the advent of full spectrum of conservation strategies. It is also clear that the importance of animal genetic resources is judged most often from the direct value of livestock breeds and conservation and breed improvement programs solely depend on the direct values of animal genetic resources. The avail-ability of diverse livestock breeds also calls for the need to prioritize breeds for conservation and conservation strategies should account for the observed and projected effects of the factors that threaten the animal genetic resources in the developing world. Awareness among policy-makers and livestock keepers about the potential roles of animal genetic resources in climate change adaptation and mitigation should be promoted.

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