Journal of Genetic and Environmental Resources Conservation, 2015, 3(2):150-163.
www.jgerc.com

Assessment of livestock genetic resource diversity in Ethiopia: An implication for conservation

Tewodros Mulualem[1]*, Meseret Molla[2] and Merkebu Getachew[3]

[1]Jimma Agricultural Research center, P.O. Box 192, [2,3]Jimma University, College of Agriculture and Veterinary Medicine, P.O. Box 378, Jimma, Ethiopia.
*Corresponding author: tewodrosmulualem@gmail.com

Abstract

About 85% of Ethiopian population has a subsistence mode of crop and livestock production. This form of agriculture contributes a large share of the gross national products (GNP). Livestock contribute 30-35% of total GDP. A review was made to assess the genetic diversity of animal genetic resources in Ethiopia, to develop conservation strategy and efficient utilization of indigenous animal genetic resources. Ethiopia can be considered as a center of livestock diversity and diverse traditional livestock breeds spread across diverse ecology, communities and production systems. This diversity of livestock is closely related to the diversity of production systems and cultures. Currently, the indigenous livestock genetic resources in Ethiopia are becoming seriously endangered due to high rate of genetic erosion resulting from biotic and a biotic factor. Thus, there is a need to develop conservation strategies for management of these livestock genetic resources in the country which should be cost effective and utilization to meet the needs of present and future generations. For sustainable utilization, the conservation strategy must be contributed to the national food security program; have high commercial/export value. Methods of conservation of livestock genetic resources to support future livestock improvement can be grouped as in-situ, ex-situ and combined conservation. Therefore, detailed analysis of the extent, distribution and diversity of livestock, good understanding on the integrity of livestock with social, religious and culture of the society and management is vital for sustainable utilization and livestock conservation strategy in the country.

Keywords: Conservation, Genetic diversity, Genetic resource, Livestock.

Introduction

Agriculture remains the mainstay of Ethiopia's economy. About 85% of the economically active population lives in rural areas, particularly in the central highlands (FAO, 1996). The majority of the population has a subsistence mode of crop and livestock production. This form of agriculture contributes a large share of the growth national products (GNP). Livestock are domesticated animals raised in an agricultural setting to produce commodities like food, fiber and traction power. More than 40 species of livestock have been domesticated (or semi-domesticated) during the past 10,000-12,000 years that contributed directly or indirectly to agricultural production (FAO, 2000).

The most common species of livestock includes all small and high ruminants, chicken, equines, camel (pseudo ruminant) and swine that are socially, economic, scientific and cultural interest to humankind in terms of food and livelihood security (Getahun, 1991). The livestock sector in Ethiopia contributes 12 and 33% of the total and agricultural Gross Domestic Product (GDP), respectively, and provides livelihood for 65% of the population. The sector also accounts for 12-15% of the total export earnings (FAOSTAT, 2013). These livestock genetic resources are vital to the economic development of the country. In many regions, they can play an important role in the subsistence of many communities and the sustainability of crop-/livestock systems. Livestock perform multiple functions in the Ethiopian economy by providing food, input for crop production and soil fertility management, raw material for industry, cash income as well as promoting saving, fuel, social functions, and employment. The country has the largest livestock population and the highest draft animal population in the continent.

Currently, the indigenous livestock genetic resources in Ethiopia are becoming seriously endangered owing to the high rate of genetic erosion resulting from biotic and a biotic factor.

Furthermore, the extensive and random distribution of exotic livestock breeds by both governmental and non-governmental organizations is believed to dilute the indigenous genetic stock. If this trend continues, the gene pool of the indigenous livestock diversity could be lost in the near future. This threat is in line with the FAO report (FAO, 1999), which states that animal genetic resources in developing countries in general, are being eroded through the rapid transformation of the agricultural system, in which the main cause of the loss of indigenous animal genetic resources is the indiscriminate introduction of exotic genetic resources, before proper characterization, utilization and conservation. Besides, genetic dilution due to foreign or exotic use, changes in production systems, markets preferences and environmental hazards, natural catastrophes, unstable policies from public and private sectors and the availability of limited funds for conservation are deteriorate the diversity of livestock genetic resource in the country (Rege and Gibson, 2001).

Genetic variation is the basis of animal breeding, selection and conservation of genetic resources. The genetic characterization of domestic animals is the first step in considering the sustainable management or conservation of endangered breeds and to determine the genetic diversity of breeds. It is important to know how unique or how different it is from other populations. In Ethiopia, limited attention has been given to the characterization and classification of indigenous livestock genetic resources and research at its rudimentary stage for the identification, description and evaluation of these genetic resources. As a result, some of the livestock animal genetic resources of Ethiopia are endangered, and unless urgent efforts are taken to characterize and conserve, they may be lost even before they are described and documented (Rege, 2003). It is also stated that an increasing loss of genetic diversity has been observed for all agriculturally used species and livestock genetic resources are considered to be the most endangered (Crawford, 1990; Crawford and Christman, 1992; Romanov *et al.*, 1996). Moreover, the majority of livestock genetic diversity is found in the country where documentation is scarce and risk of extinction is highest and increasing.

Therefore, there is a need to characterize and properly utilize the indigenous animal genetic resources under low levels of input in the country. The locally adapted animals are also more readily available to resource-poor farmers and they can be productive with high disease-resistance Yet, lack of information about the genetic resources present in the indigenous farm animals in Ethiopia has led to under-utilization, replacement and dilution through cross-breeding. Thus, characterization, utilization and conservation of these indigenous livestock genetic resources are of paramount importance. Accordingly, this paper focuses mainly on livestock genetic diversity and conservation which is the basis for improvement and conservation strategies of livestock genetic resource in Ethiopia.

Overview of livestock genetic resources in Ethiopia: Ethiopia can be considered as a center of livestock diversity: it is a route of livestock migration from Asia into Africa and has large livestock population (FAOSTAT, 2012) and diverse traditional livestock breeds spread across diverse ecology, communities and production systems (Solomon, 2008). These environmental conditions are conducive for livestock production. Central Statistical Authority of Ethiopia (CSA, 2011) showed that Ethiopia possess 43.1 million heads of cattle, 23.6 million heads of sheep, 18.6 million heads of goat, 616,396 million heads of camel, 34.2 million poultry and 6.5 million equines. There are also a variety of breeds/strains/types within each livestock species contributing to the total genetic pool. Different authors showed that there are around 24 cattle breeds (DAGRIS, 2004), 14 sheep strains (Solomon, 2008), 9 goat breeds (DAGRIS, 2004), different ecotypes of chicken and non-descript equines in Ethiopia. It ranks first, second and third in number of cattle, sheep and goat, respectively, in Africa. For all of Africa, 17.10%, 12.00%, 11.00% and 49.00% of the cattle, sheep, goat and equine population, respectively, is found in Ethiopia. Given its diversified topographic and climatic conditions, the huge livestock population size, the different types of livestock animals, which have evolved over time and adapted to the ecological conditions of their habitat, and to some extent, been influenced by the production system of their owners.

Livestock genetic diversity in Ethiopia: Globally, there are about 40 species of domestic livestock (FAO, 2012), which have been domesticated by humans over the last 12,000 years. In the process of domestication, however, separate and genetically unique breeds and strains have developed within each species as a result of human development and occupation of new areas over the planet. According to FAOSTAT (2012), there are about4,000 to 5,500 breeds and strains of domestic animals in the world. These breeds and strains are referred to as the global animal genetic resources and the genetic variation both between and within the breeds are described as the diversity within the species of domestic animals.

The selection process, both environmental and human directed, has resulted in much of the

diversity existing between the breeds. Differences among the breeds have been created by reproductive isolation, often imposed by human through pursuit of different breeding objectives and physical separation for various length of time. As a consequence of physical separation, each breed/strain has been adapted to particular ecological condition to suit the local climate and the requirements of the community.

The diversity of livestock in Ethiopia is closely related to the diversity of production systems and cultures. Local breeds are usually based in grassland-based pastoral and small-scale mixed crop–livestock systems with low to medium use of external inputs. Over the past decades, agriculture has achieved substantial increases in food production, but accompanied by loss of biodiversity, including in livestock genetic resources, and degradation of ecosystems, particularly with respect to their regulating and supporting services. Genetically diverse livestock populations provide societies with a greater range of options to meet future challenges. Therefore livestock genetic resources are the capital for future developments and adaptation to the changing environments. If they are lost, the options for future generations will be severely curtailed.

Diversity in livestock populations is measured in different forms: livestock breeds belong to different avian and mammalian species; thus species diversity can simply be measured as the number of species. On a global scale, five species show a widespread distribution and particularly large numbers in Ethiopia. Those species are cattle, sheep, chickens, goats and pigs, the 'big five' (FAO, 2007). Therefore, the majority of products of animal origin are based on quite narrow species variability. The diversity presently observed within farm animal species is the result of a long history of human practice. At the sub-species level, diversity within and between breeds and the interrelationships between populations of a breed can be distinguished. Over millennia, a variety of breeds have been developed in a wide range of production environments.

In Ethiopia, the national strategies for livestock production aims at increasing food production rather than reflect the need for a genetic pool of breeding stock, although this is slowly changing due to the implementation of the Global Plan of Action for Animal Genetic Resources (GPAAGR). Although breeding has to focus on what the market wants (mass or niche market), other factors have also needs to be taken into account. The choice of breeds/breeding used in the livestock sector needs to ensure the profitability of the farm, safeguard animal health and welfare, focus on conserving genetic diversity and promote human health. Currently, at national level, many livestock (cattle, pig, goat, sheep and chicken) breeds are already extinct or currently at risk (FAO, 2007a). Therefore, intensification of livestock production systems, coupled with specialization in breeding and the harmonizing effects of globalization and zoo-sanitary standards, has led to a substantial reduction in the genetic diversity within domesticated animal species in the country (FAO, 2007).

Livestock adapted optimally to their habitat, in most cases not tailored to maximum meat or milk output, are increasingly being displaced by high performance breeds usually trans-boundary breeds for use in high external input, often large-scale, systems under more or less nationally standardized conditions. In contrast to many local breeds, trans-boundary breeds provide single products for the market at high levels of output. Holstein-Friesian cattle one of the most successful dairy breeds in Ethiopia, while in chicken the importation of exotic breeds of chicken goes back to the early 1950's. According to Alamargot (1987), about 99% of the Ethiopian poultry population consists of indigenous chickens, while the remaining 1% consists of imported exotic breeds of chickens during the 1970's and 1980's.There has been an increase in the number of exotic breeds of chickens and at present it is estimated that these make up about 2.18% of the national poultry population (CSA, 2005, Solomon, 2007).

Genetic diversity of larger and small ruminant farm animals

Historical process and Diversity of larger ruminants: Although uncertainty still surround the existence of some domestication centers for some livestock species, the following geographic areas are important primary centers of origin and diversity of livestock species: southwest Asia including the Fertile Crescent (cattle, sheep, goats and pigs); South America (camel and guinea pigs); central America (ducks); northeast Africa (cattle and donkeys); the Indus valley region (cattle, goats and chickens); Southeast Asia (chickens and cattle); east China (pigs and chicken) (FAO, 2007).

These first African cattle initially dispersed north, as well as south to the borders of the tropical rainforest (FAO, 2007) up to the Nile Valley to Sudan and Ethiopia and rock paintings of the second millennium B.C. depicting them in Harar, Ethiopia (Albero and Haile-Mariam, 1982a; 1982b). Today, the only remaining descendants of these indigenous African taurine cattle are the trypanotolerant. West African breeds (e.g. N'Dama

and Baoule), the Kuri and the Sheko breed from Ethiopia. All these populations are now being intensively crossbred with Zebu cattle (*Bosindicus*), and their unique genetic make-up is disappearing through unbalanced genetic admixture (FAO, 2007).

Ethiopia is endowed with varied agro-ecological zones and possesses diverse animal genetic resources. Zebu cattle, which are characterized by having a large hump and a large hanging dewlap, arrived in Africa much later than the native African breed.

The livestock population is primarily of local origin and not characterized as belonging to specific breeds. However, the local breeds are generally named after the area they occupy. Even amongst these identifiable types, there has been large inter-mixing, resulting in a dilution of livestock breed characteristics. Thus, a large proportion of the population is non-descript. Little effort has been made to comprehensively describe the indigenous livestock populations of Ethiopia. Alberro and Haile-mariam (1982a; 1982b) attempted to identify and classify some Ethiopian cattle types by compiling available literature and gathering information from field trips and Ministry of Agriculture provincial offices. Cattle were classified into four broad categories: the humpless Hametic Longhorn and Shorthorn, the Zebu, the Sanga and the intermediate Sanga/Zebu.

All of these cattle types were described as having considerable adaptability to harsh climate, poor nutrition and diseases endemic to their respective areas. Alberro and Haile-mariam also attempted to describe some of the specific characteristics by which each of the types could be differentiated. For instance, the Boran and the Danakil can withstand prolonged droughts; the Abigar and Fogera are able to withstand periodic flooding while the Abigar has some trypano tolerant traits. The numbers of organizations have also attempted to characterize some of the well-known indigenous cattle and sheep breeds through on-station breed evaluation and improvement programs. Amongst these are the Ministry of Agriculture (MOA) ranches for breeds like the Boran, Fogera and Arsi; research programs for the Horro, Barka and Boran breeds initiated by the Institute of Agricultural Research (IAR) currently, Ethiopian Institute of Agricultural Research; and research/teaching programs with the Boran, Barka and Fogera types developed by the College of Agriculture at Haramaya University.

Diversity of small ruminants: Indigenous breeds constitute well over 95 % of small ruminant populations in Africa (Rege, 1992). These are well adapted to the environment and the ravages of various kinds such as drought, famine and civil wars that continually plague the continent. Their adaptive features enable them to effectively cope with the stressful nature of marginal lands.

Diversity of sheep: Ethiopia is home for an estimated 23.6 million (CSA, 2007) sheep and about 14 traditional sheep breeds (Solomon *et al.,* 2007). Their multipurpose role as source of income, meat, skin, manure and coarse wool or long hairy fleece, means of risk avoidance during crop failure and their cultural function during festivals are well documented (Solomon *et al.,* 2007; Kosgey *et al.,* 2008). This makes them suited to the low input smallholder and pastoral production system. Despite low level of productivity due to several technical (genotype, feeding and animal health), institutional, environmental and infrastructural constraints indigenous sheep breed has a great potential to contribute more to the livelihood of people in low input, smallholder and pastoral production system (Kosgey and Okeyo, 2007; Solomon, 2008). Based on the Ministry of Agriculture, Ethiopian indigenous sheep diversity has been classified into four broad categories: the hairy thin tailed, wooled thin tailed, fat tailed and fat rumped. Accordingly, attempts have been made to group some of the well-known types into these different categories (Table 3).Five major goat types have also been identified and are classified as Nubian, Highland, Adal, Somali and long tailed gishe. Additional goat classes have been proposed (Workneh, 1991; Solomon, 2008): the white Digodi (Somali) in Borana; the colored Gugi in Borana and Sidamo; the red Tsemay in north Omo; and the black and brown Konso in north Omo. Farm Africa, a British-based NGO, in collaboration with the Ministry of Agriculture and the Haramaya University of agriculture, has started a national goat survey program.

On-station breed evaluation work of some well-known sheep types has also been undertaken by different institutions. These include the IAR evaluation program on Adal, black head Ogaden, horro and menz sheep the MOA improvement program on menz and black head Ogaden sheep. Major emphasis in all of these studies was on meat, milk (goat) and wool (Menz sheep) production. Results indicate that the average mature Ethiopian sheep (rams) weighs 26-35 kg; wool production is about 0.5 kg per head.

The International Livestock Research Institute (ILRI) jointly with national Agricultural Research Center in Ethiopia is designing community-based sheep breeding strategies for some Ethiopian sheep breeds including Menz and Afar sheep breeds. To design a community based breeding strategy, detailed information on the breed and production

system need to be available. Unfortunately, information available on Ethiopian sheep breeds is scant (Workneh *et al.,* 2004) and available information so far have been based on on-station managed flocks and numerical measurements. Looking the breed from this perspective only does not consider the keepers priorities (Kosgey, 2004) so that assessing the production system, indigenous knowledge of managing the breed, identifying list of important traits for selection with full participation of farmers are prerequisite to set up genetic improvement at smallholder and pastoral level (Kosgey *et al.,* 2006).

Diversity of goat: The population of goats in sub-Saharan Africa is estimated to be about 163 million (Rege *et al.*, 2002). Migration to a new habitat and consequently the effect of natural and artificial selection have led to the evolution of breeds and types of goat, which differ in appearance and performance. Around 90 'breeds' of African goats have been recognized using criteria as geographic distributions, ecotypes or communities-tribe ownership (Rege, 1992). They presumably derive from goats that spread south from Egypt at an early date. Generally, goats of Sub-Saharan Africa are divided into three major types following their morphology; the long lop-eared type in north east and southern Africa, the small short-eared type dominant in eastern Africa and the dwarf short-eared type of West Africa. Intermediates morphological types are numerous.

The majority of Ethiopian goat population is found in large flocks in the arid and semi-arid lowlands where pastoralists in the South, East, and West keep them for milk and meat production and for sale. Goats in the highlands are widely distributed in the crop-livestock production systems with very small flock sizes as a means of cash earnings and meat. Despite the huge resource potential, production and export opportunities, goat production in Ethiopia is relatively undeveloped. Although there are severe environmental constraints to increase goat productivity, there is a considerable potential for goat production in the country, where goat milk, meat, and skin are valued commodities.

Information compiled on physical description and management system revealed that there are 14 goat types in Africa (Farm-Africa, 1996). Out of these eleven are found in today Ethiopia. The names given to the goat types of Ethiopia reflect mainly their geographical locations and to some extent also their ethnic affiliation. These are: Afar goat (adal or danakil), Abergale, Arsi-Bale, Woyto-Guji, Hararghe Highland, Short-eared Somali, Long-eared Somali, Central highland, Western highland, Western lowland and Keffa. Using a set of morphological characters, goat in Ethiopia have been classified into four major families: - the Somali family (Short-eared Somali, long-eared Somali, and Hararghe Highland), the Nubian family (Nubian and Barka), the small Rift valley family (Abergalle, Worre, Afar, Arsi-Bale, and Woyto-Guji) and finally the more heterogeneous Small East African family (Western Highland, Keffa, Central Highland and West Lowland).

Genetic diversity of non-ruminants

Poultry diversity: The word poultry is synonymous with chicken under the present Ethiopian condition. There is no exact figure representing the country's poultry population. According to (FAO 2000), the country's chicken population is about 65 million of which about 1 % consists of imported exotic breeds of chickens kept in urban and peri-urban areas. The remaining 99% consists of indigenous chickens of none descriptive breeds (Tadelle,1996;Halima, 2007). Ethiopia has about 60 % of the total chicken population of East Africa (Mekonnen, 2007), and play a significant role in human nutrition and as a source of income. The distribution and density of birds vary from place to place, but they are found in most parts of the country suitable for human settlement.

The four major Regional States, in terms of land area and human population (Oromiya, Amhara, SNNP, and Tigray) collectively accounts for about 96% of the total national poultry population (CSA, 2005). Chicken rearing is not common in the lowlands of Ethiopia and the lowlands of Ethiopia i.e. Somali, Gambella, Afar and Benishangul-Gumze Regional States collectively own 3.24% of the total national chicken population of which 2.2 % is owned by Banishing- Gumuze Regional State (Solomon, 2007; Meseret, 2010).

Oromiya region shares about 34.4% of the total national chicken population and contribute 36% of the total annual national egg and poultry meat production. The regional rural areas constitute about 97.1% of the total regional chicken population while the urban areas constitute 2.9%. Moreover, almost all the available commercial poultry farms of the country are located in Oromiya region specifically in and in the vicinity of Debre-ziet. The RegionalState own and operates a total of seven poultry breeding and/or rearing centers at different locations namely, Adama, Adelle, Ambo, Bedelle, Fiche, Kerssa and Nekemte. The Amhara region habitat about 31.3 % of the total national poultry population and contribute about 28% of the total annual national egg and poultry meat production. The RegionalState has two breeding and multiplication centers (Kombolisha and

Andessa). The Southern Nation and Nationality People (SNNP) Regional State shares about 18.8% of the total national chicken population and contributes about 18% of the total annual national egg and poultry meat production. The Regional State Bureaus of Agriculture (RSBA) operates 4 poultry breeding and multiplication centers (Awassa, Walayita Sodo, Gubre and Bonga) (Meseret, 2010). The Tigray Regional State habitat about 11.65% of the total national indigenous chicken population and contributes about 15% of the total annual national egg and poultry meat production. The RSBA operates one poultry breeding and multiplication center located in Mekelle (Solomon, 2007).

The local chickens, which are basically non-descriptive types closely related to the Jungle fowl and vary in color, comb type, body conformation and weight and may or may not possess shank feather. Broodiness (maternal instinct) is pronounced. They are characterized by slow growth, late maturity and low production performance (Negussie, 1999; Solomon, 2007; Meseret, 2010). The mean annual egg production of indigenous chickens is estimated at 60 small eggs with thick shell and deep yellow yolk color (Alemu and Tadelle , 1996).

Currently, the local chicken genetic resources in Ethiopia are becoming seriously endangered owing to the high rate of genetic erosion resulting from chicken diseases, specifically Newcastle disease and predation. Furthermore, the extensive and random distribution of exotic chicken breeds by both governmental and non-governmental organizations is believed to dilute the indigenous genetic stock. If this trend continues, the gene pool of the indigenous chickens could be lost in the near future, before they are described and studied.

Swine diversity: In Ethiopia, swine are under-utilized genetic resources though they have the potential to contribute to meat consumption and improved livelihoods in the smallholder communities (Styger, 2002). There are several reasons why local swine are sidelined in Ethiopia. First, there are negative perceptions about both the swine and the production environment arising from historical bases against the local swine and free range production systems (Lekule and Kyvsgaard, 2003). Secondly, farmers lack access to markets, viable marketing strategies and marketable products (Ramsay, 2002). Third, there is a general lack of information with regards to carcass, meat and processing quality of local swine (Styger, 2002). Fourth, there are biases in the social and religious factors in the society are a few to mention.

Ethiopia is endowed with suitable climatic conditions for production of swine. However, it has been widely neglected by research and development programs. A large pool of swine is found in commercial farms and forest areas as a wild in different parts of Ethiopia. Nevertheless, these gene pools are being lost due to social and cultural reasons. Therefore, there is a need to conserve and utilize the swine genetic resources to reduce further genetic erosion.

Equines diversity: Throughout history, equines (horses and donkeys) have been rendering considerable services as pack and transport animals to Ethiopian farmers and pastoral societies living in marginal environments (Kefena, 2012). They continue serving their destiny even for other purposes uncommon among Ethiopian communities, particularly as sources of draft power However, equines are not equally recognized as other domestic animals and no attempt has been made to characterize and describe them regardless of many essential roles they play in many communities in Ethiopia. Recognizing the contribution of equines in the national economy and realizing their role in the unforeseen future, a nationwide survey was carried out to characterize and describe Ethiopian equines at both phenotypic and molecular level (Kefena, 2012).

Donkeys Diversity: Next to China, Ethiopia possesses the largest donkey populations in the world (Alemu*et al*., 2004). Moreover, Ethiopia is one of the most strategically significant places in the Horn of Africa for domestic donkey diversities. Ethiopian donkeys are characterized by tremendous phenotypic diversities. Based on visible the external phenotypic characteristics and standard phenotypic characterization criteria developed by FAO, we identified six phenotypically distinct domestic donkey populations in Ethiopia. Jimma donkey population, which was previously reported but failed meet the new characterization criteria was rejected. Out of the six identified phenotypic ally distinct donkey populations of Ethiopia, Sinnar donkeys are the tallest of all and are characterized by white, roan, grayish and black coat colors. All coat color types have white underneath. They are elegant animals that walk fast and primarily used to produce high quality mules in Ethiopia.

On the contrary, donkey population is characterized by small body size and brown coat color. They are hardy animals inhabiting on both sides of Ethiopian highlands dissected by the Great Rift Valley. The rest of Ethiopian donkey populations are medium-size animals characterized by different body conformations and coat color patterns. It is important to note that the newly explored Omo donkeys are big and fatty donkey

type. They had been used to serve as source of meat for some tribal groups in South Omo. Currently, they occasionally used as food, but donkey milk is still common among Hamer and Erebore tribe in South Omo. According to the 12 measured morphometeric variable, the overall Ethiopian donkey populations are classified into four major morphometeric groups viz. 1) Abyssinian; 2) Sinnar; 3) Omo and 4) Afar, Hararghe and Ogaden.

Horses Diversity: Ethiopia is among the top ten countries in the world in numbers of horses (FAO, 2007a). Central Statistical Authority of Ethiopia (CSA, 2009) estimated that Ethiopia possess about 1.9 million horses and it accounts for about 42.2 per cent of total Africa's and 3.2 per cent of global horse populations, respectively. Besides, there is seven morphologically distinct domestic and one feral horse populations are presenting Ethiopia. The newly explored feral horses were named as "Kundido" base on the name of the mountain plateau on which the horses used to live. Horses are widespread in almost all agro-ecological zones of Ethiopia with high population density in the central, southern and eastern central highlands. However, they haven't been genetically characterized and their genetic origin is poorly understood.

Therefore, classification of native Ethiopian horses into eight phenotypic groups is incongruent with molecular clustering that grouped native Ethiopian horse populations into three major clusters. Therefore, differences in morphological character system within a species cannot be taken for granted as a complete tool to draw general conclusion about the genetic distinctiveness of population within species. Such phenotypic differences may implicate adaptive divergences. This agrees well with study reported in Gubitz *et al.* (2000) who suggested that differences in morphological character systems reflect ecological selection regimes (coat color patterns), history (body dimension) or both and may not accurately represent variation at a molecular level. Another interesting result emerged out of our study is that Abyssinian horses were failed to be form a distinct cluster.

Threats to livestock genetic resources: Although much less talked about, genetic erosion in farm animal genetic resources is much more serious than in crops because the gene pool is much smaller and very few wild relatives remain. An estimated 82% of the total contribution of livestock genetic resources to global food and agricultural production comes from only 14 species (FAO, 2000). Since the turn of the last century, some 16% of uniquely adapted breeds are believed to have gone extinct (Hall and Ruane, 1993). A further 32% are at risk of becoming extinct and the rate of extinction continues to accelerate (FAO, 2000). These figures give the impression that risk of loss is lower in developing countries compared with the developed world. This is an artifact of lack of data in developing countries where comprehensive breed surveys have not been undertaken. As more data become available, clearer distinction between populations identify a larger number of breeds/strains in developing countries and indicate that a substantial proportion is endangered. For example, a recent survey of African cattle (Rege *et al.,* 2002) has shown that the continent is home to 145 cattle breeds/strains and that some 22% of the original breeds have become extinct in the last 100 years and 27% of the remainder are at varying degrees of risk. Of the livestock breeds existing today, 70% are in developing countries where the risk of loss is highest. Threats to farm animal genetic resources in Ethiopia can be summarized as follows.

Genetic dilution or eradication through use of exotic germplasm. An example is the global impact of the North American Holstein-/Friesian cattle on other dairy breeds. In some instances entire breeds have effectively been replaced by this breed. Intense marketing, emphasis on a single trait (milk production) and widespread use of artificial insemination and, more recently, embryo transfer, have led to a situation where not only is the breed replacing others, but the diversity within the breed itself is rapidly diminishing because only a limited number of supposedly superior bulls are being used globally. This is demonstrated by a recent finding that 50% of the almost 5000 Holstein bulls born in 1990 in 18 countries were bred by only five sires (Wickham and Banos, 1998);

1 - Changes in production systems leading to change in breed use or crossbreeding.
2 - Changes in producer preference, usually in response to changes in socio-economic factors.
3 - Droughts, famine, disease epidemics, civil strife/ war and other catastrophes and/or political instability.

Rege (1999b) gave examples of African cattle breeds that have either become extinct or are at risk due to some of these factors. Many factors underlie these threats to livestock genetic resources. In some cases changes in production systems and consumer preferences reflect natural evolution of developing economies and markets in the country. In other cases, production systems breed choice and consumer preferences are distorted by regional and national and policy.

Conservation of livestock genetic diversity: The main reason to advocate conservation of genetic diversity is that the improvement of domestic animals in order to meet human needs, is dependent on genetic variation both within- and between-breeds/strains. Loss of genetic diversity will likely decrease the ability of animals to respond to environmental change and will result in loss of genetic information potentially useful for breeding improvement (Hunter, 1996). The earth's climate varies widely and is continuously changing. It is the diversity of species and breeds that will allow the environment to be utilized efficiently throughout the years both in temperate areas and in the tropics. The second reason to advocate conservation of domestic animal diversity is that, we can reasonably expect that large differences observed today between geographic regions in human needs for food and agriculture and in production capability will persist in the future. According to Hammond (1994) almost three quarters of the world agriculture will remain at the low- to medium-input levels where animal production environments incorporate combinations of stress such as feed shortage, drought and heat.

The third reason for conservation of domestic animal diversity is that sustainable cross-breeding schemes require at least two viable purebred populations and sometimes more. Trend towards fewer breeds will reduce the opportunities for improvement of productivity through crossbreeding. The fourth reason is that the wide variety of livestock breeds and strains available today is part of our cultural heritage and it deserves protection. At the breed level, unique genetic differences exist between the breeds of each domestic species, for example in goats, the Nubians have high milk yield, the Small East African are hardy animals and the West African Dwarf goats are trypano tolerant. Thus, genetic diversity at the level of species can be exploited to satisfy human needs for varieties.

Conservation is not only conserving endangered breeds but also about those that are not being utilized efficiently (Barker, 2001). Conservation aims at farm animal genetic resources ranging from avoiding extinction, maintaining genetic diversity and/or the cultural, ecological or socio-economic values of breeds, to provide the right conditions for their evolution within an evolving production system (Gandini *et al.*, 2004; Solomon *et al.,* 2007). Because of resource limitations, priorities need to be set on which population/breed is to be conserved. Commonly, the contribution of a breed to total genetic diversity has been analyzed using phylogenetic methods based on genetic distances between breeds (Solomon *et al*., 2007). However, Caballero and Toro (2002) showed that conservation decisions based on genetic distances can be misleading when applied to subpopulations of a meta-population, since it ignores the within-population variability component. Within-population variability constitutes a crucial part of the meta-population variability and is highly relevant for conservation strategies because of its impact on adaptive and economic traits. An approach based on marker-estimated average kinship between and within populations has recently been suggested (Caballero, 2002).Both approaches described above ignore non-genetic factors such as the cultural, economic and ecological values or merits of the breeds. However, the human socio-political context needs to be fully understood for conservation priorities to have any impact on human livelihoods (Rege, 2003). Ruane (2000) proposed a framework that incorporates both genetic diversity and non-genetic criteria for prioritizing breeds at the national level. However, applications of this framework are lacking and conservation priorities have largely been based solely on contributions of breeds to genetic diversity.

Twelve percent of sheep breeds known worldwide have already become extinct in the last 100 years (Solomon, 2007). Sheep resources of Ethiopia are not well studied and there is practically no rational conservation-based improvement plan in the country. With 23.6 million sheep (CSA, 2005) and 14 traditionally recognized breeds (Solomon *et al.,* 2007) , Ethiopia possesses highly diversified and adapted indigenous sheep populations parallel to its highly diverse agro-ecology, ethnic communities and production systems (Solomon *et al.,* 2007). However, changes in production systems, in response to socio-economic factors, have led to the use of exotic germplasm, endangering the survival of the adapted indigenous breeds. Besides, population sizes and flock structures of some populations are currently not commensurate with optimal genetic resource management levels.

Approach for conservation of livestock genetic diversity in Ethiopia: Conservation of livestock diversity has been defined as the total sum of all operations involved in the management of animal genetic resources so that the pool of genetic diversity is maintained over time (Hammond, 1993). It encompasses management of human activities in such a way that animal genetic resources are best utilized and developed to meet immediate and short term human needs for future generations. Most attention in conservation of animal diversity has been directed toward rare breeds. However, in

management of animal genetic resources, the fundamental problem is not the distinction between the breeds that are endangered and those that are not, but between those that are perceived to have little or no current utility and those which do have current utility or seem likely to have an immediate future use (Barker, 1994). FAO (1995) has recommended the following strategies for effective management of domestic animal diversity at global level and for each species:

- Identifying and listing all breeds.
- Describing and characterizing breeds in order to understand their unique qualities and potential contributions and to understand which breeds have the potential to make the greatest variety of future contributions.
- Monitoring the population statistics for each breed and regularly reporting about the population currently at risk of extinction.
- Sorting adequate samples of as many breeds as possible, generally in the form of frozen semen, ova, and embryos, to enable the future regeneration of lost populations of animals. An overview of the historical background of animal genetic resources and the reasons for concern about their future, both in the developing and developed world, has been presented by Barker (2002). He concluded that the primary focus in the conservation of domestic animal diversity is on conservation of breeds.

The conservation of livestock diversity in Ethiopia should fulfill the following criteria: (i) the conserved livestock must contribute to the national food security program. (ii) a particular livestock must have high integrity with social, religious and culture of the society (iii) the genetic resources currently have high commercial/export value. These conservation criteria are vital to the sustainable use of livestock genetic resources in the country. In general, three methods are used for conservation of livestock genetic resources to support future livestock improvement: *in-situ, ex-situ* and combined conservation approaches.

In-situ conservation: In-situ conservation, also called 'on-farm conservation', can be defined as the continuous husbandry of populations by farmers in the agro-ecosystems where those populations have evolved (Hammond, 1994). Thus, in situ conservation encompasses entire ecosystems, including immediately useful species of animal that form part of the system. Therefore, an understanding of the overall contribution of particular farm animal genetic resources to society must examine all the direct as well as the indirect contributions it makes in the Agro ecosystem. The advantages of this approach are that the animals are still being utilized, the performance characteristics can be properly recorded and evaluated, and the breeds have the opportunity to evolve. The disadvantages are that selection and genetic drift may result in unfavorable genetic changes if the population is small. There is a risk of increasing inbreeding and hence homozygosity, which is associated with reduced fitness. The animals are at risk from disease and other natural disasters. Also, they are likely to be less productive and so more costly to maintain. Moreover, the economic development and socio-cultural changes in society are affecting farmer maintenance of diversity so as to account for this process in the implementation of conservation programs.

Ex-situ conservation: *Ex-situ* approaches to conservation include maintaining breeds in farm, creating a conservation herd (gene pool) and cryo-preservation (of semen and embryos) and keeping of live animals in designated localities, e.g. government farms or ranches. In marked contrast to the situation in plants, cryo-preservation is technically feasible for very few livestock species. In the context of conservation of domestic animal diversity in Ethiopia, there are three *ex-situ* conservation

Maintaining breeds in farm: It involves the breeding animals of a sample of a breed outside its normal production environment or habitat. Many of the pros and cons of this approach are similar to the *in-situ* conservation method. However there is potentially more control over management of the population.

Creating a conservation herd (gene pool): This involves crossing several rare breeds together, then breeding them to maintain genetic variability. It is an effective way of conserving genetic variation for two or three breeds. Maintenance of genetic diversity is almost better served by pooling five breeds in a conservation herd (Notter *et al.,* 1994). However there is a greater risk of losing useful genes when more populations are combined. The disadvantage of this approach is that, although useful genes may be conserved, the identity of individual breeds is lost.

Cry Preservation: This involves frozen storage of rare breeds in the form of living semen, ova, embryos or tissues, which can be used to regenerate animals. Cryopreservation of semen and embryos is a powerful tool for preservation of genetic diversity. In the situation of a critical threat with high probability that a breed will become extinct, preservation of genetic material of individual animals in the form of germ cells and embryos is necessary to ensure that an adequate genetic pool is retained for future improvement

programs. Breeding technologies as artificial insemination (AI) and embryo transfer (ET) may provide support for this approach.

The use of frozen semen in conservation program is particularly feasible where a traditional use of AI is already strong in Ethiopia. Collection of semen of endangered local breeds should take place as part of the AI program.

Frozen storage of semen and embryos are relatively expensive, but it has the advantage after the initial investment. During storage, frozen genetic material are at less risk from disease and natural disasters than live animals, but obviously at risk from technological failures. The disadvantages are that reproductive technologies are not uniformly successful or presently available for all individuals or all species and the knowledge is not always available in the places where it is needed most. Also the breeds conserved in this way are not able to adapt to changes in the production environment or new disease challenges.

Combined conservation approach: Both ex-situ and in-situ approaches have advantages and limitations. Hence, combining a range of available ex-situ and in-situ options is the best strategy. Thus, management of farm animal genetic resources will consist of a set of actions to which the whole or part of a farm animal population is subjected to a process of genetic and environmental manipulation with the aim of sustaining, utilizing, restoring, enhancing and characterizing the quality and quantity of the animal genetic resources and its products (Rege, 2001). Under this definition, management encompasses all activities, which ensure that the population is dynamic and responsive to changes in the physical, economic and socio-cultural environment. Management also includes improving the understanding of the animal genetic resources. Sustainable management includes those actions, including policy, which ensure that the animal genetic resources meet present needs while also retaining its genetic integrity so as to be available for longer term needs (Rege, 2001). Development and implementation of genetic improvement programs is a component of animal genetic resources management. However, in Ethiopia these conservation approaches have not been given adequate attention for sustainable utilization of livestock genetic resources. As a result, various factors are threatening Ethiopian livestock sector such as live animal trade, global climate change, cross-breeding, change in the traditional production systems, priority for single productive traits and physical destruction of their environments.

Conclusions

Livestock supply about 30% of the total human requirements for food and agricultural production in Ethiopia. They are particularly vital to subsistence and economic development in country. The national strategies for livestock production aim at increasing food production rather than reflect the need for a genetic pool of breeding stock, and hence breeding has to focus on what the market wants (mass or niche market).

Although, the country have huge livestock genetic resources the genetic diversity is threatened by extinction, principally through cross-breeding and breed replacement arising from changes in producer preferences, as well as through habitat loss, droughts, famine, civil strife's, trade (export) and disease epidemics. Moreover, characterization of livestock genetic resource in Ethiopia has largely been limited to description of production systems, phenotypic description and classification of indigenous breeds. The context of the management of livestock genetic diversity is that related to priority setting, both for conservation of endangered or potentially endangered populations or breeds and for breed improvement programs. Within species, an understanding of the evolutionary history of different breeds in a country or region and quantitative data on the genetic relationships amongst the breeds, can provide critically important inputs for conservation of livestock genetic resources.

Therefore, there is a need to develop strategies for the sustainable management of these livestock genetic resources in the country which should be cost effective conservation and utilization approaches to ensure that they are best used to meet the needs of today while also being available for future generations. Unfortunately, the knowledge and information base on these resources is inadequate. Characterization to improve the understanding of these resources is of high priority. However, there is also a need to prioritize these resources in terms of target conservation, development, degree of vulnerability and how much of the limited resources should be spent on each. Finally, evaluation, conservation and efficient utilization of livestock genetic resources are thus important for livestock genetic improvement in the country. Besides, there is a need to broaden the knowledge base of the livestock genetic resources through studies on diversity and use of the available resources. This includes detailed analysis of the extent, distribution and diversity of livestock, good understanding on

the integrity of livestock with social, religious and culture of the society social and management is vital.

References

Alamargot, K. 1987. Avian Physiology of Industrial Poultry Farms in Ethiopia. Proceedings of the First National Livestock Improvement Conference Feb.11-13, Addis Ababa, Ethiopia, 114-117.

Alberro, M. and Haile-mariam, S. 1982a. The indigenous cattle breeds of Ethiopia: Part I. World Anim. Rev. 41: 2-10.

Alberro, M. and Haile-mariam S. 1982b. The indigenous cattle breeds of Ethiopia. Part II. World Anim. Rev. 42: 27-34.

Alemu, G.; Azage, T. and Alemu, Y. 2004. Research need of donkey utilization in Africa. In: D. Fielding, P. Starkey eds., Donkeys, people and development. A resource book of the Animal Traction Network for Eastern and Southern Africa (ATNESA). Technical Center for Agricultural and Rural Cooperation (CTA), Wageningen, The Netherlands. 77-79,

Alemu, Y. and Tadelle, D. 1997. The status of poultry research and development in Ethiopia, research bulletin No.4, poultry commodity research program Debrezeit Agricultural research center. Debrezeit, Ethiopia, 2-6.

Barker, J.S.F. 2002. Relevance of animal genetic resources and differences to the plant sector. In: Animal Breeding and Animal Genetic Resources. Gottingen, Braunschweig, Germany, 15-21.

Barker, J.S.F. 2001.Conservation and management of genetic diversity: a domestic animal perspective, Can. J. Forest Res., 31: 588–595.

Barker, J.S.F. 1994. A global protocol for determining genetic distances among domestic livestock breeds. In: Proceedings of the 5th world congress of genetic applied to livestock production. Guelph, Canada. 21: 501-508.

Caballero, A. and Toro, M.A. 2002. Analysis of genetic diversity for the management of conserved subdivided populations, Conserv. Genet., 3: 289–299.

Caballero, A. 2002. Analysis of genetic diversity for the management of conserved subdivided populations. Conserv. Genet., 3: 289–99.

CBD, 2010. Conference of the Parties to the Convention on Biological Diversity, Tenth meeting, Nagoya, Japan, 18–29 October 2010. http://www.cbd.int/doc/decisions/cop-10/cop-10-dec-02-en.pdf.

Central Statistical Authority of Ethiopia, (CSA). 2009. Livestock and Livestock Characteristics. Volume II. Statistical Bulletin 468. CSA, Addis Ababa, Ethiopia

Central Statistical Authority, (CSA). 2007. Statistical Report on Farm Management Practices, Livestock and Farm Implements. Part II. CSA, Addis Ababa, Ethiopia.

Central Statistical Authority, (CSA). 2006. Livestock sample survey, 2006-2007, Version 1.1, Addiss Ababa, Ethiopia.

Central Statistical Authority, (CSA). 2005. Agricultural sample survey vol. ii; statistical bulletin no. 331, Addis Ababa, Ethiopia.

Crawford, R.D. 1990. Poultry genetic resource: evolution, diversity and conservation. In: Poultry Breeding and Genetics. Ed. By R.D. Crawford. Elsevier, Amesterdam, 12-15pp.

Cunningham, E.P.; Loftus, R.T.; MacHugh, D.E. and Bradley, D.G. 1995. Molecular evolution of Africa, European and Asian cattle. In: Proceedings of the 5th world congress of genetic applied to livestock production. 7-12 August, 1994 Guelph, Canada, 21: 86-89.

Domestic Animal Genetic Resources Information System, (DAGRIS). 2004. Domestic Animal Genetic Resources Information System (DAGRIS). ed., J.E.O. Rege, W. Ayalew and E. Getahun). International Livestock Research Institute, Addis Ababa, Ethiopia.

de Haan, C.; van Veen, T.S. and Brandenburg, B. 1997. Livestock development. Implications for rural poverty, the environment, and global food security. Report 23241, November, 2001. The World Bank, Washington, DC, USA.

Delgado, C.; Rosegrant, M.; Steinfeld, H.; Ehui, S. and Courbois, C. 1999. Livestock to 2020. The Next Food Revolution. Food, Agriculture and the Environment Discussion Paper 28. IFPRI/FAO/ILRI.

Epstein, H. 1971. The Sanga cattle of East Africa. East Africa Agric. J., 22: 149-164.

Evenson, R.; Gollin, D. and Santaniello, V. 1988. Agricultural Values of Plant Genetic Resources. CABI, Wallingford, UK, 22-27pp.

Falconer, D.S. and Mackey, T.F.C. 1996. Introduction to quantitative Genetics,' Longman Group Ltd, Harlow. 10-15pp.

Farm-Africa, 1996. Goat types of Ethiopia and Eritrea. Physical description and management systems. Published jointly by FARM-Africa, London, UK, and ILRI (International Livestock Research Institute), Nairobi, Kenya. 76.

Food and Agriculture Organization of the United Nations, (FAO). 2007a. Measurement of domestic animal diversity (MoDAD): Recommended microsatellite markers,

http://dad.fao.org/cgi-bin/getblob.cgi.

Food and Agriculture Organization of the United Nations, (FAO). 2000. FAOSTAT. Statistical database of Food and Agriculture Organization of the United Nations, Rome., Italy.

Food and Agriculture Organization of the United Nations, (FAO). 1999. World Watch List for Domestic Animal Diversity. D.S. Beate 3rd ed., FAO, Rome, Italy. 726.

Food and Agriculture Organization of the United Nations, (FAO). 1996. World Watch List for Domestic Animal Diversity, 2nd ed., FAO, Rome.

Food and Agriculture Organization of the United Nations, (FAO). 1995. World watch list for domestic animal diversity. 2nd ed., Food and Agricultural organization of the united nations, Rome, Italy.769.

Food and Agriculture Organization of the United Nations, (FAO). 1992. The management of global animal genetic resources. FAO Animal Production and Health Paper 104. Food and Agriculture Organization of the United Nations, Rome, Italy.

Gandini, G.C.; Ollivier, L, Danell, B, Groeneveld, E., Martyniuk, E., Woolliams, J.A. 2004. Criteria to assess the degree of endangerment of livestock breeds in Europe, Livest. Prod. Sci. 91: 173–182.

Gemechu, K. 2013. Plant breeding for biotic stress lecture note.23-27.

Getahun, A. 1991. Growth and Sustainability: Conditions for their Compatibility in the Tropical East African Highlands. Conference on Agricultural Sutainability, Growth and Poverty Alleviation: Issues and Policies: Feldafing, Germany, September 23 – 27.

Gubitz, T.; Thorpe, R.S. and Malhotra, A. 2000. Phylogeographic and natural selection in the Tenerife gecko Tarentoaldelalandii: testing historical and adaptive hypothesis. Mole. Ecol., 9: 1213–1221.

Halima, H. 2007. Phenotypic and genetic characterization of indigenous chicken populations in northwest Ethiopia. PhD dissertation, University of the Free State, Bloemfontein, South Africa.

Hammond, K. 1994. Conservation of domestic animal diversity: Global overview. In: proceeding of the 5th world congress of genetic applied to livestock production. 7-12 August, 1994 Guelph, Canada, 21: 423-430.

Hammond, K. 1993. Why Conserve animal genetic resources? Diversity, 9(3): 30-35.

Hanotte, O.; Bradley, D.G.; Ochieng, J.; Hill, E.W. and Rege, J.E. 2002. African pastoralism: genetic imprints of origins and migrations. Science, 296: 336-9.

Hunter, M.L.J. 1996. Fundamentals of conservation biology. Blackwell Science, Inc. Cambridge, Massachusetts, USA, 482pp.

Kefena, E. 2012. Equine genetic resources of Ethiopia. PhD. dissertation Haramaya University, Haramaya, Ethiopia, 180pp.

Kosgey, I.S.; Rowlands, G.J.; Van Arendonk, J.A.M. and Baker, R.L. 2008. Small ruminant production in smallholder and pastoral/extensive farming systems in Kenya. Small Rumin. Res., 77: 11–24.

Kosgey, I.S. and Okeyo, A.M. 2007. Genetic improvement of small ruminants in low-input, smallholder production systems: Technical and infrastructural issues. Small Rumin. Res., 70: 76–88.

Kosgey, S.; Baker, S.R.L.; Udo, H.M.J. and Var Arendonk, J.A.M. 2006. Successes and failures of small ruminant breeding programmers in the tropics: a review. Small Rumin. Res., 61: 13-28.

Kosgey, I.S. 2004. Breeding objectives and breeding strategies for small ruminant in the tropics. Ph.D. Thesis, Animal Breeding and Genetics Group. Wageningen University, the Netherlands, 47-50pp.

Kunin, W.E. and Lawton, J.H. 1996. Does biodiversity matter? Evaluating the case for conserving species. In: Gaston, K.J. sd., Biodiversity, A Biology of Numbers and Difference. Blackwell Science, London, 283-308pp.

Lekule, F.P. and Kyvsgaard, N.C. 2003. Improving pig husbandry in tropical resource-poor communities and its potential to reducerisk of porcine cysticercosis. Acta Tropica, 87: 111-117.

Mekonnen, G. 2007. Characterization of smallholder poultry production and marketing system of dale, wonsho and lokaabaya woredas of southern Ethiopia. Msc. thesis presented Hawassa University, Hawassa, Ethiopia, 5-7pp.

Meseret, M. 2010. Characterization of village poultry production and marketing system in gommawereda of jimma zone, Ethiopia. MSc. thesis, Jimma University, Ethiopia, 19-27pp.

Ministry of Agriculture, (MOA). 1975. National policy on sheep research and development. Aby a Technical Committee. MOA, Addis Ababa, Ethiopia, 13pp.

Negussie, D. 1999. Evaluation of the performance of local Rhode Island Red (RIR) and Fayoumi breeds of chicken under different management regimes in the high lands of Ethiopia. Swedish University of agricultural

sciences, Department of animal nutrition and management, 1-11pp.

Notter, D.R.; Mariante, A.D.S. and Sheng, Z. 1994. Modern approach to active conservation of domestic animal diversity. In: Proceeding of the 5th World Congress of Genetic Applied to Livestock Production. 7-12 August, Guelph, Canada, 21: 509-516.

Ramsay, K. 2002. Marketing rare breeds in Sub-Saharan Africa. In: Almekinders, C.J.M. (Comp.), Proceedings of Workshop, Lusaka, Zambia, 11–14 September 2001, pp. 61-68.Available athttps://www.cbd.int/doc/case-studies/inc/cs-inc-fao-incentivesagrobiodiv-workshop2009-en.pdf (Accessed 28/10/2009).

Rege, J.E.O. 2003. An approach to the optimal allocation of conservation funds to minimize loss of genetic diversity between livestock breeds, Ecol. Econ., 45: 377–392.

Rege J.E.O.; Muigai, A.W.T. and Hanotte, O. 2002. Assessment of genetic diversity in African small ruminants: present status and future prospects. In: 53rd Annual meeting of the European association of animal production, Cairo, Egypt, 1-7pp.

Rege, J.E.O. and Gibson, J.P. 2001. Animal genetic resources and economic development: issues in relation to economic valuation. Ecol. Econ., 45: 319-322.

Ruane, J. 2000. A framework for prioritizing domestic animal breeds for conservation purposes at the national level: a Norwegian case study, Conserv. Biol., 14: 1385–1393.

Rege, J.E.O. 1999. The state of African cattle genetic resources I. Classification framework and identification of threatened and extinct breeds. Anim. Genet. Resou. Inform. Bull., 25:1–12.

Rege, J.E.O. 1998. Utilization of exotic germplasm for milk production in the tropics. Proceedings of the 6th World Congress on Genetics of Applied Livestock Production, Armidale, Australia, 25: 193–200.

Rege, E.O. and Lipner, L. 1992. Zebu cattle of Kenya: uses, performance, farmer preferences, measures of genetic diversity and options for improved use. Animal Genetic Resources Research, 1, 103, ILRI (International Livestock Research Institute), Nairobi, Kenya, 2-4pp.

Smith, C. 1984. Estimated costs of genetic conservation in farm livestock. In: Animal Genetic Resources Conservation by Management, Data Banks and Training. FAO Animal Production and Health Paper (44)1: 21–30.

Solomon, D. 2007. Suitability of hay-box brooding technology to rural household poultry production system. Jimma University College of Agriculture and Veterinary Medicine, Jimma, Ethiopia, 12-14pp.

Solomon, G.; Van Arendonk, J.A.M.; Komen, H.; Windig, J.J. and Hanotte, O. 2007. Population structure, genetic variation and morphological diversity in indigenous sheep of Ethiopia, Anim. Genet., 38: 621–628.

Solomon, G. 2008. Sheep resources of Ethiopia genetic diversity and breeding strategy. PhD. dissertation Wageningen University, The Netherlands, 9-12pp.

Solomon, A. 2007. *In situ* characterization of Gumuz sheep under farmers management in north western lowland of Amhara region. An M.Sc. thesis, Haremaya University, Ethiopia. Ethiopia, 89pp.

Steinfeld, H. 1997. Livestock development in mixed farming systems: A study of smallholder livestock production systems in Zimbabwe. Farming systems and resource economics in the tropics. Werner D. ed., Wissenschaftsverlag Vauk. Kiel, Germany, 3: 3-5.

Strauss, M.S. 1994. Implications of the convention on biological diversity: management of animal genetic resources and the conservation of domestic animal diversity. Report of an FAO Informal Working Group, 28-29 March, 1994,Rome, Italy, 1-6pp.

Styger, Y. 2002.The effect of different breeds and housing systems on the sensory and objective meat quality of processed pork. MSc thesis, University of Stellenbosch, South Africa, 4-7pp.

Tadelle, D. 1996. Phenotype and genotype characterization of local chicken eco types in Ethiopia. PhD. dissertation. Landwirtschaftlich-Gärtnerische Fakultät der Humboldt-Universität zu Berlin , Germany, 2-4pp.

Wendorf, F. and Schild, R. 1994. Are the early Holecene cattle in the Eastern Sahara domestic or wild? Evolu. Anthropol., 3: 118-128.

Wickham, B.W. and Banos, G. 1998. Impact of international evaluations on dairy cattle breeding program. Proceedings of Sixth World Congress on Genetics applied to Livestock Production, Armidale, Australia, 23: 315-320.

Wollny, C.B.A. 2003. The need to conserve farm animal genetic resources in Africa: should policy makers be concerned? Ecol. Econom., 45: 341-351.

Workneh, A. and Rowlands, G.J. 2000. Designing, execution and analysis of the livestock breed survey in Oromia Regional State, Ethiopia,

OADB (Oromia Agricultural Development Bureau, Addis Ababa, Ethiopia, and ILRI (International Livestock Research Institute), Nairobi, Kenya, 260pp.

Workneh, A. 1991. Preliminary survey of indigenous goat types and goat husbandry practices in southern and southwestern Ethiopia. MSc. Thesis, Haramaya University, Ethiopia, 1-13pp.