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National Dairy Cattle Breeding Strategy



2018 -2030

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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 dairy cattle, 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 dairy cattle 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 cattle 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 dairy cattle breeding strategy. Moreover, my enormous gratitude goes to Diriba Hunde and Dr. Million Tadesse (EIAR), Dr. Selam Meseret (EBI), Dr. Gemedo Duguma (Wolega University), Dr. Esayas Tessema (NAGII), Tariku Teka (MoA), Dr. Yitaye Alemayehu and Dr. Yoseph Mekasha (ATA) who were actively involved in the process of developing this breeding strategy document.

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Acronyms

ADGG	Africa Dairy Genetic Gain
AI	Artificial Insemination
ARDU	Arsi Rural Development Unit
CRGE	Ethiopia's Climate Resilience Green Economy
CSA	Central Statistical Authority
CADU	Chilalo Agricultural Development Unit
DAGRIS	Domestic Animal Genetic resources Information System
EARC	Ethiopian Agricultural Research Council
EIAR	Ethiopian Institute of Agricultural Research
EIB	Ethiopian Institute of Biodiversity
ESAP	Ethiopian Society of Animal Production
EVA	Ethiopian Veterinary Association
FAO	Food and Agricultural Organization
GTP	Growth and transformation plan
HLI	Higher Learning Institute
ILRI	International Livestock Research Institute
LMP	Livestock Master Plan
LSA	Livestock system analysis
MoAL	Ministry of Agriculture and Livestock
NAGII	National Animal genetic improvement institute
NAIC	National Artificial Insemination Center
NARS	National Agricultural Research System
RRI	Regional Research Institute

Executive Summery

Cattle production has supported the livelihood of several million farmers in Ethiopia. Milk and milk products have been used as source of essential nutrients, means of income generation and social interaction. In addition, dairy sector is considered as one of the next economic growth driver of the country. The demand for milk and milk product is flourishing in recent years due to human population growth and urbanization, rising incomes, and changes in demographic structure of the population. Because of growing demand and some effort on genetic improvement, the contribution of the sector to livelihood improvement of farmers has been growing. For instance, research report in Ethiopia, Oromia region showed that adopter of crossbred cows technology generated 44% more income than non-adopters.

Despite large cattle population and favorable climate, Ethiopia is not self-sufficient in milk production. This indicate that the sector has not been developed to the expected level as the annual growth rate in milk production of 1.2 percent falls behind the annual human population growth estimated at **3 percent**. Moreover, per capita consumption was about **17 kg** which was much below the average milk intake (FAO standard requirement) to be maintained for balanced diet. The country milk import was also increased from **3.1** million USD to 12 million USD from **2001-2008 years**.

Ethiopia is planning to increase milk production by about 93% in 2020 through improving traditional family cow dairy production and expand and improve specialized dairy production units so that consumption demand will be satisfied, and export of cow milk and milk products will begin. The availability of divers indigenous cattle breed, promising performance of crossbred dairy cattle, attention given by government to the sector, approval of breeding policy, establishment of Animal Genetic Improvement Institute and availability of higher learning institute, research centers and other government and non-government organization working on dairy development, research and capacity building are among good opportunities for future genetic improvement of dairy sector.

Therefore, this strategy document will serve as guideline for future development and research on dairy cattle genetic improvement, multiplication, conservation and sustainable utilization in Ethiopia. The main goals of the national dairy cattle breeding strategy are aligned and harmonized with the national livestock development policy and master plan of the country and its lifespan extends from 2018 – 2030.

The strategy provides analysis of dairy production, consumption and export trend, challenges, opportunities, intervention options, indicators of breeding programs and capacity in terms of

human and infrastructure to identify key factors which hinder the productivity of dairy farming and influence the efficiency of the sector and exploit the available opportunities. India and Brazil are used as benchmarks to develop this strategy for transforming the Ethiopian dairy into a regionally and globally competitive sub-sector by 2030.

Based on critical analysis of the past, present and future developments issues of the Ethiopian dairy sub-sectors through SWOC (strength, weakness, opportunities and challenges) analysis, strategic interventions are developed to address the fundamental issues. Important strategic issues were identified which pertains 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.

The strategy has also provides indicators for future design and implementation of breeding programs with due emphasis for selection of indigenous and pure exotic cattle breeds and crossbreeding that leads to synthetic breed in long term in selected milk shed areas. Generally this strategy has provided critical guidance to transform dairy in to competitive sub-sector and enhance its contribution to livelihoods improvement, ensure food security, provide raw materials to domestic agro-processors, import substitution and overall economic growth.

1. Introduction

1.1 Background

Livestock contribute to the livelihoods of 60-70% of the Ethiopian population (Aklilu, 2002; Ayele et al. 2003). Dairy farming is an important component of the livestock sector. Furthermore milk and milk products have been used as source of essential nutrients and social and economic development for several millions of farmers and pastoralists in Ethiopia. The report of Land O'lakes (2010) showed that the dairy sub-sector accounts for 63% of the total value of ruminant output in Ethiopia. In addition, this study indicated that 83 percent of milk produced in Ethiopia comes from cattle. The country has unexploited resource with an estimated 58 million head of cattle distributed in different agro-ecologies and production systems (CSA, 2016).

The report of CSA (2011) has also revealed that approximately 3.2 billion liters were produced annually from 10 million milking cows in the country. The milk production is increased from 0.75 billion liters in 1993 to about 3.33 billion liters in 2012 (CSA, 2012). The demand for milk and milk product is flourishing due to growing population and urbanization, rising incomes, and changes in demographic structure of the population. Because of growing demand and some effort on genetic improvement, the contribution of the sector to livelihood improvement of farmers has been growing. For instance, the report of Agajie et al (2016) in Ethiopia, Oromia region showed that adopter of crossbred cows technology generated 44% more income than non-adopters.

Despite large cattle population and favorable climate, the country is not self-sufficient in milk production due to low productivity of dairy cattle. The sector is not developed to the expected level as the annual growth rate in milk production of 1.2 percent falls behind the annual human population growth estimated at 3 percent (GRM International BV, 2007). Moreover, Per capita consumption was about 16-19 kg (Getnet, 2009; CSA, 2010) which was much below the average milk intake (FAO standard requirement) to be maintained for balanced diet. The country milk import was also increased from 3.1 million USD to 9.3 USD from 2001-2008 years (Getnet, 2009). These is mainly attributed to lack selection for indigenous breeds, less efficient and indiscriminate cross breeding, inefficiency of using ranches for genetic conservation and multiplication, absence of community-based breed improvement, inefficiency of AI and other extension services, poor involvement of private sectors on genetic improvement and services, low level of financial service arrangement, low human and infrastructure capacity and low level of knowledge on genetic improvement at farmers, experts and technicians level.

The cattle genotype of Ethiopia has evolved through natural selection that benefits these breeds to withstand harsh climates, water and feed shortages and disease challenges. The availability of divers indigenous cattle breed in the country will help to produce specialized improved breeds through selection and crossbreeding targeted for milk and disease resistance. For instance, Sheko

cattle breed found in the western part of Ethiopia is reported to be tolerant to trypanosomiasis (Sisay, 1996; DAGRIS, 2004).

In Ethiopia, the genetic improvement of dairy cattle has been focused on crossbreeding in order to combine high milk yield potential of exotic breed with adaptive potential of local breeds. Research findings showed that milk production can be enhanced by about 300-500% by using crossbred dairy cattle breeds and its associated technological packages as compared to indigenous cattle (Beyene, 1992; Kefena et al., 2006; Yilma et al., 2006). In addition, attention given by government to the sector, approval of breeding policy, establishment of Animal Genetic Improvement Institute and availability of higher learning institute, research centers and other government and non-government organization working on dairy development, research and capacity building are among good opportunities for future genetic improvement of dairy sector.

The government of Ethiopia has aspiring plan to increase milk production by about 93% in 2020 through improving traditional family cow dairy production and expand and improve specialized dairy production units so that consumption demand will be satisfied, and export of cow milk and milk products will begin. Therefore, the dairy cattle genetic improvement plan of Ethiopia can be augmented by reinforcing the indigenous cattle selection and crossbreeding activities by appropriate breeding strategy and programs.

1.2. Rationale for Developing the Strategy

The livestock sector analysis showed that dairy farming has supported the livelihood of several million farmers in Ethiopia. In addition, dairy sector is considered as one of the next economic growth driver of the country. However, because of limited intervention, the productivity of indigenous cattle (99 % of cattle population) is very low and characterized by slow growth rate, late age at first calving (57 months), low milk yield (270-350 kg per lactation, and 1.3 kg per day), short lactation length (180-240 days), and about 570 days of calving interval (CSA, 2009; Yielma et al., 2006; Beyene, 1992).

The genetic improvement of dairy cattle was mainly based on crossbreeding and the performance of crossbred cattle is promising and comparable with tropical countries. In support of this, the growth and transformation plan has projected to increase in number of crossbred cattle to 3.6 million (or almost eight times) in improved family production systems in the moisture sufficient (MRS) zone during the GTP II period. 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. Generally, low productivity of indigenous cattle, low number (1% of the national cattle

population) and fluctuation in performance of crossbred dairy cattle in Ethiopia could point out that there was a lack of appropriate breeding strategy and programs for sustainable genetic improvement. An overall breeding strategy that can guide genetic improvement of the indigenous breeds through selective breeding and/or, when appropriate, crossbreeding is required.

In order to exploit untapped cattle potential, strategies need to be developed and aligned with the current development policy, population growth, stage of economic development and demands. Furthermore, developing and aligning the national breeding strategy to the national development plans such as Growth and Transformation Plan II, the Livestock Master Plan (LMP), Climate Resilient Green Economy (CRGE) policy and research master plans prepared by the National Agricultural Research Council (NARC) is essential to transform the Ethiopian dairy into a competitive sub-sector that can enhance its contribution to livelihoods improvement, ensure food security, provide raw materials to domestic agro-processors, import substitution and overall economic growth.

1.3. Vision

By 2030, to see Ethiopia self-sufficient in milk production and the sector plays a substantial role for nutrition security and economic prosperity through applying suitable and sustainable dairy genetic improvement

1.4. Mission

To make efficient utilization of the dairy cattle 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 dairy cattle production and productivity for ensuring food and nutrition security and poverty reduction in the country and ensure better life of dairy producers in Ethiopia.

1.6. Objectives

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

The specific objectives of the dairy cattle breeding strategy are to:

- develop and implement well-organized and consistent dairy cattle genetic improvement programs for different production systems;
- apply different breeding tools including biotechnology (genomic and reproductive technology); and developing elite breed and conserve indigenous dairy cattle genetic resources
- enhance the capacity for the research system, development institutions, private sector and small holders in different production systems;
- developing climate smart dairy technologies and innovation to mitigate and adapt to climate change/variability; and
- develop and enhance the capacity of dairy sub sector

1.7. Scope of the strategy

The dairy cattle breeding strategy is developed within a framework of addressing both development and research aspects at National level. 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.

As a national strategy, this document will serve as a guideline for future research and development interventions in improving and efficient utilization of the dairy cattle genetic resources of the country. The strategy addresses major intervention issues for dairy genetic improvement which include development of suitable breeding program, strengthening of service delivery, capacity building and the application of conventional and advanced technologies that can support breed improvement, conservation and multiplication

1.7. Guiding Principles

The national dairy cattle breeding strategic intervention and the specification of the modalities of intervention is guided by a set of basic governing principles. These are;

- The national dairy cattle 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 dairy cattle 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 dairy cattle genetic improvement activities shall follow participatory approach and ensure sufficient degree of client orientation

- Through its impact path way, the national dairy cattle 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 dairy cattle 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 dairy cattle genetic improvement shall ensure commitment to excellence, knowledge sharing and access to information
- In the national dairy cattle genetic improvement engagements, monitoring mechanisms and evaluation criteria from inception of its projects and activities shall be ensured
- The national dairy cattle 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. Dairy cattle production systems and development goal

2.1.1. Dairy cattle production systems

According to LSA (2017) Ethiopia's dairy production system is categorized in to mixed-highland livestock system (MR), Low land grazing, and specialized systems. Mixed highland livestock system is predominant in the Ethiopian highlands covering about 40% of the country. This system possesses a high potential for dairy development accounting 65 - 75% of the livestock population and well known in highland smallholder milk production. In the highland areas agricultural production system is predominantly subsistence smallholder mixed farming, with crop and livestock husbandry typically practiced within the same management unit. According to MoA (2014) this system is further classified in to the mixed rainfall deficient (MRD) and the mixed rainfall sufficient (MRS) systems. The majority of milking cows are indigenous animals which have low production performance. Very small number of crossbred animals is milked to provide the family with fresh milk butter and cheese. Surpluses are sold, usually by women, who use the regular cash income to buy household necessities or to save for festival occasions.

The low land grazing (LG) system is mainly found in the pastoral and other low land areas of the country. The pastoralist livestock production system which supports an estimated 30% of the livestock population and 10% of the human population covers 50-60% of the total area (FAO, 1995). The area is mostly lying at altitudes ranging from below 1500 m.a.s.l. The cattle population is indigenous breeds. Milk production is the priority commodity in this production system. However, because of poor genetic improvement efforts, erratic rainfall pattern and shortage of feed, milk production is low and highly influenced by season.

The Specialized system is found in urban and peri-urban area where the demand for milk and milk product is very high. The system comprises mainly small and medium size dairy farms located mainly in and around towns and cities of the highlands. It is also included specialized dairy farming practiced by private investors. The primary objective of the producers in this production system is to produce and sale milk and milk product as a means of income generation. Most of the intensive dairy farms possess pure exotic dairy breeds and produce about 2% of the total milk production of the country.

2.1.2. Dairy cattle development goal

Despite the existence of large number and diversified types of cattle production in Ethiopia, the benefits obtained from sub-sector are low compared to other African countries. The per capita milk consumption in Ethiopia was estimated at about **17 kg** (LMP, 2007). This value is low compared to Kenya and Sudan and it is in the range with Tanzania and Rwanda which recorded annual per capita consumption of milk at less than 20 kg.

The Livestock master plan (LMP), which is aligned with the country's second growth and transformation plan (GTP II), has focused on enhancing livestock production. The second five-year Growth and Transformation Plan (GTP II) of Ethiopia, has also provide attention to address the sector plays a vital role on transformation agenda. Furthermore, the government of Ethiopia has aspiring plan to increase milk production by about 93% in 2020 through improving traditional family cow dairy production and expand and improve specialized dairy production units so that consumption demand will be satisfied, contribution for nutritional security enhanced, supply of raw material for expansion of agro-industry insured and export of cow milk and milk products will begin. For instance the growth and transformation plan (GTP II) has projected to increase number of crossbred cattle to **3.6 million** (or almost eight times) in improved family dairy production systems in the moisture sufficient (MRS) zone during the GTP II period.

2.2. Milk production, consumption and import situation

According to the reports of the Central Statistical Authority (2012), the country cow's milk production was estimated at 3.33 billion liters from 10 million milking cows (xxx). Research reports also showed that, the milk production was increased from 0.75 billion liters in 1993 to about 3.33 billion liters in 2012 (CSA, 2012). This is mainly attributed to increasing cattle population and flourishing of private and market-oriented dairy system stimulated by rapid urbanization, increasing milk price, expansion of milk processing industries, dairy investment reforms and increase in income.

Out of total milk produced, approximately 83% is consumed at the household level and only 7% is supplied to the formal and informal markets. The remaining balance is distributed for processing local butter, yogurt, and cheese (10 %) primarily as a means of extending the shelf life during times of surplus production. Oromia region supplies more milk to the market as compared to the other large dairy producing regions of the country.

Because of rapid expansion of urbanization and relative booming of income of some of urban community, there is high demand for milk and milk product in urban area. The highest expenditure group, which makes up around 10% of the Addis Ababa market, consumes 38% of the milk. On the other hand, 61% of the population who are in the lowest expenditure group of urban area consumed only 23% of the milk.

In the rural areas producers consume fresh milk and convert their milk to butter. It was estimated that 40% of the milk produced is converted to butter, while only 9% is converted to cheese and the remaining proportion is consumed or sold fresh (LMP, 2007).

In pastoral area the nutritional, economic and social values of milk is significant for overall health, strength and growth and income generation. In the wet season, milk consumed by pastoral children can account for 67% of the mean daily energy they require and 100 % of their protein requirements. The amount of daily milk consumption decreased by almost 25% contributing only 16% and 50% of energy and protein requirements respectively in the dry season due to lack of availability and access to milk. Furthermore, children's milk consumption will drop in an average of 50% during drought years (Sadler and Catley, 2009).

Because of big gap between demand and supply of milk and milk product, the country milk import was increased from 3.1 million USD to 9.3 USD from 2001-2008 years (Getnet, 2009).

2.3. Current development and research strategies and programs/projects

The modern dairy production in the country was started in 1950s when 300 Friesian and Brown Swiss dairy cattle received as donation from the United Nations Relief and Rehabilitation Administration (Mohamed, 2004). Then different research centers have been established and engaged on characterization, crossbred breed evaluation and genetic improvement since 1970s.

Research and development engagement on dairy cattle genetic enhancement in the last four to five decades included breed identification and characterization, crossbreeding and conservation. In terms of dairy cattle breed identification and characterization, among a total of 27 cattle breeds/populations, phenotypic characterization has been carried out for most of the breeds/populations, while characterization at molecular level was carried out for few breeds (Boran, Fogera, Horo, Sheko, Abigar (Nuer), Gurage, Ambo and Afar) (Zewdu *et al.*, 2013 and Fedlu *et al.*, 2007).

The genetic enhancement attempted on dairy cattle so far were mainly focused on crossing of exotic breeds such as Friesian, Jersey, Simmental (as sire line) with dams of indigenous origin such as Horro, Fogera, Borana, Arsi and Barka at different ecological zones. Furthermore, the National Artificial Insemination center was established in 1981 as a part of dairy genetics improvement for production and importation of dairy cattle semen. Some of the major genetic improvement efforts made at different institutions are summarized in Table 1.

TABLE 1. MAJOR GENETIC IMPROVEMENT EFFORTS MADE AT DIFFERENT INSTITUTIONS

Year	Type of efforts	Purpose/s
1950	Ethiopia started modern dairying with the batch of dairy cattle received from the United Nations Relief and Rehabilitation Administration	Commercial fluid milk production on large farms in Addis Ababa and Asmara
1970 to 1980	The Chilalo Agricultural Development Unit (CADU which was later named as Arsi Rural Development Unit (ARDU) established by the governments of Ethiopia and Sweden	Production and distribution of crossbred heifers, provision of artificial insemination (AI), animal health services, forage production and marketing
1972	Characterization and performance evaluations on crossbreeding at	To characterize and evaluate crossbreds of different blood levels under different agro-ecological zones and dairy production systems

Holetta, Werer, , Adami Tullu and Bako research Centers		
1980s	Extension and Project Implementation Department (EPID) established	Further genetic improvement through distribution of 75 % crossbreed bulls along with crossbreed heifers
1981	National Artificial Insemination Centre (NAIC), now NAGII, was established through the Ethio-Finnish cooperation on dairy development	To achieve an efficient and reliable artificial insemination service nationwide
2008/2009	Private sectors has started to engage on input and output supply (eg ALPPIS)	importer and distributor of dairy bull semen, sourced from WWS in the US

Sources: Haile et al, 2009; Yilma et al. 2011

The characterization and performance evaluation of indigenous and crossbreds of different exotic inheritance were conducted to determine which genotypes and blood levels are suitable for the different production systems and agro-ecologies. The dairy cattle research and development activities have been undertaken in different federal and regional agricultural research institutions and higher learning institutions.

Estimation of genetic parameters (heritability, phenotypic and genetic variance) was conducted for some of indigenous breeds and is good indicator for future improvement of the population. From on-station performance evaluation projects phenotypic and genetic characterization for growth traits was conducted for Boran, Horro and Fogera cattle breeds (Mekonnin H/Mariam 1992; Habtamu 2010).

Several research reports showed that the growth, reproduction and production performances of 50 % F1 Friesian crossbred dairy cattle on average are about: 24 kg birth weight, 44 months age at first calving, 2150 liters milk yield in 359 days of lactation and 474 days calving interval (Kefena et al, 2006; Gebeyehu, 1999; Beyene, 1992).

2.4. Institutional and policy framework

Institutional land escape on dairy cattle genetic enhancement dates back to the early 1950s with initiation of modern dairying with the batch of dairy cattle received from the United Nations Relief and Rehabilitation Administration., NAIC has been engaged in production and importation of semen for use in crossbreeding program. Additionally, research and higher learning institutes have been mandated on technology generation and demonstration. In terms of conservation the Abernossa, Did Tiyura, Gobe, Metekel and Mayweini ranchs were engaged in conservation of important indigenous breeds to their respective localities. Recently, the Abernosa and Gobe ranches have been sold to private investors.

Currently, quite a range of institutions are engaged in dairy cattle genetic enhancement, conservation and multiplication. At federal level the Ministry of Agriculture and livestock have the national responsibility to oversee the policy, regulation and technical domain. Additionally, the EIAR and NARS has overall responsibility of national coordination of dairy cattle genetic improvement research activities, while NAGII serves as an umbrella institution for improvement and continual supply of improved dairy genetic resources. Moreover, NAGII is in charge of preparation of national breeding policy, strategies and programs, and implement upon approval by the government. Technical institutions such as EIAR, Biotechnology institute and Biodiversity shall engage in their respective technical domains at a national level towards delivery of technologies, improved genetics, conservation and sustainable utilization. Regional Bureaus of Agriculture, livestock and Fisheries, Regional research institutions, higher learning institutions shall also engage in implementation of genetic improvement, conservation and sustainable utilization of dairy cattle genetic resources to their region and production systems.

In addition, there are non-government institutions and societies involved as a major development partners in dairy genetic improvement at different levels in different dairy potential areas of the country. These are the International Livestock Research Institute (ILRI), SNV, Land O'Lakes, FAO, Heifers International Organization, African Dairy Genetic Gains (ADGG), Ethiopian Society of Animal Production (ESAP) and other Non-Governmental Development Organizations (NGOs).

The long year's awaited national livestock breeding policy of Ethiopia was approved and issued in 2016. With respect to dairy animals the policy recognizes key tasks of identification, systematic characterization, conservation, genetic enhancement through selection or crossbreeding, multiplication and sustainable utilization of genetic resources.

2.5. Impacts of strategies and programs/projects

In Ethiopia, there was no effective and sustainable genetic improvement program for any cattle breeds, owing to various constraints. In fact, some activities were initiated on cattle breeding and genetic improvement at government ranches and research centers (e.g., Borana cattle breeding and improvement ranches at Abernosa and DidaTiyura; Horro cattle breeding and improvement ranch at Horro Guduru and Arsi cattle breeding and improvement ranch at Gobe). There was genetic enhancement through selection attempted to improved Borana breed and this attempt failed to meet the desired objectives due to short of budget, lack of appropriate breeding program, human and infrastructure and fragmented herd size. Most indigenous cattle breeds/populations were characterized at phenotypic level, genetic parameters were also

estimated for some breeds. However, molecular characterization has been undertaken for very limited indigenous cattle breeds.

Most of the started genetic improvement activities lacks properly defined breeding program and goals to bring sustained genetic change and rather focused on improvement through crossbreeding program with little success and on mere distribution of heifers. Research has not yet focused on application of recent biotechnological tools and genomic information to assisted breeding program. Breed characterization using microsatellite may not help much in identifying Quantitative Trait Loci (QTLs) that help for designing improvement program using Marker Assisted Selection (MAS) tool. In addition, the dairy cattle crossbreeding program lacked livestock policy that guides the production of proper dairy genotypes for specific dairy production system in the country. It was only recently (2017/2018) that the country livestock policy ratified.

The unplanned crossbreeding had also threatened the genetic resources base of the country. Data collected for a long time on crossbreeding works by different institutions has not been consistently documented and systematically analyzed to develop sound and sustainable breeding programs. In general, the government-initiated open nucleus breeding schemes (Ranches) in different corners of the country were unsuccessful due to absence of on-farm dairy cattle performance recording schemes, low human and infrastructure capacity, weak coordination among the responsible stakeholders and limited technological innovations. In addition, most of the dairy technologies and innovations generated by different agricultural research institutions located in different ecological zones of the country have not been multiplied and disseminated to the wider end users. Different research and higher learning institutions and development organizational efforts were fragmented and not well documented and coordinated. Generally, there are no any nationally agreed and comprehensive dairy cattle genetic improvement strategies and programs in Ethiopia.

2.6. Strength, Weakness, Opportunity and Threat (SWOT)

The dairy cattle genetic improvement status and progress has its own strengths and weaknesses to build on present scenario for future improvement. Strengths and weaknesses are the internalities of the present situation of dairy sector within the country. Opportunities and threats are the externalities of the future situation, not only within the country, but also expected from outside the borders. The analysis attempts to identify the strengths to meet the opportunities and the threats of the future and weaknesses are going to be challenged or shown up by these threats and opportunities. The following table of strengths, weaknesses, opportunities and threats is to be used to formulate breeding strategies and programs. Detail analysis of strengths, weaknesses, opportunities and threats (SWOT) of dairy cattle genetic improvement is indicated in Table 2.

Table 2. Summaries of the strengths, weakness, opportunities and challenges analyzed

Table 2. Summaries of the strengths, weakness, opportunities and challenges analyzed			
Internal factors		External factors	
Strengths	Weaknesses	Opportunities	Challenges
Genetic and breeding			
Most indigenous cattle population characterized at phenotypic level and some at molecular level Indigenous cattle selection programs for dairy initiated Availability of some established breeding herds in different research centers and ranches Availability of dairy cattle performance recording database at research centers and National Animal Genetic Improvement Institute (NAGII) The existing few crossbreds with modest milk productivity which have been developed through the on-going crossbreeding program The performance of crossbreds and improved exotic breed sire tested and verified in different agro-ecologies	Low number of crossbred dairy cattle population Absence of improved dairy breed Inefficient utilization of AI centers and liquid nitrogen production plants Weak national dairy recording, analysis and feedback system Uncontrolled animal movement Low level of community involvement on genetic improvement Poor AI delivery system Poor and inefficient extension system (eg. Limited advisory and technical support for genetic improvement) Lack of gender and production system disaggregated extension system Genetic erosion and dilution among the indigenous cattle Negative selection (selling and castrating fast growing young bulls) Critical shortage of multiplication centers (private) for crossbred dairy cattle Critical shortage of breeding ranches/ nucleus herd Absence of animal breeders' (breed) society Shortage and inefficient indigenous cattle breed conservation and multiplication ranches Lack of well-organized and consistent breeding program (with defined breeding goals) designed for dairy cattle improvement Lack of information for innovative and efficient AI delivery system The indigenous cattle population are not adequately characterized specially by molecular tools Poor intra and inter-institutional collaboration and partnerships Brain wastage (lack of coordinating professionals) Limited options for alternative exotic dairy breeds Lack of application of biotechnological tools for genetic improvement and multiplication Lack of quality standard (certification) regulatory mechanism Limited application of climate smart dairy production system to reduce the effect of climate change/ variability on dairy or reduce the contribution of dairy production for climate variability	Availability of large number of genetically diverse cattle population Conducive climate that can support high yielding dairy breeds Approval of national animal breeding policy Availability of research centers, HLI, NAGII and other organization working of dairy value chain Presence of the professional associations (ESAP and EVA) Growing demand for milk and milk products Emerging of milk processing plants and commercial dairy farms Emerging of agro-industrial parks and industries Attention given to the dairy sub-sector by donors and funding organizations Capacity building at various levels (HLI, EIAR, RRI, ATVET and others)	Climate change/ recurrent drought Small herd size in highland area Mobility in pastoral area High prevalence of animal diseases Brain drain and rapid staff turnover
Capacity building			

Availability of researchers, experts and AI technicians Availability of structure for on farm breeding activities Availability of five AI centers and about 25 liquid nitrogen production plant at different parts of the country The establishment of modern molecular laboratory at Holetta	Continuous turnover of experienced breeders, experts and AI technicians low level of breeding knowledge at expert, AI technician and farmers level Lack of sufficient trained AI technician, experts and breeders Inadequate integration and cooperation among MoAL, research institutions, HLI and development Institutions In sufficient budget allocation for management dairy herd kept by research centers and ranches for on farm breeding activities (eg. Animal handling facilities, transport) Limited training (long-term and skill and experience sharing) to develop the skill and knowledge Limited monitoring and evaluation	The government's attention for human resource development The availabilities of HLI	In-adequate budgeting for genetic improvement and capacity building Limited focus for long-term training Inefficient procurement system for utilizing the available resources
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2.7. Benchmarking

Targets to transform the Ethiopian dairy cattle development and research into a regionally and globally competent subsector by 2030 is benchmarked against countries such as Brazil and India (Table 6) that have well developed dairy cattle research platforms and made significant progresses in dairy cattle development and research. India in particular is currently the world's largest producer of milk. Therefore, Brazil and India are used as references points in the preparation of Ethiopia's 12 years dairy cattle breeding strategy.

TABLE 3. PROPORTION OF POPULATION, MILK PRODUCTION AND REPRODUCTION PERFORMANCES IN BRAZILIAN, INDIAN AND ETHIOPIAN DAIRY RESEARCH INSTITUTES

Country	Proportion (%) of crossbred/pure exotic	Lactation milk yield (kg/cow)		Lactation length (days)		Age at first calving (month)	
		50% cross	Indigenous	50% cross	Indigenous	Cross	Indigenous
Brazil	80	2849	1490	281	312	34.5	36.0
India	20	3594	2300	322	313	34.6	38.9
Ethiopia	1	2200	550	340	230	36.3	45.0

3. Strategic interventions

3.1. Genetic enhancement, multiplication and conservation

The strategic interventions across short term, medium term and long term are indicated in Table 4. The strategic issues are grouped in to genetic enhancement, multiplication of improved dairy cattle, conservation of genetic resources and crosscutting and capacity building parts.

TABLE 4. SUMMARIES OF STRATEGIC INTERVENTION IN SHORT TERM, MEDIUM TERM AND LONG TERM ACROSS THE STRATEGIC OBJECTIVES

Strategic issues	Strategic Intervention		
	Short term (2 years) 2019-2020	Medium term (7 years) 2021-2025	Long term (12 years) 2026-2030
Genetic enhancement			
Lack of well-organized and consistent genetic improvement program to develop improved dairy breeds (A, B, C)	• Demand analysis for dairy genetics (to develop breeding program and multiplication) • Identify type of breeds for indigenous cattle selection • Mapping location appropriate for crossbred improvement • Strengthening the existing genetic improvement programs • Strengthening and utilization of national dairy cattle breeding data base for progeny testing and feedback	• Developing national livestock resource map • Continue implementation of the breeding program • Continue selection of sires for progeny testing using the national dairy cattle breeding database	• Initiate embryo collection and preservation from elite dams for further use • Evaluation of semen and embryo from high yielding and progeny tested sires of indigenous, crossbred with desirable exotic inheritance and pure exotic • Continue selection of sires for progeny testing using the national dairy cattle 'breeding data base • Initiate semen collection, processing and packaging using elite bulls
A. Indigenous cattle	• Phenotypic and molecular characterization of indigenous cattle to explore diversity, identify traits of interest for further genetic improvement • Design appropriate breeding program suitable to improve indigenous cattle breeds	• Continue phenotypic and molecular characterization of indigenous cattle to explore diversity, identify traits of interest for further genetic improvement • Implement appropriate breeding program suitable to improve indigenous cattle breeds • Continuous selection and evaluation for genetic improvement of local breeds	Continue improvement of selected indigenous cattle for milk production

Strategic issues	Strategic Intervention		
	Short term (2 years) 2019-2020	Medium term (7 years) 2021-2025	Long term (12 years) 2026-2030
		• Production and selection of new generation produced based on selection criteria identify candidate indigenous breeds for dairy	
B. Crossbreed	Design and implement appropriate crossbreeding program to develop synthetic breeds suitable for specific agro-ecology	Continue developing intermediate and better performing generations of crossbred cattle	Continue developing better performing generations of crossbred dairy cattle
C. Pure exotic	Genetic improvement of pure exotic dairy cattle breeds through selection and application of biotechnological tools	Continue improving exotic dairy breeds through evaluation and selection of highly merited dairy cows	Continue improving exotic dairy breeds through evaluation and selection of high merited dairy cows
Insufficient number of skilled human power in advanced tools of breed improvement	• Short term trainings in modern tools to fill skill gaps. • Start long term specialized training of staff	• Long term specialized training of staff • Specialized skill training for technicians and other support staffs in modern tools • Deliver effective technical and business training to all actors along Ethiopia's livestock value chain	• Continue long term specialized training • Continue specialized skill training for technicians and other support staff in modern tools
Weak coordination modality and linkage among disciplines and with other stakeholders	• Establish clear linkage modality among different disciplines and stakeholders • Strengthen linkage between MoAL and other stakeholders • Develop share of responsibilities among institutions and other	• Establish information exchange platforms among MoAL, research institutions, HLI and development Institutions • Continue strengthening stakeholder linkage • Evaluate the implementation, assess gaps (challenge) and modify share of responsibilities among	• Continue strengthening stakeholder linkage and platforms • Continue evaluation of the implementation, assess gaps (challenge) and modify of share of responsibilities among institutions and other stakeholders if necessary

Strategic issues	Strategic Intervention		
	Short term (2 years) 2019-2020	Medium term (7 years) 2021-2025	Long term (12 years) 2026-2030
	stakeholders towards common goals • Establish dairy board	institutions and other stakeholders if necessary • Strengthening the dairy board	
Lack of reliable breeding services	• Evaluation of the existing AI delivery system in various dairy production systems and suggest alternative service delivery • Field testing of alternative service delivery in various production systems • Include AI education curriculum at ATVET level • Improving/ training the efficiency and skill of AI technicians • Develop and implement performance based incentives system for AI technicians • Strengthening AI and liquid nitrogen plant centers • Improving the inputs and logistics • Enhance the knowledge of dairy producers • Establishment of private and community AI service providers (establish system that encourage engagement of private sector, training, financial services (eg. loan, incentive))	• Demonstration and continue field testing of alternative service delivery in various production systems • Develop and include AI education curriculum on animal science (BSc degree) at university level • Encourage the private sectors to engage on supply of AI inputs and logistics • Organizing experience sharing and short term training for AI technicians • Strengthening AI delivery system at kebele level • Continue Enhancing the knowledge of dairy producers • Continue strengthening and promoting private and community AI service providers (Continue establishing system that encourage engagement of private sector, training, financial services (eg. loan, incentive))	• Continue demonstration of up- to- date alternative service delivery in various production systems and integration to extension • Ensure effective and accessible AI delivery at kebele level • Strengthen the engagement of private sectors on AI inputs and logistics • Continue Enhancing the knowledge of dairy producers • Develop competence private and community AI service providers

Strategic issues	Strategic Intervention		
	Short term (2 years) 2019-2020	Medium term (7 years) 2021-2025	Long term (12 years) 2026-2030
	Develop modalities for public private partnership		
Poor infrastructures and facilities	- Strengthening the existing ranches and nucleus herds that can support the genetic improvement programs and conservations - Availing laboratory equipment, other facilities including PCR machines, genetic analyzers, Sequencers, HPLC, reagents, consumables etc	- Establishment and strengthening of ranch and nucleus herds - Keep improving and maintaining ranches (nucleus herd) and equipping laboratories with advanced facilities and tools - Continue availing up-to date laboratory facilities and equipment. - Building centers and laboratories	- Continue to maintain and modernize ranches and other research infrastructures - Continue availing up-to date laboratory facilities and equipment
Lack of organized animal performance recording and feedback system	- Improve the ICT service and infrastructure - Starting to put in place data recording system at farm level	- Strengthen the ICT service and infrastructure - Continuing in placing recording system at farm level	- Continue upgrading the ICT service and infrastructure - Continuing strengthening the recording system at farm level
Lack of biotechnological tools application for genetic improvement and multiplication	Capacity building on biotechnological tools and facilities	- Adopt, optimize and apply modern biotechnological tools and techniques to produce and use genomic information - Adopt, optimize and apply animal reproductive biotechnology tools such as, multiple ovulation and embryo transfer, sexed semen, in-vitro fertilization, and estrous synchronization - Apply genomic selection methods such as SNPs, DART and other up-to-date tools	- Continue optimization and application of modern biotechnological tools and techniques to produce and use genomic information - Continue optimization and application of animal reproductive biotechnological tools such as, multiple ovulation and embryo transfer, in-vitro fertilization, and estrous synchronization - Continue using genomic selection methods such as SNPs, DART and other up-to-date tools to increase the estimation accuracy of animal selection and reduce generation intervals in progeny testing

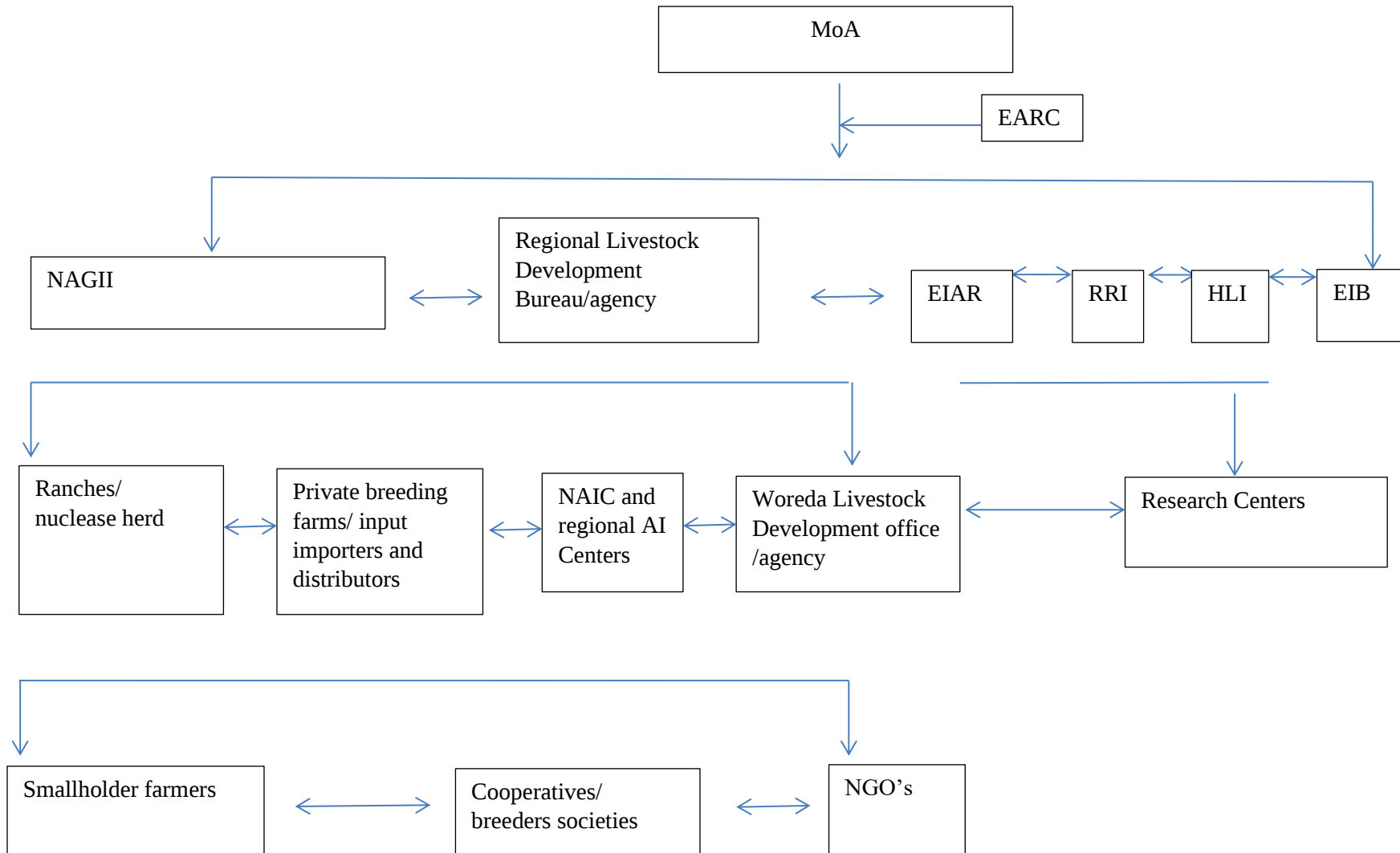
Strategic issues	Strategic Intervention		
	Short term (2 years) 2019-2020	Medium term (7 years) 2021-2025	Long term (12 years) 2026-2030
		Capacity building for biotechnological tools and facilities	
Lack of alternative options of exotic dairy breeds	- Introducing suitable exotic dairy breeds/germplasm as alternative for milk production for different agro-ecologies - Continues assessment and development of demand for dairy genetics	- Testing and verification of alternative exotic dairy breeds - Multiplication of verified alternative exotic breeds/crossbreds for pre-extension demonstration - Selection of elite bulls to use as a source of semen for subsequent breed improvement	- Pre-extension demonstration of verified alternative exotic dairy breed - Continue further improvement of the breed with selection and application of modern biotechnological tools - Initiate semen collection, processing and packaging using elite bulls - Initiate embryo collection and preservation from elite dams for further use
limited attempts for conservation of indigenous cattle breed	- Assess the status of endangered and other cattle breeds - Assess the economic importance of endangered breed (eg. disease resistant and harsh environments etc.)	- Design and apply appropriate means of conservation, improvement and sustainable utilization - Establish ranches for conservation and link with community based breed conservation - Conserve semen, oocyte and embryo of endangered cattle breed	- Continue conservation by utilization and genetic improvement - Initiate identification and conservation of DNA of important endangered breed (eg. genes of disease resistance and harsh environments using modern biotechnological tools)
Multiplication of improved dairy breeds			
Few attempts for multiplication of improved cattle breed	Optimization of protocol suitable for breed multiplication such as synchronization, timed AI, embryo transfer (in-vitro and in vivo fertilization) and sexed semen	Large scale application of multiplication tools such as synchronization, timed AI, embryo transfer (in-vitro and in vivo fertilization) and sexed semen	Commercialization of multiplication tools such as synchronization, timed AI, embryo transfer (in-vitro and in vivo fertilization) and sexed semen
Low number of crossbred dairy cattle population	Assessment of gaps and improving the efficiency of on farm cross breeding	- Strengthening on farm cross breeding - Strengthening private and community AI service providers	- Develop well- organized community based cross breeding - Develop competent private and community AI service providers

Strategic issues	Strategic Intervention		
	Short term (2 years) 2019-2020	Medium term (7 years) 2021-2025	Long term (12 years) 2026-2030
	- Supporting and promoting establishment of private and community AI service providers - Establish a system that enables optimal involvement of private sectors to produce more heifers (including delineating land for the dairy sector) - Promote and practice animal breeding technologies - Enhance breeding knowledge at expert, AI technician and farmers level - Enhance community mobilization and participation - Develop quality standard (certification) regulatory mechanism for crossbred cattle (heifers and bulls)	- Strengthening commercial and smallholder dairy farmers to produce more heifers - Continue promoting new technologies generated on animal breeding, husbandry and health - Continue Enhancing breeding knowledge at expert, AI technician and farmers level - Continue Enhancing community participation and mobilization - Develop quality standard (certification) regulatory mechanism for crossbred cattle selling and pricing	- Develop specialized dairy cattle breeder herds - Continue promoting new technologies generated on animal breeding, husbandry and health
Conservation of genetic resources			
limited attempts for conservation of indigenous cattle breed	- Assess the status of endangered and other cattle breeds - Assess the economic importance of endangered breed (eg. disease resistant and harsh environments etc.)	- Design and apply appropriate means of conseration, improvement and sustainable utilization - Establish ranches for conservation and link with community based breed conservation - Conserve semen, oocyte and embryo of endangered cattle breed	- Continue conserveation by utilization and genetic improvement - Initiate identification and conservation of DNA of important endangered breed (eg. genes of disease resistance and harsh environments using modern biotechnological tools)

Strategic issues	Strategic Intervention		
	Short term (2 years) 2019-2020	Medium term (7 years) 2021-2025	Long term (12 years) 2026-2030
Crosscutting and capacity building issues			
Weak design for gender disaggregate extension systems suitable for specific production systems	• Assess and analyze the existing extension system • Identifying constraints and opportunities for women's participation in dairy genetic improvement and development • Design suitable gender disaggregate extension system for specific production systems • Device suitable approach to enhance community involvement on genetic improvement program	• Apply suitable gender disaggregate extension system for specific production systems or agro-ecologies • Implementing strategies to address the identified constraints and to take advantage of opportunities • Test practiced extension system • Apply better approach to enhance community involvement on genetic improvement program	• Continue applying and testing the extension system and modify if necessary • Continue enhancing and testing community involvement approach
Lack of measures to reduce impact of climate change/variability on dairy genetics and shortage of technological options to cop-up with climate change	• Assessment on the impact of climate change/variability, adaptation and mitigation options • Investigation on genetic improvement options for climate resilient dairy cattle	• Assessment on the impact of climate change/variability, adaptation and mitigation options • Investigation on genetic improvement options for climate resilient in dairy cattle • Design measures that can reduce negative environmental impacts caused by dairy cattle • Emplace climate smart dairy practice such as generating adaptive, less emission and productive dairy cattle	• Continue assessment on the impact of climate change/variability, adaptation and mitigation options for dairy cattle production • Apply genetic improvement options for climate resilient dairy cattle • Practice measures that can reduce negative environmental impacts caused by dairy cattle • Continue climate smart dairy practice such as generating adaptive, less emission and productive dairy cattle
Poor infrastructures and facilities	• Strengthening the existing ranches and nucleus herds that can support the genetic improvement programs and conservations	• Establishment new nucleus herds required for respective breeding program • Continue strengthening and maintaining existing ranches	• Building advanced laboratory and facilities for advanced bio-technological tools using cluster approach or central approach

Strategic issues	Strategic Intervention		
	Short term (2 years) 2019-2020	Medium term (7 years) 2021-2025	Long term (12 years) 2026-2030
	• Availing laboratory equipment, other facilities including PCR machines, genetic analyzers, Sequencers, HPLC, reagents, consumables etc. • Availing the information technology facilities for breeding programs	• (nuclease herd) and equipping with advanced facilities and tools • Continue availing up-to date laboratory facilities and equipment. • Building centers and laboratories	• Continue to maintain and modernize ranches and other research infrastructures including lab facilities • Continue availing up-to date laboratory facilities and equipment
low number of skilled human power at different level	• Short term trainings for AI technicians, experts and researchers on knowledge and skill on breeding, modern bio-technology and software's. tools to fill skill gaps. • Start long term specialized training for special dairy breeding team (researchers)	• continue long term specialized training for special dairy breeding team (researchers) • Specialized skill training for technicians and experts in modern tools • Deliver effective technical and business training to all actors along Ethiopia's dairy breeding value chain	• continue long term specialized training for special dairy breeding team (researchers) • Continue specialized skill training for technicians and other support staff in modern tools

3.2. Institutional set up of genetic improvement



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. 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.

Breeding program is a base to create genetic change in livestock population in order to enhance the contribution of the sector to national economy, benefit livestock keepers and respective stakeholders (FAO, 2010). In addition, breeding program should address clear breeding goal which includes economically important traits and other associated adaptation traits. Three breeding programs are suggested to bring genetic change in Ethiopia dairy production. These are develop and implement straight breeding program for indigenous cattle breeds, develop and implement straight breeding program for pure exotic breeds and develop and implement crossbreeding program that leads to synthetic breed in long term for selected milk shed area. This strategy shows indicators about suggested breeding programs and thus detail of each breeding program should be prepared according to guideline of breeding programs.

TABLE 5. SUGGESTED BREEDING PROGRAMS FOR GENETIC ENHANCEMENT OF DAIRY CATTLE FOR DIFFERENT PRODUCTION SYSTEM

Production system	Objectives of production system	Suggested Breed improvement strategies	Breeding program/systems
Pastoral/Agro-pastoral	Sources of food, meat and milk	Indigenous cattle improvement	Selection program using Open nucleus/Community based approach
Mixed crop livestock system	Milk and meat	• Crossbreeding Indigenous breed with exotic dairy breed in milk shed area • Selection of indigenous breed	• Crossbreeding for 75%, synthetic breed development suitable for medium to high input and output milk shed area • Crossbreeding for - 50%, synthetic breed development suitable for low input and output milk shed area • Selection of indigenous breed using nucleus/ community-based approach

Commercial dairy production	Milk	Pure exotic and high - grade dairy cattle	Selection program within exotic/ high grade dairy cattle
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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. The percentage of each criteria's that we consider in prioritization of each breed shall be decided with multi-stakeholders consultation. However, tentative percentages in prioritizing of breeds are depicted as follows.

- 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

The designing process 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 milk, surplus heifers, male calves, culled animals and manure) and intangible benefits (insurance and financing benefits) of rearing dairy cattle.

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

4.1.2.3. Designing breeding schemes

A, Straight breeding program for Indigenous cattle improvement

In Ethiopia, the genetic improvement of dairy cattle to enhance the reproductive and productive performance was mainly based on cross breeding. This was mainly attributed to the assumption that the genetic gain expected from selection of indigenous cattle is 1-2 percent per year (Braännäng and Person, 1990) which is too slow to support the immediate high demand of milk in the country.

However, several research results revealed that there is high within breed variations both in production and reproduction performances for indigenous cattle breeds of Ethiopia (Kebede et al., 1991; Banjaw and Haile-Mariam, 1994; Haile-Mariam and Kassa Mersha, 1995; Negussie et al., 1998). Reports of the genetic characterization studies (Li et al., 2007; Zerabruk et al., 2007; Dadi et al., 2008, 2009) also showed that Ethiopian cattle populations have maintained a high level of within-population genetic differentiation which can make the genetic improvement through selection feasible. Furthermore, the simulation study conducted by Mandefro et al (2017) indicated that satisfactory genetic gains can be achieved in yearling weight, milk yield, calving interval and survival to yearling through selection of indigenous cattle breeds in Ethiopia. Selection among the indigenous animals, exploiting the individual variations, would be the most reliable way to improve the milk yield and associated traits.

An open nucleus breeding scheme that has two tiers (breeding and production unit) is suggested as an option for genetic improvement of indigenous breed in Ethiopia. Existing ranches or new nucleus herds supported with strong infrastructures and skilled human power will be used as breeding unit (tier 1). Community cattle will involve in the program as a production unit and villages will be clustered and included to specific breeding program. Major activities include genetic improvement via intensive selection of both male and female in the breeding unit and disseminate the selected genotype to the production unit (producers) through semen or natural mating. In addition, elite heifers, with full pedigree and free of any diseases, from the production unit will be allowed to enter the breeding unit. Test day records

will be employed to evaluation performance and estimate genetic gain at production unit. Each breeding unit (ranches/ nucleus herd) should have their own data base and performance and pedigree data will be collected at breeding and production units. The data base of each nucleus herds will then be linked with the national database for breeding value and genetic gain estimation and feedback. Schematic sketch of the genetic improvement and production units are indicated below (Figure 1). The detail of breeding program should be prepared according to breeding program guideline.

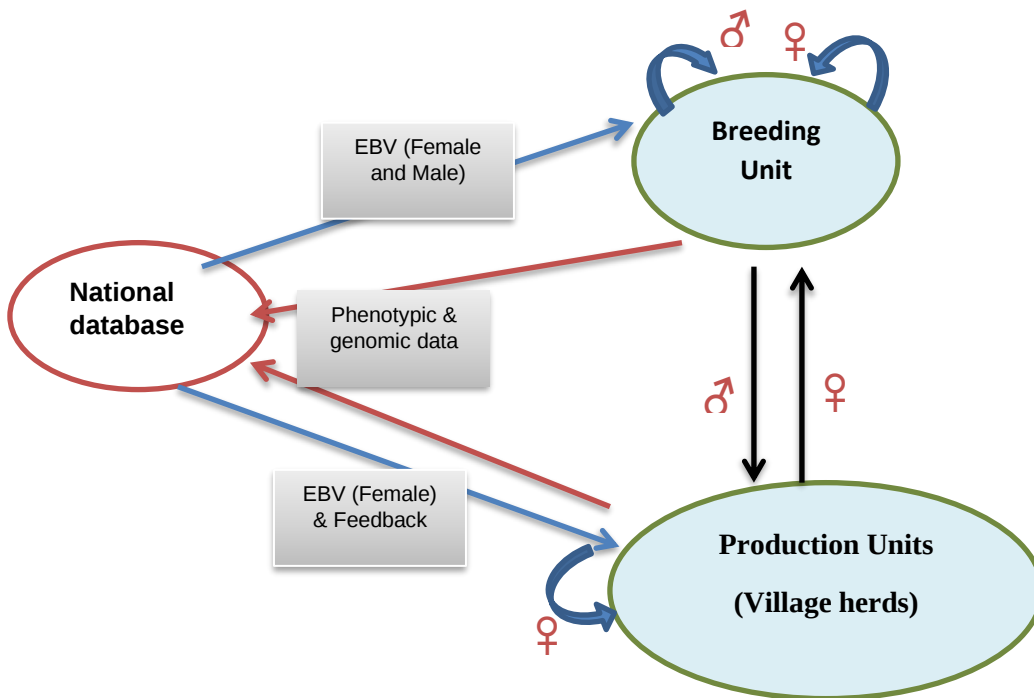


Figure 1. Schematic explanation for two tiers using indigenous cattle genetic improvement scheme

TABLE 6. SUGGESTED BREEDING PROGRAMS FOR SOME OF INDIGENOUS CATTLE BREEDS

Breeds	Suggested breeding program (second option in bracket for 1-5 & 8)
Boran	Dual (or beef)
Horro	Dual (or milk)
Fogera	Dual (or Milk)
Bagait	Dual (or Milk)
Ogaden	Dual (or beef)
Mursi	Dual (Dairy and beef)
Afar	Dual (Dairy and beef)
Nuer	Dual (or Milk)

B. Straight breeding for pure exotic breed improvement

There are very few large scale dairy farms that are distributed in and around major cities of the countries. Some of these farms are specialized in milk production by keeping mainly Holstein Friesians breed. In addition, some smallholder farmers found in and around major cities and towns have been rearing high-grade or pure exotic dairy cattle. Moreover the country has been importing exotic semen as there is limited option for elite exotic sires in Ethiopia. However, there was no any breeding program designed and implemented to improve reproduction, production and adaptation potential of this population and import substitution. Thus, similar to that of indigenous breed, straight breeding with open nucleus scheme is suggested for this system.

National artificial insemination center bull dam farm and Adea Berga Jersey research farm will serve as a breeding unit and large scale private dairy farms and smallholder dairy farms found in and around major cities and town in the milk shed area will involve as a production unit.

Major activities include genetic improvement via intensive selection of both male and female in the breeding unit and disseminate the selected genotype to the production unit (commercial farms) through semen or natural mating. In addition, elite heifers, with full pedigree and free of any diseases, from the production unit will be allowed to enter the breeding unit. In addition

the breeding unit can be further improved through introduction of semen and embryo from champion bulls in the world. Test day records or small data base will be employed at commercial farms (production unit) to evaluation performance and estimate genetic gain at production unit. The breeding unit (bull dam farms) should have their own data base and performance and pedigree data will be collected at breeding and production units. The data base of each breeding and production unit will then be linked with the national database for breeding value and genetic gain estimation and feedback. The detail of breeding program should be prepared according to breeding program guideline.

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. 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 herd, 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 3.2.

4.1.3.3. Other organizational considerations

- The geography of the breeding program need to be delineated. The geographic description includes the districts, kebeles, dairy cattle 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 bulls 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

Appropriate (planned) breeding program can help dairy farmers to maintain the desired level of crossbred population in a sustainable way (Philipsson *et al.*, 2010; Ojango *et al.*, 2015). In support of this, the level of *B. taurus* inheritance was set at about 50% to develop Sunandini breed in India (Chacko and Jose, 1988; Taneja, 2000) and 1/2 to 3/4 for bull dams to develop Brazilian milking hybrid in Brazil (Madalena *et al.*, 2012). In addition, the Australian Milking Zebu (AMZ) was developed through long term crossbreeding program to overcome the problems of traditional dairy breeds performing at reduced levels under hot, humid and tick-infested conditions (Handbook of Australian Livestock, Australian Meat & Livestock Corporation, 1989).

However in Ethiopia, despite recommendations, the level of exotic inheritance for progenies of crossbred cows was not predetermined by specific mating plan for specific area due to absence of breeding programs which shows direction to produce adaptive and productive generations at community level (Hunde 2018). The level of exotic inheritance could influence performance and adaptation of crossbred animals to the prevailing environment. For instance the study of Haile *et al* (2011) showed that the lifetime milk yield of 87.5 % exotic inheritance dairy cows (5820 kg) was much lower than that of 75% crossbred cows (7122) and F1 50% crosses (7998 kg) in Ethiopian. In addition, Kefena *et al* (2004) reported that milk yield of second-generation 50% Jersey crossbred cows (1342.66) was reduced by about 37% compared to F1 Jersey crossbred cows (2150.39) in the central highland of Ethiopia. These might indicate that the challenge of local environment (climate, feeding, disease and other management) was high on upgraded generation to express their genetic potential and gene segregation can significantly reduce performances of the cows if the breeding program is not supported with intensive selection.

The breeding program should address clear breeding goal that includes economically important traits and other associated adaptation traits. Tropical countries like India, Brazil and Australia had considered production, reproductive and adaptation traits based on farmers' interest and

agro-ecologies in the long term genetic improvement efforts. In Ethiopia, the breeding goal targeted mainly milk yield and cows were judged mainly based on daily or lactation yield. However, very important traits such as milk quality (fat and protein), reproduction and adaptation traits have got less attention. In addition, there were no appropriate recording system in place at farmers' level to determine the level of exotic inheritance as well as to evaluate performance and survival of crosses under farmers' management condition. Therefore developing and implementing appropriate breeding program can further augment dairy cattle genetic improvement and the contribution of the sector to the national economy.

Lessons from tropical countries showed that fixing the exotic inheritance at desirable level is essential to generate adaptive and productive generations and develop synthetic (new) breed in long term. Crossbreeding activities have been undertaken in different part of milk shed areas and thus there are crossbred cattle population produced in the last many years. Even though these animals have different exotic inheritance, it is possible to incorporate in to appropriate breeding program so that the new generation will have desirable and similar breed level. Herds with different exotic inheritance or selection criteria found in the same production system or agro ecology can be merged together in to similar program by aligning their previous breed composition and improvement target for a common selection criterion.

Thus crossbreeding program that leads to synthetic breed in long term is suggested for selected milk shed areas. This breeding program will have two mating plan so that the level of exotic inheritance will be maintained accordingly. The decision of breed level to be fixed and type of exotic sire to be used for the breeding program should be based on the interest of the community, feed availability, animal disease condition, market (input and output) and other scenario of specific area. In addition, crossbreeding program should not affect the indigenous cattle genetic resource and area should be delineated for crossbreeding.

Mating plan suggested for medium to high input-output milk shed areas delineated for cross breeding

The following mating plan is suggested as better option to develop new (synthetic) breed in long term for medium to high input-output milk shed areas such as Holetta, Selale, Debrebrehan and Asella peri-urban and rural areas (Figure 2).

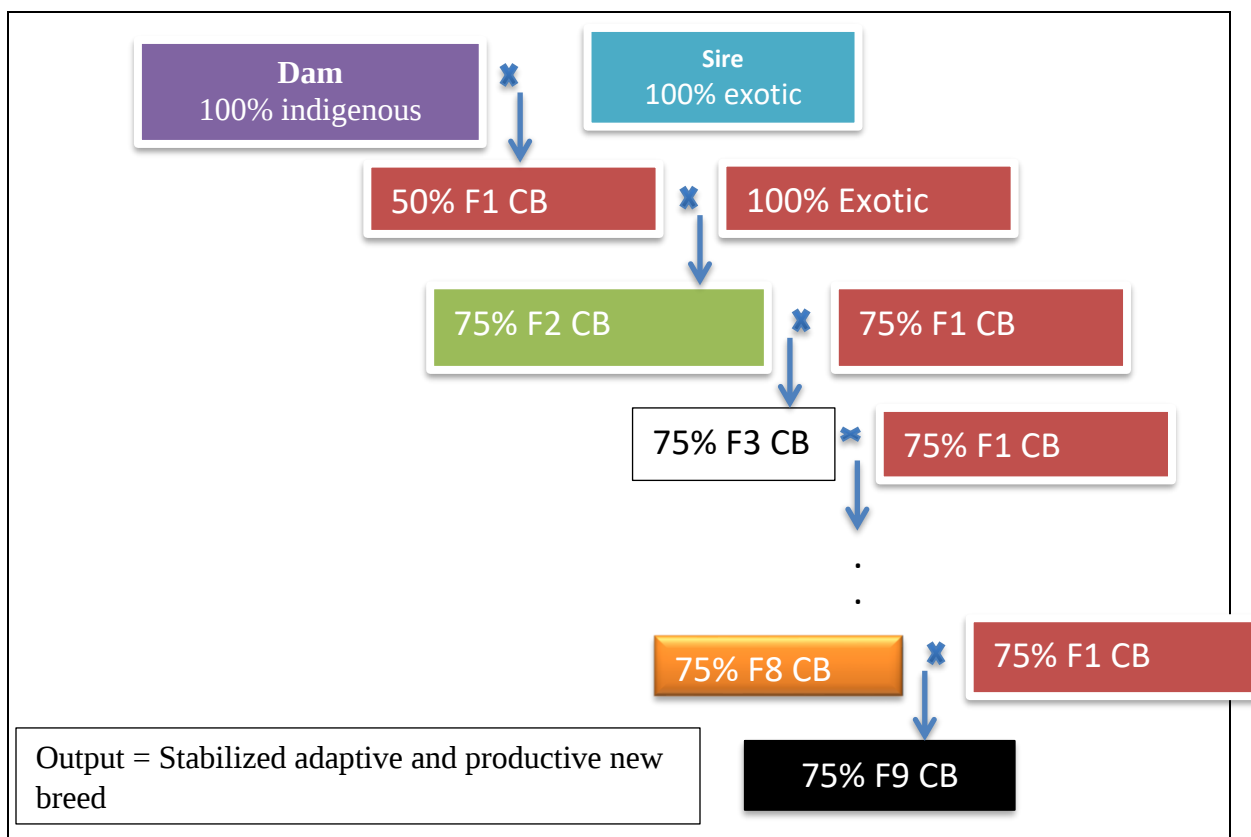


FIGURE 2. MATING PLAN SUGGESTED FOR MEDIUM TO HIGH INPUT-OUTPUT MILK SHED AREAS DELINEATED FOR CROSS BREEDING

Breeding and production unit for medium to high output areas delineated for cross breeding

Similar to the breeding scheme of indigenous cattle, this scheme should have breeding and production units (herds). Different herds found on the hands of research centers and higher learning institutes, bull dams (Friesian and Jersey) as well as new ranches (nucleus herds) to be established if necessary, will be used as breeding unit. Any crossbred dairy cattle kept by smallholder farmers in peri-urban and rural area will be considered as production unit. The same mating plan mentioned in the above table is recommended for both tiers so that similar breed level can be stabilized at on station and on farm level. It is also possible to restrict the duty of breeding unit at 2nd crossbred generation so that they can produce and supply best 75% sire to production unit and breed stabilization is limited at on-farm level (production unit) in this case. Indigenous cattle found on the hands of farmers will be used as a dam for the first crossbred generation. In addition, the program should be linked with breeding unit established for improvement of exotic herd (Jersey and Friesian) or pure exotic bull dam nucleus herd as exotic sire semen is required to produce the first two crossbred generation. Starting from 3rd generation inter-see mating (straight breeding) procedure will be followed. In breeding unit, the crossbreeding should be supported with intensive selection of both male and female.

Seventy five percent exotic inheritance best sire will be recruited based on breeding value and used to improve both production and breeding unit. All crossbred heifers or cows with any level of exotic inheritance found in participating village should be inseminated with 75% exotic sire. The detail of breeding program should be prepared according to the guideline.

Mating plan suggested for low input-output milk shed areas delineated for cross breeding

Fifty percent exotic inheritance crossbred cattle could be more suitable for low input - output areas and the next generation should be maintained at the same breed level using selected 50% F1 bulls (semen from F1 bulls) for all crossbred cows and heifer in order to develop composite new breed in long term (Figure 3). Activities of breeding and production unit in low input - output areas are almost similar to breeding and production unit for medium to high output areas except breed level to be maintained. The detail of breeding program should be prepared according to breeding program guideline.

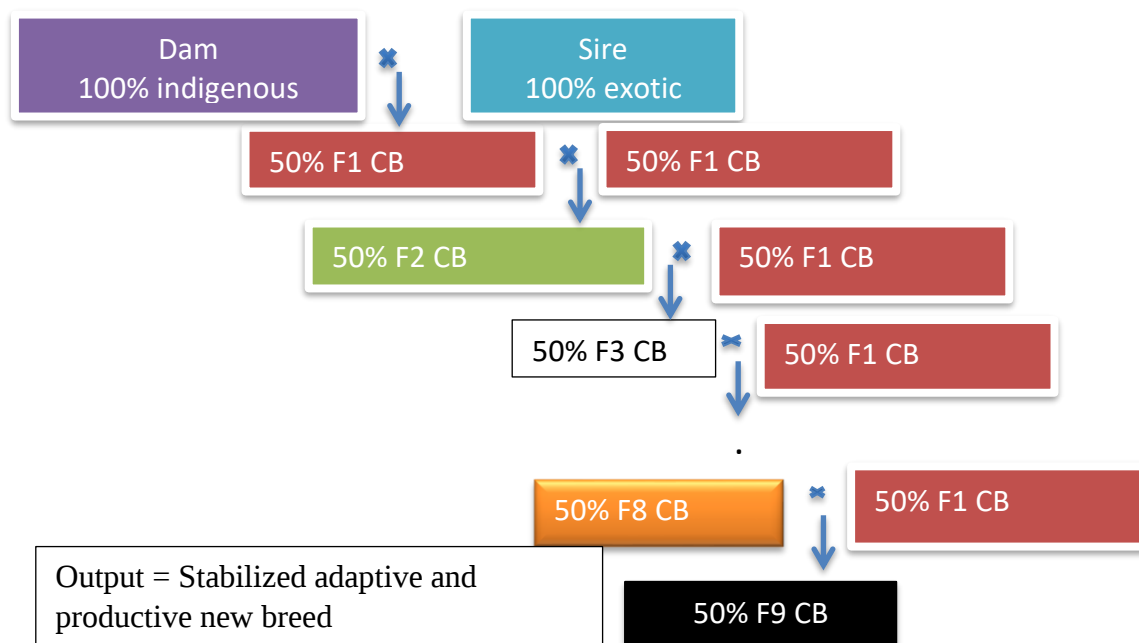


Figure 3. Mating plan suggested for low input-output milk shed areas delineated for cross breeding

5. Roles and responsibilities of Institutions

TABLE 7. ROLES AND RESPONSIBILITIES OF DIFFERENT INSTITUTIONS

Stakeholders	Roles and responsibilities
MoA	Develop a system that ensures integration and coordination of Stakeholders engaged on breed improvement activities
	Build human and infrastructural capacity required for genetic improvement
	Build capacity for supplying, distributing and marketing of inputs and out puts to ensure success of genetic improvement and follow up the implementation of the strategy
	Promote better technologies and training services
	Establish a system that ensures quality standard for product supply
	Establish a system that ensures access to quality veterinary services to improve the prevention and timely control of animal disease that could influence the success of genetic improvement
	Conduct quarantine on import and export of livestock, fish and their products; prevent communicable livestock diseases and the outbreak of migratory parasites
NAGII	Prepare and implement national breeding programs and follow up of implementation of strategies and program
	Establish, organize and lead animal breeding centers required for genetic improvement
	Build human and infrastructural capacity required for genetic improvement
	Establish national animal breed recording system, set up database, Collect breed improvement data, develop webpages and follow up its implementation
	Run breeding program, analyses of the data and genetic gain, the measure productivity and provide feedback to users
	Undertake research on dairy cattle genetic improvement
	Ensure sufficient availability of liquid nitrogen and other necessary breeding inputs for semen preservation in semen banks, for field operation purposes and follow up its execution
	Promote breed improvement activities on public media by developing webpages, fliers, posters and through other knowledge sharing means and follow up its outcome
	Establish synergy between the Institute and regional operation system and provide technical support on animal breed improvement
	Provide technical trainings for beneficiaries on improved breed; organize workshops, symposia and seminars concerning animal breed improvement, facilitate experience sharing programs among stakeholders involved in animal breed improvement
	Lead animal resources registration, movement, exchange and uses in consonance with international conventions
Ethiopian Institute of Agricultural Research	Generate and adapt dairy breeding technologies
	Coordinate dairy genetic improvement research activities conducted at research centers, higher learning institutions, and others
	Development of breeding program, undertake suitability mapping for dairy genetics and analysis of breeding program
	Establish an effective system for coordination between the federal research centers and other stakeholder involved on breed improvement

Stakeholders	Roles and responsibilities
	Collect, organize and disseminate information on dairy genetic improvement research activities and results available in the country or abroad, and develop and coordinate information exchange mechanisms
Regional Research Institute	Generate and adapt dairy breeding technologies
	Develop breeding program, undertake suitability mapping for dairy genetics and analysis of breeding program
	Collect, organize and disseminate information on dairy genetic improvement
Institute of Biodiversity Conservation	Initiate policy and legal proposals on the conservation and sustainable utilization of the dairy animal genetics
	Survey and explore the diversity and distribution of the country's dairy animal genetic resources, identify and characterize the status of breeds for conservation and sustainable use status
	Develop means of conservation by utilization
National Animal Health and Diagnostic center	Evaluate and certify health of Bulls and heifers used for dairy genetic improvement
	Involve in importation of dairy bulls and heifers
	Undertake and monitor herd health programs
National veterinary institute	Produce vaccines to prevent disease that can influence breed improvement
Ethiopian biotechnology Institute	Support in introduction, optimization and application of dairy biotechnologies
Higher learning institutions	Undertake dairy genetic improvement research
	Produce competent human power and involve in human capacity building
	Participate on implementation and analysis of breeding program
Regional and Woreda bureau/Agencies of Livestock development	Implement dairy breeding strategies and programs
	Facilitate Land and finance for dairy nucleus herd strengthening and establishment
	Engage on breed improvement, multiplication and conservation
	Build human and infrastructural capacity required for genetic improvement
Agricultural Investment Agency	Identify agricultural investment potential lands
	Transfer investment lands to investors
	Bridging role between private investors and out growers
	Provide necessary information and advisory services to agricultural investors
Agricultural transformation Agency	Provide technical support on dairy genetic improvement
Private sectors	Involve on implementation of breeding program and multiplication of improved genotypes
	Participate on service delivery (AI Delivery)
	Participate on input and output production and delivery
Development partners	Technical and financial support on dairy genetic improvement

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 livestock 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

The direct beneficiaries of this strategy will be smallholder farmers, pastoralists and commercial dairy farmers especially those participating in the pilot genetic improvement scheme and will be provided with extension services on dairy cattle breeding, husbandry to improve production, efficiency and profitability of their herds. Technical institutions such as MoA, research institutions, higher learning institutions and AI centers are beneficiaries of the genetic improvement strategies and programs, since they are expected to participate in the process of developing and later implementing the national strategy and programs. Moreover public private companies' for instance private AI service providers, milk collectors, processors, consumers, jobless youth and others will involve and benefited throughout the implementation of the strategy.

8. Crosscutting issues

Gender

While women take an active role in dairy cattle breed improvement, management, processing and marketing of products, their identity as farmers is highly questioned within the livestock development framework in Ethiopia. In addition, women's access to land, technology and decision-making power is critically impeded. Unless these structural and cultural barriers are actively addressed by dairy cattle breeding strategy women's location within the dairy cattle

improvement process will continue to be marginalized hampering efforts to achieve nutritional security and overall growth and transformation.

This strategy will attempt to reduce structural barriers, augmented by local cultural perceptions that have largely precluded women's participation in the dairy cattle breeding process. In addition, women's participation in the dairy cattle breeding through access to breeding technologies and improved genetic materials will be addressed. 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 dairy cattle extension strategies. It also may require finding ways to actively recruit and retain women development agents and dairy cattle breeding technician (AI technician).

Climate change

Climate change is one of the major challenges of our time as it adds considerable stress to our societies and to the environment. The livestock production system contributes to global climate change directly through the production of methane (CH₄) from enteric fermentation and manure management and Nitrous Oxide (NO₂) from manure production (CRGE, 2011, IPCC, 2006). Livestock emissions in Ethiopia are estimated to amount 65 Mt CO₂e in 2010, more than 40% of total emissions in Ethiopia (CRGE, 2011). These emissions from livestock are projected to increase from 65 Mt CO₂e in 2010 to 124 Mt CO₂e in 2030, mainly driven by an increase in methane from enteric fermentation and manure (90% of emissions in 2030). Emissions from manure left on pasture range and paddock account for only 10% of livestock emissions in 2030.

As demand for animal products (meat and dairy products) grows worldwide, every effort must be made to reduce the amount of CH₄ emitted by livestock production. The government of Ethiopia has a target of reducing GHG emission from livestock by 48 MtCO₂e per year by 2030 (CRGE, 2011) without affecting economic development. Mitigation, as a response strategy to global climate change mostly refers to measures that reduce the amount of emissions (abatement) or enhance absorption capacity of greenhouse gases (sequestration) (Lipper et al. 2014, (FAO, 2013a). The potential for mitigation depends on emission levels, technology availability, enforcement and incentives offered. Such actions or measures include adjustments both in technology and practices in order to continue meeting the food demands of the growing population. Experiences from other countries indicated, with genetic improvements and better animal care and health practices it is possible to improve the productivity of each animal,

reducing the overall numbers of animals needed to meet demand and delivering profound benefits for the environment.

Nutrition security

Livestock has been serving as source of nutrient-rich foods products for several million populations. Furthermore, it is the main and priority source of food in pastoral area. In addition, it helps to supplement and diversify the staple crop based diets of the consumers. Milk and milk products, and eggs are mainly the important livestock products used to complement the food value and/or mitigate seasonal fluctuations in grain availability (Randolph *et al.*, 2007).

Milk is considered as a food of high nutrient density, providing essential nutrients which include fat, protein, lactose, calcium, potassium, phosphorus, vitamin A, vitamin B12, riboflavin, niacin and vitamin D. Thus dairy as source of food, regularly supply essential nutrient required for normal growth, health and instigation of mental capacity of future generation.

Thus, genetic improvement of dairy cattle would substantially help to enhance the production and productivity in terms of quantity and quality so that a regular supply of highly essential dairy source food ensured in order to build a healthy and productive society.

9. Monitoring and Evaluation

TABLE 8. MONITORING AND EVALUATION

Intervention issues	Time frame		
	Short-term (2 years 2019-2020)	Medium-term (5 years 2021-2025)	Long-term (5 years 2026-2030)
Development and implementation of breeding program	- Number of breeds identified for dairy genetic improvement - Number of developed breeding program for specific production system or breeds	- Number of functional breeding program - Number of additional breeds identified for dairy cattle genetic improvement - Number of additional breeding program developed and implemented	- Some indicators progress of implemented breeding program (Genetic progress/gain) estimated for specific population - All breeds appropriate for dairy production identified - Breeding program developed and implemented for the rest of all identified dairy breeds
Application of biotechnological tools for genetic improvement, multiplication and conservation	Number of protocols optimized and verified	- Number and type of protocol applied to support breeding programs - Number of wereda practice animal reproductive tools (synchronization, embryo transfer, sexed semen) - Number of breeding programs supported with genomic information	- Measure the contribution of biotechnological tools for genetic improvement - All participant weredas effectively practice synchronization, embryo transfer and sexed semen utilization - All sire selection activities in all breeding programs supported with genomic data
Multiplication of improved dairy cattle	Actions taken to increase number of dairy cattle - number of private multipliers who produce and sell heifers - Number of private AI technicians trained and engaged on breed improvement - Number of community AI technicians trained and engaged on breed improvement - Number of breeds societies established	- Number of improved animals multiplied - Analyze outcomes gained because of multiplications such as milk production - Number of additional private AI technicians trained and engaged on breed improvement - Number of additional community AI technicians trained and engaged on breed improvement - Measure contribution and activities of breeds societies - community engagements on breeding program - measures taken to improve the challenges that hinder breed multiplication and conservation - actions taken to strengthen private and community AI technicians, breed multiplier and societies	- analyze the trend of number of improved dairy cattle and dairy product production, consumption and import - analyze the contribution of private AI technicians for genetic improvement - analyze the contribution of community AI technicians for genetic improvement - Measure contribution and activities of breeds societies community engagements on breeding program - measures taken to improve the challenges that hinder breed improvements

Intervention issues	Time frame		
	Short-term (2 years 2019-2020)	Medium- term (5 years 2021-2025)	Long-term (5 years 2026-2030)
	community engagements on breeding program		actions taken to strengthen private and community AI technicians, breed multiplier and societies
Improving breeding services	- gaps of breeding services analyzed and alternative measures taken to in place reliable breeding services - Performance based incentives for AI technicians devised - Number of AI technicians trained - Number of farmers trained on breed improvement - capacity and gaps of AI centers for efficient semen and liquid nitrogen production and distribution Analyzed and strengthened - number of new AI centers established for semen and liquid nitrogen production and distribution	- Measure changes observed because of in placed breeding services - Effectiveness of breeding service improved significantly - AI course included in university curriculum - Trends of number of AI technicians trained over the year and ratio of AI technicians to cattle population improved - Number of farmers trained across the year and measure the change of farmers knowledge - Measure the change on capacity of production and distribution of AI center (significant change expected) - Dairy farmers have good access for AI services based on farmers satisfaction level study - Dairy farmers have satisfactory access for synchronization, embryo transfer and sexed semen services based on farmers satisfaction level study - number of additional AI centers established for semen and liquid nitrogen production and distribution	- Measure changes observed over the year because of in placed breeding services - Dairy farmers have good access for breeding service based on farmers satisfaction level study - Sufficient and qualified AI technicians available for breed improvement - Sufficient and effective AI centers accessible for all breeding programs
Capacity building	- Number of strengthened nuclease herd (existing) and measure the status - Number of short-term training arranged and number of AI technicians, experts, breeders and actors along the dairy value chain trained - Number of long- term training (PhD and MSc) arranged and experts and breeders trained	- Number of additional nuclease herd established to serve as breeding unit for designed breeding program - Additionally established nuclease herds fulfilled with human and other facilities - Number of additional laboratories established and equipped with modern lab. facilities - Number of additional short-term training arranged and number of AI technicians, experts, breeders and actors along the dairy value chain trained - Number of additional long- term training (PhD and MSc) arranged and experts and breeders trained	- All required nuclease herd established to serve as breeding unit for designed breeding program - All established nuclease herds fulfilled with human and other facilities - All breeding program supported with sufficient professionals - Modern functional laboratories available to support breeding program - Number of additional short-term training arranged and number of AI technicians,

Intervention issues	Time frame		
	Short-term (2 years 2019-2020)	Medium- term (5 years 2021-2025)	Long-term (5 years 2026-2030)
	• Data base and ICT facilities in placed at ranches • Laboratories and offices engaged on breed improvement equipped with facilities and ICT • Clear coordination modalities and roles and responsibilities developed for stakeholders involved in breeding programs	• Information exchange platform established among ranches and national data base and stakeholders • stakeholders involved in breeding programs act according to the roles and responsibilities	- experts , breeders and actors along the dairy value chain trained • Number of additional long- term training (PhD and MSc) arranged and experts and breeders trained • Information exchange platform strengthened among ranches and national data base and stakeholders
Climate change and gender	• Number of intervention options (approaches) devised to enhance Participation of women on dairy production • Intervention option developed to reduce the impact of climate change on dairy cattle • Intervention option developed to reduce the impact of dairy cattle production on climate change	• Number of intervention options devised and implemented to enhance Participation of women on dairy production • Gender disaggregated extension system developed and implemented at different agro-ecologies • Number of intervention options implemented to reduce the impact of climate change on dairy cattle • Number of intervention options implemented to reduce the impact of dairy cattle production on climate change	• Participation of women on dairy production improved significantly because of intervention option and extension systems • Climate smart dairy production in placed

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