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Issues and concerns in smallholder livestock genetic improvement programs in Africa

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ABSTRACT

Improvement of smallholder livestock genetic resources is of vital importance to agriculture, food production, rural development and the environment on the African continent. Inconclusive considerable debate on smallholder livestock improvement strategies and utilization of local livestock genetic resources has been going on since the past two decades. This has been necessitated by the realization of the need to reduce poverty and enhance food security and produce more animal products to feed the ever increasing national populations in Africa, which seen more compelling than ever. It has been acknowledged that partly the overall continental increase in livestock productivity can be achieved through appropriate and support of the smallholder livestock improvement programs. It is believed that within the smallholder livestock production systems which is characterized by a generally low input-output system, the sustainability of animal breeding efforts to improve animal productivity becomes a dominant factor. Smallholder livestock improvement is not achieving the expected increase in livestock productivity to meet the growing demand for animal products for several reasons, including poor infrastructure, investment environment, financial resources and lack of local expertise and scientific research in addition to poor livestock support services. There is perceived need for improved livestock production in the smallholder areas, however livestock productivity has remained very low, but indigenous livestock are numerous which makes them attractive as potential tool for poverty reduction and improvement of family food security and livelihoods in smallholder farming in Africa. Changes in the demand for livestock products will

be largely be driven by human population growth, income growth and urbanization, however the production response in different livestock production systems to meet this demand will be associated with livestock improvement thrust which take into account the modern science and technology in livestock improvement. This discussion attempts a rapid summary of some issues and concerns perceived important in promoting smallholder livestock improvement programs, in relation to recent and previous outcomes, coupled with a brief assessment of some of the challenges faced in implementation of smallholder livestock improvement programs. Some of the challenges and opportunities such as unfavorable livestock policies, dilapidated infrastructure and limited livestock research and characterization of local livestock populations are highlighted. Genetic improvement of livestock indigenous to Africa for targeted performance characteristics of economic benefit for smallholder farmers is necessary for effective selection for both use in straight breeding and crossbreeding. In future, livestock improvement programs are likely to be increasingly characterized by differences between developed and developing countries, and between highly intensive production systems on the one hand and smallholder livestock production on the other hand. How smallholder livestock improvement programs will be implemented in the coming decades is highly uncertain, however, of the many uncertainties, one seem over-arching. Can future demand for livestock products be met through sustainable intensification of smallholder livestock improvement programs on the African continent? With the right institutional and financial arrangements, government, research institutions and donor agencies support can assist in successful implementation of smallholder livestock improvement programs on the continent, improving the capacity of smallholder livestock resource poor farmers to contribute significantly to individual national economies.

1. Introduction

Livestock remains important to the livelihoods of 80% of the 800 million people living in Africa and approximately 160 million poor people who keep livestock in Sub Saharan Africa (FAO, 2005). Based on this scenario, promotion of smallholder livestock improvement programs should take a center stage, considering the importance of the smallholder livestock industries in Africa, the demand of food for animal origin, the constraints in livestock animal diseases which has impacted negatively on the continent's food security. The need for livestock and livestock products such as meat, milk, eggs, poultry, etc. in Africa will increase due to the increasing number of people in the region by 2025 (FAO, 1995). Rising incomes, continuing urbanization, and correspondingly changing food consumption and agricultural production patterns, and the middle class, which have adopted a new feeding habits based principally on animal proteins. Africa through the smallholder livestock improvement programs have the capacity to satisfy its own protein needs, if the challenges on smallholder livestock improvement programs are resolved. It is visible that the local livestock genetic resources constitute important reservoir of livestock genetic material which has failed to be given adequate recognition for the benefit of contributing to animal products and improve the socio-economic of the general African population. This has been exacerbated by the fact that genetic potential of most smallholder livestock populations across Africa are unknown and hardly exploited because the common objective has been to meet livestock protein requirements

from large scale commercial entities, which use imported livestock breeds. This has resulted in the level of support for smallholder livestock production in individual countries being low or absent. The misleading or controversial developed world assessment of smallholder livestock farming sector has worsened an already desperate situation to improve livestock productivity in Africa. However, previous reports on smallholder livestock improvement efforts in the sector point to the fact that genetic basis exists for vital production livestock characters, and production can be enhanced if appropriate livestock genetic improvement strategies are employed (Ruvuna et al., 1989; Ahuya, 1997; Garwe et al., 2001; Muchenje et al., 2007; Chinogaramombe et al., 2008). Research and innovation today is mostly directed towards intensification of livestock production in large scale commercial entities, where as the needs of resource poor smallholder livestock producers are in the sustainability and resilience of livestock production systems.

While smallholder livestock production sectors play major roles in sustaining the livelihoods of most rural populations in Africa, the small scale livestock farmers are constantly faced with production challenges which has resulted in perpetual low livestock productivity. There is considerable uncertainty as to how smallholder livestock improvement programs may be implemented or proceed to improve livestock productivity in Africa in the coming decades. This is a result of mixed outcomes in the previous smallholder livestock improvement programs in Africa, which have been implemented with varying degree of success and/or failure. More often than not indigenous livestock have been labeled as of low genetic potential for traits of economic importance and genetic improvement plans are based on replacement of indigenous breeds with exotic breeds or crossing them with temperate breeds.

2. Possible smallholder livestock improvement strategies

Different strategies for livestock improvement for identifying genetically superior animals of different species for economic importance are available to breeders (Corteel, et al., 1984). One of the conditions for operation of these schemes for genetic improvement is the realistic evaluation of production and market development in which are a characteristic of specific countries or environment (Wiggans, 1982). The various reported studies on smallholder livestock improvement in Africa have attempted to employ the most common methods of genetic improvement, such as selection within populations and/ or crossbreeding. Selection through grading of livestock and identification of potentially productive animals through the use of an ingenious rational way of keeping records have been used in some smallholder livestock sectors (Otte and Chilonda 2002). This is on the understanding that written records in smallholder livestock production do not exist. Smallholder livestock producing communities rely significantly on indigenous knowledge to memorize events and activities in a sequential way to acknowledge individual animal and ancestors' performance. However, pastoralists are able to memorize information on livestock up to a point and often forget some characters overtime especially when change of certain local conditions claim part of the herd, in such cases as drought, theft, disease epidemics and natural disasters (Blench 2001).

The use of indirect selection criteria although fraught with difficulty and is best avoided where possible in commercial livestock improvement programs, could be a solution to smallholder livestock improvement efforts. Nevertheless, considerable efforts need to be made to develop the method which would be useful in dealing with particularly illiterate livestock farmers. Primary among the traits suited would be disease resistance where the problems of ensuring uniform exposure to disease among animals is beyond the capabilities of most experiment in smallholder livestock settings. Several theoretical and applied breeding programs to improve productivity in smallholder livestock sector were still focusing on selection solely on output such as milk yield and meat production, ignoring the antagonistic relationship with other important parameters such as disease resistance and reproductive performance. It has been noted that in an attempt to implement successful strategies in livestock development farmers' socio –economic and pedo-climatic situation should be considered when planning such strategies for livestock development in the smallholder farming systems (Mapiye, et al., 2009). Smallholder livestock may prefer animals with good adaptive traits and ability to produce and reproduce with minimum care. Also in the context of climate variability there is a likelihood of an anticipated increase in environmental stressors due to decrease of pasture quantity and quality and increase in the incidence of diseases caused by climate change. The response of indigenous livestock breeds to such calamities due to their adaptability to prevalent droughts and disease will be essential in the future. Hence, within breed selection of the adapted indigenous breeds should be promoted as strategy for efficient on-farm sustainable conservation and utilization of livestock

indigenous breeds. Blench (2001) acknowledged that the pastoralists have their own experiences and a highly developed knowledge as well as culture about livestock, that fit well with their type of livestock husbandry and in many places have even developed traditional strategies for some traits.

Smallholder livestock farmers need to fully participate in the choice of targeted production characteristics which need to be improved for selection of animals. Yet small scale livestock farmers needs are often neglected in livestock improvement programs. Therefore, for any livestock improvement strategies to be effective livestock development programs, they should address the reality that most smallholder livestock famers aim to achieve. Such consideration will no alienate the smallholder farmers and could be the key to improving livestock productivity and empower the livestock resource poor farmers. Smallholder goat farmers in semi-arid and sub-humid areas in Tanzania preferred the Small East Africa goats because the animals are abundantly available and well adapted to the local environmental conditions (Chenyambuga and Lekule, 2014). The participation of smallholder livestock farmers in selection of important traits is very important. Berhanu et al (2012) observed that the most important criterion for selecting breeding bucks in agro-pastoral and smallholder pastoral communities of Ethiopia was large body size. In another study, Mbuku et al (2006) found that big body size and milk yield of the buck's dam and offspring quality are the most important criteria for selecting breeding bucks in smallholder pastoral communities of Northern Kenya.

Crossbreeding has been practiced and its potential benefit in world over for different type of livestock species has been documented (Tawonezvi et al., 1988; Ruvuna et al., 1989; Ahuya, 1997; Khombe et al., 1985; Moyo, 1999). Despite their ability to adapt to stressful environmental conditions, most available indigenous livestock in Africa lack the genetic capability to achieve the growth, milk, eggs, etc production potential hence crossbreeding has been explored to upgrade them. In appreciation of the low performance of the local livestock and on the other hand the failure to perform as expected by the imported animals crossbreeding for different animal species was introduced (Assan, 2013). The local genotypes impose limit on productivity that is being achieved in livestock production. Crossbreeding has been employed to on the assumption that it will enhance genetic improvement by matching genotype with the environment of the local livestock genotypes. In certain instances, given reasonable management, crossbreds where capable of satisfactory performance on smallholder livestock conditions. The introduction of crossbreeding have been a viable option to upgrade the local livestock for meat and milk production in some instances.

In an attempt to improve livestock production, programs did not allow for the poor performance of indigenous breeds to be fully assessed. This consideration did not radically use appropriate choice of breeding systems for the less productive indigenous species, this was clearly a major set back. The complexities of smallholder livestock production system called for a great scope for innovative thinking and implementation of livestock improvement strategies. Implementers of livestock improvement programs were caught unaware because they used wrong assumptions in dealing with smallholder livestock systems development programs There was need for use of local knowledge as a substitute for real experimentation which could prove to be valuable in discovering some of the sensitivities in livestock improvement in smallholder production sector. The outcome was that the smallholder livestock crossbreeding programs in Africa were implemented with varying degree of success (Ayalew et al 2003).

The use of crossbreeding as a genetic improvement strategy in different livestock species is mainly aimed at exploiting the heterosis effect in the crossed animals. Crossbreeding is a way of realizing quicker genetic improvement matching genotype with the environment and benefiting from complementarity of breeds involved (Ahuya et al 1987). Breed complementarity means the matching of livestock breeds so that a high number of desirable traits are combined, or alternatively, so that deficiencies in one breed are covered by strengths in another. The effect is at its best when the crossed animals is a combination of breeds genetically far removed and/or efficiency is enhanced through the use of specialized sire and dams. It is well known that the basis of expression of any quantitative trait in animal production is a function of its genetic merit plus the way it interacts with the environment. The best system will possibly be one where an environmentally adapted females excelling in all aspects of mothering ability, is crossed with a males from a true sire line/breed excelling in all aspects of growth efficiency and carcass. World over crossbreeding has been widely used in some species particularly pigs and poultry to exploit both breed differences and heterosis (hybrid vigor). Crosses between improved livestock and indigenous livestock have often shown large amounts of heterosis which might be expected because of the large genetic distance between the two types (Zaman et al 2002). Introduction of high yielding specialized livestock breeds may bring drastic changes for increasing overall productivity like birth, growth rate and kid survivability

(Keeping, 1951). There is also some evidence that hybrid vigor is more important under a suboptimal than optimal environment. As a breeding practice crossbreeding does not denote the indiscriminate mixing of livestock breeds. Rather, it is the systematic use of livestock breed resources to produce offspring of a specific type. For example a terminal crossbreeding program uses a male of superior growth and carcass merit (i.e Boer) to produce kids for the slaughter market, while maintaining moderate sized indigenous goat females that excel in fitness and reproductive performance (Assan, 2013). Crossbreeding has been practiced extensively and its potential in livestock improvement are well documented (Baserra et al 2004; Shrestha and Fahmy, 2007; Stanisz et al 2004; Brzostowski et al 2008). However, there has been mixed feeling on the use of crossbreeding in smallholder livestock improvement programs.

3. Some expected outcomes from crossbreeding in small stock, as one of the important class of livestock species for resource poor farmers in Africa

It has been well documented that crossbreeding tropical goats with exotic breed could increase meat production (Kyomo, 1978; Mchau, 1979; Senyatso, 1986). The aim of crossbreeding is to transmit the superior phenotypic characteristics of the improved goat breed to the F1 offspring. Hass (1978) has compared the growth rate of Boer goat crosses to that of indigenous Small east African goats in Kenya and found that the birth, weaning and average daily gains were better in the Boer crosses than in the indigenous Small East African goats. Similar results of increased birth weight, growth rate and mature weight in Boer*Cashmere goats crossbred were reported by Newman and Patterson, 1997) Elsewhere greater birth weight and average daily gains for Boer crossbreds than for other goats breeds and types have also been reported at a number of locations (Van Niekerk and Casey, 1988) including the United States (Lewes et al 1997; Cameron et al 1999; Luo et al 2000). Birth weight, weaning weight and average daily gain were improved by crossing Spanish, Nubian or Angora with Boer goats (Brown and Machen, 1995) and similar positive effects on growth rates due to crossbreeding were also found in India and China using Boer goats (Jiabi et al 2004; Nimbkar et al 2000) and in India with Alpine and Toggenburg goats (Nimbkar et al 1996). Birth weight of Blended kids were higher than the 2.1 kg reported for indigenous goats and Kamorai*indigenous crosses (Des and Sendalo, 1991) and higher weights at maturity for Blended kids could be exlained by this advantage and the positive correlation between weaning weight and mature weights. Kassahun et al (1989) observed higher crossbred birth weight and weaning weight of Saanen* Adal goat kids than Adal goats in Ethiopia and those reported for Sudanese goats (Wilson, 1976). Apart from improved weight gains in Spanish*Boer crosses Waldron et al(1997) reported improved fertility in crossbreds.

Gebrelul et al (1998) observed greater ADG for individually housed growing Boer crossbreds than for indigenous goats (88 vs 114 g/d) with a difference similar (26 g/d) to that observed by Prieto et al (2000Working with Boer and Spanish crosses Cameron et al., (2001) reported higher dry matter intake, average daily gain than Spanish goats. Due to crossbreds better average daily gain kids took less time to reach the required weight at slaughter compared to purebred kids (Dhanda 2001). Haas (1978) as cited by barry and Godke) observed a slightly greater difference in ADG from 150 to 365 d of age approximately 35g/d between Boer crosses and indigenous small East Africa goats, although ADG were considerably lower (ie 33 vs 68g/d). Kiango (1996) reported weight gain of 78g/d for the SEA* Norweagian crosses in Mgeta highlands. This value was higher than the value obtained by Safari et all (2005). and the difference could mainly be due to favorable climatic conditions and variability in feed quality in Megta highlands.(Madsen et al 1990). Genotype influenced weight gains with a difference of 11, 27, and 16g/d in favor of crossbreds (Safai et al 2005). In the same study the differences in growth rate between genotypes was lowest in animals of lower ages suggesting lowest heterosis expression at early age. Anous and Mourad (1993) working with Alpine bucks and Rove does in Egypt indicated increasing heterosis in weight gain with the increase in age of kids. F1 Bachthao*Co crossbreds goats in Thanhninh expressed clearly their hybrid vigour on growth. The body weight of F1 goats was higher than Co goats and crosses were adapted to the local conditions and gave high productive performance (Thong, 2003) . Hybrid vigor of body weight increased from 8.8% at birth to 43.2% at 36 months of age and mean value of heterosis was 28.6%. Introduction of high yielding specialized breed may bring drastic changes for increasing overall productivity like birth weight, growth rate and kid survivability (Keeping 1951).

The demand for goat meat exceeds supplies in many parts of the world notably in the tropics and subtropics, where 74% of the world‘s goat meat is produced (Devendra and Owen 1983). Unlike in developing countries there has been an increasing interest in goat breeding and farming observed recently in many developed countries which

has been related to the fact that goat products are considered a delicacy of great nutritional value (Park, 2000; Dankow et al 2006; Marichal et al 2003; Walisiewicz-Niedbalska et al 2004). Goat meat is considered to be relatively lean with a low percentage of fat around 3 to 5 g/ 100g (Webb et al 2005). Past decade has been characterized by rapid changes in consumer trends pertaining to meat consumption which have forced meat producers and manufacturers need to meet consumer demand, trends and preferences for their products or business to survive in an increasingly competitive markets. The origin of animals, carcass characteristic and meat quality are important criteria for consumers when it comes to making purchasing decisions. Therefore the producer may sort to employ production systems which furnish with acceptable carcass and meat quality (Warren et al 2008) and maintain health in consumers.

Regardless of how much selection has been applied to different goat meat breeds none has been perfect in provision of desirable carcass and meat quality to consumers. Therefore no single breed has all of the attributes required to produce efficiently in all environments and satisfy all markets (Shrestha and Fahmy, 2007). However selection within breeds for carcass characteristics will have created a great deal for variation between breeds. The quickest way to make use of this genetic variation on carcass parameters between goat meat breeds is to crossbreed Carcass and meat evaluation studies on two way rotational crossing which took cognizance of numerous identifiable carcass biochemical and physical meat properties have been common in the past decade outlining the potential for efficient carcass genetic improvement of the efficiency of goat meat production. However, very few studies in goats have been reported on the influence of three way rotational crossing on carcass and meat quality improvement. The fatty acid composition in meat from ruminants can be impacted by both breed (Banon et al 2006; Marichal et al 2003) and nutritional factors (Demirel et al 2006). Therefore it can be hypothesized that proper choice of goat breeds combination in a three way rotational crossing and various feeding regime may lead to production of quality meat with desirable fatty acid profile and physical meat quality attributes.

Genetic variation on specific carcass combining properties in three way rotational crossing have not been characterized and documented in goats (Dadi et al 2005). Crossbreeding has played a major role in improving important carcass traits necessary for commercial production in goats (Ding et al 2010; Shrestha and Fahmy,2007), in cattle (Urick et al 1981), and in pigs (Riette et al 1999). Systematic crossbreeding aimed at utilization of general and specific combining abilities of goat breeds on biochemical and physical carcass properties has had considerable success invigorating interest in commercial goat meat production (Cameron et al 2001). Considerable variation exist among goat breeds on carcass properties and meat quality (Hoffman et al 2003) and knowledge of variation in carcass properties, fatty acid profiles, sensory characteristics of different genotypes and their crosses in different management system can be used to identify optimal breeds combinations and crossbreeding systems for existing markets. Genotype is an important factor in any production system since it influence carcass and meat quantity (Madruga et al 2008). Breed differences in fatty acid profiles, sensory attributes and physical meat quality attributes offer an opportunity to improve efficiency of desirable goat meat production (Banskalieva et al 2000). To produce quality goat meat with maximum consumer appeal producers need to recognize the importance of meat quality attributes interaction between goat breeds in the utilization of genetics/genotype and nutritional regimens.

Crossbreeding has played a major role in improving important physico-biochemical meat quality properties for commercial goat production (Assan 2012). The nutritive value of goat meat is closely related to its chemical composition, primarily to protein concentration but also to the amount and composition of fat and to the level of the least desirable ingredient-cholesterol which has been associated with coronary disease. Consumer preferences for meat quality is difficult to define, nature fatty acids profiles and sensory attributes have been cited as most important meat quality features in the developing world (Bukala and Kedzior, 2001). The breed of bucks used for crossing usually affected the fat content of meat in some cases also protein content (Brzostowski 2008) were interbreed crossing resulted also in significant differences in the fatty acid composition of intramuscular fat of meat. Stanisz et al (2004) also demonstrated that Boer bucks used for crossing contributed to an increase in the intramuscular fat content of meat in the progeny to and to an improvement in the tenderness and juiceness. The intramuscular fat of meat from crossbred kids contained less hypercholesterolemic acids (OFA's) and had more desirable UFA:SFA and DFA:OFA ratios compared to the intramuscular fat meat from purebred kids. The ration between saturated and unsaturated fatty acids contained in intramuscular fat can be a measure of dietary properties of meat hence intramuscular fat impacts not only the nutritive value and sensory properties of goat meat but also the dietary properties related to the level of UFA's (Leibetseder 1996; Ender et al 1997; Oprzadek and Oprzadek, 2000).

4. Improved infrastructure, marketing and funding and other services as constraints in smallholder livestock improvement programs

Appropriate livestock infrastructure is critical to smallholder livestock improvement and development programs. Without proper infrastructure in smallholder livestock sector new technologies may not be transferable from local research centers. Proper and adequate infrastructure is a prerequisite to facilitate livestock selection programs. The stagnation and dilapidated of infrastructure is a cause of failure of most smallholder livestock improvement program in most developing countries. Inaccurate livestock improvement outcomes have been attributed to lack of appropriate infrastructure to control animal movement or management. Often where infrastructure is intact livestock improvement operations or management are deemed successful. The successes for small dairy farmers accessing milk markets and proper infrastructure in Kenya show that crossbreeding technologies can make a vital difference to profitability resulting in motivation of smallholder farmers in improving their dairy stock (Ahuya et al., 1987). In order to take advantage of the intended livestock improvement programs in Africa, emerging markets demands and proper infrastructure can assist small scale livestock producers to enhance livestock production. Smallholder livestock farmers access to basic livestock support services and technologies such as good roads, veterinary services and grazing lands, as well as livestock production policies and markets which take into account their need is essential. Enabling livestock resource poor farmers to profit from the dynamic high value livestock markets fuelled by appropriate livestock improvement programs is key to livestock production sustainability. Smallholder livestock farmers could climb out of poverty by taking advantage of the demand for livestock products in Africa. It is assumed that the rising population, improved incomes in some cases and explosive urbanization in Africa, could potentially create market for livestock products which smallholder livestock producers can take advantage of and prosper. Creation of new markets provide livestock farmers to offload livestock products at higher prices, greater diversity of sales and more opportunities for livestock production future growth. The constraints in livestock improvement has been worsened by smallholder livestock producers lack access to information and technology to improve production. Unfavorable public livestock policy and lack of support services exacerbated by poor infrastructure separates the smallholder livestock farmers from high value livestock markets. This should be in tandem with reducing barriers to smallholder livestock participation in high value livestock markets. This becomes a prerequisite for successful livestock improvement ventures. New arrangements can be created for smallholder livestock producers in providing them with better livestock inputs services, which makes it easy for more livestock resource poor farmers to enter along the livestock market chain. A study by Musemwa et al., (2007) observed that factors such as lack of access to formal marketing channels as well as high transaction costs associated with marketing were the main factors restricting smallholder farmers from participating in the vibrant formal market where they could earn higher incomes. However, while the establishment of efficient livestock marketing channels can certainly assist smallholder livestock producers to realize higher income, it can be argued that the starting point is the presentation of quality livestock products which matters which can assist individuals to venture into high value markets..

Funding of smallholder livestock improvement is a critical entry point to sustainable livestock improvement programs which may have a huge impact on the overall individual countries livestock development. This can include training, education and extension as major components of the livestock improvement programs. Generally smallholder livestock improvement programs are not given priority and are mostly under funded to support increased animal production. There is need for Africa to change this scenario, which means something needs to be done in this regard. This has affected the related training for scientists and agriculture education at tertiary level for new approaches in animal breeding which has hindered progress in enhancing smallholder livestock improvement ventures. Adequate funding from government to support smallholder livestock improvement programs is needed in training animal breeding personnel in Africa. There is great potential in local animal genetic resources, but this is currently not exploited due to limitation in funding and unavailability of local expertise in issues to do with livestock breeding. On the other hand simultaneous interventions for improved livestock management and marketing need to be generated locally and facilitate smallholder livestock farmers to achieve maximum benefit from local livestock. Any perceived interventions should integrate different management components which encompasses livestock health and housing, appropriate feeding standards and breeding procedures, with the actual disposal of livestock products to well established value chain markets. Few local livestock genetic resources have not been characterized which can be a starting point for long term improvement strategy for smallholder livestock sector. It is assumed that supported with improved market access there is

greater expectation in facilitating a more commercial oriented in indigenous livestock by smallholder livestock farmers in Africa. However, there should be caution in radical shift of livestock development from subsistence to commercial farming system because it results in shrinkage of local animal genetic resources pool if crossbreeding is used.

Smallholder farmers seem not to be motivated in improving livestock productivity simply because they do not participate in livestock high value markets. This is an areas of concern which policy makers have failed to address to solicit fully participation of small scale livestock producers. Livestock marketing systems are sectors which have the potential to motivate small scale livestock farmers to participate in livestock improvement programs, however this sector is facing a lot of challenges which need to be addressed promptly and adequately to solicit success in smallholder livestock improvement programs. Accessibility of most of livestock support services and their offer to the average smallholder livestock farmers is limited. There is no economic justification for livestock ownership in smallholder farming sector other than cultural-social aspects hence smallholder livestock farmers are less motivated in improving their livestock. Livestock improvement programs have failed to take off due to unfavorable smallholder livestock production policy, budgetary constraints and problems with inter institutional cooperation, substantially reducing program benefits and overall livestock industry sustainable development. Even though livestock keeping offers a promising opportunity to combat poverty in Africa, specially as the demand for animal products such as meat and milk continue to rise, however policy inconsistency and poor livestock support services tend to not favor smallholder livestock production.

5. Challenges and possible solutions n implementation of successful smallholder livestock improvement programs.

The goal of any livestock improvement program is to achieve rapid genetic improvement in traits of economic importance. In order to achieve this purpose accurate assessment of livestock genetic merit for any targeted traits in a population. This require a field base to be successful, thus involve data collection, analysis and utilization on technical, production, economic, biological and genetic parameters. If such processes are done properly would be the basis of successful smallholder livestock improvement programs. Common multipurpose use of smallholder livestock makes the choice of selection objectives and traits of economic importance difficult. Single sire populations, communal grazing, small individual population sizes, ownership patterns and lack of basic genetic parameters have complicated the implementation of smallholder livestock improvement programs. The practice of keeping several types of livestock is common in most smallholder holdings of developing countries where farmers keep different types of livestock species mainly for socio-economic and socio-cultural reasons (Bebe et al 2003). Some traits such as meat quality may not be important for smallholder livestock production hence this entails that correlations among such traits may not be crucial for consideration in implementation of livestock improvement programs in smallholder livestock production. The choice on which traits to promote in smallholder livestock improvement programs should be guided, as an appropriate response to the relative resources, technology and level of management of smallholder farmers. Before one considers intervention aimed at improvement of smallholder livestock it is necessary to know both the limitation imposed by the production environment and the genetic potential of the stock available in terms of all important economic traits. Imposition of choice of traits could be fatal due to lack of motivation from farmers. Before embarking on any smallholder livestock improvement program the goals and objectives to be achieved must be clearly specified. This allows in devising breeding systems that will allow to approach the specified goals and objectives. Choice of quantitative traits for improvement is very critical, however these should be in line with the needs of the smallholder livestock farming sector. Quantitative traits differ from individual to individual on a continuous scale over a wide range. Thus, there is essential a continuous variation among individuals in the population and between the extremes. Such traits are polygenic in nature because they affected by many genes. In most African countries no categorically livestock breed distribution has been done and that imported exotic breeds are basically crossed with local livestock species and have varying breed composition. This entails the characteristics and extent of livestock genetic diversity in not fully known and documented.

One typical example of a livestock improvement program which went wrong was the attempt to improve goat meat production and animal production at the household level through crossbreeding of Boar goat with local Malawi goat. In terms of productivity hybrid goats easily attained weaning weights of at least 20 kg in 12 months (Ambila et al., 1980). However the long term negative effects arose when farmers abandoned the hybrids due to

low disease resistance and yet the chances of re-establishing the original pure Malawi goat populations seemed to be low. The author still believes that goat crossbreeding has a role to play in Zimbabwe, where after the land reform a new distinct nomenclature of farmers has been created the A2(small scale commercial farmers). These farmers have been given individual sizable land especially in the semi arid areas of Zimbabwe. Controlled breeding is possible on these entities and famers can grow their own feed resources. In such a scenario which is somehow different from the Malawi situation proper crossbreeding can be done without the effects of contaminating the rest of the livestock population. The advantage is that the market for goat meat is growing in Zimbabwe, which is an entry point for commercialization of smallholder goat production. Another success story of crossbreeding as a strategy for livestock improvement is the Kenya dairy goat crossbreeding program in smallholder farming sector. This serves as a typical example of the genetic improvement program in smallholder livestock production sector, where increased milk production through importation of exotic breeds, with proper planning for sustainable conservation of the indigenous livestock gene pool. On the same note expensive arrangement of delivery of vastly improved artificial insemination service at the smallholders, door steps and progressively bring under organized breeding through artificial insemination or natural service by high quality sires, all breed able females among rural livestock population has been a major challenge. This can influence the success of the smallholder livestock improvement program, done in an effort to undertake smallholder livestock improvement programs so as to enhance livestock genetic capabilities as well as their availability. It is reasonably to suggest that crossbreeding can be a viable option in a situation where proper measures for conservation of indigenous livestock gene pool are put in place. This takes into account that crossbreeding implementation in smallholder livestock sector is being carried out where breeding season may not be defined and is largely uncontrolled mating. Livestock graze communally which might be difficult to maintain pure breeds. The direct use of exotic goat breeds was faced with problems of lack of adaptability and resistance to various diseases and parasites, and hence, little success was achieved (Chenyambuga and Lekule 2014). After the failure of the direct use of exotic breeds, crossbreeding was promoted by using the Small East African goats as the dams and the exotic breeds as sires. Improvement of meat production traits was undertaken through crossing the SEA with the Boer from South Africa

Despite the dominance of crossbreds in the smallholder dairy sector in Zimbabwe, there have been few attempts to assess their milk production, and no selection for dairy trait has been undertaken (Chinogaramombe et al, 2008). Local farmers engaged in dairy production mainly considered adaptability, availability and milk yield when selecting which dairy breed to use. It seems that without a thorough understanding of the motivation on livestock improvement issues by smallholder farmers and without their participation, livestock improvement programs are unlikely to be successful. Smallholder livestock improvement programs must be based on appreciation of livestock indigenous knowledge on livestock breeding. More often than not previous livestock improvement programs smallholder livestock farmers were taken as passive recipients and incorrect assumption about the behavior and goals of smallholder livestock improvement. The crossbred goats were found to have higher production potential for milk (Eik et al 2008), high growth rate and better reproductive performance (Das and Sendalo 1991) compared to the indigenous breeds. However, it was observed that upgrading beyond the F1 level did not achieve the higher production expected, in fact the crossbreds with 75 % exotic blood and higher grades were less economical than the better Small East African goat..

The silent upgrading of indigenous livestock with exotic type to achieve productivity gains has its own short comings. Although the local animal genetic resources outnumber the exotic type of livestock crossbreeding with these constitutes a significant threat to the local animal genetic pool. Crossbred can bring economic advantages where there are reliable input supplies, support services and markets (Hedge, 1993). Crossbreeding may dilute and threaten the survival of the local animal genetic resources. Intense crossing in certain cases can replace the local livestock with imported animals. Charray et al., (1992) stressed that genotype environment interaction with respect to adaptive traits is the main obstacle to successful crossbreeding with exotic sheep. The crossing of indigenous livestock species with exotic can improve productivity on short term basis, however may be faced with improper matching of resultant animals with level of management in smallholder sector. On the other hand if crossbreeding is not properly managed can result in indiscriminate crossing which may end up with genetic erosion of indigenous animal genetic resources. If indiscriminate crossbreeding proceed unchecked will result in genetic dilution or complete replacement of local livestock breeds by exotic species. Characterization although expensive, need to be the starting point for many of the improvement programs. This will enable Africa to estimate the extent of loss of livestock genetic diversity and to identify genetically unique livestock populations in terms of productive characteristics on which appropriate genetic improvement measures can be targeted. In smallholder

livestock production sector breeding is not controlled in the majority of populations, as no structured selection procedures are followed. Inferior males are used sometimes communally and inbreeding is common of which has not been determined, which has greatly affected the survival traits.

On smallholder dairy production, about 70 % of smallholder dairy the farmers practiced uncontrolled breeding in Zimbabwe. The fact that few farmers owned a bull implies that these bulls may be used to mate close relatives, potentially increasing the inbreeding levels in the population. Furthermore, most of the bulls would be of unknown pedigree, although generally of known genotype, implying that systematic selective breeding is lacking. Increased inbreeding and the use of unproven bulls and limited Artificial Insemination (AI) services may have unfavorable long-term effects on productivity through the degradation of the herd genotype (Bebe et al 2003). Although on-station research showed advantages in the use of crossbred dairy cattle (Smith et al 1996; Muchenje et al 2007), for resource poor farmers crossbreeding of indigenous cattle with exotics to increase production is not a recommended option, especially in the semiarid areas. This is because of the relationship between breed, level of inputs and the environment, and the consequent loss of control of the composition of a communally managed herd (Moyo et al 1993; Gandiya 1999; Garwe et al 2001). Indigenous breeds should be subjected to selection for specific production traits and an explanation of adaptation is needed (Garwe et al 2001). Group/village co-operatives of community bull schemes using bulls of proven genetic merit in dairy improvement programs may be an attractive alternative to expensive artificial insemination technology and reduce inbreeding. In smallholder livestock production sector there is a tendency of having a higher ratio of breeding males to females which makes inbreeding a major problem. Chenyambuga et al (2008) suggested that random mating was advantageous for the smallholder livestock farmers as it minimizes the problem of inbreeding, particularly for small herds, and it removes the cost of keeping males, especially to resource poor farmers.

Assan (2011) demonstrated in his discussion that there is a strong reason to believe that the use of open nucleus breeding systems in smallholder livestock improvement programs with consistent selection for important livestock characteristics may be a viable option in Africa. Suggested that goat characteristics affecting both the economy of production and consumer desirability of product will be effective leading to marked improvement over a period of a least several generations of small scale goat producers. Therefore stressed that genetic improvement for performance traits tends to be cumulative and permanent and that response of even a few per cent in gross efficiency often means a several fold increase in income. Open nucleus breeding schemes for smallholder livestock improvement should be tested since they seem attractive particularly with small populations where within herd selection programs are ineffective. Complex ownership patterns and multiple uses of livestock in smallholder farming sector makes selection of livestock improvement goals difficult. However, the other concern is the genotype*environment interaction if animals are selected from on station breeding programs.. This only occur when the management of the on station population becomes very much better than the smallholder livestock farming sector management then the superiority of the young males may not be achieved in the smallholder sector. Possible solution to genotype*environment interaction is to site the testing station to be representative of all cooperating smallholder livestock as far as a possible. On the other hand, on station improvement programs involve improved management and feeding in order to maintain good reproductive rates. Strict hygiene on station is also vital to reduce the risk of losses from diseases. However, in smallholder livestock improvement using open nucleus breeding schemes might not be feasible because of the costs involved in establishing a experimental population. Another factor which may limit success is that returns are long term therefore it may be difficult to convince poor smallholder livestock farmers to contribute to the experimental population. The most difficult component may be the choice of selection objectives for several smallholder livestock farmers, however there is need to link selection objectives to market trends in long term. The risk of concentrating best animals in one risk (De Jong 1996).

Most on station livestock improvement programs targeting smallholder farmers underrated the influence of genotype and environment interaction on livestock production resulting in their failure. It is well known that the basis of expression of any quantitative trait in animal production is a function of its genetic merit plus the way it interacts with the environment. The presence of genotype by environment interaction implies that certain genotypes perform best under certain conditions but others are preferred under different conditions. The manifestation of genotype by environment interaction is particularly in better conditions on station where livestock have been tested, produced and utilized. In most cases animals have been exposed to good nutritional environments on station, however where management is inadequate such as smallholder environment animals have failed to perform to their expectation. High plane of nutrition on station and good health management have

falsely elevated livestock production levels. However, the reduction in performance due to disease related conditions have also been experienced when these animals have been transferred to smallholder farming situation. Animal selected on station seem to be very sensitive to poor management associated with smallholder production sectors. The selection of animals on good management may not be appropriate for smallholder farming sector due to disagreement between the actual and predicted performance due to genotype and environmental interaction influences.

6. Implications for Africa

The discussion does serve to emphasize that smallholder livestock improvement programs have a role to play in the national development and economies in Africa. Strong growth opportunities to improve smallholder livestock production systems in Africa, adapted to the environment, production objectives and market opportunities exist, if the constraints are addressed. However, smallholder livestock production systems are not a homogenous group, nor are the constraints associated with the system. Therefore, there is a need for identification of the existing smallholder livestock production system typologies and their associated constraints for better targeting of livestock improvement strategies and institutional innovations to address issues related to animal agriculture, food production, rural development and the environment on the African continent.

Whilst there is a well ordered structure in livestock improvement programs in developing world due to favorable livestock production policies, in Africa the smallholder livestock farmers' voices seem to be missing from the livestock improvement policy processes. Also the lack of smallholder livestock gender sensitive development policies are limiting any progress in the implementation of smallholder livestock improvement programs. Therefore, more need to be done to build institutions able to incorporate the voice of smallholder livestock farmers into smallholder livestock improvement policy process. The issue of funding of smallholder livestock programs has been a major constraint, being worsened by the fact that too few livestock development organizations are engaged with, and able to support smallholder livestock improvement programs and the smallholder livestock value chains which may motivate the smallholder farmers to improve their stock. An orderly strong links of individual governments and private sector and the livestock research community in Africa along with good understanding of livestock improvement thrust can contribute to the success of smallholder livestock improvement. Livestock research innovation systems are identified as extremely useful in linking research, public and private actors, value chains and policy.

The establishment of smallholder livestock improvement programs should encompass all known social and economic consideration as viewed by the smallholder farmer themselves. The exclusion of some of the issued considered pertinent by farmers may translate to failure of smallholder livestock improvement efforts. The farmers should feel as partners in the livestock improvement efforts than outsiders. The motivational aspect of smallholder livestock improvement programs could be derived from strengthening the market integration of smallholder livestock farmers by promoting the latter in livestock value chains – from input and service provision to production. Encouraging better interaction among livestock farmers and service providers will improve dissemination of livestock improvement information. Due to lack of information, ssmallholder livestock farmers may unknowingly encourage inbreeding through keeping animals for a long period and use of same genealogy for breeding. The smallholder livestock farmers have not regarded out sourcing of elite bulls as a means to improve their indigenous stock through selective improvement. Therefore, smallholder farmers should be encouraged to rank their female stock and culled others in order to ensure reduction of the large numbers of unproductive animals which can result in improvement of level of productivity in individual herds.

For the few livestock improvement programs attempted in Africa choice of improvement strategies have not well been thought to such an extent that crossbreeding as a genetic improvement strategy has endangered local livestock populations to the extent that unrecoverable loss of precious Africa livestock genetic resources could be observed. Although crossbreds were economically viable but the F2 populations in most cases showed deterioration and decrease in milk yields. Generally crossbreds were more often productive as compared to most local livestock breeds, but their tendency to wilt under smallholder production environment characterized by low input and harsh climatic conditions and susceptibility to diseases was unacceptable and worrying. Crossbreeding may seem to be attractive in short term, however Africa fall the risk of letting local livestock breeds go extinct if measures of conservation are not put in place. It is suffice to suggest that within breed selection of the adapted indigenous livestock breeds should be promoted as strategy for efficient on-farm conservation and sustainable

utilization of local animal genetic resources in Africa. It should be acknowledged apart from our concern on productivity local livestock breeds are an integral part of Africa's eco-system, cultures and heritage, thus it is imperative to develop the smallholder livestock sector with caution. The solution to this problem is possibly an attempt should be made to develop indigenous livestock breeds in their own conditions and environments. However, implementers should acknowledge the fact that selection and recording system in smallholder livestock production sector do not exist or where it is practised is full of errors. This impede any genetic progress through selection, and for any meaningful livestock improvement program a proper recording system should be embraced. The inconsistency of livestock improvement results may point to the fact that no single livestock improvement strategy might work well in all kinds of African environment because of the differences in socio-economic and cultural environment. Different countries due to their different socio-economic environment and ago ecological characterization has to evolve their own livestock improvement strategies in the context of selection within populations and/or crossbreeding. Countries can decide on optimal mixture of livestock of different breeds required and also breeding goals in terms of expected genetic progress to be achieved within their specific smallholder livestock production sector. It is also important to design specific breeding programs and the control measures that should be adopted to enhance the desired genetic gain taking into account the availability of infrastructure. The developing of smallholder livestock improvement programs sometime have been hampered by availability of appropriate infrastructure and appropriate technologies, this has resulted in failure in building the capabilities of livestock resource poor farmers in rural areas. Therefore, appropriate infrastructure and improved technologies might be necessary for the success of such ventures. The gains from livestock improvement in smallholder livestock production sector are immense-billions of people on the African continent would benefit in terms of better nutrition and improving the general households welfare of the resource poor livestock farmers.

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