



Ethiopian ATA
Agricultural Transformation Agency
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National Small Ruminant Breeding Strategy



2018 -2030

National Small Ruminant Breeding Strategy

2018 – 2030

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Foreword

In the years ahead agriculture awaits a daunting task of feeding burgeoning population in a resource constraint world and under the influence of climate change while keeping society and environment safe. Livestock development would undoubtedly play a key role within the agriculture to fulfil its task, particularly in ensuring food and nutrition security and environmental safety. Nevertheless, the contribution of the sub-sector compared to its potential is disproportionately low. Lack of national legal framework and absence of well-established and functional breeding programs, inadequate support and lack of commitment and institutional set up to support breeding programs are among the major constraints hampering the development of successful breeding programs and were among the major bottlenecks limiting the success of livestock genetic improvement and conservation efforts in the country. In order to solve the problems, the Ministry of Agriculture in collaboration with development partners developed a national livestock breeding policy that has been approved by the Council of Ministers of the Federal Democratic Republic of Ethiopia.

This national breeding strategy was therefore drawn within the context and in conformity with the need and evolving national and global emerging trends while taking the advantage of the current and emerging opportunities. The strategy is developed within a framework of addressing both development and research aspects at national level. It covers the analysis of the existing situation, identifies challenges and opportunities with regard to breeding of small ruminant, and evaluates the institutional arrangements and address the variation in terms of agro-ecology and production system as well as the biodiversity within the species populations of the country. The strategy is framed in alignment with, among others, the national Livestock Master Plan; and Livestock Genetic Improvement Roadmap, and Livestock Breeding Policy.

Hence, the strategy is believed to guide development of tailored small ruminant breeding program by resolving the current disorganized breeding initiatives, which would improve the efficiency and effectiveness of genetic improvement initiatives; transformation of ongoing fragmented, project-based and research-based breeding activities into sustainable breeding programs; increase in the economic contribution of adapted indigenous small ruminant genetic resources through conservation based genetic improvement and minimization of irrational crossbreeding activities; integration of research and development institutions to work towards the same breeding goal; and creation of job opportunities for small businesses delivering improved genetics through involvement of the private sector in genetic improvement.

The current breeding strategy was developed by the Ministry of Agriculture (MoA) through the facilitation of the Agricultural Transformation Agency (ATA). Various federal and regional stakeholders from the public and private sectors were integral to the development of the strategy.

Indeed, laying down a 12 years plan seems a time too distant to accurately predict. However, by scanning and analysing the national and global trends, and possible future scenarios and signals we believe that we have captured the coarse portrait of the future. Despite this, we by no means claim that it is a complete

document. Rather, the assumption is that, the strategy will serve as a live document to develop breeding programs and remain dynamic to respond to newly emerging problems that can be revised subsequently as necessary.

On behalf of the MoA and my own, I would like to extend my sincere appreciation and thanks to ATA for the financial support, coordination and technical contribution starting from planning to finalize the small ruminant breeding strategy. Moreover, my enormous gratitude goes to Dr. Solomon Gizaw (ILRI), Dr. Solomon Abegaz (EIAR), Dagne Muluneh (MoA), Dr. Zelalem Tesfaye (TARI), Dr. Yoseph Mekasha and Dr. Yitaye Alemayehu (ATA) who were actively involved in the process of developing this breeding strategy document.

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Acronyms

AEZ	Agro Ecological Zones
AI	Artificial Insemination
ALRC	Andasa Livestock Research Center
ARARI	Amhara Agricultural Research Institute
ARC	Abergele Research Center
ARDU	Arsi Rural Development Unit
BHS	Black Head Sheep
BRC	Bako Research Center
CHG	Central Highland Goats
CRGE	Ethiopia’s Climate Resilience Green Economy
CSA	Central Statistical Authority
CADU	Chilalo Agricultural Development Unit
DA	Development Agents
DBARC	Debre Birhan Agricultural Research Center
EARO	Ethiopian Agricultural Research Organization
EJAP	Ethiopian Journal of Animal Production
EIAR	Ethiopian Institute of Agricultural Research
EBI	Ethiopian Biodiversity Institute
ESGPIP	Ethiopian Sheep and Goat Productivity Improvement Program
FAO	Food and Agricultural Organization
GTP	Growth and transformation plan
HLI	Higher Learning Institute
HU	Haramaya University
ILRI	International Livestock Research Institute
LES	Long Eared Somali Goats
LMP	Livestock Master Plan
MoA	Ministry of Agriculture

MoA	Ministry of Agriculture
ME	Monitoring and Evaluation
MOET	Multiple Ovulation and Embryo Transfer
MWRC	Melka Werer Research Center
NAGII	National Animal genetic improvement institute
NARS	National Agricultural Research System
OARI	Oromia Agricultural Research Institute
PPI	Pairs of Permanent Incisors
RLA	Regional Livestock Agency
RRI	Regional Research Institute
SARC	Sirinka Agricultural Research Center
SARI	Sari Agricultural Research Institute
TARI	Tigray Agricultural Research Institute
WARC	Werer Agricultural Research Center

EXECUTIVE SUMMARY

Ethiopia is a country of great agro-ecological and cultural diversity and resultant domestic animal biodiversity. Sheep and goats are among the most important livestock species making significant contribution to the livelihood of farmers and pastoralists, and also the national economy of the country. Current estimates put the population of sheep and goats at 58.6 million (CSA, 2016) and almost all belong to the indigenous type. The sheep and goat genetic resources possess important adaptive traits which make them cope with adverse conditions such as lack of feed and water, heat, disease pressure and therefore, making them more suitable for rearing in the sometimes harsh environments. Despite the adaptive advantage, wide diversity and large population in the sheep and goats, productivity is low. Attempts in the past with regard to genetic improvement of sheep and goats were fragmented and not guided with clear breeding strategy, and were mainly based on introduction of exotic breeds. The success and sustainability in this regard was low. A breeding strategy that should guide the genetic improvement of small ruminants in the country is critical to the success of breeding activities that will be implemented to improve the production and productivity of the sub-sector. A situation analysis that scanned existing challenges and opportunities, the available resources, relevant past and on-going development and research activities, national development goals and institutional setups has been undertaken. Important strategic issues were identified which pertain to institutional, previous genetic improvement initiatives, investment, lack of market orientation of past genetic improvement initiatives, genotype multiplication, modern biotechnology tools and monitoring and evaluation.

Strategic interventions that focus on institutional, rational utilization of the small ruminant resources, revamping and restructuring of ongoing genetic improvement initiatives, initiating new breeding programs, accelerating genetic improvement, public private partnership model for commercialization of genetic improvement, conservation based breeding, database system and capacity development were considered. Accordingly, the expected outputs of the strategy will be to resolve the current disorganized breeding initiatives which would improve the efficiency and effectiveness of genetic improvement initiatives; transformation of ongoing fragmented, project-based and research-based breeding activities into sustainable breeding programs; increase in the economic contribution of adapted indigenous small ruminant genetic resources through conservation based genetic improvement and minimization of irrational crossbreeding activities; integration of research and development institutions to work towards the same breeding goal; and creation of job opportunities for small businesses delivering improved genetics through involvement of the private sector in genetic improvement. In terms of targets the strategy addresses both the public and the private sector, research and development institutions, and international development partners. Strategies for designing and implementing breeding programs were indicated by way of designing options for selection and cross-breeding programs. The design options include prioritization of breeds, designing, organizing and implementing breeding programs for straight breeding initiatives and terminal crossing and synthetic breed development for cross breeding.

The strategy is expected to benefit the smallholder small ruminant breed keepers, commercial companies, women and youth with special focus to jobless graduates of animal science. Institutional roles and responsibilities of national and international organizations in line with the strategic interventions were

identified with the National Animal Genetic Improvement Institute (NAGII) taking the lead. The time frame for implementation of the strategic interventions has been shown to range from short (0-2 years) to medium (3 to 7 years) and long term (8 to 12 years). Strategy for accelerating genetic improvement, use of advanced reproductive technologies and genomic tools in breeding programs were identified to happen or extend to long term while most other interventions were planned to happen within the short to medium term period. Investment plan as per the time frame was suggested and a World Bank project which is in pipeline has been indicated as one potential source for rolling out the strategic interventions in the short term. Monitoring and evaluation activities were identified along with indicators, means of verification and institutional responsibilities. Crosscutting issues as pertains to the breeding strategy and which include gender, environment and nutrition were identified. In addition to the above, need for development of additional documents to put the breeding strategy in perspective was identified. Some of these documents need to be worked out in the near future while the others are attached as annexes.

1. INTRODUCTION

1.1 BACKGROUND

Due to its geographic location, Ethiopia was the entry point for various livestock breeds from their centers of domestication into Africa. In addition significant agro-ecological and cultural variations exist in the country. As a result the country is endowed with a rich diversity of animal genetic resources (AnGR) which play important roles in the national economic development and the livelihoods of millions of Ethiopians making invaluable contributions to food security and income. To date, 28 cattle, 9 sheep, 8 goat, 8 horse, 6 donkey and 7 chicken 'breeds' have been identified (EBI, 2015).

Small ruminants are important component of the mixed agriculture, pastoral and agro-pastoral production systems in Ethiopia. Current estimates put the population of sheep and goats at 58.6 million (CSA, 2016) and almost all belong to the indigenous type. The estimate excludes some pastoral areas and previous estimates put the total population as high as 66 million (Asfaw et al., 2011). Sheep & goat production system in Ethiopia can be divided into three major and two minor production systems (Solomon et al., 2010). The major production systems are highland sheep barley production system, mixed crop-livestock production system and pastoral and agro-pastoral production systems whereas the minor production systems included ranching and urban and peri-urban landless sheep and goat production system. The sheep and goat genetic resources possess important adaptive traits which make them cope with adverse conditions such as lack of feed and water, heat, disease pressure and therefore, making them more suitable for rearing in the sometimes harsh environments. However, level of production and productivity is not on par with the population size and there are critical constraints mainly related to feed, health and genetics, which limit productivity. There exists between and within breed genetic diversity which can provide the raw material for breed improvement and for the adaptation of livestock populations to changing environments and changing demands (FAO, 2015). Limited attempts were made to improve production and productivity through introduction of exotic breeds and selective breeding but the success and sustainability in this regard was low.

Generally small ruminant productivity is poor. With an average off-take rate estimate of about 36.5 per cent for sheep and goat (Hurissa and Eshetu, 2003) and a carcass yield of 9.25 kg per animal 222,833 ton of meat can be produced. For a population of 100 million this amounts 2.0 kg per capita consumption per annum. On the other side, demand for live animal and meat export is also showing sizable increase. These entail, to meet the demand for domestic consumption and export, an unprecedented need to raise productivity through increased off-take rate and yield per animal, and there exists potential to accomplish these targets. With improvement in fertility (conception and frequency of birth), prolificacy, survival and growth, sizeable improvement in productivity can be achieved. Such achievement and its sustainability require efficient functioning of the value chain

1.2 RATIONALE FOR DEVELOPING THE STRATEGY

Absence of well-established and sustainable breeding programs and schemes and their components (recording, evaluation, distribution etc.), inadequate support and lack of commitment and institutional set up to support breeding programs are among the major constraints hampering the development of

successful breeding programs. An overall breeding strategy that can guide genetic improvement of the indigenous breeds through selective breeding and/or, when appropriate, crossbreeding is required to:

- Make efficient utilization of the small ruminant genetic resource base of the country for the betterment of the national economy and household nutrition and income of producers;
- Reverse real and potential threats of loss of the indigenous genetic resources
- Ensure realization of faster genetic progress

1.3 VISION

By 2030, to see the small ruminant subsector transformed into a sustainable supplier of products of sufficient quantity and standard quality to the domestic and export market, consumer and the community.

1.4 MISSION

To make efficient utilization of the small ruminant genetic resource base of the country through sound genetic enhancement, breed conservation and sustainable utilization for the betterment of the livelihood of producers and increased contribution to the national economy.

1.5 GOAL

To enhance small ruminants production and productivity for ensuring food and nutrition security and poverty reduction in the country and ensure better life of sheep and goat keepers in Ethiopia.

1.6 OBJECTIVES

The general objective of the strategy is to guide the future genetic improvement, conservation and sustainable utilization of the small ruminant sector along with transforming existing fragmented genetic improvement initiatives into organized, rationalized, scientific and sustainable breeding programs through institutional and technical reforms.

Specifically, the small ruminant breeding strategy is to outline the detailed directions in:

- developing and implementing well-organized and consistent small ruminants genetic improvement programs for different production systems;
- applying different breeding tools including biotechnology (genomic and reproductive technology); and developing elite breed and conserve small ruminant genetic resources
- enhancing the capacity for the research system, development institutions, private sector and small holders in different production systems; and
- developing climate smart small ruminant technologies and innovation to mitigate and adapt to climate change/variability.

1.7 SCOPE OF THE STRATEGY

The small ruminant breeding strategy is developed within a framework of addressing both development and research aspects at National level. It covers the analysis of the existing situation, identifies challenges and opportunities with regard to breeding of small ruminants, and evaluates the institutional arrangements and address the variation in terms of agro-ecology and production system as well as the biodiversity within the goat and sheep populations of the country. A time line of 12 years (the remaining two years of GTP 2 and the full duration of GTP 3 and 4) is envisaged in revamping existing breeding research and development programs, identifying priority for new ones and developing a framework for the breeding programs.

1.8 GUIDING PRINCIPLES

The national small ruminant breeding strategic intervention and the specification of the modalities of intervention is guided by a set of basic governing principles. These are:

- The national small ruminant genetic improvement shall be an integral part of the national research for development efforts and guided by basic principles put forward by the national livestock master plan.
- All the activities shall be founded on the policies and priorities set in road map for national genetic improvement strategy for small ruminants in the Livestock master Plan embracing the notions of cost-effectiveness, technical efficiency and responsiveness to stakeholders in both the public and private sector
- In the process of project formulation and implementation, real participation and engagement of the community shall be ensured. The national small ruminant genetic improvement activities shall follow participatory approach and ensure sufficient degree of client orientation
- Through its impact path way, the national small ruminant genetic improvement shall ensure its research for development outputs will contribute to macro level goals of economic/ social transformation, sustenance of environment and livelihood improvement
- During project formulation and implementation the required ethical, social and environmental impacts shall be ensured
- In the national small ruminant genetic improvement engagement special emphasis shall be given to capacity building, institutionalization of integrated approach, institutional pluralism and effective engagement of partners and stakeholders on the basis of comparative advantage
- Due attention shall also be given to inclusiveness in terms of diversity and equal opportunity for all encompassing gender-sensitive approaches in its research for development engagement
- In all of its deliberations, the national small ruminant genetic improvement shall ensure commitment to excellence, knowledge sharing and access to information
- In the national small ruminant genetic improvement engagements, monitoring mechanisms and evaluation criteria from inception of its projects and activities shall be ensured
- The national small ruminant genetic improvement activities shall be free from all forms of malpractices and shall ensure transparency, accountability and devotion to ethical standards of all concerned actors at all levels

2. SITUATION ANALYSIS

2.1 SMALL RUMINANT DEVELOPMENT GOAL

Looking the current situation, despite the existence of large number and diversified types of small ruminant genetic resources in Ethiopia, the benefits obtained from sub-sector are low. To improve the situation the country has developed the national Livestock Development Master Plan (LMP). The LMP is intended to improve the small ruminant genetic resources by investing in genetic selection programs with an integral component of interventions to reduce mortality in the young and adult stock. The LMP targets a 20% live weight gain, a 3% increase in dressing percentage, a 4% increase in parturition rate over 20 years and an annual increase of 4–5% in adult sheep and goat net off-take rate. In line with the LMP, the GTP II plans to:

- Facilitate the development of genotype improvements and improved livestock breeds that enhance productivity and resilience to climate change, with a focus on:
 - Enhancements to artificial insemination (AI) delivery services, coverage and efficiency;
 - Fostering of environment for effective private-sector participation; and
 - Promoting appropriate biotechnological tools for genetic improvement;
- Enhance market orientated utilization of indigenous and introduced animal genetic resources;
- Promote climate change adaptation, mitigation and greening of value chains (CRGE). The CRGE focuses, *inter alia*, on value chain efficiency of livestock production. This includes increased animal productivity vis-à-vis their efficiency in converting inputs (mainly feed); and
- Enhance broad participation of livestock keepers and private sector in genetic improvement programs.

2.2 SMALL RUMINANT PRODUCTIVITY

Despite the huge and genetically diverse resources and an emerging opportunity for small ruminant export markets, most of the indigenous breeds are characterized by slow growth rate and their average yearling weight is by far below the required standards by most of the export abattoirs and off take rate is very low at 33% (EPA, 2002).

Several studies have characterized the small ruminant production systems and their productivity under village conditions (e.g. Endeshaw 2007; Gurmesa et al. 2011; Assen and Aklilu, 2012; Dhaba et al. 2012) and under controlled and improved conditions in research centres. On-station studies on characterization of performance of some indigenous sheep and goats have shown that the sizes required by the market may not be achieved until about one year of age unless higher supplemental feeding is practiced (e.g. Galal et al., 1981). Carcass yields were shown to be low. Goats appear to have higher dressing percentage than sheep. Milk production performance of goats along with its quality has also been a subject of research particularly in areas where goat milk is consumed (Getnet et al, 2000; Fekadu and Eyasu, 2000; Mestawet et al, 2012). Estimated average daily milk production as high as 1.5 kg has been obtained in some goat breeds (e.g. Getnet et al., 2000). In a study on sheep milk production potential, 0.54, 1.4 and 1.73 kg of milk yield per day was obtained for Menz, Awassi X Menz cross and pure Awassi ewes, respectively. The average days of lactation length were 98, 112 and 120 for Menz, Awassi X Menz cross and pure Awassi ewes, respectively (Haile et al, 2017, in press).

On station and on farm genetic improvement of Menz sheep has resulted in sizeable gain in terms of weaning and yearling weight (Gizaw et al. 2007). Community based breeding program on indigenous sheep breeds has also resulted in sizeable improvement in different traits. In Horro the average increase was 0.31 ± 0.060 kg per year, followed by average increase of 0.26 ± 0.058 kg per year in Bonga and 0.14 ± 0.006 kg for Menz. This is quite substantial in an on-farm situation. In Horro and Bonga sheep, where twinning rate was one of the selection traits, the litter size of lambs born increased over the years in both breeds: the increase was 12% (from 1.28 to 1.46) in Horro and 8% (from 1.48 to 1.61) in Bonga (Haile et al, 2017).

Crossbreeding has been used to improve the productivity of a number of sheep and goat breeds in the country. The intent of the crossbreeding was combining the adaptability of the indigenous breeds to the environment with high performance of the various exotic breeds. Some preliminary results of on-farm evaluation have shown performances in terms of daily gain and weaning weight of crossbred (37.5%) lambs were not superior to local lambs (Hassen *et al.*, 2002). There was superiority in birth weight, but this was not maintained at weaning implying the inability of the local dam to support higher growth rate potential of the crossbred lamb. On-station studies have shown superiority of crosses (in terms of weight and wool yield) over local animals. both under feed supplementation and without supplementation. The superiority was very high under supplementation (Sisay *et al.*, 1991) implying exotic animals require superior management. Similar result was obtained for carcass traits (Sendros *et al.*, 1998; Tsegaye et al., 2013). Other studies (Brännäng *et al.* 1987; Sisay *et al.*, 1988) have also shown superior performance of crossbreds.

The relative performance of the crossbreds with respect to reproductive traits was not consistent (Sisay *et al.*, 1988; Brännäng *et al.*, 1987; Getachew et al., 2013). Getachew et al. (2016) have undertaken a comprehensive review of results of crossbreeding in sheep. Apart from growth, wool production and reproductive performance, the effect of crossbreeding on milk production (particularly in goats) and skin quality has received little attention (e.g. Tadelle, 2008, Taye et al., 2009; Seid, 2011). Improvement in the level of milk production as a result of crossbreeding has been observed under on station condition (e.g. Kassahun et al., 1989).

Growth rate of goats under traditional systems is low. Dressing percentages ranging from 42.5 to 44.6% were reported for Long-eared Somali, Central Highland and Afar goat breeds (Ameha et al. 2007). Preliminary results from on-station research show that crossbreds between indigenous (dam) and Boer (sire) goats grow faster than purebred indigenous goats. However, similar performance evaluation under on-farm conditions has not been undertaken in addition to overall performance of other production and reproductive traits.

2.3 CURRENT DEVELOPMENT AND RESEARCH STRATEGIES AND PROGRAMS/PROJECTS

2.3.1 Development strategies and programs/projects

Between 1970's to 2015, a number of development strategies have been developed to improve productivity of small ruminants in Ethiopia (Table 1). Key strategies for mixed crop livestock system and in some cases for the pastoral community were developed. Earlier strategies focused on on-station evaluation, selection within indigenous animals, crossbreeding, multiplication and dissemination of crossbred rams and bucks.

Table 1. Development strategies

Period	Key strategies	Institution
1970's	-Evaluation; Selection; Crossbreeding; Multiplication and Dissemination.	CADU, ARDU
1970's	-Dissemination of selected and crossbred rams	MoA
1996	<u>Mixed crop-livestock system</u> - Selection, crossbreeding, Dissemination - Dual purpose crossbred for barley sheep system ; - Research on selection and breeding methodology <u>Pastoral</u> - Community breeding ranches; commercial ranchers - Selection program for extensive lowlands - Research on crossbreeds for extensive system	MoA
2001	National Animal Genetic Improvement Institute	ULDIP
2011	National Dorper breeding strategy + breeders consortium	ESGPIP
2015	Promotion of community-based breeding	LMP

2.3.2 Research strategies and programs/projects

Research strategies and programs to improve the productivity of indigenous sheep and goat resources in Ethiopia has begun in the 1970's. There has been a lot of effort to formulate strategies to guide the small ruminant research and development in Ethiopia (e.g. MoA, 1996; EIAR, 2001; EIAR, 2011; Hailu et al, 2011, Gizaw and Abegaz, 2011) and develop breeding programs (Table 6). These strategy documents could be vital to direct and regulate genetic resource utilization and conservation, developing research and development projects that are relevant to the country's development needs, and institutionalization of the research system to effectively and efficiently deliver research outputs. However, most of these strategy document seem to be left at draft stages as grey literature and are not accessible or circulated widely to users. As a result, there has been a tendency to develop strategy documents anew every half decade or so. There is little or no reference to previous documents while developing new ones. And yet, there is very little difference between strategy documents although a progression in the research strategy is observed (Table 2). A major gap in strategy-led research programs is the lack of adherence to strategies when projects and programs are developed. Although strategies commonly claim agro-ecological and system-specific implementation strategies, this is for the most part not the case. Strategies focus more on

technological interventions or design of research agenda and little or no consideration on institutional aspects of research organization.

Table 2. Breeding research strategies and programs (based on strategy documents and research programs)

Breeding research strategy			
Period	Contents/focus of strategy		
Pre-IAR	Crossbreeding; evaluation with feeding; forage development		
IAR (1990)	- Center dev't; AEZ and system consideration; - Breed identification; on-station/on-farm comparative evaluation; Crossbreeding, nucleus Selection;		
EARO (2000)	- Center development; AEZ and system consideration - Characterization of breeds, systems; crossing, selection		
EIAR (2015)	Coordination NARS; Targeted breed characterization; Village- and nucleus-programs; breeding and reproduction biotechnology; Value chain approach; sustainable prod system; marketing strategies and policy analysis		
Breeding programs/projects			
Period	Program/project	Breeds	Institution/organization
Sheep			
1970's 80's	Crossbreeding	Arsi, exotic	CADU, ARDU
1970's -	Crossbreeding	Menz, exotic	MoA, (Debre Birhan Ranch
Mid-1970's-80's	Selection	Horro, Afar, BHS, Menz	IAR, (DBARC, WARC, SARC)
2000's	Selection	Washera	ALRC
Current	Selection	Afar	MWRC
Current	Selection	Horro	BARC
Current	Selection	Menz	DBARC, CGIAR, Villages
Current	Selection	Bonga	BRC, CGIAR, Villages
Current	Selection	Doyo-Gena/Adillo	ARC, SARI, ICARDA
Current	Selection	Dauro-sheep	ARC, EIAR, SARI
Current	Selection	Blackhead Somali	Jigjiga RC, EIAR
Current	Selection	Various breeds	SARI, ARARI, OARI...
Current	Selection	Washera	ALRC, EIAR, communities
Current	Crossbreeding	Awasi	DBARC, SARC, Amhara livestock agency
Current	Crossbreeding	Dorper	ESGPIP, ARARI, SARI, SoRPARI, TARI, HU
Current	Crossbreeding	Rutana	Western Amhadra
Goat			
Mid-1970's 80's	Crossbreeding	Anglo-Nubian	Farm Africa, Agri-service, AUA, ACA
Mid 1970's -80's	Crossbreeding	Saanen	IAR
Mid-1970's 80's	Selection	Afar	IAR
Current	Selection	Aris-Bale	OARI
Current	Selection	Abergele	ICARDA, CGIAR, communities (Amhara and Tigray)
Current	Selection	Central highland	Godar RC, DBARC, SARC
Current	Selection	Woito-Guji	Arbaminch RC, ICARDA
Current	Crossbreeding	Boer	ESGPIP, ARARI, OARI, SARI, HU

2.3.3 Impacts of strategies and programs/projects

Despite the immense research and development effort, the output from both research and development is minimal. Some of the research-based breeding projects/programs are promising. For most programs, no comprehensive data were available to do on-farm comparisons of herd productivity and cost-benefits

or to evaluate the sustainability of the programs. Although there are some promising initiatives, dissemination of improved genetics from nucleus centres to villages has been a challenge. Most of the projects failed to result in sustained genetic improvement due to several factors, including absence of appropriate designs/schemes, expertise to lead and implement science-based programs, and long-term commitment which is a basis for genetic improvement programs. The Awassi sheep crossbreeding program is a case in point. Ram multiplication and dissemination from the government farms has been inefficient with little impact on the village sheep population despite a high investment including a number of rounds of importation of the exotic germplasm and existence of two large multiplication ranches.

However, there are promising research programs, including community based selective breeding and crossbreeding projects/programs (e.g. the Awassi and Dorper sheep nucleus and village-based projects, village-based sheep breeding programs for Menz sheep and in sheep breeds in SNNPR region including Bonga sheep) For instance, a village-based crossbreeding project has been sustained as a source of crossbred rams (Table 8). Although limited for the most part within the research station, there has been very good achievement in Menz sheep central nucleus breeding project. However, these achievements are still under research phase.

2.4 CAPACITY AND INVESTMENT IN GENETIC IMPROVEMENT

Investment for genetic improvement needs considerable amount of capital and commitment to sustain the genetic improvement programs. In Ethiopia, sources of funding for breeding programs are from the public sector. The private sector and the non-governmental institutions are not engaged in long-term breeding programs. Large sums of public resources have been invested in ranches, research farms, Importation of exotic sheep and goat breeds from abroad since the 1970's and extending to the present time.

However, investment in institutions and human expertise (including retaining available expertise within the public sector) are minimal. For instance the human resources dedicated to leading and running breeding programs are way below requirement.

2.5 STRENGTH, WEAKNESS, OPPORTUNITIES AND THREAT (SWOT) ANALYSIS

Drawing on the situation analysis in sections 2.1 to 2.4, a SWOT analysis is presented below:

Strength

- Livestock master plan that promotes genetic improvement of the indigenous breeds
- Presence of ample information on the small ruminant genetic resources of the country
- Adoption of research-for development approach by some research centres.

Weakness

- Absence of well-established and sustainable breeding program and schemes
- Absence of national database systems on small ruminant resources and poor recording systems
- Underutilization of modern tools to promote production and productivity in small ruminants
- Underutilization of indigenous small ruminant in crossbreeding schemes
- Inadequate and un-sustained financial support for breeding programs

Opportunities

- Relatively large flock size and higher dependency on small ruminants in the highlands
- Presence of diverse small ruminant genotypes with different prolificacy levels
- High domestic and export demand for small ruminants
- Relatively short cycle of small ruminants (8-9 months between the lambing/kidding)
- Presence of exotic small ruminant breeds fitting the low input system in some areas and preferred by smallholder producers and investors
- Emerging of new stakeholders/target groups (agribusinesses, investors, microfinance, women and youth entrepreneurs, CBBPs)

Challenges

- Inadequate technologies that can transform the small ruminant sub-sector and enable utilization of the wealth of genetic resources
- The presence of negative selection as a result of common practice of selling superior males and uncontrolled mating
- Un-integrated research and development effort among the stake holders (Research, Universities, MoLF, CGIAR, NGO's,)
- Inbreeding and its deleterious effects
- Inadequate support and lack of commitment to support breeding programs
- Impacts of climate change on feed and water availability
- Inadequate capacity (human, infrastructure)

2.6 STRATEGIC ISSUES OF SMALL RUMINANT BREEDING STRATEGIES

Key strategic issues are identified from the situation analysis and the SWOT analysis. The issues are categorized and described below. These issues are the basis for developing the proposed strategic interventions in Section 3.

2.6.1 Institutional issues

There has been no clear institutional arrangement for conservation and genetic improvement of the small ruminant genetic resource in Ethiopia. Absence of clear and detailed direction for institutionalizing genetic improvement programs (earlier strategies: MoA, 1996, EIAR 2015, LMP 2015) was not set to enable and give directions for the institutionalizing genetic improvement programs. Roles and responsibilities of the different institutions engaged on genetic improvement of small ruminants were not clearly set and this created an overlapping efforts on the same tasks among NARs, EIAR, IBD, MoLF, CGIAR, and NGO's.

Research and development strategies and breeding programs are not coordinated. Efforts of national research and development institutions, universities and international development partners are not in some cases coordinated, even when working on the same topic/breed/breeding objective. The recently approved establishment of the National Animal Genetic Improvement Institution's urgent task would be to correct this incoordination.

Consequences: Despite the fact that Ethiopia launched genetic improvement program on small ruminants in the early 1970's, the country at this time had no efficient genetic improvement programs. Indiscriminate crossbreeding and dilution of the indigenous genetic resources is one of the area that needs an immediate correction and direction.

2.6.2 Sustainability of genetic improvement initiatives

Genetic improvement should be a long-term vision. Genetic improvement requires a long-term investment and commitment. Nonetheless, most of the genetic improvement initiatives are project-based. Donor-supported projects launched in the country performed very well during the projects life, but fall apart after the projects are phased out and donor support is terminated. A case in point is the Dorper and Boer crossbreeding projects. There has been poor adoption of NGO-supported genetic improvement projects into sustainable breeding programs by the public sector.

2.6.3 Absence of rational strategy for utilization of indigenous and exotic genetic resources

There is a lack of a guiding framework for utilization of the identified indigenous genetic resources based on agro-ecological potentials and production systems specificity. As a result genetic improvement activities are currently initiated haphazardly. This has resulted in wastage of public investment and threatens the survival of the adapted resources. Secondly, there has been almost no organized selection programs to improve the local resources. On the other hand, there is no binding guide for crossbreeding activities using exotic breeds, which has resulted in irrational breeding activities and failures.

2.6.4 Inefficient genotype multiplication

Inefficient genotype multiplication is a major challenge hampering the effectiveness of breeding programs, particularly crossbreeding programs. Performance of cattle and sheep genotype multiplication centers is far below the demand and below expectations given the huge investment in the centers.

2.6.5 Limited public Investment in breeding expertise

Investment by the public sector is mainly in infrastructure and breeding materials (local and imported flocks). Very minimal investment in expertise has contributed to low efficiency and in some cases failure of breeding programs and absence of science-based genetic improvement practices (well-designed breeding programs). Current investment in man power by the public sector is shown in Table 13.

2.6.6 Absence of investment by the private sector

Almost all the investment in genetic improvement comes from the public sector. There is virtually no investment by the private commercial sector and very minimal by smallholders and pastoralists.

2.6.7 Limited application of modern biotechnology tools

Genetic improvement can be accelerated through application of modern technological interventions. Limited genomic and biotechnology research and development and lack of focus of research in these fields (Most of the research on genomics in Ethiopia on small ruminants used to deal with genetic resource characterization and evolutionary genetics) have contributed to the absence of these tools in small ruminant genotype multiplication and genetic improvement.

2.6.8 Monitoring and evaluation

Monitoring and evaluation is a mechanism to ensure proper implementation of a given project/program in accordance to prior plans and help to do amendments timely. Absence of clear direction in most research-based genetic improvement programs (flocks lying idle, dissemination strategy) and absence of M and E such programs resulting in continued expenditure without results.

There are several initiatives on genetic improvement for small ruminants initiated long ago and the recent direction and implementation of CBBP are among few. Genetic progress (the ultimate milestone of genetic improvement programs/projects) not monitored and reported for most selection programs/projects. Absence of pre-evaluation of genetic and bio-economic feasibility of breeding programs are some gap discovered.

2.7. BENCH MARKING

Ethiopian sheep and goat breeds are in general inferior to exotic breeds, including African breeds. Table 3 shows performance levels of Ethiopian and African sheep and goat breeds. The percentage inferiority of Ethiopian breeds ranges from 8.5 to 230%. This indicates the need for a huge genetic improvement need. However, lower performance levels are also associated with higher adaptation to the environment, and thus genetic improvement initiatives need to consider the potential of the production environment the breeds are located. Furthermore, access to inputs and profitable markets need to be considered. There are also traits which the local breeds are superior to the exotics (e.g. age at first kidding, Table 3) and such traits need to be conserved.

Table 3. Productivity potential of indigenous Ethiopian sheep and goats in comparison with bench marked countries

Sheep traits	Horro	Afar	BHS	Menz	Bonga	Arsi-Bale	Gumuz	Washera	Siemen	Begait	Adillo	Farta	Maximum in Ethiopia	Dorper (South Africa)	Difference	Difference in percent
Birth weight (kg)	2.9	2.5	2.7	2.2-2.5		2.8	2.79	2.7	3.04				3.04	3.5-4.5	0.96	46
Weaning age (days)	120			120									120	100	20	
Weaning weight (kg)	15	13	14.2	10.9									15	36	21	140
Six month weight (kg)	19.7	18.4	17.7													
Yearling weight (kg)	24	26	24.8	15.5-19.1	27.8			24.7	22.87			20.08				
Carcass weight (kg)	7.5		18.7										18.7			
Dressing percentage	37.8		46.1										46.1	50	3.9	8.5

Goat traits	Long eared Somali	Short eared Somali	Rift valley	Afar male	Arsi-Bale male	Central highland	Woito Guji	Abergelle	Maximum level achieved in Ethiopia	Boer goat from South Africa	Difference	Difference in percent
Birth weight (kg)	2.3		2	2.3	2.32			1.9	2.32	3-4	1.18	51
Weaning age (days)				90					90	100	10	
Weaning weight (kg)	6.89		6.32	8.3				6.84	8.30	20-25	14.2	171
Yearling weight (kg)	13.38	19.77	13.93	15.1	15.5			14.15	19.77	50-70	40.23	203
Age at 1 st kidding (months)		19.9			28.46		14.9	14.93	14.90	10.12	4.78	-32
Carcass weight (kg)	9.2			9.8	9.5	8.3	8.8					
Dressing percentage	43.7			39.5	45.4	42.5	45.2					
Daily gain (gram)								53	53	53	107	202

3. STRATEGIC INTERVENTIONS

3.1 INSTITUTIONAL INTERVENTIONS

3.1.1 Institutionalizing and coordinating breeding initiatives

Direction:

- Genetic improvement activities involving a breed of sheep or goat need to be coordinated across institutions in the national system (development, research and education institutions) as well as across the national system and international development partner institutions involved in the same or similar activities. The current institutional arrangement or rather lack of institutional arrangement in genetic improvement activities is described under section 2.
- Stand-alone genetic improvement initiatives as short-term projects should not be allowed, such initiatives need to be registered and be part of a breeding program of NAGII. Similar conditions should apply to ongoing projects.
- Institutional (re)structuring/arrangement for on-going and new breeding initiatives (activities, projects, programs)

Intervention action points:

- Identification of breeding initiatives (activities, projects, programs) major programs/projects
 - Identify initiatives under implementation by the national livestock research, education, development system, international development partners, and NGOs,
 - Identify duplication of efforts (different institutions working on same breed/location but independently)
 - Identify/analyse existing institutional coordination of the initiative
 - Stakeholder analysis
- Delegate roles and responsibilities to institutions that would contribute to identified projects/programs as per the structure of the NAGII

Proposed institutional coordination of breeding initiatives: Roles and responsibilities of institutions need to be coordinated by the NAGII as illustrated in the proclamation. The various institutions could be delegated to contribute in designing, implementing and monitoring and evaluating a particular program. Institutional intervention at grassroots level to overcome the challenges of scale and fragmentation of smallholder systems should also be considered. This would take the form of cooperative village breeding groups. A proposed coordination and roles and responsibilities of institutions is shown in Fig. 2 and described below:

- **MoA through NAGII:** Leadership, coordination, M&E
- **National sheep and goat centre:** Implementation wing of NAGII. Coordinate and support breeding programs across the country; centre of excellence in expertise and facilities
- **IBC:** Characterization, conservation and regulation (in collaboration)

- **LHA (Region to kebele level):** Implementation (multiplication and dissemination)
- **NGOs:** Implementation through LHA
- **NARS (EIAR, RARIs, Universities.):** research support, technical backstopping (design of programs, recording schemes,...), Nucleus breeding flocks, M&E
- **International Research Institutes:** research support, technical backstopping, Genomics & biotechnology support/studies,
- **Commercial studs (pure breeding) and multipliers (crossbreeding):** Communities

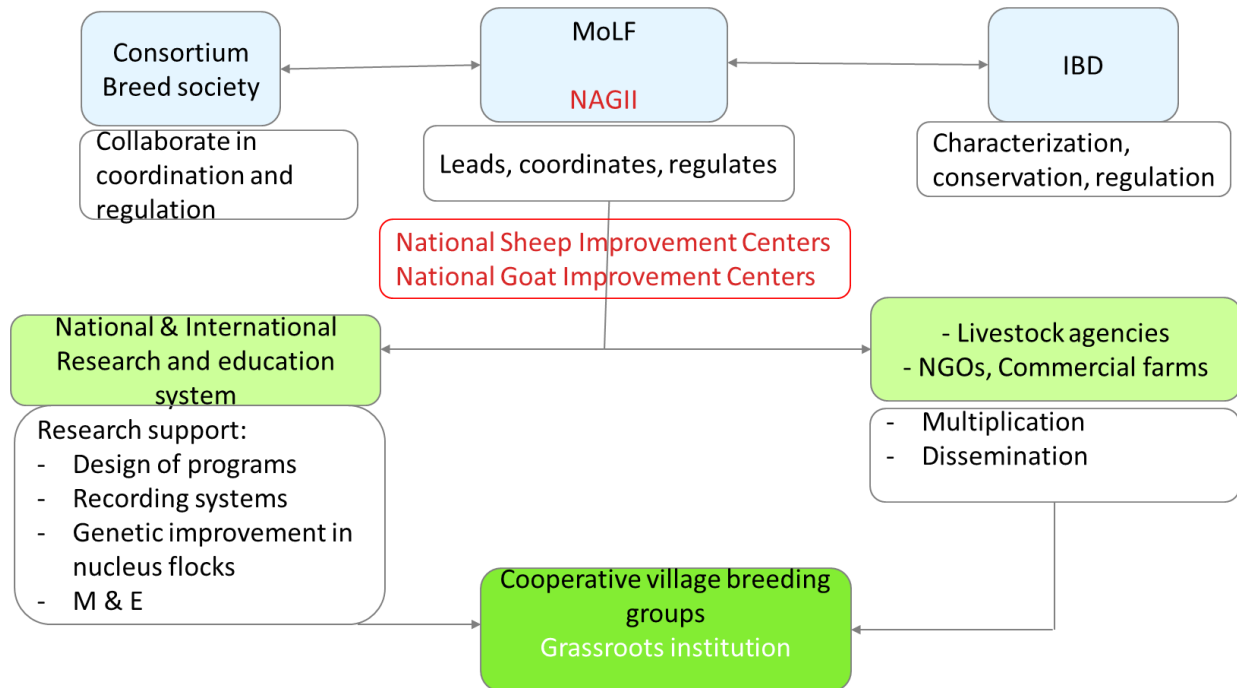


Figure 1. Coordination and roles and responsibilities of institutions in a breeding program.

3.1.2 Aligning research and development strategies

- EIAR 15-years small ruminant research strategy and this strategy need to be aligned.
- The research strategy need to address the roles and responsibilities assigned to it in this document.

3.2 GENETIC IMPROVEMENT INTERVENTIONS

3.2.1 Strategies for rational utilization of sheep and goat genetic resources

The strategy for conservation-based and sustainable utilization of the indigenous genetic resources is to develop suitability maps for genetic improvement options. The factors included in mapping would include the merits and demerits of breeds, agro-ecology, production system, and sheep and goat keepers' breeding objectives. Rationalizing genetic improvement would also consider different strategies for the domestic and export market

segments. While a detailed mapping would be developed in the future, the following could be proposed for genetic improvement options.

3.2.1.1 Genetic improvement of sheep breeds/breed groups

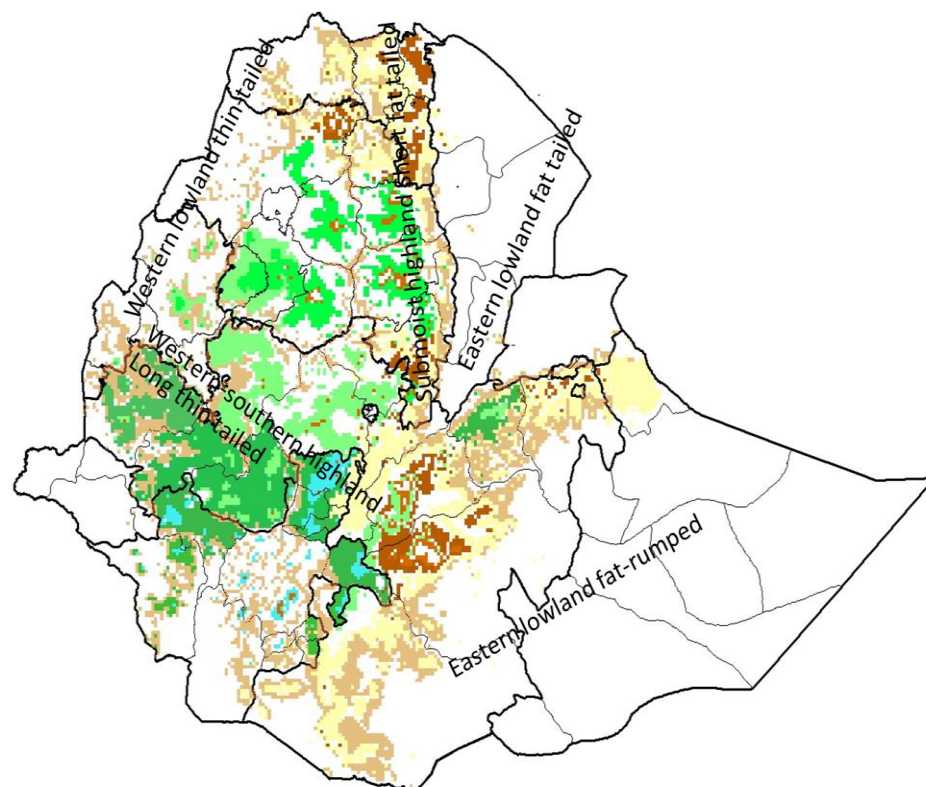


Figure 2. Approximate geographic and agro-ecological locations of breed groups

(i) Subalpine short fat tailed breed group

The sheep types in this category include Menz, Wollo, Farta, Sekota/Tigray Highland, and Semen sheep. This breed group is found in central & northern highlands. The agro-ecology includes subalpine and cold highlands. The area is marginal with little rain and degraded landscape. The sheep are small in size reared in relatively large flocks under extensive rearing system.

Selective breeding: The strategy to be adopted should be conservation of these adapted genetic resources with genetic improvement through selective breeding for growth rate (efficiency of growth). The strategy to prioritize targeting could include threat status, breed merits and contributions to genetic diversity of the different breed types of sheep in this category.

Crossbreeding: Crossbreeding of these sheep types with Awassi is a major improvement program in Amhara region. The suitability mapping is highly relevant to delineate geographic, agro-ecological, production system zones for crossbreeding. Crossbreeding should be in

higher potential areas with access to markets. An example of suitability map for delineation of crossbreeding zone based on agro-climatic and production system is provided in Fig. 4.

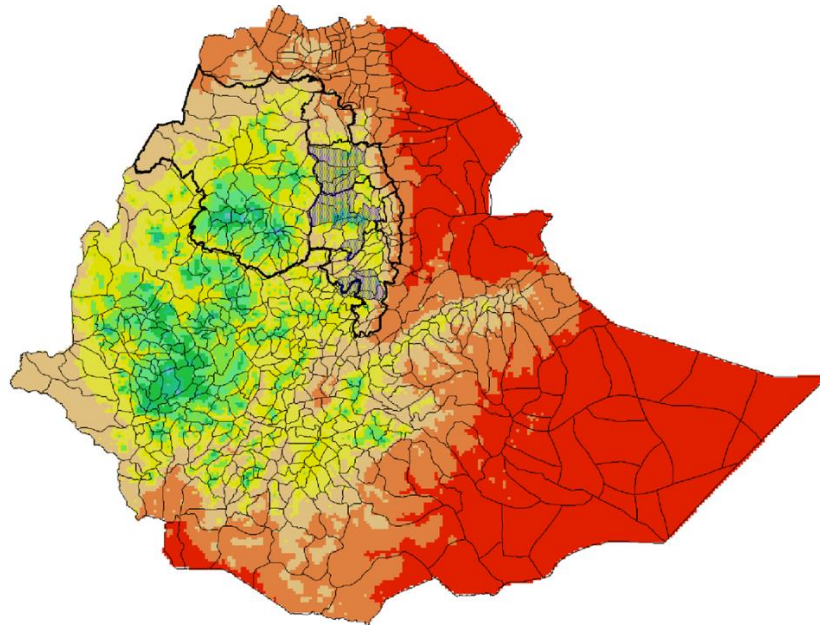


Figure 3. An example: Suitability map for crossbreeding of short fat-tailed sheep with Awassi mapped based on ratio of precipitation and evapotranspiration (Awassi-Belt: light-dark shaded districts).

(ii) Long fat tailed breed group

This includes Bonga, Horro, Arsi, and Washera breeds. They are located in the central and western (mid-) highlands. The area is high potential cropping area. The sheep are large in size and highly prolific.

Selective breeding: Selective breeding for growth and reproduction is the most appropriate strategy. Genomic tools to identify major prolificacy genes is recommended to accelerate genetic progress.

Crossbreeding: These breed resources are highly productive and thus can be used as terminal sire breeds for slaughter lamb production. However, a suitability map is required which would include access to market for finished terminal lambs. A terminal crossing system is recommended.

(iii) Fat rumped /tailed lowland breed group

This group includes, Afar, Black Head Somali, and Nuer sheep breeds. The sheep have medium-large body size. They are found in Eastern Ethiopia under (agro-) pastoral production system.

Selective breeding is most appropriate. Selection criteria would include traits of adaptation, growth and efficiency. Nuer sheep could be a valuable genetic resources for trypanosomiasis control and thus genomic studies to identify trypanotolerant genes are recommended.

(iv) Thin-tailed lowland breed group

Gumz, Begait and Rutana sheep belong to this group. They are large sheep, particularly Begait sheep are very large sheep. They are found in Western lowlands, reared under extensive system.

Selective breeding: Gumz sheep are threatened by crossbreeding with Rutana sheep. Conservation through increasing the breed's value to its keepers through selective breeding for growth is recommended. The selection program could target the Gumz community who are mostly keeping the pure Gumz sheep (flocks of most other communities are already mixed with Rutana blood).

Begait – Begait is a large sheep with high prolificacy. Based on its merit and the relatively less favourable environment, the strategy could be to maintain its adaptability and high performance through selective breeding for efficiency of growth, milk and adaptation traits.

Crossbreeding of Rutana and Begait: Rutana is widely reared by commercial farmers (also a mode of production for Begait) in large flocks. It can be used for improving the local sheep in the area for export market in the Sudan. The breed is not yet well used for local consumption. Both Rutana and Begait can be valuable sire breeds for crossbreeding in the lowland areas. However, research is required regarding the meat taste of Rutana for local consumption.

The proposed genetic improvement interventions are summarized in Table 4.

Table 4. Sheep genetic improvement

Agro-ecology	Production system	Breeds	Areas to be covered	Traits of focus	Suggested improvement schemes	New breeding programs
Arid and semi-arid areas	Pastoral/Agro-Pastoral	Afar and Black head Somali sheep	Afar, Somali region, Borena zone of Oromia, Omo zone of the south	Adaptability, Meat, milk	Central nucleus based selective breeding	Black head Somali sheep
Central and northern highlands	Mixed and Agro-pastoral	Short fat tailed sheep, Semien sheep	The Central and Northern regions of Amhara, Tigray region	Adaptability, meat and associated traits.	CBBP based selective breeding, cross breeding	
Western and North and south Western highlands	Perennial crop Mixed cereal/perennial crop livestock	Horro, Arsi, Bonga, Washera	All zones of Oromia excepting eastern Hararghe and Borena zones, Awi, east and west Gojjam zones of Amahara	Meat and associated trait, prolificacy	CBBP based selective breeding, central nucleus based selective breeding	Arsi sheep,
Western and north western lowlands	Agro-pastoral/ Commercial farming	Gumuz, Begait, Rutana, Fallata	Benishangul gumuz region, south western region of Tigray and western Amhara	Meat and associated traits, prolificacy/milk	CBBP based and Central nucleus based selective breeding, cross breeding between indigenous breeds	Gumuz crossing with Begait/Rutana/fallata,

3.2.1.2 Genetic improvement of goat breeds/breed groups

Compared to sheep the diversity in the goat genetic resources appears to be low and about 75% of the genetic diversity is contained in four (Afar, Keffa, Abergalle and Gumez) breeds (Tesfaye, 2004). More importance is attached to milk in goats than in sheep and past attempts to cross indigenous goats with exotic breeds have considered, in addition to meat related traits, milk production performance.

Arid and Semi-arid lowlands

Most of the goat breeds have good reproductive performance and adaptability to the marginal environments they are kept. As such selective breeding should be the first option for genetic improvement. Evaluation of the crossbreeding works in the past have shown that, under on farm condition, crossbreds were not found to be more profitable than the indigenous genotypes (Workneh, 2000) and adoption rate was also low (Teressa, 2004). This entails until significant research findings support the use of exotics in crossbreeding or as pure breeds, use of the indigenous genotypes should be the focus of genetic improvement. However, the available limited information with regard to the level of within breed variability indicates there is low level of within breed than between breed diversity (Addisu et al., 2002; Tesfaye, 2004). Research towards identifying appropriate exotic genotypes that can raise productivity under crossbreeding with the local or in pure form need to be generated to make informed decision. The pastoral areas where large flocks are common appear amenable for implementation of selective breeding. In designing the breeding programs the genotype by environment interactions need to be considered along with taking care of antagonistic relationship between genetic merit for production and adaptation.

Some transboundary breeds which were not covered in previous studies are believed to be unique in their size (relatively larger), reproductive performance (more prolific) and milk production (Begayit and Fallata goats). As such, in goats crossing between indigenous breeds may need consideration and research support in identifying nicking breeds is required.

In Arid and semi-arid areas (South Eastern, Eastern, North Eastern and central North Ethiopia) where Pastoral and agro-pastoral production is the dominant system the breeding objective should focus on adaptability, milk, meat and associated traits. Due to the mobility of the flock, and difficulty in record keeping and follow up, implementing CBBP would be very difficult. A central nucleus breeding scheme would be an option from which improved genetics can be delivered to producers (Pastoralists and Agro-Pastoralists). Participatory visual selection of animals in establishing the base population for the nucleus is important and adequate public funding is required under this condition.

Humid and sub-humid low and mid altitude areas

In the humid and sub-humid low and mid-altitude areas (Ben Shangul region, North and North Western Amhara and Western Tigray), where Agro-pastoral production is common the

breeding objective should focus on milk, meat and associated traits especially prolificacy. Under this system also a central nucleus breeding scheme to implement a selective breeding program would be required. For some of the breeds crossbreeding (with other indigenous or exotic breeds) may need consideration. However this need to be preceded by research work to identify the suitability of the crosses and the type and level of crossing.

High land areas

In the high land areas of Ethiopia (Central, Western and eastern highlands) where perennial crop and mixed crop-livestock system exists meat is the most common product and milk has no significant importance. As such the breeding objective focuses on improving size and number of animals to be produced per doe and revolve around growth, survival and reproduction. Community Based breeding program for selective breeding of the indigenous goats would be a prior option towards improving productivity. In addition to that crossbreeding with appropriate indigenous or exotic meat type breeds may need to be considered and the strong research work on identifying the right breed and type and level of crossing is required.

Remarks for sheep and goat genetic improvement strategy are the following:

- A suitability mapping of genetic improvement strategy needs to be developed based on detailed literature and field studies and stakeholder participation;
- Zonation of improvement through selective breeding and crossbreeding need to consider breeds, breeds potentials and limitations, agro-ecological suitability/potential, production system, geography/access to market; and
- New goat breeds for improving meat production through terminal crossing need to be sought out. Options would include local populations with potential for meat production (needs careful characterization) and exotic ones (e.g. breeds from Pakistan).

Table 5. Goat genetic improvement

Agro-ecology	Production system		Breeds	Areas to be covered		Traits of focus	Suggested improvement schemes		Breeds requiring New breeding program
Arid/Semi-arid low lands	Pastoral/Agro-Pastoral		Somali goats (including Borena), Afar goats, Abergelle, Konso (Woito-Guji)	South Eastern, Eastern, North Eastern, central-North		Adaptability, milk, meat and associated traits	Central nucleus based selective breeding		
Humid-sub-humid low and mid-altitude areas	Agro-pastoral, Mixed crop livestock		Gumz, Begait,	Benishshangul, north and north-Western Amhara, western Tigray		Milk, meat and associated traits (mainly prolificacy),	Central nucleus based selective breeding; crossing with milk type indigenous or exotic		Gumz goats crossed with Begait
Highland	perennial crop	Mixed crop livestock	Arsi Bale, Central highland, Kaffa, Hararghe highland, Western highland	Highland (Central, western, eastern)		Meat and associated traits (prolificacy)	CBBP, cross-breeding (terminal), Indigenous meat type and exotic		Central highland

3.2.2 Revamping and (re)structuring ongoing genetic improvement initiatives

3.2.2.1 Coordinating and transforming/scaling up community-based breeding activities/projects

Several community-based sheep and goat breeding activities are currently being implemented by different institutions and for a number of breeds. Most of these activities are research projects and their status is not up to expectation (See description in section 2.3). It is an urgent task to revamp and (re)structure these activities. The activities are listed in the table below.

Table 6. Different sheep and goat breeding activities being implemented by different institutions

Breed/population	Year started	Institutes involved
Afar, Bonga, Horro, Menz sheep	Since 2007	NARS, ICARDA, ILRI, BOKU
Bonga	Since 2012	SARI, ICARDA, ILRI
Horro	Since 2012	ARRI, OARI, ICARDA
Menz	Since 2012	ARRI, OARI, ICARDA
Menz	Since 2012	ARARI/DBARC
Atsibi, Doyogena	Since 2012	SARI, TARI, ICARDA
Washera	Since 2016	ARARI, EIAR
Central highland goats	Since 2012	ARARI, ICARDA
Woito-Gudgi, central highland (Ambo). Abergelle goats	2011-2014	ARARI, SARI, TARI, OARI, ILRI
Abergelle goat	Since 2015	ARARI, TARI, ICARDA
Bensa (Sidama), Merab-Abaya (Gomo-Gofa) gaots	Since 2015	SARI, ILRI/LIVES
Abera, Gumer sheep	Since 2012	SARI
Dauro sheep	Since 2017	SARI
Central highland goat	Since 2017	ARARI, EIAR
Black head Somali sheep	Since 2017	Somali regional state, EIAR
Borana Goat	Since 2017	OARI, ICARDA
Some breeds		IBC

Strategic Actions

- (i) Identify breeding initiatives currently ongoing and review of ongoing projects by different institutions and produce document with institutional and technical recommendations.
- (ii) The evaluation of activities would include the status of breeding activities, design of breeding scheme, and Genetic progress achieved.
- (iii) Revise institutional arrangements and roles and responsibilities of organizations working in similar breeds/regions.
- (iv) Transform projects limited to few villages into breed-level breeding programs for selected breeds
- (v) Develop implementation plan (budget, additional staffing, and physical resource)
- (vi) Research support:

- Develop design for scaled-up breed-level program using appropriate tools (e.g. ZPLAN; an example design is presented in Gizaw et al., 2013).
- Research on genetic selection (based on breeding values) and index selection in village flocks.

3.2.2.2 Transforming central nucleus breeding research projects into development programs

A similar review as for the community-based breeding activities (Section 4.2.2.1) need to be conducted on flocks (mostly lying idle) and forward recommendations on the way forward. The core strategy is to transform these activities into development programs.

Table 7. Status of different sheep and goat breeding activities being implemented by flock size and location

Breed	Flock size		location	Status
	Female	Male		
Abergelle goat crossbreeding (Begait X Abergelle doe)	82	40	Tankua Abergelle	
Abergelle goat pure breeding	275	25	Sekota	?
Afar sheep pure breeding			Afar	?
Arsi-Bale goat pure breeding			Adamitulu	?
Awassi crossbreeding			Amed guya, Debre birhan	? v
Begait sheep pure breeding			Humera Ranch	??
Begait sheep/goat pure breeding			Humera RC	??
Boer goat crossbreeding	70	40	DBARC/Ataye	v
Boer goat crossbreeding	50	3	Sirinka	v
Boer goat crossbreeding	140	46	Jinka research	v
Dorper cross breeding			Sirinka research	v
Dorper cross breeding			Fafem/Jijiga	
Dorper cross breeding			Sirinka research	v
Dorper sheep crossbreeding	227	55	Debre-Birhan	v
Dorper sheep pure breeding	320	48	Debre-Birhan	v
Dorper sheep pure breeding			Areka	??????
Gumuz sheep pure breeding				?????
Horro sheep pure breeding	250	27	Bako	???
Menz sheep pure breeding	460	51	Debre-Birhan	v
Woito-Guji pure breeding	82+70	23	Arbaminch research	?

Action points

- Identification of nucleus flocks of indigenous breeds in research, multiplication centers, universities
- Identification of nucleus flocks of crossbred, exotic breeds in research, multiplication centers, universities
- Evaluation of the status of activities with the flocks (progress, future plan, ...)
- Evaluate facilities (breeding pens, flocks, experts, ...)
- Evaluation document to be prepared. The document would outline the status, future plan for the resources, and implementation plan.
- Develop similar activities into breeding programs if evaluation is positive. Otherwise close, breeding activities should not continue as research per se except in especial cases such as evaluation of new breeds

3.2.2.3 Evaluation, documentation and structuring of ad hoc crossbreeding activities

A number of unplanned crossbreeding activities are underway in Ethiopia. The Rutana x Gumz sheep crossbreeding is a major activity in western lowlands and threatening the survival of Gumz sheep. On the other hand, Rutana is now a major 'Ethiopian' breed in terms of number and contribution. Similar activities include Felata goat, Bonga sheep, Washera sheep and Begait sheep and goat crossbreeding activities, mostly initiated by communities and some by development agents. These activities do not have plans and are not documented. A review and recommendation is required.

Action points

- Identify activities for the following ad hoc crossbreeding initiatives:
 - Rutana crossbreeding
 - Felata crossbreeding/pure breeding?
 - Bonga crossbreeding
 - Washera crossbreeding
- Review of the activities (rationality of activities and conservation issues):
- Recommendation on the way forward, and plan to implement recommendation; and
- Formalizing into programs of activities/initiatives deemed appropriate.

3.2.2.4 Reinitiating the planned National Dorper breeding program

The Dorper crossbreeding program was initiated as a national program by ESGPIP. Unfortunately, the program is now in disarray since the program was discontinued prematurely, a good example of failure of breeding initiatives by non-governmental institutions. Currently, a large resource of the pure Dorper sheep are available in the country, but some are in danger.

Action points

- (i) Review, update and adopt available Dorper sheep crossbreeding strategy and program documents. A national Dorper breeding strategy and program is available. Additional strategy/program framework is provided in "Dorper Valley" project (See ARARI research document);
- (ii) Assessment of the breed resources and the respective facilities;
- (iii) Stakeholder analysis for developing the national breeding program;
- (iv) Institutional coordination and restructuring of the various centres; and
- (v) Review ESGPIP exit strategy document and implement.

3.2.3 Proposed new breeding programs

The indigenous sheep resources of the country have been categorized into nine breeds. These include Short fat tailed, Horro, Bonga, Gumz, Arsi, Semien, BHS, Afar, Washera sheep. In addition to these new breeds such as Rutana and Begait have been identified in areas which were not covered by previous studies and are believed to have unique adaptive, productive and reproductive performance.

The indigenous goat resources of the country have been categorized into eight breeds. These include Arsi-Bale, Somali goats, Gumez, Keffa, Woyto-Guji, Abergalle, Afar and highland goats. Begait, and Falatta goats have been a recent additions to the breed list and these two breeds are believed to have merit in terms of adaptability, production and reproduction and may need to be considered for crossing with other indigenous goat breeds in similar agro-ecologies.

Because of limitation of resources towards conservation and improvement of indigenous breeds there is a need to prioritize. Methods of prioritization focusing on conservation has been forwarded by a number of researchers (Weitzman, 1992; Ruane, 2000; Eding and Meuissen, 2001) and has been applied by number of other researchers (e.g Gizaw, 2008). However, prioritization for improvement may need a different approach. A proposed prioritization criteria is presented in section 5.

Existing breeding programs are limited in magnitude and coverage of breed, agro-ecology and production system. Therefore in addition to revamping the existing ones there is need for new breeding programs.

Due to lack of adequate information on all breeds for the parameters to be used in prioritization, expert knowledge has been used to set priorities in this small ruminant strategy document. This can be improved by gathering the required information and revisiting the prioritization.

3.2.3.1 Proposed new programs for sheep

Arid and Semi-arid lowland areas - Black head Somali sheep

The BHS sheep are kept to generate income to large extent and for meat and milk use to a lesser extent. Productivity in terms of growth and Milk is limited. For Black Head Sheep Helen (2015) reported age at first lambing of 13.78 and 14.71, kidding interval of 8.81 and 10.22, marketing age of 6.4 and 6.89 and average milk yield of 0.91 and 0.86. Despite the importance of the small ruminant resources in these areas to the livelihood of producers and the nation and the large population size, except some on station characterization and crossbreeding efforts, no sustainable breeding program has been implemented on this breed. As such breeding program for the breed need to be a priority. Due to the common practice of selling male animals at about the age of 7 months it is conceivable that negative selection can happen. But this can create an opportunity to gather phenotypically superior males for further genetic evaluation at a central nucleus. Therefore a central nucleus scheme of a meaningful size is proposed. Methodological, Institutional, infrastructural and other capacity aspects need to be worked out. In developing the breeding programs the approaches and methods described in section 5 need to be considered

Western and north and south western highland - Arsi sheep

Despite the huge population size (more than 6 million) of the breed and the significant contribution to the local market no improvement program was implemented on Arsi sheep. Meat is the major product and increasing income from the sale of sheep through increasing the size of sheep is an important area to be addressed. As such new community based and central nucleus based breeding programs are suggested. Action points indicated for BHS also apply here.

Western and North western lowlands - Gumuz Sheep

The Gumuz sheep is one of the genetically unique sheep breeds of the country (Solomon, 2008). It is adapted to humid and sub- areas of Western Ethiopia. There is extensive dilution of the breed from other breeds in adjacent areas. Though controlled cross-breeding of the breed with other sheep breeds adapted to similar agro-ecology can be beneficial through increasing the growth, milk and reproductive performance of the sheep the uncontrolled breeding can result in the loss of the genetic diversity the breed represents. As such a controlled cross-breeding program is suggested to be initiated as a new program. In addition to action points listed under the BHS research activity need to be undertaken to evaluate the crossbred performance, identify the optimal type and level of crossing.

3.2.3.2 Proposed new programs for goats

Humid and Sub-Humid - Gumuz goat

The Gumuz goat is also one of the goat breeds with significant contribution to the goat genetic diversity in the country (Tesfaye, 2004). Apart from that its contribution to the livelihood of the producers (indigenous community) in the form of nutrition (milk and meat) and income is high. There is potential to increase the goat production system as the region is sparsely populated and feed resources are abundant. Other breed of goat, Begait, is found in a similar agro-ecology adjacent to the breeding tract of Gumuz goats. Begait has larger size and more milk production potential. A new cross breeding program is proposed between Gumuz and Begait sheep. In a similar manner to the Gumuz sheep, research work on the feasibility of the crossing and the type and level of crossbred to be used need to be determined before a full scale implementation is rolled out.

Highlands – Central highland goats

The central highland goats are among the goat breeds contributing to the domestic demand. New consumer demand is growing in the area of consumption of raw goat meat, a tradition which was not common before. That is creating a new niche market for goat producers. Due to the relatively large frame size of central highland goat breed it could be one of the breeds to meet the demand from the new market. Besides the breed has relatively higher prolificacy (Netsanet, 2015). However the breed appears lacking muscle on the thigh part of the body, a part which yields sizeable portion of deboned meat. A new breeding program is proposed

to improve the breed by selective breeding (if there is adequate within breed variability in the thigh fill) or through crossing with other breeds. Significant amount of research information need to be generated in relation to the existing variability, the right exotic breed to be used and the type and level of crossbreeding before embarking either of the breeding programs.

3.3 STRATEGIES FOR ACCELERATING DELIVERY/MULTIPLICATION OF IMPROVED GENETICS

3.3.1 Accelerating delivery of improved local genetics

3.3.1.1 Estrus synchronization

Action points

- Use of estrus synchronization in community breeding programs, open nucleus breeding schemes and smallholder cooperative breeding groups.
- Using AI in crossbreeding programs. This needs to develop AI method and AI scheme appropriate for small ruminants. It also requires building expertise and AI (reproductive technology labs in national centers and mini-labs where appropriate.

Research support:

- Investigation and validation of different estrus synchronization protocols for sheep and goat that can be technically and financially affordable by major producers.
- Looking for a feasible tool for artificial insemination in small ruminants especially in sheep.

3.3.1.2 PPP model for commercialization of genotype multiplication - Commercial stud breeders

- Transferring the role of genetic improvement of indigenous breeds through selection to the private sector.
- Opportunity to reinstate central nucleus breeding scheme which has failed in the public sector but is more efficient genetically than village-based schemes
- Appropriate to Begait sheep/goat. - Public sector support to other areas is required. Is it in the breeding policy?
- Develop selective breeding and dissemination scheme. A PhD research on Begait goat is underway, could be adopted.

3.3.1.3 PPP model for small businesses multiplying improved local genetics

The public sector is the sole institution for genetic improvement programs. While it is appropriate for the public sector to involve and subsidize genetic improvement as public good/service, involvement of the private sector is important to support the public sector and also as an opportunity for private businesses. One such opportunity would be improved genetics delivery small businesses. This would create job opportunity for jobless graduate youth. Breeding programs could thus be designed to involve the small businesses. A detailed description of such a design including the business models for small businesses is provided for sheep and goat selective and crossbreeding programs in Ethiopia (FAO, 2018).

Action points

- A breeding program document incorporating business models in breeding programs is provided in ANNEX IV (attached a separate file).
- Review the design as appropriate and adapt for other breeds/programs as necessary.

3.3.2 Accelerating delivery of exotic genetics

3.3.2.1 Genotype multiplication through efficient crossbreeding design

Efficiency of crossbred ram and buck multiplication in the public genotype multiplication centers is very low. The factors for the low efficiency are both the crossing scheme followed to produce crossbred rams/bucks and flock management at the centers. The crossing scheme to produce 75% crossbred rams/bucks (the strategy adopted officially) involves repeated back-crossings which results in very few rams/bucks multiplied per year. The strategy would be:

- 50% ram/buck distribution instead of 75% crosses only.
- Synthetic breeds/inter se mating population formation (new breed).
- Research support required to design crossbreeding scheme and synthetic breed development.
- Reduce disease (medi visna): Regional labs responsibility for epidemiological surveillance and monitoring.

3.3.2.2 Use of biotechnology tools

(i) Estrus synchronization and Artificial Insemination (AI)

Action points

- Use of estrus synchronization in community breeding programs, open nucleus breeding schemes and smallholder cooperative breeding groups
- Using AI in crossbreeding programs. This needs to develop AI method and AI scheme appropriate for small ruminants. It also requires building expertise and AI (reproductive technology labs in national centers and mini-labs where appropriate

Research support

- Investigation and validation of different estrus synchronization protocols for sheep and goat that can be technically and financially affordable by major producers.
- Looking for a feasible tool for artificial insemination in small ruminants especially in Sheep

(ii) Embryo production and transfer

Multiple ovulation and embryo transfer (MOET): This model has been extensively used to multiply genetically superior goats and sheep and many protocols have been developed to optimize its application in research as well as in commercial practice (Bartlewski, et. al., 2008; Perera et. al., 2008; Gonzalez-Bulnes et. al., 2004). Using this method, a female is hormonally stimulated to have multiple ovulations (superovulation). This technology involves, injection of progesterone and FSH and letting the animal to mate naturally or inseminated artificially. Then excellent embryos will be transferred into synchronized recipient ewes or does.

Therefore, when we need to utilize the genetic merit of dams this model is feasible. This model is applicable in all breeding schemes.

Action points

- Use of multiple ovulation and embryo transfer procedures in all breeding schemes at ranches, nucleus sites and specialized ranches.

(iii) Introduction of genomic tools in breeding programs

Action points

- Establishment of reference flocks for identifying causal variants for genomic selection
 - Identify one breed of sheep and goat each in each region (group work).
 - Collaboration between CGIAR, EIAR, RARIs. Develop a project for CGIAR support.
 - The focus could be identification of genomic regions for discrete traits such as multiple births.

3.3.2.3 PPP model for commercialization of Crossbred ram/buck multiplication

- Emerging commercial large scale crossbreeding farms, but very few, could supplement the severe crossbred ram shortage.
- One farm (Azerber sheep farm) is designed to produce crossbred rams and synthetic breed; could be a model.
- Public sector support is required.

3.3.2.4 PPP model for small businesses multiplying crossbred rams/bucks

The public sector is the sole institution for genetic improvement programs. While it is appropriate for the public sector to involve and subsidize genetic improvement as public good/service, involvement of the private sector is important to support the public sector and also as an opportunity for private businesses. One such opportunity would be improved genetics delivery small businesses. This would create job opportunity for jobless graduate youth. Breeding programs could thus be designed to involve the small businesses. A detailed description of such a design including the business models for small businesses is provided for sheep and goat selective and crossbreeding programs in Ethiopia (FAO, 2018).

Action points

- A breeding program document incorporating business models in breeding programs is provided in ANNEX IV (attached a separate file).
- Review the design as appropriate and adapt for other breeds/programs as necessary

3.4 CONSERVATION OF INDIGENOUS GENETIC RESOURCES

3.4.1 CONSERVATION-BASED BREEDING STRATEGY

Mapping breed resources, their production environment and systems and characterization of their merits and demerits is required to conserve the resources while improving their merits. Breeding program designs (both selection and crossbreeding) also need to consider alternative designs that promote conservation.

3.4.2 CLASSIFICATION, STANDARDIZATION OF NOMENCLATURE AND DOCUMENTATION

Classification and nomenclature of the sheep and goat genetic resources is currently in disarray. MSc and PhD theses and other documents take the liberty of identifying and naming breeds, including designating populations of a district as a distinct breed. Classification and nomenclature is important for organizing genetic resources into management units for improvement and conservation and thus need to be standardized and authorized.

IBC should be the authority for characterization, nomenclature and documentation. IBC is mandated to this activity, but its authority need to be strengthened and need to spearhead the task to correct the current misleading classification and nomenclature. For this it needs to collaborate with the national and international research system and universities. MSc and PhD studies on animal genetic resources characterization need to be coordinated with the IBC efforts. IBC need to develop plan for characterization and share with the above institutions. Appropriate nomenclature is useful for prioritization of breeds for conservation and improvement.

3.5 CAPACITY DEVELOPMENT AND INVESTMENT

3.5.1 NATIONAL SHEEP AND GOAT IMPROVEMENT CENTERS

Currently, sheep and goat breed improvement research and development is fragmented across regional states and within states across research and development centers, which are at times competitive rather than complementary. This has been a challenge for efficient utilization of scarce resources, mainly expertise, resulting in most initiative being run without scientific principles and methods of genetic improvement.

The centers will be the implementation wings of NAGII. The centres will have a critical mass of scientists. Their role will be to guide and/or develop the design and genetic evaluation of ongoing and new sheep and goat breeding programs in the country. These centres will function as both research and development centres. The national database will be established in these centers. The national sheep and goat improvement centres will have satellite centres as needed, representing production systems, breeds, and agro-ecological zones.

Action points

- (i) **Establishment of national centres:** One centre of excellence for each of sheep and goat in each of the two major production systems (pastoral and mixed crop livestock systems) can be

established at national level. The criteria to select locations will be developed by a team of experts.

- (ii) **Capacity building of the centres:** the centres will host critical facilities for research and application of molecular genetics and reproductive technologies in small ruminant breeding. The centers will be staffed high calibre scientists in good number.
- (iii) **Map the structure of coordination** between the national canter and satellite canter which represent the major breeds, agro-ecologies and production systems.
- (iv) The centres shall host the national database system.

3.5.2 LABORATORY FACILITIES AND EQUIPMENT

Molecular and reproductive technology labs (especially to support oestrus synchronization and AI activities) in national centres are required. Two advanced labs are proposed, one for each of sheep and goat national centres.

3.5.3 DATABASE SYSTEM

A database system for each breeding program is to be organized. The central database could be located at the national sheep and goat centres and/or at NAGII.

3.5.4 POOLING BREEDING RESOURCES

Breeding programs are resource-intensive. Large flocks and large data set are required to develop effective breeding programs. Efficient utilization of breeding resources is needed. Currently, sheep/goat breeding resources (flocks, facilities and expertise) for the same breeds are located in different institutions. Begait goat, cattle in research and multiplication centres, Menz sheep and Awassi sheep in research and multiplication centres are cases in point. These resources need to be utilized for both research and multiplication of the breeds. The current distinction in breeding and research with separate centres is not both technically and resource-wise feasible. Breeding research is not like other agricultural disciplines where technologies are generated transferred to the extension system for dissemination. Breeding research involves huge investment, requires large flocks which are available in development/multiplication centres, is a long term venture and research flocks (e.g. genetically improved flocks) cannot be abandoned after the research phase is completed but should be continued, only the balance of research and development components of a program will shift. Research and development need to be considered as a continuum of one activity.

Institutional coordination/leadership addresses such inefficient utilization of the scarce breeding resources and this will be the duty of NAGII. Means to pool breeding resources across institutions need to be devised.

3.5.5 NUCLEUS CENTRES

New breeding programs proposed in this strategy require investment. Existing nucleus centres under research centres (if accepted to continue and developed into breeding programs) need to be strengthened.

3.5.6 HUMAN RESOURCE/EXPERTISE DEVELOPMENT

The gaps/strategic issues identified in capacity in Section 2 need to be addressed. The following are key intervention areas:

- Assigning technically relevant/appropriate experts to run breeding programs, including managerial/directorate levels;
- NAGII needs to be staffed with capable experts that could lead the national programs technically;
- Establish and capacitate national centres of excellence staffed with a critical mass of expertise;
- Formation of advisory technical team comprising of national and international professionals (this will advise NAGII and national centres); and
- Training program to be develop to staff for the national centres and NAGII.

3.5.7 INVESTMENT PLAN

The terms are defined as follows: short term 2018-2020, medium term 2021-2025, long term 2026-2030. Investment fund raising is required. The fund for the short term could be availed from the World Bank MoLF project (in pipe line) which includes breeding components, specifically breeding components for small ruminants.

Table 8. Investment plan for the implementation of the small ruminant breeding strategy (costs need to be estimated)

Breeding strategy interventions	Short term cost	Medium term cost	Long term cost
Revamping genetic improvement initiatives			
1. Scaling up Menz sheep cooperative village breeding program	√		
2. Accelerated Bonga sheep breeding program (AI and estrus synchronization)	√		
3. National Dorper crossbreeding program	√		
4. Awassi sheep crossbreeding program			
New breeding programs			
5. BHS sheep selection program		√	
6. Washera sheep selection program		√	
7. Begait sheep and goat selection program		√	
National sheep improvement center		√	
National goat improvement center		√	
Molecular genetics facility		√	√
Reproductive technology facility		√	
Advanced reproductive technology facilities (labs) in North, west, South, East and central regions (one per region)			√
Training of PhD breeders for (NAGII and national centers)	√	√	
Trainings of MSc breeders (for satellite breeding centers)	√	√	
Establishing database systems (1 for each Nat'l center + NAGII)	√		
Review of ongoing breeding initiatives	√		

4. STRATEGIES FOR DESIGNING AND IMPLEMENTING BREEDING PROGRAMS

The objective of this section is to provide technical/operational guide for the implementation of the strategy. The strategy core elements are institutionalization (which is clearly provided in the strategy document) of breeding initiatives and design and implementation of breeding program. Breeding programs are the main activities to translate the strategy into action. A scientific breeding program design is outlined. A template breeding program is appended to this strategy document. The steps outlined here for designing breeding programs doesn't strictly follow the conventional procedure but more of the practical aspects considering the Ethiopian conditions.

4.1 DESIGN OPTIONS FOR SELECTION PROGRAMS

4.1.1 PRIORITIZATION OF BREEDS

Prioritization of breeds is required since resources are limited and breeding programs cannot be developed for all breeds. The prioritization could be at national or regional level. Prioritization will be based on different aspects: the preferences of the communities keeping the breeds, the merits and demerits of the breeds, the production environment, the significance of the breeds at national and community level. Consultation on the breed literature and stakeholders workshops are required for

the prioritization. Time frame for the implementation of breeding programs will be prepared. The percentage of each criteria's that we consider in prioritization of each breed shall be decided with multi-stakeholders consultation. However, the proposed criteria for prioritization are listed below.

- Population size (10%)
- Genetic uniqueness and attributes of the breed (15%)
- Contribution to livelihood (income and nutrition) of producers (25%)
- Contribution to export trade (25%)
- Contribution to local supply (25%)

4.1.2 DESIGNING BREEDING PROGRAMS

Approach: There has been quite a tremendous effort in research on designing breeding programs for small ruminants. The designing process should therefore rely heavily on desk research than field work. However, a key element is that it should be participatory and need to get approval from the different stakeholders including and mainly the livestock keepers.

4.1.2.1 Definition of breeding goal

Breeding programs need to be designed to address both the objectives of the breed keepers and the national strategy including the market requirements. Definition of breeding objectives include identification of traits and their economic values. Economic values can be estimated through participatory consultation of livestock keepers and end markets. This approach is suitable for community-based programs where selection programs on scientific index selection based on breeding values may not be feasible. For central nucleus programs, bio-economic models (in combination with participatory approach could be adopted to define breeding goals. Traits with higher economic values are considered the breeding goal traits.

4.1.2.2 Relative economic weights of traits

For formulating selection indexes economic weights of breeding-objective traits are required. Relative weights can be derived using participatory approaches by asking farmers to allocate pebbles or seeds to the traits according to their preferences for traits. However, this method provides only relative weights, not relative economic weights. Thus, use of Bio-economic models to derive relative economic weights is paramount important. Bio-economic models can be constructed on Microsoft Excel spread sheets to derive economic values of traits, considering both tangible (direct regular cash income from sale of surplus lambs, finished lambs, culled animals, manure and skin) and intangible benefits (insurance and financing benefits) of rearing Menz sheep.

- A bio-economic Excel Tool can be found at ResearchGate website. Another tool, less suited for smallholder systems is ECOWEIGHT.

4.1.2.3 Design of breeding schemes

The breeding structure need to be defined based on sound breeding principles. There is now enough research output on design of schemes for small ruminants. A key consideration here, which is missed out in most projects, is the scale of the program. The design need to address a significant proportion of the breed population. The scheme to be designed need to address the population targeted. That is the genetic gain generated need to be able to be disseminated to the whole population. Two main

types of schemes/breeding structures can be considered, but there are different variations of each scheme:

Community-based breeding scheme: This could be a one-tier scheme where villagers organize and implement selective breeding to improve their own flocks. However, when designing village programs at scale addressing a large proportion of the breed population, a two tier village program need to designed. This involves establishing cooperative breeding villages strategically across the breeding tract. These will be where genetic gain is generated, which will be disseminated to the rest of the flocks. The strategy for opting a breeding scheme/structure would depend on the need for accelerating genetic progress and the need for conserving the adapted resources. Breeding structures for genetic improvement of sheep and goat resources through selective breeding do not exist in Ethiopia. Village- (community-) based selection schemes have added advantage of conservation of local breeds through community-based management of genetic resources. Village-based schemes are currently more popular and seem more feasible with several advantages over central nucleus schemes, and thus may be adopted for several situation. However, the genetic progress achieved is slower than the central nucleus scheme (See Gizaw et al., 2013). A number of studies have been conducted and the design for village-based schemes have been improving which makes the scheme attractive.

Central nucleus scheme/structure: this involves establishing a nucleus flock at government ranch or a private commercial farm. Selection is conducted in this flock and genetic gain is disseminated to village flocks through rams/bucks or through AI. The central nucleus scheme has not been tested well, except as research initiatives which lacked vision and improved genotypes have not been disseminated to the village communities. Research on alternative design of village and central nucleus breeding schemes has been underway recently and information on feasibility of alternative schemes is available. Choice of schemes for designing new breeding programs should depend on information generated from previous research as well as bio-economic and operational feasibility studies specific to each situation. Central-Nucleus based schemes could complement to accelerate progress of village programs and could be linked to village-based scheme to jumpstart and accelerate genetic progress. It is also applicable where large scale commercial farms exist. For instance, Begait goat improvement scheme was designed based on commercial goat farms as central nuclei (See PhD thesis by Hagos, 2018).

4.1.2.4 Pre-evaluation of breeding schemes

The breeding program need to be evaluated before implementation for its genetic and economic feasibility using appropriate tools such as ZPLAN. The selection of schemes would be based on their return to investment and operational feasibility and other criteria such as the need for conservation (for instance community-based breeding programs are suitable for in situ conservation strategy).

4.1.3 ORGANIZATION AND OPERATION OF BREEDING PROGRAMS

4.1.3.1 Recording scheme and database system

A recording scheme is designed based on the type of breeding scheme chosen. Intensive recording is required in the tier where selection is conducted and genetic gain is generated. For community-based programs, this is mainly in the dispersed village nuclei. If the central nucleus scheme, recording is restricted in the central nucleus flock, but minimal recording is also necessary if the design links the central nucleus with the village nuclei. A database system is established for each breeding program.

4.1.3.2 Institutional arrangements

See Section 5.

4.1.3.3 Other organizational considerations

- The geography of the breeding program need to be delineated. The geographic description includes the districts, kebeles, the sheep/goat population, the number of participants need to be recorded.
- Awareness creation is required among the communities and other stakeholders in the program.
- Consultative meetings with communities and stakeholders, a fully participatory approach throughout the period of the program need to be followed.
- Training of communities and experts on animal breeding principles and methods.
- Selection of villages and organization of cooperative breeding groups is required for community-based programs.

4.1.3.4 Annual breeding plan

Both the life of program plan and annual breeding plan need to be developed. However, the detailed plan will be for the annual planning. This may include annual budgeting, selection, breeding activities (selection activities and mating activities), establishment of cooperative villages, number of improved rams/bucks generated; and dissemination range within the program boundary each year.

4.1.3.5 Monitoring and evaluation

The annual plan and the life-of-program plan is detailed in a logical framework. A monitoring and evaluation plan is set and strictly followed. A key component of the M and E is genetic progress achieved (genetic gain) and the expansion of the scope of the program (dissemination improved genetics to communities).

4.2 DESIGN OPTIONS FOR CROSSBREEDING PROGRAMS

(i) ***Terminal crossing scheme:*** This is a more urgent need. The strategy has to address indiscriminate crossing out of the adapted local breeds. Alternative crossbreeding designs have been suggested (Gizaw et al., EJAP). The designs would accelerate genetic improvement, easily applied under smallholders uncontrolled mating systems, achieve and maintain desired exotic blood level are reducing indiscriminate crossbreeding. Terminal crossing would be a primary choice to minimize indiscriminate crossing, conserve the adapted local breeds, and overcome the complication associated with upgrading method. Terminal crossing needs to be planned in selected systems, such as market-oriented system localized in areas with access to inputs and services and markets. Delineating the terminal crossing zone would avoid indiscriminate crossing and leave the local breeds breeding tract for the production of replacement females needed by the terminal crossing zone, which do not produce their own replacement females. A conservation-based crossbreeding has also been designed for Dorper crossbreeding program which delineates crossbreeding zone as “Dorper valley” (See ARARI research documentation and ESGPIP Dorper project exit strategy). These would be followed as cases for designing new crossbreeding programs. A sample terminal crossing system is shown in Fig. 5.

(ii) **Synthetic breed development:** A self-replacing synthetic population developed from crossbred population is a choice for situations where crossbred populations are to be maintained (unlike terminal crossing) since it avoids the complication involved in other crossbreeding schemes. The scheme also accelerate multiplication of crossbred genotypes in multiplication centers.

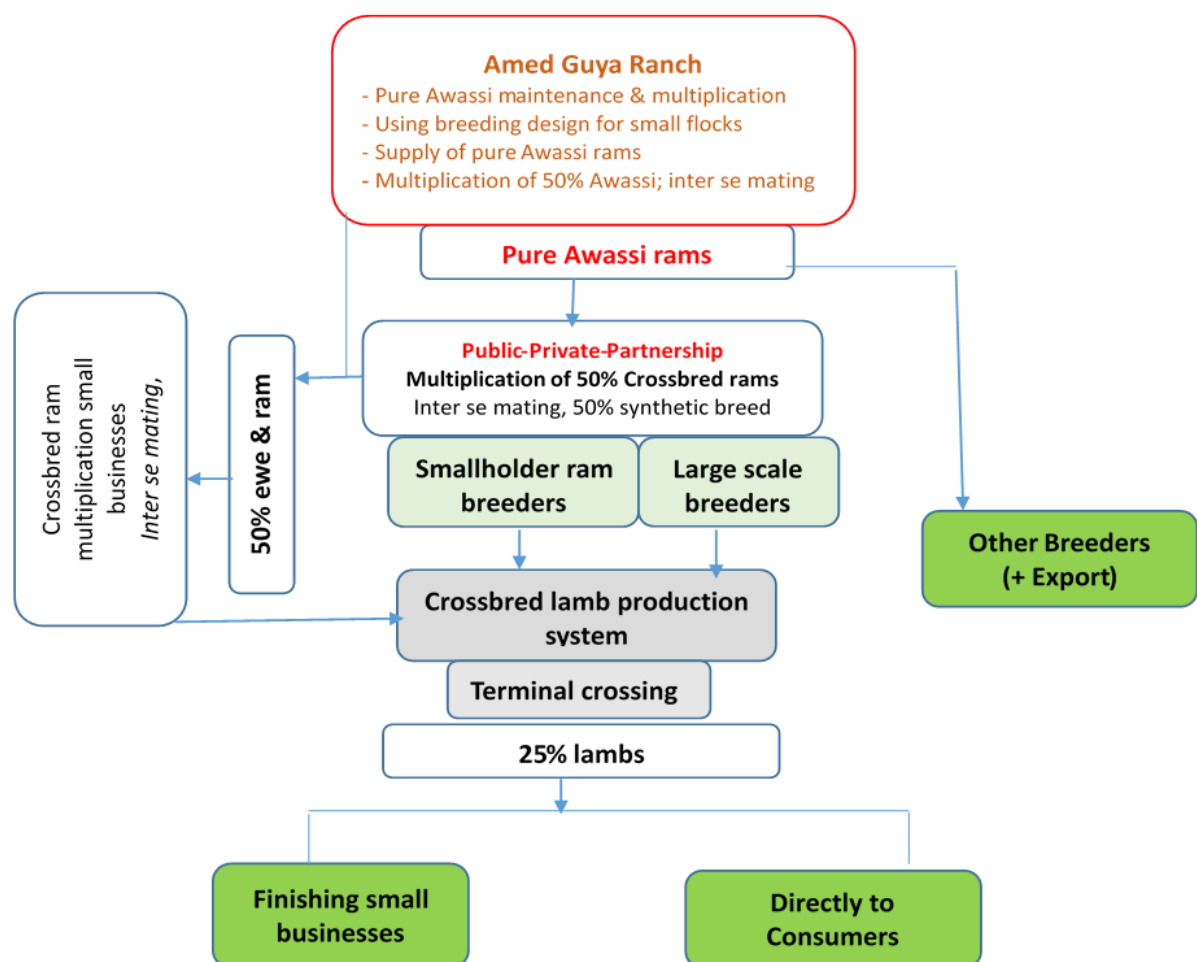


Figure 4. A sample terminal crossing system

5. ROLES AND RESPONSIBILITIES OF INSTITUTIONS

Table 9. Roles and responsibilities of institutions for implementing small ruminant breeding strategy

Breeding strategy interventions	Institution	Roles/responsibilities
1 Institutional interventions		
1.1. Institutionalizing/coordinating breeding initiatives	NAGII	- Identification of breeding initiatives, Identify duplication of efforts
	NAGII	- Delegate roles and responsibilities to institutions that would contribute to identified projects/programs as per the structure of the NAGII
1.2. Aligning research and development strategies	NAGII, EIAR, RARIs, HLI	
1.3. Restructuring/integrating and/or coordinating breeding resources	MoLF, Regional Bureaus, EIAR, RARIs, HLI	- Pooling breeding resources
	MoLF, Council, EIAR, Regional Bureaus, RARIs, HLI	Establishing National sheep and goat improvement centers
2. Revamping and (re)structuring ongoing genetic improvement initiatives	NAGII, Regional Bureaus, RARI, Int'l DPs, HLI	Coordinating & scaling up community-based breeding activities/projects
	NAGII, RARIs, HLI	Review of central nucleus-based research projects/flocks
	NAGII, EIAR, RARIs, HLI	Evaluation, documentation, and supporting ad hoc crossbreeding activities
	NAGII, RARIs, HLI	Reinitiating the planned National Dorper breeding program
3. Rationalizing sheep and goat genetic improvement interventions (short term 3yrs)	EIAR/RARIs, Regional Bureaus, Int'l DPs	Develop suitability mapping for selective and crossbreeding for breed groups
	EIAR/RARIs, Int'l DPs	Design appropriate selective breeding and crossbreeding programs
4. Capacity development	Federal/Regional Gov'ts	Assigning technically appropriate expertise to run breeding programs, including at managerial/directorate levels
	Federal Gov'ts	Staffing NAGGI with capable experts to lead national programs technically
	Federal/Regional Gov'ts	Establish and capacitate national centers of excellence, staffed with a critical mass of expertise
	NAGII	Formation of advisory technical team comprising of national and international professionals to advise NAGII and national centers
	Federal/Regional Gov'ts, HLI	Training program to strengthen NAGII, national centers, breeding centers
	Federal/Regional Gov'ts, Int'l DPs, HLI	Establish and support technically and materially Molecular labs, reproductive technology labs in national centers
5. Strategy for accelerating genetic improvement	CGIAR, EIAR, RARIs, HLI	Develop a project for CGIAR support in genomic selection

Breeding strategy interventions	Institution	Roles/responsibilities
	RARIs, HLI	Identify one breed of sheep and goat each in each region to establish reference flocks for genomic selection
	CGIAR, EIAR, RARIs, HLI, MoA, BoAL, RLA	Introduction of oestrus synchronization in village breeding programs
	RARIs, EIAR, CGIAR, MoA, BoAL, RLA	Introduction of AI in crossbreeding programs (Dorper, Begait, Awassi, Boer, ...)
	CGIAR, RARIs, EIAR,	Develop small ruminant AI Scheme (document) (institutionalizing AI, facilities and manpower, efficient small ruminant AI scheme)
6. Developing new breeding programs and new breeds	Regional Bureaus, RARIs, NAGII, HLI	Identify and prioritize breeds in each state – stakeholder Group Work
	NAGII, Research, MoA, CGIAR	Developing breeding programs (design, plan, guidelines,
7. PPP model for Commercialization of genetic improvement	Regional and national Gov'ts, NAGII	- Public sector Support required
	CGIAR, EIAR, RARIs, HLI	- Support in designing breeding programs for commercial farmers
8. Standardization of genetic resources nomenclature and documentation	EBI, NAGII	
9. Genetic improvement programs as opportunity for small businesses	CGIAR, EIAR, RARIs, HLI	- design support to incorporate job/small business opportunities in programs
	Regional and national Gov'ts	- Credit facilitation
10. Database system	NAGII	

HLI - Higher learning institutions; RLA - regional livestock agencies; BoAL Bureau of agriculture and livestock, EBI - Ethiopia biodiversity institute

6. EXPECTED OUTPUTS

- The strategy is expected to resolve the current disorganized breeding initiatives which would improve the efficiency and effectiveness of genetic improvement initiatives
- Ongoing fragmented, project-based and research-based breeding activities will be transformed into sustainable breeding programs
- Conservation-based genetic improvement through scientific selective breeding programs of the adapted indigenous small ruminant genetic resources would increase their economic contribution to their keepers and their survival as breeds. Irrational crossbreeding activities will be minimized
- The research and development institutions will be integrated and work towards the same breeding goal
- Involvement of the private sector in genetic improvement will increase and job opportunity created for small businesses delivering improved genetics

7. TARGET GROUPS AND BENEFICIARIES

This strategy targets both the public and the private sector. The strategy incorporates research and development institutions, international development partners to work together towards the same goal. The strategy is expected to benefit the smallholder small ruminant breed keepers, commercial companies interested/involved in livestock businesses and jobless youth, particularly jobless graduates of animal science.

8. CROSSCUTTING ISSUES

Gender and youth

In almost all production systems where sheep and goats are reared the contribution of women and children is very high. Women often have a predominant role in managing small ruminants and other animals that are housed and fed within the homestead. Where milk from small ruminants is important decision on use for household consumption and use of the income is usually made by women. However proceeds from sale of animals and decision to slaughter for household consumption more often than not comes from the household head which in most cases is the male. In preparing this breeding strategy consideration was given to identifying, understanding the relevance of and addressing the different livelihood needs, priorities, interests, and constraints of men and women along lines of age, socioeconomic status and ability. The breeding objectives to be refined will address the trait preference aspect along the gender line (e.g. ease of milking) and its implication on the production dynamics (e.g. more milk improves household nutrition and income but may also increase the time required to milking and manage the milking animals). In the strategy the involvement of jobless youth, mainly animal science graduates, were considered to play important role in running the business of multiplication of improved genetics. Women and children play important role in record keeping for community based breeding programs and this need to be taken into consideration in implementation of the breeding programs. Furthermore, as opposed to focusing solely on

technologies that increase breed productivity, the strategy and program should actively promote seeking technologies that also reduce women's labor burden. The program should actively promote alternative ways of delivering extension that allow women to learn about breed improvement technologies and effectively utilize them. This will require awareness about constraints to women's participation to be recognized and incorporated into small ruminant extension strategies.

Environment

Increase in productivity improves efficiency by which resources are transformed into useful products (e.g. forage can be efficiently changed into live-weights) resulting in less environmental footprint per unit product. Sustainable improvement is at the core of the development of the breeding strategy, as such appropriate species, breeds and types of products were considered in defining breeding objectives. This will enable the sustainability of the environment and also the improvement that can be attained. The consideration of agro-ecologies and production systems in developing the breeding strategy addresses the sustainability of the impacts of the breeding programs and appropriateness to the environment it takes place.

Nutrition

The role of sheep and goats in ensuring food security is significant. In addition to serving as food source, sheep and goats are a source of cash to purchase food items. In the development of the breeding strategy and programs traits contributing to increased food production and income are considered. Quality of food to be produced from sheep (meat and milk) are also be part the breeding objective.

9. MONITORING AND EVALUATION

Table 10. Monitoring and evaluation for designing and implementing new breeding programs

Activities	Indicator(s)	Means of Verification	Responsible
Strategy document prepared	Strategy document endorsed	Workshop evaluation	NAGII
Institutionalizing and coordinating fragmented ongoing breeding initiatives	Number of breeding initiatives identified and institutionalized	Reports	MoA
Review of breeding initiatives	Documents produced to facilitate implementation of strategy	Reports, workshop review	NAGII
Revamping ongoing breeding initiatives	Number of breeds for which program is revamped	Reports, field monitoring	NAGII
Developing new breeding programs	Number of sheep programs initiated Number of goat programs initiated	Reports, field monitoring	NAGII
Commercializing genetic improvement	No. of commercial farms engaged in genetic improvement No. of small businesses initiated	Reports, field monitoring	MoA/NAGII

10. TIME FRAME

Table 11. Time frame for implementation of the small ruminant breeding strategy

Breeding strategy interventions	Term
Institutional interventions	Short to medium-
Revamping and (re)structuring ongoing genetic improvement initiatives	Short-
Rationalizing sheep and goat genetic improvement interventions	Short-
Strategy for accelerating genetic improvement	Short, medium, long
Developing new breeding programs and new breeds	Medium-
PPP model for Commercialization of genetic improvement	Medium
Standardization of genetic resources nomenclature and documentation	Short to medium
Genetic improvement programs as opportunity for small businesses	Short to medium
Database system	Short to medium
- Advance reproductive technologies:	Long
- Oocyte collection and in vitro maturation, In vitro fertilization, embryo transfer and somatic cell nuclear transfer (cloning).	
- Extensive use of multiple ovulation and embryo transfer	
Introduction of genomic tools in breeding programs	Medium to long

11. ANNEXES

- Annex I: Scaling up Menz sheep cooperative village breeding program
- Annex II: Accelerated scaling up of Bonga sheep breeding program (AI, estrus synch)
- Annex III: National Dorper crossbreeding program
- Annex IV: Breeding program design with business models

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