East African Community
Lake Victoria Basin Commission

scaleWAYS

Scaling out resilient Water and Agricultural Systems

Scoping Study on the Status and Development Ambitions for Fodder Production in the extended Lake Victoria Basin (e-LVB)

Prepared by VIRED International

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About the study

This scoping study was conducted by the Victoria Institute for Research on Environment and Development, Kenya. It provides the fodder related research of the consultancy services for the 'Scoping Study on the Status and Development Ambitions for Rice Cultivation and Fodder Production in the Extended Lake Victoria Basin (e-LVB) in Burundi, Kenya, Rwanda, Tanzania and Uganda' (REOI - LVBC/SVS092).

The study was performed under the leadership of *Prof J.B. Okeyo-Owuor* and the scoping study team members of the partner states including:
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The scoping study provides key input for 'Scaling out resilient Water and Agricultural Systems (ScaleWAYs)', a collaborative research and implementation project between the International Institute for Applied Systems Analysis (IIASA), the Lake Victoria Basin Commission (LVBC) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The geographic focus of ScaleWAYs is in the extended Lake Victoria Basin (e-LVB), which encompasses the headwaters of the River Nile to its outlet at Laropi, Uganda. The e-LVB is an international transboundary watershed including Burundi, Kenya, Rwanda, The United Republic of Tanzania, and Uganda. The ScaleWAYs stakeholder-based approach has identified two production systems of particular relevance for development and sustainability in the e-LVB, namely rice systems and fodder/livestock systems. This report presents results of the Scoping study of fodder production systems in the main five countries of the e-LVB.

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1 Introduction

1.1 Background

Agriculture is the mainstay in Tropical Africa which hosts some of the world's poorest countries. In this region, the national economies hardly keep pace with population growth even as self-sufficiency ratios for cereals and other staple foods decline. At the same time, most households depend on food aid and imports for survival. The EAC-LVB countries are important livestock production areas in East Africa. However, in some fragile environments with a constant threat by droughts, livestock diseases, and pests, the livestock can still survive. In much of this region, overgrazing and resource degradation affect livestock production, while other regions' apparent potential is hardly used. Overall, livestock productivity and the availability of livestock products like meat and milk for human use are relatively low compared to the other regions globally, even as livestock products are a significant source for subsistence with prevailing low consumption levels. Much of the country's livestock products are imported, making Kenya a net importer of many livestock products. Therefore, the need to enhance and intensify livestock production in the country is obvious.

In the light of a formidable challenge posed by the rapidly growing human population and climate change efforts aimed at intensifying livestock development must be carefully planned considering the high diversity of the natural and human environment as well as the variable agro-climatic conditions within extremes ranging from semi-arid, deserts, humid to natural vegetation and dense rainforests. Also, the intervening highlands and plains in EAC partner states provide different ecologies for human and livestock populations, some of which are yet to be exploited for crop and livestock production. In the past two decades, traditional shifting cultivation in the rain forests and pastoral nomadism in the arid zone dominated most of the country's landscape. Over time, many commercial plantations and ranches have evolved mainly to sedentary farming systems, especially livestock and fodder production systems. The distribution pattern of the human and the livestock populations and the penetration of modern forms of agriculture have been influenced in many ways, affecting over 40% of arable and rangeland.

Livestock production is a form of agricultural output with many facets and manifestations that vary from one situation to another. Livestock production by a nomad who keeps camels and cattle for milk to secure his subsistence is different from a peasant who keeps chicken at home for sale on the market. The various livestock species – cattle, camels, sheep, goats, equines, pigs, and poultry kept in different parts of the region vary radically in their management requirements, production and productivity, and the products they supply /or the functions they fulfil. However, the same livestock species may also be kept for entirely different purposes. For instance, on some farms, cattle are kept producing beef for sale, supply milk, dung for improving soil fertility and provide tractive force in farm work. Besides, the same product and function, say meat for sale, can be provided by radically different management principles. And the roles of livestock are by no means restricted to production. Keeping animals for prestige and the payment of bride price are examples of their role in many parts of Africa. This function permeates the emotional, social and cultural spheres of many African societies.

Livestock production in East and Central Africa countries is also characterized by significant complexity in environment and livestock types, products, functions and management principles, and human sphere interactions. Therefore, livestock improvement efforts are dodged with many problems, and little has been done to improve overall performance levels

due to limited research efforts and poorly understood. The complexity of livestock production and development in the region is hindered by the arid and semi-arid conditions and infestation by tsetse flies and ticks which have been the subject of research and management for many years.

Another critical challenge is suitable fodder availability and quality, especially in savanna grassland and semi-arid ecologies. The most recent aim in livestock production is related to the rapid increase in the demand for livestock products to meet the fast-growing human population and meet the requirements of people with high-income levels. In the year 2007, IFPRI estimated that by 2050, meat per capita consumption would double in the Sub-Saharan Africa region compared to the consumption rates in the year 2000. The situation is also right in the EAC partner states. Recently there was an extraordinary increase in the world prices of many food commodities: the livestock prices, especially dairy products, mirrored rice, wheat, and maize. Therefore, livestock products are now vital food staples. A report by FAO indicates that in ten years (between Jan 1998 and December 2007), the price of whole milk powder rose by a factor of 2.5, and the cost of butter doubled. Although the current economic crisis can slow down this trend, it cannot reverse the nutrition demands driven by millions of new entrants to the middle-class economy in the region and the Middle East. There will be a continued shift away from traditional staples such as roots and tubers, to increased livestock product consumption, particularly meat and dairy products, requiring market opportunities for the livestock sector. Further, the frequent outbreak and endemic nature of livestock diseases in the region's parts pose a significant threat in the export market due to the stringent international food safety standards. However, opportunities still exist in the national and regional markets.

This scoping study report provides valuable scientific information on fodder production systems in LVB-EAC. In the SSA, between 80 and 90% of the poor keep livestock of some type. In Kenya, Uganda and Tanzania, over 60% of animals are held in arid and semi-arid areas, where livestock constitutes the primary asset for more than 90% of the population. Due to the liberalization of the livestock industry in EAC's partner states, many efforts have been placed on livestock production expansion programs. There is an overall policy shift towards privatization and frameworks for private sector operations. In EAC countries, reforms have been undertaken in research, extension, and other livestock production and services sectors. However, not many efforts have been put on improving feed and fodder research and production to address better livestock production adequately. The study's main output is the situation analysis, policy issues, and stakeholder related to fodder production systems in EAC partner states. Data collection methods employed desktop review, focus group discussions (FGD), Key informant's interviews (KII) and field observations in selected study sites in each partner state as agreed in the scientific meeting in Entebbe on 26-28 February 2020. Documents reviewed included published materials and grey literature obtained from the research institutions' EAC partner states.

1.2 Livestock opportunities and prospects in the EAC region

Essential elements in turning livestock or any asset potential to incomes and development are the means of production, production potentials, market opportunities, and how to link potential and possibilities. In EAC, especially the LVB, two issues are worth analysing, i.e., if the livestock asset provides a potential for poverty reduction and livestock enterprises' opportunities to transform such livestock assets into incomes and wealth creation. Therefore, it is crucial to study and understand how much cash income livestock keepers can generate and reduce poverty substantially and sustainably compared to the traditional livestock sector in the EA region. Further, it is worth understanding if the means of livestock production (feeds and

fodder, among others) are sufficient to sustain the production value chain in both the medium and long term. And finally, are the market opportunities for livestock and livestock products large enough to drive the growth of the livestock sectors in the region and sustain the livelihoods of the poor.

1.3 Livestock and Reduction of Poverty in East Africa

It is worth noting that the livestock enterprise can generate higher and more reliable income than most traditional agricultural activities, which offers a good reason for livestock keeping for many households in the SSA region. Therefore, livestock enterprises may increase income levels with improved production systems, processing and marketing (Staal, 1997, MoAC/SUA/ILRI, 1998, Mdoe et al., 2002). But available statistics show wide variation between the actual and estimated number of livestock in the region. Reports from Kenya demonstrate that the dairy herd's size could be twice that given in official statistics (Republic of Kenya, 2006). The livestock census in Uganda has been in progress. It is expected that reliable statistics will gauge the real situation for rural households in this sector. It is estimated that the size of fodder dependent livestock asset in the region comprises 41 million cattle heads, 33 million goats, 14 million sheep, 900,000 camels. It is also worth noting that other livestock such as poultry, pigs, and beekeeping is also crucial for smallholders in the region. Thus, there is great potential for the livestock sector's contribution to poverty reduction if there are profitable and sustainable planning and production systems, including utilization of fodder and other feeds in the region. Currently, the production systems, yields and income levels of fodder-based livestock enterprises in the LVB are relatively low. For instance, on average, beef production is estimated as just below 800,000 MT, mostly from beef cattle in the arid and semi-arid areas and little from dairy cattle. Small ruminant livestock is estimated to yield an average of 130 MT. Since this scoping study is interested in fodder production systems, this report mainly focuses on analyzing cattle and small ruminant production in the EA region. Although enough is known of technical possibilities of livestock production systems, too little of such knowledge has been applied and put into practice (Nestel *et al.*, 1973), mainly on fodder production reasonably justified this scoping study. Some of the information given on policies, strategies, production, and fodder utilization for livestock production may be valuable for refinement and local adaptation in the LVB region. In the region, production systems for livestock and fodder are based on land characteristics and separate ecological zones, i.e., subdivided into arid, semi-arid, sub-humid and humid zones; as well as highland areas which can be more readily translated into production systems and also estimated country by country as provided in this report.

In the EA region, five (5) classes of livestock production systems are distinguished: - Pastoral Range-livestock Production Systems - Crop-livestock Production Systems in the Lowlands - Crop-livestock Production Systems in the Highlands - Ranching Systems, and - Landless Livestock Production Systems. These are summarized below in this report under the 'production and productivity and 'development possibilities' sub-topic mainly based on the livestock in the main categories of large ruminants (cattle and camels) and small ruminants (sheep and goats. Other species are not dealt with in this study. The essential difference between ruminants and non-ruminants is that the former can be fed on roughage. Thereby plant material that is of no direct use for man can be converted into food for man and other useful products. Ruminant animals can also be grouped as grazing animals, i.e., animals that depend primarily on grazing for their feed. The similarity of the feed base ruminants of different size and species into reference units are useful but not used here.

1.4 Livestock production and environmental in arid and semiarid lands (ASALs)

In recent times livestock grazing has been seen causing environmental degradation such as water pollution, deforestation and desertification in Tropical Africa and globally. There have been reports on livestock contributing to the greenhouse effect, declining biodiversity and pillaging grain crops. These are generated by the way livestock has been managed recently, mostly on short-term benefits and unsustainably. In ASALs, the previous governmental owned rangelands which replaced that traditional land tenure; uncontrolled crop farmer resettlements in areas only able to sustain livestock production; repeated droughts; common political interference and also decreased mobility because of increased insecurity have tended to interfere with the traditional ecological balance and limited the regeneration of indigenous pastoral areas. Such short-term production activities have also led to the development of intensive animal production systems with no concern for the environmental impact. (Preston and Murgueitio, 1992).

Nevertheless, according to Sidahmed and Yazman (1994), traditional pastoral systems are stable since they respond to high climatic variability; hence there are good prospects for animal production, which is fully compatible with environmental protection in ASALs of Tropical Africa. Breman and Ridder (1993) found that in ASALs, animal production can be entirely sustainable if some precautions are taken, especially by estimating the carrying capacity taking a dry year as a baseline reference. For grazing capacity, only half of the biomass of herbaceous perennial, and for browsing, only 15 per cent of palatable plants' annual biomass production should be considered available. Other management aspects include fire control (strictly used as a rangeland management tool only when necessary). Surveillance of cattle's presence around villages and watering points and protecting fragile soils during the rainy season may also be considered. In Botswana and Zimbabwe, Abel and Blaikie (1990) confirmed that because the intrinsic resilience of rangeland was not acknowledged, much effort had been wasted trying to stabilize production instead of promoting a "tracking" strategy that better-followed variations in rainfall. Niamir (1991) confirmed that although a reversion to the traditional systems would be ideal, there is still much room for improving existing traditional systems and developing locally appropriate techniques. Galaty and Johnson (1990) reported that, in ASALs, the traditional pastoral regimes are superior to the mixed agricultural systems promoted in the Sahel. Perrier (1990) observed that rangeland management projects hardly succeed due to inappropriate approaches which underestimated the complexity of the local production systems and usually only managed to disrupt these systems, generating conflicts and the deterioration of range management, hence the need to revert this tendency by promoting range management systems such as repeat-seasonal grazing rather than rotational grazing, based on a systems approach (Perrier 1990). This needs a thorough understanding of the local production systems, leading to new prospects arising from innovations in these systems, such as introducing fodder trees, feed supplements, bush, and rice straw.

In reality, in most ASAL areas, the livestock mobility/pastoral system usually implies significant interaction with crop production systems, primarily through manuring contracts between farmers and herders, providing draught animals and utilizing crop residues as feed rather than having a pure livestock production system. Since there are no chemical fertilizers in the ASALs, animal manure helps promote short-cycle crop production and strengthen food security, despite the scarcity of rains. There are numerous positive roles of livestock to the environment that are best demonstrated in integrated sustainable farming systems. For instance, livestock production has less demand for fossil energy compared to a crop production system. Further, the fast-growing world population and grain requirements have led to the conversion

of areas previously meant for fodder to grain growing to satisfy human needs, with livestock relying more and more on crop residues and by-products in some parts of the region. By-products and residue /wastes from livestock keeping are also valuable to environmental quality. According to Devendra, 1992, the different livestock components in a farming system are provided as a) draught animal power, b) fertilizer production, c) Weed control, and d) fuel source.

Other positive impacts of livestock, especially on fragile ASAL ecosystems, ensure much more regular income than from crop production alone and provide small farmers with enough security and no need to expand cultivation. The integration of livestock into crop production systems also offers local labour opportunities, thus reducing the continued rural-urban migration, common in many SSA & LVB countries. Finally, in areas such as southern and eastern African countries, animal production systems, both cattle and wildlife, have shown a sustainability trend by ensuring biological diversity conservation, e.g., in Masai Mara areas and Serengeti National Parks. These areas have demonstrated good coexistence between livestock herds and wildlife. In the Kenya rangelands, McDowell *et al*. (1983) found that converting an existing cattle ranch into one comprising a mixture of game and cattle was the best form of range utilization.

1.5 Fodder and feed requirements of animals

Fodder, a type of animal feed, is any agricultural foodstuff used specifically to feed domesticated livestock, such as cattle, rabbits, sheep, horses, chickens and pigs. "Fodder" refers mainly to the animals' food, rather than that which they forage for themselves. Fodder is also called provender and includes hay, straw, silage, compressed and pelleted feeds, oils and mixed rations, and sprouted grains and legumes. Most animal feed is from plants, but some manufacturers add ingredients to processed feeds of animal origin. Fodder is also known as coarse food for livestock, often considered readily available in raw material and minimal value.

Generally, fodder is composed of entire plants or leaves, and stalks of cereal crops and natural grass fed to domestic animals. The availability of fodder is one of the limiting factors in livestock production. Ideally, livestock husbandry should be mainly based on the fodder produced on the farm itself, and it is work noting that there is a direct link between the feed and the health of the animals. Thus, a diverse and balanced mixture of food is a pre-condition for good animal health, but it is worth noting that both field and zero-grazing have their advantages and disadvantages. It is worth noting that fodder cultivation can also be integrated into the farm without much competition with crop production.

If livestock is to be productive (for milk, meat etc.), they should get suitable food in sufficient quantities. If in some farms fodder production may be limited, it is advisable to keep fewer animals and supply them with adequate nutrition. The appropriate amount and the mix of feed items depend on the type of animal and its primary use (e.g., cattle for milk, meat or draft, etc.). Dairy cows require fresh grass and possibly other feed items of good protein content. It is worth noting that a balanced diet will keep an animal healthy and productive. The quantity and quality of fodder fed to an animal may be seen from the shine of its hair and level of milk or meat production. For ruminants, most fodder should comprise mainly roughage (grass, leaves) which can be supplemented by a variety of leguminous plants rich in protein. If mineral content in the available fodder is insufficient to satisfy the animal's requirements, it would be good to provide mineral supplements containing other additives.

1.6 Fodder production and management systems in Africa

1.6.1 Field or zero (shedding) grazing

In many tropical Africa regions, there occur favourable periods with abundant fodder alternating with less favourable periods when little or nearly no animal feed is available even as animal keeping requires fodder throughout the year. Fodder can be produced on the farm on an annual or perennial basis, fed directly, cut and fed green and cut and preserved for future feeding. In many cases, perennial fodder trees crops are grown, cut and fed to livestock. Livestock grazing requires less labour than zero feeding, more land is needed, and much care keeps the animals from raiding on other crops. It may lead to lower productivity (milk, meat), but it is a better option for animal health and welfare. Shed keeping or zero-grazing allows easy collection, storage, or composting of dung, which can be applied to soils to improve crop productivity. The suitability of grazing or shed feeding/zero-grazing options depends on the agro-climatic conditions, the cropping system, and land availability. Combining both in a fenced area would lead to high productivity and animal-friendly husbandry with extensive grazing, often the most suitable for grasslands or semi-arid regions.

1.6.2 Integrating fodder cultivation in the farm

In most smallholder farms, fodder cultivation will compete for space with the cultivation of crops. These systems' economic and ecological benefits need to be well evaluated on a case-by-case basis. But there exist options for integrating fodder and farm crops without compromising much land, as listed below:

- Grass or leguminous cover crops in tree plantations
- Hedges of suitable shrubs
- Shade or support trees
- Grass on bunds against soil erosion
- Grass fallows or green manures in the crop rotation
- Crops with by-products such as paddy straw or pea leaves

1.6.3 Pasture management and overgrazing

Good livestock management corresponds to good pastures management throughout the year. Many different types of grasses occur and are well adapted to the diverse climatic region. It may be worth ploughing the grazing site during pasture establishment or management and sowing the preferred/appropriate grass varieties for livestock needs. The most common threat to grassland is overgrazing, and if the protective grass cover is destroyed, topsoil will be erosion and pastures or land degraded, making it difficult to regenerate. Therefore, there is a need to critically observe an appropriate carrying capacity, use and intensity of grazing land to ensure high productivity of fodder and livestock products.

Livestock keepers should provide sufficient time for pasture rehabilitation, recovery and regrowth after intensive grazing. Fencing off areas and rotation of the grazing animals on several land pieces will also reduce infection from parasites such as ticks, tsetse and others during grazing periods. The intensity and timing of grazing and the cutting of the grass often influence other types of plants growing in the pasture, some of which may require control or removal. It is also valuable to rehabilitate pastureland with improved grass varieties and legumes for higher yield, higher nutritional value and palatability. Suitable grass species may be transplanted or grown from seed, while legume seeds can be planted between grass lines, and some multipurpose trees can also be planted to provide fodder, fuel, timber and shed.

1.6.4 Fodder and pasture production systems for ruminants

Cattle, goats and sheep are ruminants that depend on foraging worldwide. In tropical countries such as partner states in the LVB, most herds are kept by smallholder, mostly feed on natural green pasture grass and crop residues throughout the year. The fodder/pasture (forage) used in EAC are either annuals, perennials, or permanent vegetation and crops available or grown on arable land. They are grazed or cut and fed to the livestock either green or conserved in hay or silage, among other crop residue mixtures. They may also be grown in rotation with cultivated cash crops. Their high productivity and quality per unit area make them appropriate for small-scale farmers since they provide a) immediate feeding material for the livestock, especially in a zero-grazing system and b) surplus material to be conserved in the form of hay or silage to be fed on in the dry season and feed scarcity. There are also leguminous pastures with high protein content and also fix atmospheric nitrogen into the soil. Short season grain crops like sorghum and maize make excellent silage either alone or intercropped with legumes. The addition of legumes in the fodder crops boosts milk and meat production yields and save on expensive feed concentrates. Some fodder trees may be grown as hedges, or borders between crops will also provide lush and protein livestock feed.

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2 BURUNDI

2.1 The natural environment and climate

Burundi has an incredibly unique environment, with its relief being a characteristic of East Africa's Great Rift Region. It has a very rugged terrain with an altitude varying from 770m at the edge of Lake Tanganyika to 2,670m at the highest point. There are 11 natural regions in Burundi and the country's different provinces: Buragane, Bututsi, Kumoso, Mugamba, Kirimiro, Buyogoma, Bweru, Bugesera, Buyenzi, Mumirwa and Imbo. The 11 natural regions (provinces) of Burundi are grouped into five (5) agro-ecological zones, i.e., the western plain of Imbo, the west escarpment of Mumirwa, the Congo-Nile Ridge, the central shelves and the north-eastern depressions. Climatic factors such as rainfall, temperature and length of the dry season vary from one agro-ecological zone to another. While these natural regions vary climatic conditions and indeed their agro-ecological zones, the uniqueness of natural habitats and the human population influences livestock production systems (Ndayirukiye, 1994).

Rainfall in Burundi varies from 2000 mm in higher altitude to 1000 mm in the North East's depressions (including the Nyavyamo Watershed, the selected pilot project area for this scoping study). Burundi has abundant water resources, thanks to good rainfall and water retention by marshes and lakes. Still, much of these water resources are generally poorly managed in rational and efficient socio-economic use. There are two seasons in Burundi, i.e., dry and rainy seasons, that are sometimes irregular in terms of duration and quantity of precipitation. In general, the country enjoys a tropical climate that varies with the altitude of its 11 natural regions zoned into three i.e.

- A zone with low rainfall, long dry season (6 months) and low altitude (below 1,000 m) covers 7% of the territory in its western and north-western part
- A zone with average rainfall, a dry season lasting less than five months and of average altitude (1,000 m and 1,500 m) which occupies 24% of the territory in the East and North and North-East (Table 2.1)
- A large central zone of high altitude (1,600 to 2,400 m) with abundant rainfall and a short dry season of 3 months that occupies more than 2/3 of the country

The drought phenomena recorded in the Northeast regions have pushed the population to exploit the marshes. The country's forest cover has been low, but the rate had decreased from 8% in 1992 to 6% in 2000. It is estimated that more than 30,000 ha of woodland were destroyed between 1993 and 1996. Burundi has also seen a dramatic reduction in its natural ecosystems under the pressure of poor riverside populations who use them for livelihood, e.g., land clearing (slash-and-burn agriculture), overharvesting and grazing, settlement and bush fires.

Table 2. 1: Climatic characteristics of agro-ecological zones in Burundi

Agro-ecological Zones	**Altitude (m)**	**Rainfall (mm)**	**Temperature (°c)**	**Dry season (months)**	**Percentage of the country area**
Imbo Plain	774 -1000	800-1000	>23	5-6	7%
Western Mumirwa Escarpment	1000-1400	1100-1900	18-28	3-4	10%
Congo-Nile Ridge	1700-2500	1500-2000	10-16	3	15%
Central Platforms	1350-2000	1200-1500	17-20	3-4	52%
Northeastern depressions of Kumoso and Bugesera	1125-1400	900-1200	22-24	5-6	16%

Source: MEEATU, 2005: Description of Burundi: Physical Aspects

2.2 The Livestock Sector in Burundi

Livestock is a key sub-sector and plays an important role in the Burundian economy. In the country, the main products from livestock are milk, meat and manure. In Burundi, the most important types of livestock kept are cattle, goats and sheep. There are also pigs and backyard animals (poultry, rabbits and guinea pigs) and beekeeping. In 2019, the national livestock population consisted of 770,000 cattle, 3,000,000 goats, 350,000 sheep, 540,000 pigs, 400,000 rabbits, 3,000,000 poultry and 250,000 hives. In general, livestock production contributes 14% to the national GDP and 29% to agricultural GDP (DOS, 2010).

In Burundi, manure has become of primary benefit to many farmers to increase agricultural production. The quantity of manure produced from livestock keeping is estimated according to annual manure production by species. According to statistics from the Sectoral Livestock Policy: manure from cattle is about 8 Tonnes/year/head, Goat: 573kg/year /one, Sheep: 573 kg/year/one, Pig: 1777kg/year/one, Rabbit and guinea pig: 104.4kg/year and Poultry: 61kg/year/one (MINAGRIE 1993). It is also worth noting that livestock keeping is one of Burundi's main household strategies for risk management and poverty alleviation. It is estimated that livestock provides an income equal to the poverty line to an estimated half a million people, or 6.5% of the rural population in Burundi's rural areas, even as the exact figures still need to be determined. Table 2.2 shows the situation of milk and meat production in Burundi

Table 2. 2 The situation of milk and meat production in Burundi

Provinces	Qty of milk (litres)	Number of animals slaughtered				
		Cattle	Goats	Sheeps	Pigs	Quantity of meats (Tons)
Bubanza	25081055,5	1092	2923	759	824	236,178
Bujumbura	499803,75	9745	16448	2532	5543	1860,5475
Bururi	1011113	2510	12090	9210	4981	866,7675
Cankuzo	680201	1376	26952	1963	21738	1913,310
Cibitoke	2.239.428	6792	45592	4995	4193	1655,2305
Gitega	1.219.846	4039	251792	113911	922	3873,933
Karusi	837911	880	17969	1627	1390	388,989
Kayanza	42.474.415	228	19977	2172	78369	5520,0285
Kirundo	280926	479	66939	535	12174	1493,676
Makamba	10128	3862	12675	3620	3855	928,2375
Muramvya	3.842.604	4204	38883	2949	5908	1342,818
Muyinga	241096	1596	35478	2967	1626	671,220
Mwaro	1549173	1120	11026	6634	3956	577,170
Ngozi	5304346,5	5507	110648	19874	15190	2943,468
Rumonge	91218	1609	3229	284669	10817	3538,4445
Rutana	134734	1824	20402	1051	2988	670,3155
Ruyigi	402917	1493	24967	1626	1706	556,047
Total	84.755.068,75	48356	717990	461094	176180	29036,3805

Source: Annual Report, Directorate in charge of Livestock 2018 – 2019

Although in Burundi livestock farming involve keeping of large ruminants (Cattle), small ruminants (goats and sheep), pigs, poultry, rabbits and apiculture, this scoping study targets mainly fodder production and use for large ruminants (cattle), and to some extent small ruminants (goats and sheep). Of the four livestock production systems, the traditional Agro pastoral system (SAPT) is the main one, especially for Burundi's cattle production system. The other three methods are the semi-intensive or integrated system, the intensive system, and the intensive dairy system (IDS). They are also becoming a key factor in cattle production,

especially through declining farmland areas and the reduction of indigenous fodder. SAPT is mainly practised in medium-altitude areas with moderate population density, low altitude areas, and high-altitude pastoral areas. Here the leading cattle breeds are Ankolé breed, Ankolé x Sahiwal crosses, and Friesian x Ankolé crosses. Grasses, especially (*Eragrostis olivaceae*), are the primary fodder found in the rangelands that dominate sides and tops, edges of paths, tracks and roads of the mainly infertile highland ecologies. After grazing, the animals return to the barn in the evening for milking and security. These extensive cattle farms contribute 25% of national meat production and 40% milk production (DOS, 2010).

The semi-intensive or integrated system results from a slow but irreversible evolution of the extensive grazing system dictated by the decreasing pasture due to demographic and land pressure, leading to livestock production intensification agro-sylvo-zootechnical integration (IASZ) and the desire to use manure and crop residues for other purposes. This system is present throughout the country except in the Imbo plain, where livestock farming competes with food and industrial crops. The system consists of mainly crosses of Friesian x Zebu, Montbéliard x Zebu, and Ayrshire x Zebu crosses kept in a cement-floor stall enable the collection of manure for farm use. Here the caws are fed on green grass and supplemented with dry and green cut fodder, harvest residues and agro-industrial by-products. This system accounts for 20% of the cattle population and provides 36% of national milk production and 13% meat production (DOS, 2010).

The intensive system is landless livestock (mainly cattle) production system where all feeding inputs are purchased, and labour is paid. Finally, the intensive dairy system (IDS), also called the "zero-grazing system", is also a landless type that is developing around the national capital and the main provincial capitals and is today on the increase countrywide. These farms have an average of 10 exotic (Friesian), or cross-bred cows fed on cultivated green fodder, concentrates and occasionally crop residues. This system contributes about 5% of the cattle, but it provides 23% of the national milk and 5% of the meat production (DOS, 2010). Goat keeping is beginning to be integrated with Agro Sylvo Zootechnical Integration (IASZ). This system produces 17% of national meat production (DOS, 2010).

In Burundi, cattle and goats provide the bulk of the meat supply for the markets. Meat marketing channels are still traditional and informal. Generally, the infrastructure is poorly equipped and rarely meets hygiene and health quality standards, except in the pork sector, which offers processed products (charcuterie) for a minimal market. Post-production activities are limited by transport, rudimentary slaughter systems and processing are absent and inadequate market outlets (DOS, 2010). The milk sector is based almost exclusively on the different cattle breeds. Depending on the farming system, between 30% and 65% of the milk produced is marketed.

In most cases, milk is sold directly by the producer to neighbours without processing. When it is sold to collectors, its artisanal processing is limited to simple heating and transport to markets, and right hygienic conditions are rarely observed. A few collectors make yoghurt before transporting the milk to the consumption areas. With increased support from development partners, more milk collection centres are being installed and functional in different regions. This study found that a UHT unit had just been installed and collaborated with the existing collection centres. Boosted by attractive prices and margins, the milk market has experienced a revival as the collection centres also increase. In densely populated regions, livestock farming in general and extensive grazing, in particular, is declining. Further, if the

ambitious government policy on national reforestation and limiting erosion is implemented by April 2021, extensive livestock farming adversely is affected.
Two types of solutions have been considered in this case and are being studied in Burundi. They are:

a. The integration of livestock farming into agriculture
b. The association of livestock farming with reforestation.

2.3 Cattle rearing systems and fodder production in Nyavyomo area, Burundi

Despite the reducing pastoral areas, extensive livestock farming, especially cattle keeping, remains the most preferred practice by most (70-80%) farmers in Nyavyomo are in Burundi. Most of the pastoral practices occur in areas where land pressure is less intense. However, this practice may decline if the recently enacted law (Law No. 1/21 of 4 October 2018) is put into force by April 2021. The agro-sylvo-zootechnical integration system, common in rural Nyavyomo areas with high land pressure, is a progression from the extensive agro-pastoral system towards intensification, specialization in milk and manure production. It is also characterized by partial stalling. In this system, the integration level between agriculture and livestock enables high manure recovery and is the most profitable investment in cattle and fodder production. It also offers good scope for improving productivity with sustained efforts and reasonable market access in the study area. The intensive dairy system, which is now the highest level of livestock production intensification in Burundi, is not well developed in the Nyavyomo area.

2.4 Challenges to the development of pastoral resources

Burundian livestock farming has evolved from an extensive to an intensive system even as it has been confronted by several constraints, including the shrinking of grazing land due to population growth. Also, there is a gradual reduction in the vegetation species eaten by livestock due to overgrazing and uncontrolled bush fires. Pasture improvement programmes have been undertaken but not in the entire country. Researchers are convinced that in Burundi, including the Nyavyomo area, the pasture is generally poor and cannot increase milk or meat production leading to introducing fodder crops/species in agrostological stations. The introduced fodder species are well adapted to local climatic conditions leading to satisfactory yields, increasing dissemination in many rural areas and small quantities. The introduction of high-performance livestock breeds, especially ruminants, has also forced decision-makers to develop manufacturing units for feeds with high nutritional value. However, this sector has been confronted with the country's low industrialization level, which does not generate enough agro-industrial by-products.

In Nyavyomo, like in other parts of Burundi, cattle keeping is a critical element of household strategies for risk management and poverty alleviation. It provides an opportunity for households to add value to crop residues and kitchen waste, thereby improving agricultural productivity. Similar challenges in the country also exist in the Nyavyomo area. They are summarized as the low genetic quality of livestock, food and water shortages due to climate change, lack of abundant forage species and poor animal health issues. There is also a lack of financial capital for equipment and operation and low capacity and human resources training. Further, the right strategies are needed better to use existing fodder, agricultural by-products and kitchen waste to improve crop and livestock production.

2.5 Natural pastures, type and contributions

During this scoping study, it was found that natural pastures play an essential role in feeding livestock, especially cattle in Nyavyomo and are the primary feed resources for all ruminants. There are, however, varied quality and quantity of the feeds depending on the season, rate of grazing and subsequent regrowth after each grazing seasons. There are also some disparities in the growth and development of natural pastures in Nyavyomo and other Burundi ecosystems. In highly populated areas such as Buyenzi and Kirimiro, ranges are scarce because of limited fallow land and scattered and localized pastures in the slopes bordering marshes and streams. Livestock also grazes on roadsides, embankments and often on farms. However, in low populated areas such as in Bututsi, Buyogoma and Moso, some continuous pastureland still exists despite continued encroachment for extensive agriculture and poor management of some community grasslands.

In the Nyavyamo area, the leading and characteristic grazing areas are briefly described below

a. Bututsi grazing lands. This area was initially covered by rain forest but has been transformed into short Savannah grassland dominated by *Exotheca abyssinica*. According to Vancoppenolle *et al.* (1984), four main types of pasture: (i) Pastures in *Eragrostis-Hyparrhenia*, which is located on medium (5-15%) and low (0.5%) slopes with *Eragrostis olivacea* (50-60%), *Hyparrhenia newtonii* (20%) *and Exotheca abyssinica* (10%) as the main grazing species; (ii) Pastures in *Eragrostis-Hyparrhenia-Loudetia*: located on steep slopes (15-30%) and the edge of hilltops and dominated by *E.olivacea* (70-80%), *H.newtonii* (5%) and *Loudetia simplex* (10-15%). Species such as *Exotheca abyssinica, Themeda triandra* and *Perotis vaginatis* are rare. (iii) Pastures at *Loudetia simplex* is found on hilltops and on outcropping lateritic slabs, which are dominated by *Loudetia simplex* is (30-50%), *Eragrostis olivacea* (25%), *Perotis vaginatis* (15%), *Hyharrhenia newtonii* (1-2%)*.; (v) Eragrostis olivaceae* type pasture dominates the generally acid and eroded areas but has potential for fodder production and pasture improvement since the climate favour cattle production.

b. Imbo grazing lands- the study of pastures in this area began in 1952 by INEAC and was continued by Vancoppenolle and Nyole in 1982. The mapping of Imbo-basse Rusizi was carried out from aerial photographs taken in 1973 and are summarized as (i) Dense Forest grazing with *Hyphaene bengueensis var ventricosa Kirk* covers the saline alluvial soils along the Rusizi River. The upper strata are tree-covered, and the middle strata are shrubby and suffused. On the "cleared" (cleared or burnt) parts, species such as *Hyparrhenia figariana, Hyparrhenia filipendula, Bracchiaria ruziziensis, Setaria longiseta, Sporobolus pyramidalis* and others occur (ii) Overgrazed grass under *xerophytic* groves with the lower razed stratum comprising of low forage value such as *Eragrostis ciliaris, Perotis pantens, Chrysochloa hubbardian,* and numerous *Babantis aegyptiaca.* There are also xerophytic groves scattered within this grassland; (iii) post-cultural grazing areas with *Sporobolus pyramidalis and Hyparrhenia figariana* species found on vertisols with vegetation dominated by *Sporobolus pyramidalis* and various *Hyparrhenia* spp. This takes the form of an open meadow with scattered *Acacia albida* forming the upper stratum with about 1% overlap. There is also *an intermediate stratum (less than 5%)* represented by a few *Balanites aegyptica* scattered here and there within the dominant herbaceous stratum; (iv) The lawn with *Chryosochloa hubbardiana Germain* and *Risopoulous*. It is a short grassland supported by clayey soil and compact at depth. There are two strata: the upper stratum with 10% overlap and the lower herbaceous stratum dominated by *Chrysochloa hubbardiana, Eragrostis tremula, Dactylocteridium aegyptium, Chloris pilosa* and *Setaria pumil; (v)* The wild Acacia hockii pasture is a savannah that develops on soils leached from gullies, slopes and

foothills, which have been cleared or recently burnt down. The upper shrubby and sufficient stratum of 30% cover is essentially *Acacia hockii*. But the lower herbaceous stratum of 50% cover is dominated by various species of *Hyparrhenia* sp. Other species such as *Hyparrhenia spp* also occur in this area, including *Acacia hockii* and *Balanites aegyptica* under which short carpet of *Chrysochloa hubbardiana* extends also exist that are of little interest to cattle grazers; (vi) The pasture with *Hyparrhenia figariana* and *Loudetia arundinacea* is found on rocky soils on the slopes and hilltops and has the appearance of savannah with shrubs and suffrutex which form the intermediate layer and 5% cover. The lower herbaceous stratum, with 40 to 60% overlap, is dominated by *Hyparrhenia spp., Heteropogon contortus, Michrochloa kuntii, Diheteropogon emplectens* and *Rychelitrum repens*. The rugged topography of the area makes this pasture unattractive for cattle.

c. The ravine pastures are found on the area's rugged topography and are of limited interest to pastoralists. The gully tops are bordered by a short lawn of *Chrysochloa hubbardiana,* which is of no interest to livestock. The steep slopes and cliffs support vegetation where woody species such as *Sanseveria Dawei stapf, Jasminum eminii Gilg, Scadoxus multiflorus* are abundant. Only the gullies' bottoms, with varied grass cover of *Brachiaria ruziziensis, Chloris gayana, Sporobolus pyramidalis, Hyparrhenia figuriana, Hyparrhenia filipendula, Heteropogon contortus, Panicum maximum* found in 235 ha are useful but are inaccessible for cattle.

d. Cynodon nlenfuensis vanderyst grazing is from rudimental vegetation heavily degraded in former livestock cattle gathering Kraals and the upper shrubby of *Acacia sieberana, Balanites aegyptica, Hyphaene benguelensis var ventricosa, Euphorbia candelabrum,* some of which are used as shades. The herbaceous vegetation of more than 90% cover mainly comprises *Cynodon nlenfluensis vanderyst and Eleusine indica*.

e. Flooded temporary pastures with *Sporobolus pryramidalis* and *Balanites aegyptiaca* are found on vertisols with a broad depression and shallow slope. The upper stratum is composed of suffrutex and shrubs (mainly *Balanites aegyptiaca* with 10% overlap), and the lower stratum is herbaceous, dominated by *Sporobolus pyramidalis* with an overlap of about 50%. This pasture is of little interest to livestock as it is underwater throughout the rainy season.

f. The marshland pastures are drying up and are draining on vertisols are colonized by plant species of the pasture type. Towards their periphery, the floristic procession becomes rather ruderal and post-cultural in character: woody plants reappear (Balanites and Acacia) under which a dense carpet is spread out, dominated by *Cynodon nlenf*luensis accompanied by *Sporobolus pyramidalis, Plucea ovalis, Hyparrhenia rufa* and *Chloris gayana*.

g. Pastures under *Hyphaene benguenlensis* and *Hyperthelia dissoluta* occurs on light, sandy-clay soils and is scattered with numerous *Hyphaene benguelensis* and a multitude of *xerophytic* groves with the shrubby and sufficient intermediate stratum of a 30% cover and the herbaceous lower stratum (30% cover) is dominated by wild *Stylosantes mucronata* and other dicotyls not grazed by cattle.

h. Temporarily flooded pastures at *Mimosa pigra and Oryza longistaminata* consist of a set of more or less extensive beaches scattered in depressions on vertisols within the *Chrysochloa-Bulbine* association. The suffrutescent stratum (1-50% overlap) contains species such as *Mimosa p*igra, *Mimosa investa, Hygrophyla auriculta* and an herbaceous stratum (60% overlap) containing other species.

i. Grassland with *Sporobolus spicatus (Vahl) Kunth* grows on low permeable alluvium and is characterized by high salinity. Species such as Sporobolus spicatus are sought after by cattle, which keep them short. The floristic procession includes Sporobolus

spicatus, Chrysochloa hubbardiana and Eragrostis ciliaris, which constitute the only herbaceous stratum of 0.1 m height and 50% overlap. At present, these grasslands are not of great interest to livestock; however, some bare beaches, particularly saline, are still exploited by pastoralists who collect the surface layer to give to the livestock as a mineral supplement.

j. Buyogoma grazing lands- Few studies have been carried out in this natural region. Investigations by Nigarura (1991) identified four types of pastures (i) Pastures with Melenis minutiflora associated with woody plants (Katshya africana and Triumfetta flabellatopilosa) and a legume (vigna unguiculate); (ii) Pastures with Hyparrhenia diplandra associated with Triumfetta flabellatopilosa and a legume Indigofera sp. (iii) Pastures with Eragrostis olivacea associated with Lantana Camara and a legume Eriosema lebrumii; and (Vi) Pastures with Hyparrhenia-Eragrostis.

k. The Moso grazing lands - The Moso region is an area that still has grazing land, and the extent of rangelands was estimated at 287 000 ha in 1970 (Ministry of Planning, 1970). Still, it is not sure its value for livestock grazing (ISABU-MOSO 1979) shows a very high floristic richness with the presence of at least 300 species. Besides, the presence of relatively rich pasture species such as *Panicum maximum, Themeda triandra, Hyparrhenia filipendula* is worth noting. But species common to degraded soils such as *Loudetia simplex, Exotheca abyssinica, Micochloa kunthii* also exist in the area. Degradation is mainly due to overgrazing and bush fires caused by transhumance.

l. The Mumirwa grazing lands- The shrubby savannas with *Hyparrhenia diplandra and Pteridium aquilbinum* show all degradation stages: *Loudetia simplex, Eragrostis racemose, Monocymbium ceresiforme*. Because of both the population density and the soil topography characterized by often steep slopes, the development of pastoral resources to support only intensive livestock farming is still possible, i.e., the introduction of fodder capable of growing in Mugamba and Imbo. This relatively fertile region of transition between Mugamba and Imbo offers an abundance of fodder's cultural advantage.

m. The Mugamba grazing lands. This region is covered with pastures with *Exotheca abyssinica* and *Eragrostis blepharoglumis*. These slow-growing pastures of low nutritional value (proliferation of *E.blepharoglumis*) do not provide an adequate ration in dry periods. The improved Mugamba rangelands' management remains a suitable area for introducing new fodder species and genetically improved animals in permanent stabling; in some corners, semi-permanent stabling is still possible.

n. The Bugesera grazing lands (including the pilot area of the project*)*- There are shreds of wooded pastures at Acacia sieberiana dominating a grassy mat of *Brachiaria sp*. (Study of the Livestock Master Plan dossier n°3, October 1997). In this region, permanent stalling remains the only method of rearing livestock. The development of irrigation infrastructures in the dry season and suitable watering such as the region is often threatened by drought.

2.6 Fodder production systems in Burundi

a. *Native fodder and its importance*. At present, except for a few regions where the natural grass is varied (quackgrass, wild Desmodium, *Chloris gayana*, hyparhénia), natural pastures alone can no longer cover the needs of ruminants. The exploitation of crop residues (rice straw, wheat straw, maize straw, sorghum straw, sweet potato cords, bean pods, peanut remains) is of short duration, considering that appropriate conservation techniques are not yet available for many farmers. Improved fodder crops were introduced in Burundi in the early 1970s at the same time as the IASZ systems. Under the impetus of research services (ISABU, mainly) and development projects, they have

widely spread and are now an integral part of the Burundian landscape. For many years now, research has made precise recommendations on the forage species (grasses and legumes, herbaceous and shrubs) that are best suited to the country's different conditions. The most widespread fodder species are *Trypsacum* and *Pennisetum* (Bana grass) for grasses and Calliandra, Leucaena and Mucuna for legumes. The national livestock restocking programme allowed the acquisition of one animal under the conditions of having 0.1 ha of crops or 2 km of crop length (it is a simple calculation because in the association Agriculture - Livestock due to the exiguity of the land we cultivate on the contour lines: 50 metres length and 20 metres between the contour lines are then calculated to make the equivalent in Ha and Km). Fodder, in the case of cattle and 0.05 ha or 0.4 km in the case of goats. The 2019 FGD data for forage crops on agri-livestock producers are estimated at 19750 ha and 2122 km on the contours. Thus, taking a conservative estimate of the rate of ABPs and IPAA for national food is 30%. These resources' contributions to animal feed can be estimated based on national crop production by applying the appropriate processing coefficients.

b. *Improved fodder and its importance.* Today, improved fodder wins over natural fodder. Indeed, with the galloping demography, pastures are almost exhausted to make way for food crops. It is with the progress of research (ISABU) and the technical and financial support of development projects that the government has succeeded in popularizing improved fodder crops such as grasses providing more UF, *Trypsacum Laxum*, *Setaria sphacelata, Pennisetum purpureum* and Bana grass and Calliandra, Leucaena, Mucuna for legumes providing more MAD, and the use of crop by-products. These other fodders are most of the times fed to the animals in a green state and provide the animals with different UFL and MAD (Local Fodder Unit and Digestive Nitrogenous Material) according to their growth stages.
c. *Vegetable by-products as fodder*. With the small size of pastures, crop by-products (rice straw, wheat straw, maize straw, sorghum straw, sweet potato cords, bean husks, peanut remains) are increasingly being used as animal fodder. However, as their use and conservation methods are not yet clearly understood by many livestock farmers, their exploitation is insufficient and is of little benefit. It would also appear that many of these by-products have high fibre content, low nitrogen value, deficient mineral and vitamin value. SPA agricultural by-products and SPAI (Agricultural by-products SPA and Industrial Agricultural by-products SPAI) such as rice bran, wheat bran, maize bran, palm kernel cake, cotton cake, etc. are widely used to supplement fodder in ruminants and monogastric livestock farming to catalyze and correct the low nutrient content of ingested fodder.
d. *Fodder storage and marketing*. There is an almost total absence of fodder preservation techniques such as silage, tedding, urea treatment of different kinds of grass and kitchen scraps. Therefore, the forage deficit during the dry season is usually very remarkable. This leads to a significant drop in production and economy. Green fodder and industrial, agricultural by-products (SPAI) are sold and bought in large quantities with higher prices during this period. The SPAI is used as a supplement concentrate, making up for the large protein deficit due to the fodder's low quality undergoing drought.

2.7 Institutional and policy frameworks

Current policies place great importance on the system of intensification and agro-sylvo-zootechnical integration. They, therefore, put particular attention to the crossing of local breeds with more efficient breeds, especially for cattle and, to a lesser extent, for goats and sheep. The promotion of feed is based on improved and cultivated fodder, the valorization of agricultural

and agro-industrial by-products. As a result, the Law on Permanent Stabling and Prohibition of Ravaging of Domestic and Backyard Animals was introduced and enacted in 2018.

Strategies linked to livestock breeding promotion through fodder production

Livestock feeding is the main limiting factor for livestock intensification. Burundi's extension efforts focus primarily on the promotion of improved and cultivated fodder-based feeding (grasses and legumes); diversification of fodder crops and food resources; raising awareness among agro-pastoralists on fodder management and conservation techniques; the valorization of agro-industrial by-products and farm by-products; the use of quality concentrated feeds and the improvement of animal watering conditions (collective or individual).

The law on permanent housing and the ban on domestic animals' roaming and farmyard animals is done through livestock farmers. Simultaneously, existing breeding centres and cooperatives are equipped with seedlings and cuttings for fodder species. Through the ministry of livestock and all the projects intervening in the livestock sector, the government is responsible for distributing them to the farmers. The ISABU carries out routine work on the agri-livestock disseminated scientific information on fodder crops' regional and climatic adaptation, especially improved fodder crops and techniques for use and conservation. Improvements ate also done on the value of natural pastures by introducing some fodder species such as *Desmodium intortum*, *Pueraria phaseoloid*, *Centrosema sp*, *Styosanthes sp*, etc., as well as organic manure. Hopefully, this will lead to the transformation of animal husbandry practices with the following priorities: stabilizing livestock production systems, ensuring confinement in traditional/family livestock management systems, watering animals in stall/confinement, and ensuring good feed management and food resources. This gives the priorities for expansion and diversification of fodder crops, the valorization of local food resources (SPA, SPAI), the development of public-private feed mill capacities, optimization of feed rations, environment protection (soil conservation measures).

Existing institutional and policy frameworks related to fodder production systems

The Livestock sector is managed by the Ministry of Agriculture and Livestock through its Directorate-General for Livestock at the central level. This Directorate-General operates through its three Directorates which are:

- the Directorate for the Promotion of Animal Sectors,
- the Directorate for Animal Health and
- the Directorate for the Promotion of Halieutic Sectors.

At the decentralized level, the Directorate General of Livestock relies on 17 Provincial Offices of Agriculture and Livestock via the Provincial Livestock Services. These are, in turn, supported by the communal veterinary services. Other actors operating in the sector are agri-breeders, progressive breeders, livestock traders, pharmacists, international and regional organizations and NGOs, academic and research institutions, livestock professional associations, private breeders, butchers and processors of animal products.

Existing institutional and policy frameworks and strategies to support or limit fodder production and use

The measure in place that promotes rice and its livestock farming products originates from the national programme to develop pig and poultry farming. Their diet is based practically on agricultural by-products (SPA) and industrial agricultural by-products (SPAI). The latter is mainly composed of rice bran, wheat bran, etc., which are used to feed the pigs. Further through

support by IFAD's PNSADR-IM programme, the Government has trained 15 Master Trainers who will practice the Field School Producer (FSP) approach in livestock farming. This research and development approach teaches farmers to discover their problems and find the necessary solutions. In this framework, they learn by practice how to make rice by-products profitable to multiply fodder crops.

The livestock sector is managed by the Ministry of Agriculture and Livestock through its Directorate-General for Livestock at the central level. This General Directorate operates through its three Directorates, i.e., the Directorate for the Promotion of Animal Sectors, the Directorate for Animal Health and the Directorate for the Promotion of Halieutic Sectors. At the decentralized level, the Directorate General of Livestock relies on 17 Provincial Offices of Agriculture and Livestock via the Provincial Livestock Services, supported by the communal veterinary services. Other actors operating in the sector are farmers, progressive livestock farmers, livestock traders, pharmacists, international and regional organizations and NGOs, academic and research institutions, livestock professional associations, private livestock farmers, butchers, and processors of animal products.

Overview of policies and strategies for fodder production systems and related aspects of water management

The Ministry of Environment, Agriculture and Livestock is implementing its soil protection policy while at the same time digging contour lines to reduce soil erosion and on which fodder grasses and fodder shrubs are planted. Therefore, it is proposed to review existing and develop new policies and strategies in rice and fodder production, which will be reported later. There is progress or changes related to water management issues. For instance, animal watering needs to be much better considered and addressed in support programmes. In addition to related health problems (deficiencies, ionic imbalances, parasitism, etc.), water constraints, feed consumption and feed efficiency, and productivity.

2.8 Approaches to increase fodder production

i. Introduction of new forage crops

Grassland research has been entrusted to the Agronomic and Zootechnical Research Institute (IRAZ) and the Agronomic Sciences Institute of Burundi (ISABU). There is a good collection of forage grasses and legumes in the fields and Agrostological Gardens of the ISABU.

ii. Production of seeds, plant material and necessary seedlings

There are seeds and other planting materials of many fodder species produced and distributed in the country. These include particularly legumes and chips or cuttings of *Penissetum, Panicum, Brachiaria and Tripsacum,* for which demand is still growing. On the other hand, many species are currently collected in small quantities of seeds for research or even simple maintenance. Fodder seed multiplication has been carried out at the Mahwa and Mosso stations.

2.9 Problems associated with fodder production and food balance sheet

a. ***Evolution of pastoral resources and pastoral fodder* balance**

Data on the evolution of pastoral resources are scarce, incomplete and hardly precise. However, information on declining natural pastures and their substitution by food crops under the influence of land pressure is indisputable. According to the Burundian Economic statistic Institute (ISTEBU), between 1969 and 1997, pastoral areas decreased by 400,000 ha, while sites devoted to food and industrial crops and afforestation increased by 425,000 ha. The reduction in pastoral regions during the period 1991-2002 would have reached 6% per year. Available data from FAO on anthropogenic pressure on pastures show general declining trends

of pastoral areas at 1.5% per year from the early 1950s. This trend appears to have upset the balance between feed requirements and pastoral resources for ruminants since the 2000s.
The reduction in pastoral areas has reduced the feed value of natural pastures and lead to profound changes in the way herds are managed. The main reasons for the decrease in the grazed areas' feed value were overgrazing due to reduced space and loss of animal mobility, and substitution of pasture for food crops. The changes in the floristic composition of the grazed areas already reported in the 1994 Livestock Master Plan have visibly continued. Currently, the average productivity and feed value of dry fodder of pastureland are about 1.6 tonnes of dry matter per hectare (MS), 0.55 Fodder Unit (UF) and 30 gr of Digestible Nitrogenous Matter (DNM). The 2007 pastoral balance sheet was established by considering the average productivity and feed value per hectare of pastures according to the seasons and based on the average feed requirements of ruminants in UF and MAD. According to the estimates made, the pastoral balance sheet, excluding fodder crops, is in deficit whatever the season. The shortages are 78% for UFs and 82% for requirements for MADs. At present, natural pastures alone can no longer cover the needs of ruminants.

b. ***Pastoral and water resources balance***

Burundi has three categories of water resources, including surface water (from lakes and rivers), groundwater and rainwater, all of which contribute to livestock watering. Therefore, the country has real advantages in water availability and distribution for livestock production. Water management and forage production go hand in hand. Water management directly stimulates the establishment of fodder crops through the three categories of water resources in Burundi (rainwater, groundwater and surface water); rainfall contributes to fodder availability at a very high percentage, unfortunately, estimated statistically. The fodder resulting from the contribution of surface water, therefore by irrigation, is in the category of SPA and SPAI.

2.10 Critical market structures for the fodder and livestock sector

For the law on permanent animal housing to come into force, the government sensitises all farmers to produce a lot of fodder to sell it to livestock farmers who need it. Similarly, fodder grass conservation techniques that are being popularized will enable fodder to be marketed during the dry season. The means of marketing livestock products mostly concern milk, for which there are milk collection centres throughout the IFAD funded project area: IFAD, in its development projects in Burundi, integrates the livestock component of all categories (cattle, sheep, goats as well as the lower court, etc.). These are supply points for local milk traders. There are also a few milks processing houses where milk can be sold as yoghurt, cheese, etc.

2.11 Stakeholders/main actors, roles and who can participate in fodder CoP

The livestock and fodder production value chain in Burundi exists and expands with increasing interest in this sector. The MINEAGRIE and Livestock Directorate are policy and decision-making bodies. They also have the roles of setting coordination and regulation mandates for the industry. They function to align and seek funding to support development projects in the agricultural and livestock sector. The Provincial Directorate in charge of Agriculture and Livestock (BPEAEs and related institutions plans, regulates and executes livestock production programmes. Research in Burundi is carried out through ISABU, the University and other individual people. ISABU and the University Research Institute are also research institutions for promoting livestock, hillside cooperatives, private individuals and trade in husking machines, among other things. Development partners support several development projects such as IFAD, World Bank, ADB, etc., whose roles are worth mentioning. There are also NGOs and other development partners interested in the forage production chain. Many of these

stakeholders can be part of ScaleWAYs Community of Practice (CoP), and their role in fodder production systems is essential. A structured list of key institutions and individuals at both basin and country-level is provided in Table 2.3.

Table 2. 3 List of key stakeholders/main actors, their roles and participation potential in CoP for fodder production value chain

Stakeholders/main actors	Roles/responsibilities	Participants in CoP
MINEAGRIE	A decision-making body (Coordination - regulation); development projects involved in the agricultural and livestock sector	---
Provincial Directorate in charge of Agriculture and Livestock (BPEAEs)	Regulates and executes production programmes	**X**
ISABU	Conduct research for the promotion of livestock & fodder production, s research	**X**
University Research Institute (researchers)	Conduct research in livestock and fodder production systems	**X**
Development project partners (IFAD, World Bank, ADB...)		**X**
NGOs and other development partners in the forage production chain	Support livestock & fodder production systems-implementation, seed production, training and marketing	**X**
Hillside cooperatives	Support farmers in production and marketing	----
Private farmers (individuals)	Farmer to farmer production & extension activities	---
Traders with husking machines	Buy and sell milk and fodder and processing machines	**X**
Researcher (see list of participants in Entebbe 26-28.2.2020 meeting	Researching fodder/livestock	**X**

2.12 Gender aspects in fodder production systems

In Burundi, it usually is women who take care of the field and household chores. Fodder production work includes planting shrubs, multiplying cuttings and stumps, and setting up fodder fields. At each stage, a woman is active and often takes the lead. The role, benefits and burdens of men, women and youth in fodder/animal production systems vary considerably. In fodder/animal production systems, women and children are involved in monitoring, weeding and are mainly responsible for cutting, transporting and distributing fodder to feed livestock. On the other hand, men (whether elderly or young) care for long-distance livestock grazing, fodder management, and fodder and livestock security.

2.13 Potentialities of the agricultural/livestock sector.

Despite the predominance of subsistence farming, which is facing severe constraints, Burundian agriculture has real potential, which, until 1993, enabled it to maintain a relative balance between population and production growth.

The most important of these are in particular:

- Fertile land with good agricultural production potential and which can quickly be intensified, particularly in the natural regions of Imbo, Mumirwa, Buyenzi, Bweru, Bugesera, Moso and part of Kirimiro.
- a young, large and hard-working population capable of providing abundant agricultural labour.
- generally, abundant rainfall spread over 6-9 months a year, a mild and varied climate allowing a wide range of fodder crops to be grown (tropical and temperate crops).

- a very extensive hydrographic network enabling a third crop to be produced and obtained in the lowlands and marshes in the dry season in addition to two harvests obtained in two seasons a year on the hills.
- a remarkable diversity of fodder species and crops cultivated in the different natural regions of the country.
- Experienced technicians in the agricultural sector (about 8,000) are deployed in the field, and some still outside the country.
- a dense network of communication routes in relatively good condition.
- the emergence of the private sector and community associations for production and agricultural supervision.
- the capacity of rural populations to adapt to the new liberal environment and to organize themselves into associations to better manage the activities for which they are responsible (management of livestock credit as part of the community solidarity chain, water management and maintenance of irrigation infrastructure, etc.).
- the good willingness by farmers to adapt and apply modern production technologies, including for livestock and fodder production systems in permanent stalls (zero-grazing system).
- the possibility of increasing productivity through intensification, as current yields are still far below potential yields.
- the enormous deposits of limestone, dolomitic and phosphate rocks available in the east of the country in the Moso natural region, in the west (Bubanza and Cibitoke provinces) and the north (Ngozi and Kayanza provinces), the exploitation of which would provide the necessary amendments to improve acid soil fertility. Such potentialities of red soils appreciated by cattle are possible in the project area since these cases existed around the 1970s - 1980s; research can reveal/identify these sites, saline soil

With well-focused research work and proper exploitation of available livestock and fodder germplasm, it is undeniably to find opportunities to revive and modernize the sector.

2.14 Potentials for developing local fodder resources

The conservation of fodder is necessary in animal husbandry as it allows fodder to be available at all times. ISABU has experimented with many improved fodder crops. Several fodder species have shown more promise in terms of biomass productivity.

In the current context of the dynamics of agricultural systems in Burundi, it is clear that little attention is being paid to the importance of fodder crops. The new law on the permanent stalling of all livestock makes the practice of fodder crops and the development of all local food resources almost obligatory. From the point of view of the overall integration of livestock farming into agriculture, the promotion and intensification of fodder crops must be a priority to solve the problems of animal nutrition and, subsidiarily, because of their complex impact, fodder crops constitute a vital link in the sustainable management of natural resources. The abundance of fodder induced by fodder crop intensification is directly related to fodder storage systems in periods of abundance. Conventional forage conservation techniques refer to hay and silage making whose datasheets have been developed with conservation techniques variations. From silage in tower silos, sliced silos to silage in plastic tubes. The same applies to hay. However, we have to admit that these techniques are not very popular among farmers, whose need is more pressing than ever.

a. Legume hay

The development of livestock farming seems possible under the conditions of a better choice of fodder species adapted to local possibilities and better reasoning for the use and

supplementing of local fodder supplies and, in particular, the use of the by-products of food crops available on farms. The presence of legume tops (beans, niébe, pigeon peas, etc.) should be noted in most farms. Studies have shown that legume tops are an excellent fodder supplement for ruminants. But unfortunately, the finding is that most of the leaves go up in smoke after harvesting or are used as bedding.

b. Cereal straws (wheat and rice)

Cereal straw is the fodder that should not be neglected. Despite their low energy value and almost zero nitrogen value, they can be the basis for feeding animals with minimal needs. Depending on the crop, wheat and rice straws are the most available. The volumes of straw generated by rice and wheat crops are significant. However, it is a minimal quantity of straw that is used as animal feed. Studies on their chemical composition have shown that they have a considerable fodder value. Alkali-based treatments have been proposed to increase their nutritional value. However, little extension work has been carried out in this direction.

c. Valorization of the leaves of shrub legumes

Shrubby fodder legumes have long been popularized in Burundi. Calliandra, in particular, has spread throughout most of the country. Their leaf biomass production is very high. However, it is with regret that they are used more as stakes or firewood than cattle feed. Often used in the fight against erosion, it is advisable to initiate actions to harvest and preserve legume leaves to facilitate storage and allow exchanges between producers and breeders. It is also essential to use them as ingredients to formulate rations for all types of animals (chickens, pigs, rabbits.)

2.15 Nyavyamo Watershed- the pilot project for fodder intensification

a. Description of the fodder site landscape

The ***Nyavyamo Watershed*** is located in Kirundo province, with rich vegetation found in both the protected areas and around the Cohoha and Rweru lakes. In the protected areas, the following types of vegetation can be found: *Accacia gerrardi*, *Acacia polycantha*, *Bredelia atroviridis*, *Acacia meansis*, *Albizia sp*, *Ficus sp*, etc. Some are used as livestock feed, especially cattle, goats and sheep during the dry season. Table 2.4. below gives an estimated number of ruminants in the Nyavyamo watershed.

Table 2. 4 Estimated number of ruminants in the Nyavyamo watershed, Kirunda Province.

Commune	Cattle	% Of Cattle	Goats	% Of Goats	Sheep	% Of Sheep
Kirundo	5467	20	20 714	12	812	9
Ntega	2519	9	20 849	12	2285	24

Source: Kirundo Provincial Agricultural Investment Plan (PPIA), April 2013

It should be noted that the number of staff has increased in recent years, so a survey is essential.

- The types and species of fodder from food crops in the pilot project area are mainly the remains of sweet potatoes, rice, beans, sorghum, but after harvesting. A project for sunflower dissemination and oil processing produces residues that are used as animal feed.
- The system and use of fodder remain traditional; the fodder described above is supplemented in some cases by frequently cultivated fodder crops such as *Pennisetum, tripacum*, sétaria, fodder harvested on the spot, spontaneous fodder harvested in the fields as well as crop residues are directly distributed to domestic animals.
- Potential for sustainable intensification options for fodder/animal production: Full watershed management of the pilot project area is necessary since the watershed

overlooking this area is undeveloped. This development will play multiple roles, diversification by planting many fodder species, protecting rice from flooding, managing rainwater conservation, and improving its quality and quality. An assessment of the length of the catchment area as well as the fodder species requirements is essential.

Socio-economic and technical factors influencing livestock and fodder production

a. Marketing opportunities: Farmers in the Nyavyamo watershed area need capacity building to improve farming and livestock practices to transform from self-subsistence farming and livestock to the modern market system produce high quality and marketable livestock products and fodder. The area has suitable land, labour and water resources that can be capitalized on and made profitable provided there are appropriate technologies for exploiting and transforming available resources and markets. The technical and socio-economic factors or that limit fodder production are:

- Access to infrastructures and technologies: infrastructures, especially roads, need to be improved and rehabilitated. Access to infrastructure and technologies: The infrastructure, especially roads and energy, are inadequate in the area.
- The specific livestock and fodder production practices are still mostly traditional in this watershed pilot project zone, and only rice cultivation is planned for the area since. Here rice is cultivated twice a year, from January-February to harvest in May-June, the second season July-August to harvest in November and December. Other crops are grown traditionally and are prone to climatic risks, and the production remains low. It is necessary to improve the cultivation methods and to follow the meteorological information.
- Production efficiency, demand, and marketing: production can be efficient if new agricultural techniques are disseminated and popularized in the communities. The pilot area of the project needs both technical and financial partners to improve production.

It is well known that this province is the breadbasket of the country since the 1990s, and the Nyavyamo marshland, with its water availability and its watersheds, will be valuable for the intensification of livestock farming through fodder production in the area. Marketing is complementary and a consequence, improved and intensified production systems for fodder and livestock. This factor will be driven by the new policy prohibiting extensive production systems and promoting intensification.

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3 KENYA

3.1 Introduction

In Kenya, livestock production is a vital part of the agricultural sector. The sector employs 50 per cent of the farm labour force and generates many jobs along the value chain. About 60 per cent of the livestock population is found in the arid and semi-arid lands (ASALs), where 90 per cent of the people raise animals for milk and beef production. In the high rainfall areas, the sector provides employment and income mainly through dairy, poultry and pig production (GoK, 2019). The dairy sector is a significant source of jobs in rural areas, with small scale farms being prevalent and producing about 80 per cent of the total milk in the country (GOK, 2017).

Regarding private sector employment in 2019, the leading industries, manufacturing; agriculture, forestry and fishing; and wholesale and retail trade and repair of motor vehicles, accounting for 15.9, 14.4 and 13.0 per cent of the total private sector employment, respectively, despite a suppressed growth in agriculture, forestry and fishing industries resulting from changing and unpredictable rain seasons, which greatly affected farming activities (GOK, 2020).

The livestock sector accounts for about 4.4 per cent of the country GDP (USD 3.4 billion in 2017) or about 14.2 per cent of the agricultural value added (GoK, 2018). Due to expanding urbanisation, a rising middle class and export opportunities in the region, there is a growing demand for milk. This growth attracts domestic and international private investors seeking to seize business opportunities in the domestic and export markets (Business Daily, 2016). The livestock sector contributes about 2 per cent of the country's export earnings. About 3.6 million households keep cattle, contributing from 40 to 73 per cent to their total income (FAO, 2019). Dairy, beef and chevron account for about 30, 15 and 26 per cent of livestock export value.

The quantity of formally marketed milk increased by 5.3 per cent from 634.3 million litres in 2018 to 668.2 million litres in 2019. The dairy sub-sectors improved performance supported the agricultural sector's growth indicated by the volume of milk deliveries to processors, which increased by 5.3 per cent from 634.3 million litres in 2018 to 668.2 million litres in 2019. Other exported products include hides and skins and live animals. Kenya imports low volumes of livestock products and live animals (FAOSTAT, 2019). Cattle products, beef and cow milk contribute almost 80 per cent of all meat and milk consumption. Market transactions are primarily in urban areas as self-consumption of animal source foods dominates in rural areas.

Table 3.1 shows the details of livestock slaughtered and dairy products from 2015 to 2019. The value of livestock and livestock products increased marginally from KSh 146.8 billion in 2018 to KSh 147.9 billion in 2019. The number of cattle and calves slaughtered rose by 10.8 per cent from 2,781.7 thousand in 2018 to 3,080.8 thousand in 2019. Similarly, the total number of goats and sheep delivered to slaughterhouses increased by 10.3 per cent from 10,247.6 thousand in 2018 to 11,302.7 thousand in 2019. The number of pigs slaughtered increased by 6.5 per cent from 388.2 thousand heads in 2018 to 413.5 thousand heads in 2019 (KNBS Economic Survey, 2020).

Table 3. 1 Livestock Slaughtered and Dairy Products, 2015-2019

	Unit	2015	2016	2017	2018	2019*
Recorded Milk Production	Mn. Litres	615.9	648.2	535.7	634.3	668.2
Milk Processed						
Milk and cream	Mn. Litres	437.9	448.6	410.6	468.4	491.8
Butter and ghee	Tonnes	1,646.4	1,444.9	1,127.3	1,249.4	1,013.4
Cheese	Tonnes	302.9	311.2	338.3	384.3	305.4
Livestock Slaughtered						
Cattle and Calves	'000 Head	2,274.5	2,460.2	2,590.0	2,781.7	3,080.8
Sheep and Goats	'000 Head	6,560.8	8,220.2	9,206.7	10,247.6	11,302.7
Pigs	'000 Head	282.9	313.6	360.1	388.2	413.5

Source: Kenya National Bureau of Statistics, Economic Survey 2020 (* Provisional)

3.2 Livestock production systems

Kenya has about 18.8 million cattle, 76 per cent are beef cattle, and 24 per cent are cows. Beef is mostly produced in arid and semi-arid areas (ASALs), where about 36 per cent of the Kenya population live. Dairy production is concentrated in high potential agro-ecological zones where fodder and pastures are available. Livestock production systems in Kenya occurs in a wide diversity of agro-climatic conditions and related altitudes, temperatures, soil conditions and level and reliability of rainfall. The high and medium rainfall areas exhibit ample rainfall and are rich in volcanic soils (FAO. 2019). The rangelands, commonly referred to as the ASALs, are characterised by high ambient temperatures and humidity, low and erratic rainfall, and poor soils. Humid, subhumid, and semi-humid areas are associated with arable farming characterised by intensive and semi-intensive livestock production. The systems in semi-arid, arid and very arid regions are predominantly characterised by extensive livestock production under free-range, pastoralism and ranching (Leal, 2017). The beef cattle production systems are mainly in pastoral, semi-intensive (agro-pastoral), ranching systems, and feedlots. In contrast, dairy cattle (zero-grazing) include intensive and semi-intensive and extensive production systems.

Beef production

Pastoral Systems are low-input, low-output subsistence production systems practised in arid and semi-arid areas where the keeping of indigenous breeds, with herds varying from 20 to several hundred heads on communal grazing areas and water sources is the main livelihood. Milk and beef are the leading products. Agro-pastoralists raise their animals in semi-arid regions besides practising some crop farming. Animals browse and feed on crop residues and by-products and provide manure and draught power to increase crop productivity. Like in the case of pastoral systems, milk and beef are the main products. Ranching is a large-scale commercial system with an average of 1 000 heads of cattle with structures for disease control, feeding, and water storage. Beef is a critical product and targets leading local and export markets. In Feedlot production systems, animals are kept for a short period, about three months. They are fattened and then sold to prime local and export beef markets hence commercially-oriented a capital-intensive system (FAO, 2019).

Dairy production

Intensive dairy production milk production highly intense, with stall-feeding of exotic cows on high-quality feed, concentrates, and supplements. Located mainly in the mid-and high-altitude agro-ecological zones, about 85% of intensive dairy farms keep herds of between 5 to 15 cows. In the Semi-intensive dairy production systems, farmers keep between 3 to 20 cows, usually as part of a more massive, mixed herd of animals containing small ruminants and chickens. Dairy cows graze and when in milk, are provided with some feed supplements. Unlike intensive dairy

production systems, Extensive dairy is pasture-based, where 20-200 dairy cows graze on natural or improved pastures in large, fenced farms. During dry periods animals are provided with mineral and hay supplementation. Figure 3.1 shows the number of livestock under each system.

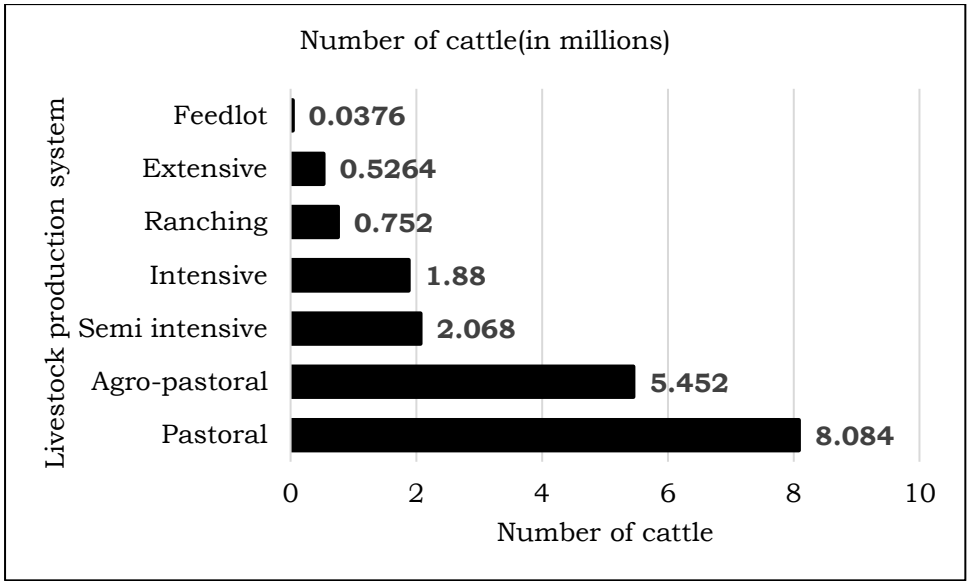

Figure 3. 1 Number of cattle in different production systems

Source, FAO 2019

3.3 Livestock inputs

Livestock inputs are critical factors of production in the livestock sector. The main types of livestock production inputs include water, pasture, fodder, feed supplements, fertilisers, germplasm, vaccines, and drugs. On the other hand, livestock producers' primary services are animal health, animal breeding, research and extension, and animal identification services. Agro-vets dealers, feed manufacturers and suppliers, farmers' organisations, and government institutions provide livestock input services. In the medium to high rainfall areas, most farm inputs are readily available in the markets, except for a few vaccines sometimes sourced out of the country. However, in the arid and semi-arid areas, livestock input suppliers are few and poorly distributed. They are concentrated in towns hence limiting availability and access to inputs and services. The relatively meagre infrastructure in such areas such as roads increases transportation and storage costs for livestock inputs, placing livestock inputs' prices beyond most farmers' reach and increasing the production cost. The farmers are currently meeting all the costs of inputs except for compulsory vaccinations administered during significant disease outbreaks. The quality of livestock inputs may also be affected by poor manufacturing practices and inadequate cold chain facilities (GoK, 2019).

3.4 Research and technology development and extension

Research and technology development is critical for enhancing productivity and competitiveness in the livestock industry. Most of the livestock-related research and technological development is funded by the National Government through the National Research Fund (NRF) and undertaken by Kenya Agricultural Livestock Research Organization (KALRO), universities and international research institutions such as the Consultative Group on International Agricultural Research (CGIAR) and the International Center for Insect Physiology and Ecology (ICIPE). Livestock research is an expensive undertaking and has not

received adequate investment by government, private sector and development partners. Besides, research agenda-setting is dominated by funding agencies, creating a need for increased government investment to prioritise national research needs. Most research has concentrated on addressing technical production problems (feeding, breeding, health and husbandry) but with limited attention to key genetically modified organisms (GMO) and socio-economic parameters. Modern biotechnology to improve livestock productivity and reduce disease losses exists but has not been exploited in Kenya. Existing opportunities include improving animal breeds and production, which have enormous potential benefits for the industry. In Kenya, livestock extension is the mandate of the County Governments while the national government formulates policy, standards and builds capacities of service providers. Extension services such as agro-veterinary pharmaceutical companies, animal feed manufacturers, milk processors, Non-Government Organisations and Community-Based Organisations are critical in livestock production. However, there is limited collaboration and sometimes conflicting interests among various service providers. There is also a little collaboration between the research system, training and extension, leading to insufficient access and low quality of services to livestock keepers. Also, there is inadequate staffing, funding, and guidance for delivering extension services at the county level. The use of ICT has increasingly become critical in extension service delivery. However, it is necessary to develop and share these delivery systems, regulate and monitor the quality content of the information being transferred to ensure the adequate capacity of extension agents and improve understanding and knowledge among livestock keepers and producers (Tata & McNamara, 2018). Chatfield et al. (2015) detail how two ICT-based technologies improve extension services. CommCare, one of the most widely adopted and technologically advanced ICT platforms developed by Dimagi, incorporated a for-profit social enterprise for front-line workers, equip extension workers' mobile phones with branded software for quality extension service and accountability. Digital Green (DG) uses participatory local video content as a basis for facilitated instruction to amplify the effectiveness of agricultural extension agents. However, agricultural extension workers' use of ICTs is limited by inadequate information technology resources and ICT infrastructure, costs, electricity problems, network connectivity, content, and farmers' capacity to use new technology (Nakasone and Torero, 2016). However, Climate change is affecting agriculture significantly. Temperature increases are a challenge to agricultural production due to decreased yields, higher risks of pest attacks and disease outbreaks, lower quality and quantity of feed and forage and water availability depletion. Heat impacts animal health by increasing parasites and pathogens and the risk of mycotoxin contamination in cereals and pulses. These changes affect crop and livestock production and products available, such as milk (Pingali et al., 2019).

3.5 Fodder production in Kenya

Fodder refers to crops used as food for livestock. There are three significant fodder groups fed to animals either green feed or as hay, i.e., crops harvested dry or dried after harvesting or as silage products. Fodder can be:

- Grasses include cereals, which, when harvested green, mostly contain crude protein and some minerals. These are sold as bales of hay or silage.
- Legumes include pulses that are harvested green and are above all rich in proteins and minerals
- Root crops cultivated for fodder are high in starch and sugar but low in fibre, making them easy to digest.

Most fodder crops' fibre content consists of cellulose, a complex carbohydrate polysaccharide that is indigestible for humans, but a good source of energy for animals, particularly ruminants.

There are various fodder types grown in Kenya, but the most common and widespread are Napier grass, Boma (Rhodes) grass, and natural pastures. Hay (from Boma (Rhodes) grass) and Lucerne is the most commercialised fodder, while Napier grass sales are usually between farmers within the proximity. Moreover, commercial production of maize silage and trading is emerging in some parts of the country (SNV, 2013). Estimating national pastures and fodder demand is difficult due to the various livestock production systems' dynamics and inaccurate information on livestock populations and acreages under fodder production and conservation. A recent study by USAID-KAVES suggests that Kenya suffers large deficits of livestock feeds, mainly forage for dairy cattle. The deficit is over 3.6 billion bales of hay annually, worth USD nine billion (USAID-KAVES, 2017). The demand is expected to increase, given the emerging fodder demand by neighbouring countries (MoALF, 2017). Production of these fodder quantities would require an additional 15 million acres of land under fodder crops and pasture, which can be realised by shifting to arid and semi-arid areas (MoALF, 2017). Gross margin analysis evident in the Ministry of Agriculture, Livestock, and Fisheries shows that pasture and fodder farming is profitable, and there is adequate demand (MoALF 2017).

Fodder production and conservation have been viewed as a lasting intervention for improving households' nutritional status through enhanced and subsidized livestock production (Mulwale et al., 2014). Given this, through Kenya Agricultural and Livestock Research Organization (KALRO), the government introduced several natural fodder improvement technologies (AfDB, 2010), which smallholder farmers are increasingly adopting in dry areas. Some of these technologies include natural pasture conservation and range pasture reseeding (Kidake et al., 2016). These technologies have been aimed at increasing livestock feed availability during dry periods and diversifying income through the sale of hay and grass seeds (Lugusa et al., 2016). These interventions have been aimed at promoting growth and development for the people living in drylands. However, scantiness of information on the fodder value chain implies a poor understanding of fodder production in terms of the existing production and marketing practices, and its contribution to households' income

3.6 Types of fodder

Although livestock production in Kenya comprises different species such as cattle, goats, and sheep, among others, for this scoping study, we have mainly focused on the fodder production system for cattle to promote beef and dairy value chain and other products and those grown or have the potential to grow in the study area, Nyatike.

3.6.1 Grasses

a. Napier grass (*Pennisetum purpureum*)- Napier grasses varieties commonly grown include Bana grass, Clone 13, French Cameroon, Kakamega 1, and 2. The establishment of Napier grass can be through root splits or canes, and planting can alone or intercropped with forage legumes. The intercrop to improve the quality of the feed and reduced costs for nitrogen fertilizer can be with forage legumes like (*Desmodium uncinatum* (silver leaf), *Desmodium intortum* (green leaf), S*tylosanthes guyanensis* (stylo). It is adapted to grow across a wide range of soil conditions and agro-ecologies, from sea level to 2100 m, and it can withstand minor dry spells, although it grows best in areas where the annual rainfall is between 750 and 2500 mm. Planting involves putting one cane/root split in holes 15-30 cm deep at a spacing of 0.5m x 0.5m and 1m x 0.5 m in areas with over 1400 and 900-1400 mm rainfall, respectively. When planting cane cuttings, two of the three nodes should be buried into the soil, leaving one above the soil surface. If intercropped

with legumes, it can be drilled along the Napier grass rows or in between the rows when planting Napier grass seeds at the rate of 3 - 5 kg/ha. For Napier grass, three fertilizer and manure management practices are recommended depending on the farmer's financial resources. These are (i) Applying 10 tons/ha of farmyard manure (FYM) at planting and the same amount in subsequent years, preferably in splits after every harvest, (ii) Using farmyard manure at planting then 5 tons/ha FYM in following years, and (iii) Applying 60 kg of slurry in furrows at planting followed by split application of the same quantity twice a year or after harvesting. Frequently weeding is required till full establishment and after each harvest to maintain high productivity. Harvesting is when Napier is 1m tall or every 6-8 weeks to obtain optimal quality and quantity. At each harvest, to avoid weakening the root system, which leads to low production in subsequent harvests, maintain a stubble height of 5-10 cm from the ground level. One of the recommended nitrogen fertiliser rate split applications should be made one or two months before the end of the rain season to increase Napier grass yields during the dry season. Napier grass is often fed fresh in cut-and-carry systems. To reduce the selection of leaves and stems by the animal, Napier can be chopped manually or mechanically before feeding. Chopping and wilting in the sun reduces moisture, stimulates appetite, facilitates rumination, and improves forage utilisation. Napier is rarely used for pasture, but if so, it should be heavily grazed to avail the young leaves and shoots with the highest nutritional value to ruminants.

Grazing at 6-9-week intervals at the height of about 90 cm gives proper utilization. Nitrogen can be applied after each grazing or cutting in high-rainfall areas, as well as removing coarse, leafless stems (FAO, 2015). Haymaking requires that Napier grass should be cut at an early stage as mature stems become too rough. Napier grass can make high-quality silage and can be ensiled alone. However, its high cell wall content and low concentration in water-soluble carbohydrates (WSC) impair the ensiling process; hence it is often ensiled with materials that improve the silage quality and nutritional value (protein or energy). Napier grass competes very efficiently with weeds and has been used as a mulch (25 cm layer) for weed control for water storage and reduced soil losses on slopes. It develops a robust root system that may help prevent riverbank erosion. It is used for erosion control and forage production in alley-cropping systems of agroforestry. When planted as hedgerows, it makes fences and provides effective windbreaks for crops and houses.

b. Maasai love grass (*Eragrostis superba*) is a quick-growing densely tufted perennial species, growing up to 1m tall with large, flat, attractive spikelet to 16 mm long, green, often flushed purple when young. It requires a rainfall range of 500-875 mm and prefers sandy soils but also occurs on clay loams and clays, tolerant to salinity, alkalinity, and droughts but less tolerant to waterlogging and slightly to the shade in areas below 100 masl. Land preparation, which includes the use of ox-plough, range pits, no-till, and mechanisation, should be completed before the start of rains. Planting is through broadcasting or drilling in furrows at a seed rate of 5kg/ha and can be adjusted according to seed germination capacity, quickly covering the ground through rhizomes. *Eragrostis superba* is compatible with other range grasses such as *Enteropogon macrostachyus*, *Chloris roxburghiana*, and *Cenchrus ciliaris.* Weed control is critical during the first year and is done by hand by either uprooting or using a hoe or using selective herbicides. The seeds are harvested when they show signs of browning (straw-like colour) before the start of seed fall by striping the ripe panicles during dry conditions. Seed yields can go up

to 1ton/ha of seeds per harvest. The seeds should be stored in an airy dry place away from moisture and rodents. The nutritional value of Eragrostis *superba* is Crude protein content (CP) of 7-12% of dry matter and crude fibre of 30-35%. It is relatively palatable and readily grazed when tender, but it becomes stemmy and unpalatable near maturity. Dry matter Yields are up to 13.5tons/ha/yr, equivalent to 898 bales of hay each at 15kg.

c. Guinea grass (*Panicum maximum*/ *Megathyrsus maximus*)/ Guinea grass (*Panicum maximum*)/cv. Makueni - Guinea grass (*Panicum maximum*)/*Megathyrsus maximus* is a dominant tropical grass used throughout the tropics for pasture, cut-and-carry, silage, and hay. It is a fast-growing and leafy grass, which is palatable to livestock with an excellent nutritional value. However, supplementing its protein to meet dietary requirements or improve animal performance is generally recommended. Many Guinea grass cultivars have been developed (FAO, 2009). The difference between Guinea grass (Panicum maximum) and Guinea grass (Panicum maximum)/cv. Makueni is the reproductive development, i.e., 'Makueni' is indeterminate. Guinea grass is native to tropical Africa and is now widely naturally found in open grasslands, woodland and shady places within 16.3°N and 28.7°S. It grows best under an annual rainfall above 1000 mm with no more than a 4 to 5-month dry period. The yearly average day-temperature should range from 19.1°C to 22.9°C (Heuzé & Tran 2020). Guinea grass can be managed as a long-term pasture grass if grazed consistently but should not be grazed under 35 cm height or very wet conditions. The grass should have a rest-period until the re-growth is 2.5 leaves/tiller. For silage and hay, 60-90 cm is a proper cutting height, but it can be cut at up to 1.5 m for higher yields of acceptable quality, as it does not become coarse even if left to grow to that height. Better quality silage Guinea grass should be cut before or during the opening of flowers. Ensiled Guinea grass has a pleasant texture, and mixing grass of different ages does not affect silage quality. Guinea grass yields an average of 30 t DM/ha/year depending on the cultivar and fertilizer application and seed yields of around 1.7-3.1 million seeds/kg. For example, unfertilized Guinea grass yields around 7t DM/ha, while N-fertilized pastures can yield up to 42t DM/ha. Guinea grass's other benefits are soil erosion prevention when well managed since it provides rapid ground cover. However, it can spread very fast and become a weed in ungrazed areas where soil disturbance has occurred and in sugarcane fields since it grows well in shaded conditions. Buffelgrass (*Cenchrus ciliaris*) is a highly adaptable, tufted tussock-forming perennial grass with a deep, sturdy rootstock that may go 2 metres deep. *Cenchrus ciliaris* is a significant pasture grass in the tropics cultivated for permanent pastures and leys or as a forage. *Cenchrus ciliaris* has numerous qualities such as the ability to establish quickly and provide high-value forage with yields 2-18 t DM/ha without fertilizer, and up to 24 t DM/ha with the addition of a complete fertilizer and giving quality hay when cut in the early flowering stage, yielding up to 2.5 t/ha per cut. After harvesting the seed, the old grass can give low-quality roughage for drought feeding with supplements. *Cenchrus ciliaris* rarely makes silage due to its low moisture content). *Cenchrus ciliaris* is palatable and once established, can withstand heavy grazing and trampling. *Cenchrus ciliaris* should not be grazed before 4-6 months and possibly up to 9-12 months after sowing, depending on establishment conditions. Cutting or grazing can be at 7 cm high withstanding continuous or rotational grazing at 6-8 week cutting intervals. Grazing on *Cenchrus ciliaris* should be between 42 and 56 days of plant

age when the maximum dry matter production occurs, as the stem-leaf ratio increases rapidly with plant maturity. *Cenchrus ciliaris* may be sown with Columbus grass (*Sorghum* x *almum*). It establishes slowly but grows for a more extended period than Columbus grass (*Sorghum* x *almum*), a short-lived perennial to provide good quality pasture. Similarly, Rhode's grass (*Chloris gayana*) and Guinea grass (*Megathyrsus maximus*) are also useful cohorts. It also thrives in conjunction with legumes such as *Desmanthus leptophyllus, Desmanthus virgatus, Desmanthus bicornutus, Leucaena leucocephala, Macroptilium atropurpureum*, sickle bush (*Dichrostachys cinerea*), *Stylosanthes hamata, Stylosanthes scabra, Stylosanthes seabrana,* and *Stylosanthes humilis*, because of the improved N status of the soil. Frequent grazing improves the Nitrogen content of the grass. Cenchrus ciliaris should be cut in the early flowering stage for haymaking when the nutritional value is highest. *Cenchrus ciliaris* is valuable for erosion control though it can be a noxious weed and a fire hazard.

d. Columbus grass (*Sorghum halepense*) - Columbus grass (*Sorghum halepense*) is a robust, tussocky, short-lived perennial with numerous tillers, thick short rhizomes, thick and solid culms reaching up to 4.5 m, and waxy leaves2.5-4.0 cm wide. The inflorescence is a large pyramidal panicle with secondary and tertiary branches, which droops as the seed ripens. Columbus grass (*Sorghum x almum*) provides valuable fresh forage used as pasture or in cut-and-carry systems. Optimal growing conditions are an annual rainfall ranging from 460 to 760 mm, average day-temperatures between 15°C and 22°C, and fertile, well-drained loamy and heavy clay soils, with soil pH ranging from 5 to 8.5. Columbus grass may withstand drought periods but has no waterlogging tolerance or flooding (Heuzé et al., 2015). The cutting is every 6 to 12 weeks down to 5 cm. Though the hay and silage are coarse, the quality is good, provided cutting is at the mature stage and done when the weather is not too wet. Columbus grass is a fast-growing and high-yielding species that weakens within three years. It can be grown in pure stands and thrives when mixed with other grasses such as *Megathyrsus maximus, Cenchrus ciliaris,* or *Chloris gayana,* which is beneficial as the farmer first benefits from the fast-growing Columbus grass and later from the other perennial species. Columbus grass responds well to additional N, P, and K fertilizers and yields 4-20 t DM/ha, and seed yields of 0.3-1.6 t/ha.

e. Brachiaria Grass- The crude protein content of Brachiaria grass ranges from 9% to 20%. It has high plant vigour producing more biomass even on low fertile soils and fast recovery after grazing. It is palatable to livestock, nutritious, and easy to digest. It is drought tolerant, has fewer pests and diseases, and produces fewer greenhouse gases per litre of milk produced. It is challenging to intercrop Brachiaria grass in long term associations with fodder legumes due to its aggressiveness. However, it can be used in crop pasture integrated systems where grass seed is oversown on maize crop planted earlier to produce high-quality forage in the offseason. Brachiaria *brizantha* is native to tropical Sub-Saharan Africa from 25ºS to 12ºN and is now widely naturalised in the humid and sub-humid tropics, where its natural habitat is grassland valleys and open woodlands. It is a warm-season grass for the lowlands, from sea level up to 2000 m in the tropics and up to 1000 m in higher latitudes. The optimum temperature for growth is about 30-35°C. The leaves are frost-sensitive, but the plant survives light frost. Brachiaria brizantha grows best with 1500-3500 mm average annual rainfall, though it tolerates less than 1000 mm

rainfall and can withstand dry seasons of 3-6 months during which it remains green, unlike other tropical grasses (Heuzé et al., 2016). Only four Brachiaria varieties are cultivated as pasture in Kenya; namely, *Brachiaria decumbens* cv. *Basilisk*, *B. brizantha* cv. MG4, *B. brizantha* cv. *Piata* and *B. brizantha* cv. *Xaraes* best suited for semi-arid, sub-humid and humid areas. Brachiaria hybrid cv. Mulatto II is suitable for coastal lowlands and many regions in Kenya. The seeds require fine soil; therefore, the seedbed should be well prepared. Thorough mixing of the soil with well-cured manures at a rate of 2 to 4 tonnes per acre is recommended after ploughing and harrowing. Soils low in phosphorous need application of 100 kg triple superphosphate (TSP) fertilizer per acre. Seeds or vegetative methods can propagate Brachiaria grass. Planting materials include seeds, root splits, and stem cuttings. Vegetative propagation can be done on a small scale but may not apply to large scale farming. Planting should be at the onset of rains. For seeds, create shallow furrows (1 – 2 cm deep) spaced at 50 cm and drill the seeds at a rate of 2–3 kg per acre along the furrows covering with light soil. Instead, sow the seeds in a nursery bed in furrows, spaced at 5 cm and mulch with dry grass, and transplant the seedlings at the age of six to eight weeks. When using Brachiaria root splits plant on each hill at a spacing of 50 cm between rows and 25 cm within rows. A total of 64,000 to 96000 root splits are required per acre. Pasture removes a substantial amount of soil nutrients in the cut-and-carry system; therefore, to maintain soil fertility, the application of 2–4 tonnes of well-cured manure per acre is necessary. An application of 80 kg calcium ammonium nitrate (CAN) fertilizer per acre per season is advised since Bracharia is quick to respond to Nitrogen. Removal of weeds manually or chemically through selective herbicides to control broad-leaved weeds should be done during the early stages of crop cultivation. Pest and disease control is also vital against the red spider mite and shoot-borers and rusts, ergot, smut, and leaf spots. Optimal intake of digestible nutrients occurs when pasture utilization coincides with the late head stage or early bloom stage. After sowing, the grass takes about 21 weeks to flower, which is the most suitable stage for feeding livestock. Re-growth takes about three weeks. Harvesting of the first crop should be five months after planting by cutting at the height of 5 cm above the ground. Harvest the next crop every 8 – 12 weeks, depending on rainfall, soil fertility, and management. The grass can persist up to 20 years with proper management. With appropriate management, the grass can yield up to 140 kg per hectare of seeds, with the maximum yield in the second year of establishment. The average dry matter yield is 10 to 40 tonnes per hectare, depending on soils, rainfall, and management. Brachiaria grass is suitable for both cut and carry and grazing systems and can be conserved as hay or silage. It can play a significant role in soil improvement, soil conservation, increasing biodiversity, and minimizing greenhouse gas emissions.

f. Rhodes grass (*Chloris gayana*)- is a tufted perennial, with foliage from 0.5-1.2 m, and fertile tillers from 0.9-2 m tall, native to Kenya and many other sub-Saharan Africa countries found in open woodland and grassland, riverine and lake margins, and seasonally waterlogged plains, on a wide range of soils. Varieties of Rhodes grass in Kenya include Boma, X-Tozi, Elmba, Mbarara, and Masaba. It is excellent for making hay but can also be grazed. Rhodes grass can grow under a wide range of rainfall (650 -1200 mm) and can persist under drought, does not tolerate acidic soils, and prefers pure stands but can also be undersown with oat or maize. Rhodes grass is widely adapted, quickly established, tolerant of heavy grazing and high

salt, has an early nutritive value, few pests or diseases of economic importance, and good seed production with some varieties capable of suppressing nematodes (e.g., cv. Katambora). However, it has limitations such as a short nutritive peak in many cultivars, fluffy seed challenging to sow intolerant to acidic, infertile soils, thus require high fertility to persist and low shade tolerance. Seeds or root splits can establish Rhodes grass. A more rapid cover can generally be obtained by planting from seed, which has a challenge of reduced germination rate. Seeds are sown at a 10kg per hectare rate, and under suitable conditions, it rapidly gives good ground cover. Seed matures 23-25 days after flowering. DM yields generally range from about 10-25 t/ha, depending on variety, soil fertility, environmental conditions, and cutting frequency. In the second year, yields may be double those of the establishment year, but this also depends on management and environmental conditions. Although Chloris gayana can survive on infertile soil, it is very unproductive and may eventually die out, mainly if grazed regularly. Young growth is very palatable, but after the plants have seeded, they are less attractive. Rhodes grass is less suitable for the cut-and-carry system. It makes good hay if cut at or just before very early flowering. Generally, they are not suited for silage. Provides fair stand over roughage when mature due to its higher cold resistance and lower loss of dry leaves. Develops good ground cover and effectively controls erosion once established (needs regular defoliation to maintain cover. Stands increase and can be grazed 4-6 months after planting, although the highest production is reached in the second year. Since feeding value declines rapidly with the onset of flowering, it is vital to maintain the stand in a leafy condition by fairly regular defoliation. Annual live weight gains of up to 160 kg/head and 850 kg/ha are achievable. Production declines without a vigorous legume or the use of fertiliser nitrogen. It produces up to 300 hay bales/acre with cutting intervals of 6-8 weeks and produces good quality hay at the early flowering stage. Seeds are available from leading producers in the country, and after the first batch, one can subsequently make their seeds from this, and 350kg/ha is achievable.

3.6.2 Legumes

a. **Common stylo** (*Stylosanthes guianensis*)- is a tropical legume shrub widely grown for forage throughout the tropics and subtropics. Stylo is a short-lived, erect or semi-erect perennial legume that can reach a height of 1-1.5 m. There are seven varieties of stylo, notably var. *guianensis* (common stylo). Stylo is particularly suited for forage in areas with a marked dry season. Stylo used for hay, cut-and-carry systems, and pasture is relatively palatable to livestock when mature and can grow on relatively infertile soils. It can be intercropped with rice and oversown in natural grasslands. While generally used for ruminant production, *Stylosanthes guianensis* is also used to feed pigs. Shrubby stylo (*Stylosanthes scabra*) is a relatively upright (i.e., erect) shrubby plant growing 0.3-2 m tall, producing small hairy (i.e., pubescent) fruit topped with a short hook (1.5-2 mm long). Soft hairs densely cover its stems, some of which are sticky (i.e., glandular). Stylo is found from 20°N to 32°S and from sea level up to an altitude of 2000 m, where annual rainfall ranges from 700 to 5000 mm. Stylo thrives in places where yearly temperatures are between 23 and 27°C in most soils, from sands to light clays (including those that are relatively infertile or deprived of P), provided they are well-drained. Stylo, a full light species, is not salt tolerant and prefers soil pH ranging from 4 to 8.3. Fine stem stylo prefers neutral soils (Heuzé et al., 2017). The seeds are tiny and hence should not be buried too deep in the soil. Stylo

broadcasting can be done during overseeding in grasslands. Provided there is no dry spell during its establishment, in humid areas, Stylo sowing is all through, while in drier parts, sowing should be at the onset of the rainy season. Stylo can be sown alone or mixed with companion species such as tropical grasses, e.g., *Brachiaria* spp., *Andropogon gayanus*, *Chloris gayana*, *Digitaria eriantha*, *Heteropogon contortus*, *Hyparrhenia rufa*, *Melinis minutiflora*, *Pennisetum purpureum* or *Setaria sphacelata.* However, when sown with Guinea grass (*Megathyrsus maximus*), shading can occur. Although intercropping with other legumes is rare, Stylo can be intercropped with rice, maize, or cassava, depending on soil fertility. Stylo is a high yielding forage legume that can produce 10-20 t DM/ha depending on soil fertility. Stylo is sensitive to heavy grazing, and the first grazing should be 6-8 weeks after sowing, followed by a rotational grazing cycle of 4–8-week rest intervals. Stylo can improve the nutritional value of natural grasslands. Stylo can be used in various ways, including a cut-and-carry system, hay and silage, rotational grazing, soil improver, and weed control.

b. **Leucaena (*Leucaena leucocephala*)** - is a fast-growing, perennial legume with a deep taproot and highly branched. Leucaena is valuable for its wood, which is used to make good quality charcoal. Leucaena is one of the highest qualities and most palatable fodder trees of the tropics. Leucaena (*Leucaena leucocephala*) grows well in areas where annual rainfall ranges from 650 to 3000 with day-temperatures within 25°C and 30°C. It prefers neutral to mildly acid, well-drained soils. Leucaena is tolerant of drier areas receiving rainfall of up to (300 mm) and drought periods (up to 6-7 months). It can withstand light frost, although with lower yields, moderate salinity and short waterlogging periods of less than three weeks. Heavy frost, acid soils, low P, low Ca and high Al are detrimental to Leucaena (Heuzé & Tran, 2015b). Leucaena may be grazed lightly in the first year after sprouting and grazed heavily after the second year. The average yield ranges from 3 to 30 t DM/ha/year depending on soil, temperature, and moisture conditions. For optimal results, harvest intervals can vary from 6-8 weeks in very productive areas and up to 12 weeks in less productive ones. Leucaena's contribution to the environment is diverse. It may include soil nitrogen-fixing, erosion control and land reclamation, provides shade, acts as a windbreaker and provides green manure in alley cropping systems since the leaves decompose quickly.

c. **Sesbania (*Sesbania sesban*)** - is a fast-growing, perennial legume tree with a shallow root system. Sesban is used as forage (grazed or cut-and-carried) and as green manure. It provides good quality firewood. Ideal growth conditions for sesban are 500-2000 mm annual rainfall and an average yearly temperature of 17°C-20°C. It grows on a wide variety of soils, from loose sandy soils to heavy clays, tolerant to saline, alkaline and acidic soils, and soils with low P levels. It can withstand waterlogging, except during the first stages of seedling growth (Heuzé et al., 2015b). Sesban yields up to 20 t DM/ha/year if conditions are favourable. In cut-and-carry systems, cutting when it is 1-2 m high and cutting frequency is usually five times a year. A cutting height of 75-100 cm and leaving some foliage is recommended to ensure the plant's re-growth. Stems often break during grazing, but the rapid re-growth below the breakpoint improves yield. Grazing by goats should be avoided since goats are responsible for ring barking, which results in high plant mortality (75-80%). Sesban is an N-fixing shrub suitable as a soil improver. It provides green manure, and its leaves produce rich compost. It is used

in alley cropping: its nodules provide N to neighbour crops and improve their yields. Sesban can be intercropped with maize, beans, cotton, para grass, signal grass, etc. Sesban is a good windbreaker and provides shade and support for other plant species.

d. **Greenleaf desmodium (Desmodium intortum)** - is a large perennial tropical forage legume. It can be grazed as a long-term pasture, cut and offered fresh in cut-and-carry systems, or cut from irrigated pastures for conservation as hay or silage. It is a valuable ground cover providing abundant leaf material that decomposes slowly in the soil. Greenleaf desmodium grows under optimal temperature ranges between 25 and 30°C and in the tropics performs better at altitudes between 500 and 2500 m. It can be grown in areas where annual rainfall is above 900 mm up to 3000 mm. It is more susceptible to drought and has better tolerance to flooding and waterlogging than Silverleaf desmodium. Greenleaf desmodium can grow on a wide range of soils but is intolerant to soils, too acidic (pH above 4.5-5) and saline, heavy frosts or fire. DM yields of Greenleaf desmodium range from 12 to 19 t/ha/year, which is higher than Silverleaf desmodium (7-9 t DM/ha/year). Better yields are obtained with longer cutting intervals of 30-85 days. Greenleaf desmodium has tiny seeds and requires a well-prepared seedbed for establishment. It is possible to propagate Greenleaf desmodium by rooted cuttings. Once established, Greenleaf desmodium thrives and spreads rapidly because of its stolons. Greenleaf desmodium is usually sown in association with grass or another legume. It grows well with a wide range of grasses such as Setaria spp., Pennisetum purpureum, Pennisetum clandestinum, or Digitaria eriantha.

   Greenleaf desmodium may be grown in association with Napier grass (Pennisetum purpureum) to increase its protein content (from 11% in a pure Napier stand to 15% in mixed grass). Greenleaf desmodium combines well with other legumes such as siratro (*Macroptilium atropurpureum*) or perennial soybean (*Neonotonia wightii*). Greenleaf desmodium is generally introduced into natural pastures to increase the DM yield. Greenleaf desmodium has moderate needs for added fertilizers and only requires P, S, K, and Mo. Greenleaf desmodium is susceptible to pests such as the Pyralidae caterpillars, which can cause massive losses. Greenleaf desmodium is very palatable and can be heavily grazed but cannot stand constant heavy grazing or frequent defoliation that removes the bud promoting sites. After grazing, there should be enough vines and leaves left to allow good re-growth. The optimal length of the rest period is from 3 to 12 weeks. It can be cut for hay, although it makes good quality silage when mixed with molasses. Greenleaf desmodium is an N-fixing legume that can improve soil fertility. It can be used as ground cover as it needs only four months to cover the soil and to prevent weeds from developing.

e. *Calliandra calothyrsus* - is a small, leguminous tree with pink flowers. It is fast-growing, and its economic returns can be realized in the first year of planting. The tree can produce fodder continuously for more than ten years. It can be grown in various sites on the farm since it does not compete with crops growing adjacent to it, as long as it is managed appropriately to reduce the shading effect. *Calliandra calothyrsus* grows from sea level up to 1800-2200 masl but does better up to 1300 m. It grows best with annual rainfall between 700 and 3000 mm and yearly temperatures ranging between 22 and 28°C. Calliandra does not withstand frost but is tolerant of dry spells lasting from 1 to 7 months and more than two weeks of

waterlogging. Calliandra grows a wide range of light-textured, infertile soils, from acidic sandy soils to deep volcanic loams, although it does not withstand compact, poorly drained, alkaline calcareous soils (Wambugu et al., 2006).
Calliandra improves the milk production of both dairy cattle and goats. It can also be fed to other types of livestock such as sheep, rabbits, and chicken. A cow needs to be fed with roughly 6kg of fresh leaves per day, a goat about 0.7 kilograms to harvest 6kg fresh leaves every day, you need to plant 500 calliandra trees at a spacing of 0.5m (1½ ft), making 250m (800 ft) of the hedge. This seems like a lot, but a farm of 1 hectare (1½ acres) has over 400 metres (1280 ft) of the external boundary, plus additional sites (along internal edges, along contours, around the homestead) where calliandra can be planted. Other uses for Calliandra are soil fertility improvement, stabilizing soils and water conservation structures, bee forage, fuelwood and stakes for climbing beans and tomatoes. Apply manure to the beds at the rate of 1 part of manure to 4 parts of soil; this translates to 1 "debe" of manure for every 3-metre length of the nursery. Mix the soil and the manure well. A seedbed of 1 x 3 metres produces about 400 seedlings and requires 40g of seed. 1½kg is sufficient for planting a nursery bed 40m long, which will produce about 5300 seedlings; thus, 100g of seeds would need a seedbed of about 7.5m that can produce approximately 1000 seedlings. To ensure good germination, you need to soak the seeds in cold water for two days (48 hrs). Make a furrow about 2cm (1 inch) deep in your bed for accurate sowing. Place the seeds in the furrow and cover them lightly with soil. Space the furrows 10cm (4 inches) apart and leave 5cm between seeds within the furrow. Avoid putting the seeds too deep into the soil because they will rot. The inoculant can be applied to calliandra seeds or young seedlings. For seedlings, mix the inoculant with water in a bucket and stir thoroughly using a stick. A 200g of inoculant packet can make a solution of 60litres, which is enough for 40 metres of nursery bed in which about 500g of seed has been sown. Water the seedlings thoroughly before applying the inoculant to the soil.

Apply the Rhizobium using leafy branches, repeatedly dipping them into inoculant solution and shaking it off on the seedlings. If the inoculant is to be applied to seeds, mix it with water to make a solution. Mix the pre-soaked seeds with the solution and sow immediately, avoiding excessive exposure to heat and light. Annual forage yields of 7-10 t and up to 20 t DM/ha have been obtained under variable growing conditions (Tuwei et al., 2003). Calliandra can be browsed or cut-and-carried to livestock. Drying calliandra leaves before feeding to livestock may have adverse effects on forage quality, but this is debatable (Hove et al., 2003). When used in cut-and-carry systems, it should be fed immediately after cutting.

3.6.3 Root crops

There are several root crops with nutritious vines, such as sweet potato (*Ipomea batatas*) fed to cattle as a supplement. In Kenya, the leading sweet potato fodder varieties include Kiganda, Muibai, Sandak, Mugande, KSP 20, Mafuta, Musinyamu, and Helena. Most of the cultivars are suitable as dual-purpose with numerous benefits such as increasing calf's growth rate, promoting rumen development, ideal for recently calved and sick animals and increasing milk yield. There is no advantage of ridging or mounding during seedbed preparation for fodder production, but weeding is required whenever weeds appear. To feed the cows, cut and carry the vines to the cow and feed up to 15 kg fresh material per day, as a supplementary feed to Napier grass or other basal feeds.

3.6.4 Grain crops and Crop Residues

Sorghum (*Sorghum bicolor*), a coarse perennial grass, although usually treated as an annual, is adaptable to broad geographical and climatic areas even under scarce water and fertilizer conditions. In Kenya, sorghum is a dual-purpose crop used for both grain and forage. In Kenya, KALRO has developed several dual-purpose sorghum varieties, some of which provide good fodder for livestock grazing. For example, at the KALRO station in Lanet, other brown sorghum varieties such as Ikinyaruka, BJ28, and BM30 are dual-purpose and is even more than 10% digestible compared to different local types. Sorghum fodder may be used for animal feed as green chops, hay- sorghum and silage. For beef cattle, the crop can be harvested a few days later and be ensiled with green grains when the top seeds are in the dough stage and the bottom ones in the milky stage. There is also sweet sorghum used for silage which should be cut before the seeds mature to avoid wastage of the more digestible and nutritious stages.

Further, sorghums have a high water use efficiency compared to maize. Where the water is scarce, it is necessary to conserve or reallocate available water for sorghum forage growth and development because, under such environments, sorghums are extremely valuable for forage. This scoping study in Nyatike areas in LVB, Kenya, found that cattle directly graze sorghum remains in the field after grain harvest, providing little nutritional value to the cattle. Crop residues include all inedible phytomass of agricultural products such as cereal and legume straws, leaves, stalks, tops of vegetables, sugarcane, oil plants, and tuber crops litter, and pruning's of nut and fruit trees. Most crop residues are also used as cooking fuels, animal feed, and soil fertility management, among other uses. But they are also fed to domestic animals, either chopped and added to residue mixes or left in the fields for stubble-grazing. Characteristics of crop residue fodder include deficient prude protein, low in calcium and low-quality roughage which cannot be used for feeding ruminants without supplementation. They are low in digestibility, reduce the Voluntary Dry Matter intake (VDMI), and the animal cannot consume enough to maintain its weight. But there are also ways of improving crop residues that include the lignocellulose complex consists of considerable energy which can be unlocked through chemical treatment, e.g., application of NaOH, ammonia, urea. But over-application of these chemicals is not desirable both to people and livestock. For rice straw, chemical treatments include soaking the straw in NaOH solutions; ammonia and urea treatments are safer and provide nitrogen lacking in straw.

3.7 Central Fodder Production systems in Kenya

Several systems of intensive fodder production exist in different regions. In semi-arid areas similar to the current scoping study, area prospects are limited for producing fodder crops. In such areas as characteristic degraded forests and other wastelands, perennial species-based systems such as grassland and silvopasture are recommended. Table 3.2 below shows the Fodder production systems developed at the IGFRI.

Both formal and informal sub-sectors characterise fodder production and marketing in the arid and semi-arid areas of Kenya. Commercial fodder producers dominate the formal sub-sector, while the informal one includes trading amongst farmers in the same region. Most importantly, all-year-round access to quality feed and fodder determines the competitiveness of the dairy sector. Fodder is the dairy industry's backbone, mainly because dairy cows as ruminants highly dependent on forage for milk production. Developing a high-quality and innovative forage sub-sector will minimise farmers' production costs and seasonal fluctuations in milk supply and improve operational profits. Experienced farmers usually employ appropriate, quality and quantity forage to meet a significant proportion of livestock feeds and nutrition, rather than the

expensive compound feeds. According to SNV (2013), although smallholder farmers in Kenya are aware of and exposed to different fodder crops, only 55% grow at least one fodder type.

Table 3. 2 Fodder production systems developed at the IGFRI

	Cultivated fodder		Grassland/pasture		Tree-based fodder	
Systems	An intensive fodder production system	Food fodder system	Cultivated grassland	Improved pastures	Silvopasture systems	Horti-pasture system
Purpose	Round the year availability of nutritious green pasture	Availability of fodder between significant food crops	For quality grass as fodder	To improve the fodder quality, soil restoration	Fodder availability in the lean period, soil and moisture conservation	Additional fodder income from orchards
Potential application	Intensive dairy units	Household livestock	Grazing based animal husbandry		Wastelands and degraded forest development projects farmers are interested in developing their degraded lands or utilisation of the understorey of orchards	

Further, the recent degradation and loss of natural pastures caused by persistent droughts, climate change and poor land-use practices have exacerbated the situation, as evidenced in the ASAL areas compared to other areas. In Migori County effect of climate change on smallholder dairy farming is shown in Figure 3.2. According to Omollo (2017), the challenges in animal feeding and the growing demand for fodder have motivated government initiatives to support fodder establishment, production, and marketing in collaboration with development agencies.

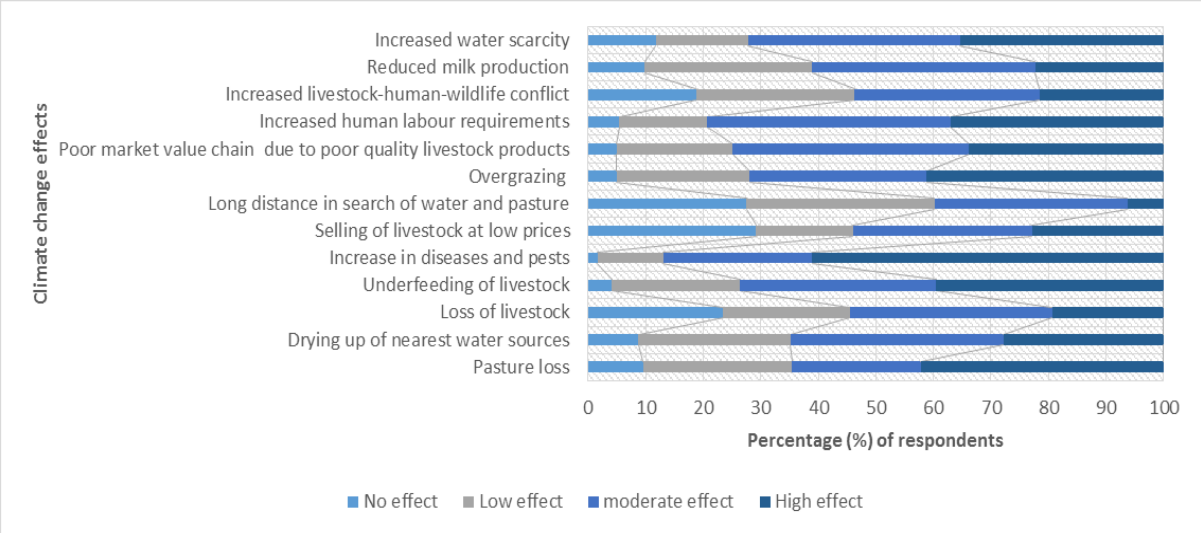

Figure 3. 2 Climate change effects on smallholder dairy farming in Migori County (n=367)

Source C.O. Odhiambo et al. 2019

3.8 Selected pilot: Nyatike sub-county, Migori County

3.8.1 The study area

In Kenya, the Scoping study for fodder intensification was conducted in Migori County. The county is located in southwestern Kenya between latitude $0^0$24' South and $0^0$40' South and

Longitude 34^0East and $34^0$50' East and at Tanzania's border. The County has six agro-ecological zones, i.e., the Upper Midland (UM) 1-4 covering Rongo Sub-County, Kehancha, and Ntimaru in Kuria East and Kuria West Sub- Counties respectively to Lower Midland (LM) 1-5 covering parts of Rongo, Migori and Nyatike Sub-Counties. It is characterized by an inland equatorial climate modified by the effects of altitude, relief, and the influence of Lake Victoria's vast body of water. The rainfall is generally continuous with little distinction between first and second rains—annual rainfall averages between 700 mm and 1800 mm. The long rains occur between March to May, and the short rains occur in September-November. Temperatures show a mean minimum of 24˚C and a maximum of 31˚C, with high humidity and potential evaporation of 1800 mm to 2000 mm per year. The Migori county comprises eight (8) sub-counties: Rongo, Awendo, Uriri, Suna East, Suna West, Nyatike, Kuria West, and Kuria East (Figure 3.3). Nyatike Sub County was selected for the scoping study because of its proximity to Tanzania and semi-arid climatic conditions, and the characteristic livestock grazing zone compared to other sub-counties.

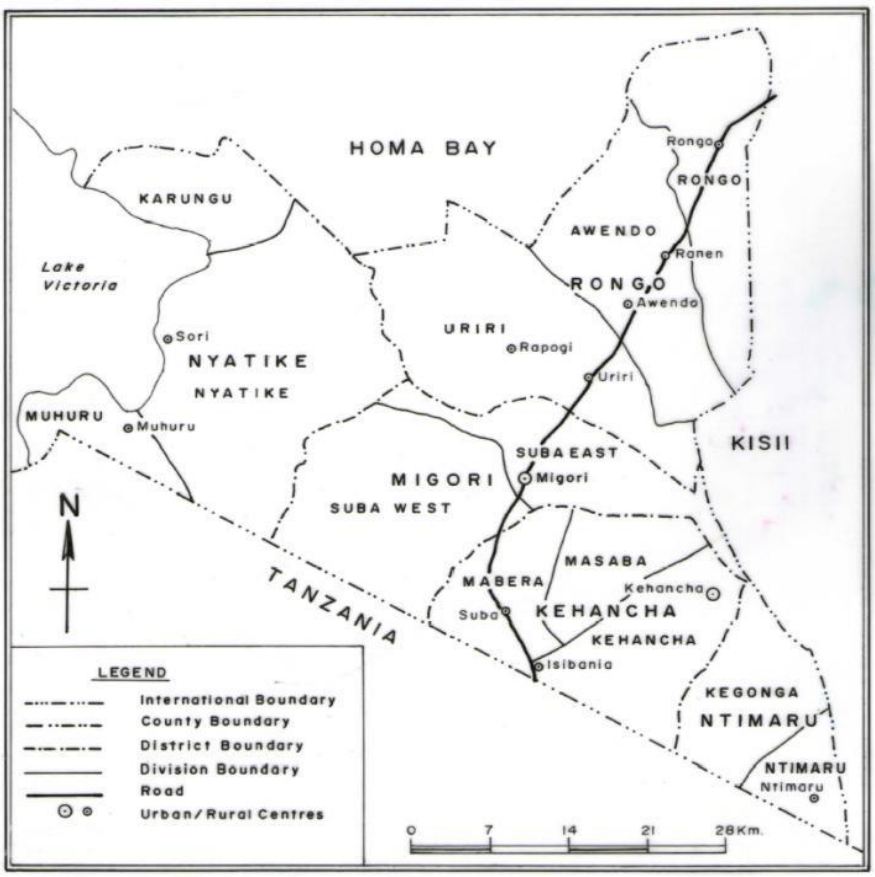

Figure 3. 3 Administrative boundaries in Migori County

3.8.2 Methods of data collection and management

A combination of documentary reviews and interviews was carried out to collect data, including the following:

a) Review of project documentation and literature on fodder production mainly in Kenya, especially in Migori County and other areas of LVB-Kenya.
b) Key informant interviews (KIIs) were conducted with officials of the Ministry of Agriculture staff at the county and sub-county level and KALRO- Naivasha

c) FGDs (6 FGDs) were held in 6 locations farmers in the Nyatike sub-county while observing the WHO COVID-19 pandemic protocol.
d) Field observations on types of pasture/fodder, their status/pr4oduction and livestock keeping in the study area.

The Kobo Collect Toolkit survey was designed/digitised was used for the study. Three enumerators with previous experience conducting surveys helped collect data at the study site using their smartphone mobiles' survey tool. The consultant trained the enumerators before the study on the questionnaire, data collection methods, the 'dos' and 'don'ts' during the field survey and general expectations regarding confidentiality and informed consent, independence and impartiality, credibility, participation and openness. The data collected was exported from the server database to MS Excel 2016 in an XML format and cleaned up, analysed and used to describe and present the findings. The data was organized and analyzed using SPSS and EXCEL to enable descriptive analysis through the range of responses in categories and identifying recurrent themes.

3.8.3 Fodder production system in Nyatike sub-county

Figure 3.4 presents fodder types planted in Nyatike. The study found that the production and utilisation of Boma (Rhodes) grass were insignificant in the Nyatike sub-county. It is worth noting that Boma (Rhodes) grass is the valuable and most traded fodder type in the sub-county and Migori County. In Migori County, Brachiaria grass was recently introduced by the Accelerated Value Chain Development (AVCD) project, especially in the Nyatike sub-county. The extent of its production and utilisation is still deficient despite its immense potential. In the Nyatike sub-county, only the Thim Lich farmers group in North Kadem Ward was growing *Bracharia*. Other farmers produce Napier grass which is the most popular among cultivated fodder crops along the Lake Victoria shore. The study finds that the average area under Napier grass is 0.08 acres.

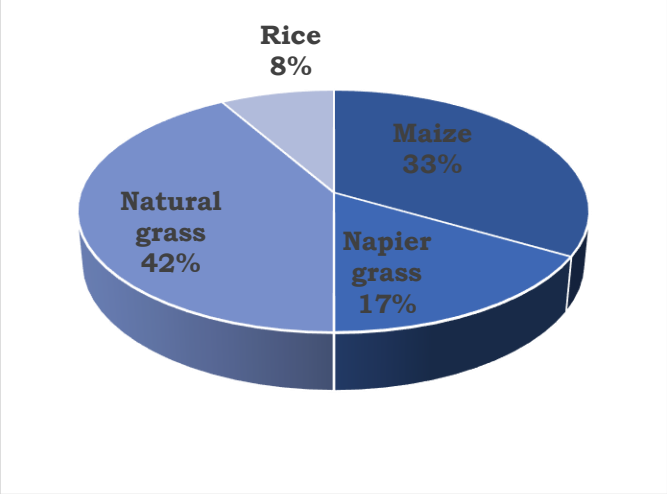

Figure 3. 4 Categories of fodder planted in Nyatike

Source: ScaleWAYS survey 2020

Although *Desmodium* has been introduced to increase the crude protein, it has not been taken up by farmers following reasons because of the expensive seeds, requires rhizobium inoculant and high rainfall areas (more than 1500 mm per year) and susceptible to many pests and diseases. Desmodium also does not tolerate drought and may require supplementary irrigation

in lower rainfall areas. It even does not tolerate alkaline soils. Crop residues and other by-products with low nutritional value contribute significantly to cattle feed, especially during the dry season. These include maize stovers, sweet potato vines, sugarcane tops, bananas stems, and legumes fed to livestock once the crop is harvested. The study found that there is also increased interest in rice production, and its straws are increasingly being used as fodder in off/dry seasons. Parts of the sub-county grow sugarcane whose tops left in the field are grazed to livestock, especially cattle in dry seasons. Both rice straw and sugarcane tops previously grazed are currently traded and offer youth and farm owners a business opportunity.

Table 3. 3 Fodder approximate acreage and central growing locations in Migori County

Fodder type	Hectares	Major locations
Napier	3742	Awendo, Kehancha, and Uriri, where dairy production is mostly done under zero-grazing
Bracharia	17	Newly introduced into the County but has potential
Desmodium	40	Awendo Rongo and Uriri. The Greenleaf desmodium is preferred to the Silverleaf desmodium
Rhodes grass	152	
Sweet potatoes vines	14	Kehancha and Kuria Nyatike during drought
Calliandra trees	17000	Uriri, Awendo and Rongo
Natural pastures	22934	Along the lakeshore
Rice straw		Kuria, Nyatike and Rongo

Source: ScaleWAYS Scoping Study 2020

We observed that Nyatike has massive potential for fodder production since land is available, and the persistent drought problem can be solved through irrigation using the Kuja and Obware Rivers. The areas with high potential for fodder intensification in the Nyatike sub-county, Migori County, are found in Table 3.4.

Table 3. 4 Proposed sites for fodder intensification in Nyatike sub-county, Migori County

No	Place	Location
1	Kabuto	Located in Got Kachola and North Kadem Wards
2	Block 2.1	Located in North Kadem Ward
3	Kanyasa	Kanyasa Ward
4	Obware	Located between Kanyasa and North Kadem Wards

3.9 Fodder value chain mapping and key stakeholders

Fodder value chain mapping

The fodder value chain in the Nyatike sub-county is still underdeveloped, despite the existing potential for fodder production, access, utilization and increased market information linkage. This scoping study found that in Nyatike, several Agro-vets (shops selling agricultural inputs) and general retail shops lead in farm input supplies, including engaging in some fodder value chain activities. Some government departments, non-governmental organizations, and fodder farmers are also involved in the fodder value chain at different levels. But some actors along the fodder value chain are lack capital, quality seed, consistent markets, and storage space. Table 3.5 shows the fodder value chain actors in the Nyatike sub-county.

Table 3. 5 Description of Fodder Value Chain Actors

Actor	Roles	Key Characteristics, Activities, and Functions
Nyatike producers Farmers/ farmers' Groups	• Production of fodder and crop residues. • Harvesting fodder and crop residues • Selling excess fodder and crop residues. • Fodder conservation through deferred feeding • Fodder storage - Processing fodder and crop residue	✓ Production is mainly at subsistence level by smallholder farmers & cattle keepers. Some also sell what they consider excess. ✓ Napier is harvested and sold green in the proximity. ✓ Conservation and the sale of crop residues are becoming popular due to frequent long-dry-spells. ✓ Conservation of natural pasture is done using fences
Fodder Traders/individuals	Harvesting, aggregation, and transportation	✓ Youths – buy and sell green fodder (Napier grass) from farmers. ✓ Farmers & youth harvest, aggregate, and transport to strategic locations in market centres. ✓ Youths sell crop residues, including maize stovers, sugarcane tops, and rice straws, when feed is scarce during dry spells.
Transporters	Aggregation, transportation	✓ fodder/crop residues are transported mainly by bicycles or hand carts, donkeys and individuals. ✓ Cut-and-carry (especially Napier) is mainly done by most of the cattle keepers.
End-users	Harvesting, storage, And processing of fodder/residue	✓ End-users of fodder are smallholder farmers. ✓ Rural farmers mostly depend on grown fodder, ✓ Urban and peri-urban farmers mainly rely on marketed fodder and supplements in dry seasons.

Source: ScaleWAYS survey 2020

Fodder value chain

The Napier grass is the most popular fodder grown and has the shortest value chain in the Nyakike sub-county. It is commonly sold directly from the producer to the consumer (fodder-deficit dairy farmers or dairy farmers who do not produce fodder) (Figure 3.5). It was observed that, except for hay, most farmers buy fodder from producers directly using their means of transport. Although elsewhere for the value chain for hay it is the producer to the retailer (e.g., Agro-vets stockists and traders selling animal feed ingredients) to consumers, the position is still rudimentary in rural and urban areas of Nyatike Sub- County. Table 6 shows estimated the gross margins of *Bracharia* sp and stovers from studies conducted on the fodder value chain in other parts by Chamgiwadu Farmers' Cooperative, Migori County. The findings suggest that there is excellent potential towards enhancing the fodder value chain in this county, which needs further exploration and efforts. Farmers in the Nyatike sub-county and the entire Migori county employ several coping strategies to feed dairy cattle when fodder is in short supply, especially during dry periods, which are becoming frequent.

Similarly, the high cost of dairy concentrates encourages farmers to use locally available feeds more efficiently. A study conducted in Rongo, Migori County, by USAID-Kenya Crops and Dairy Market Systems Activity (KCDMS) analysed a setup where a farmer with a pulveriser uses maize stovers, Boma Rhodes, Desmodium, and other legume residues to make a total mix ration (TMR) for use and sale excess to neighbours. The gross margin was approximated at 40% of production cost, making this process precious to farmers (Table 3.6).

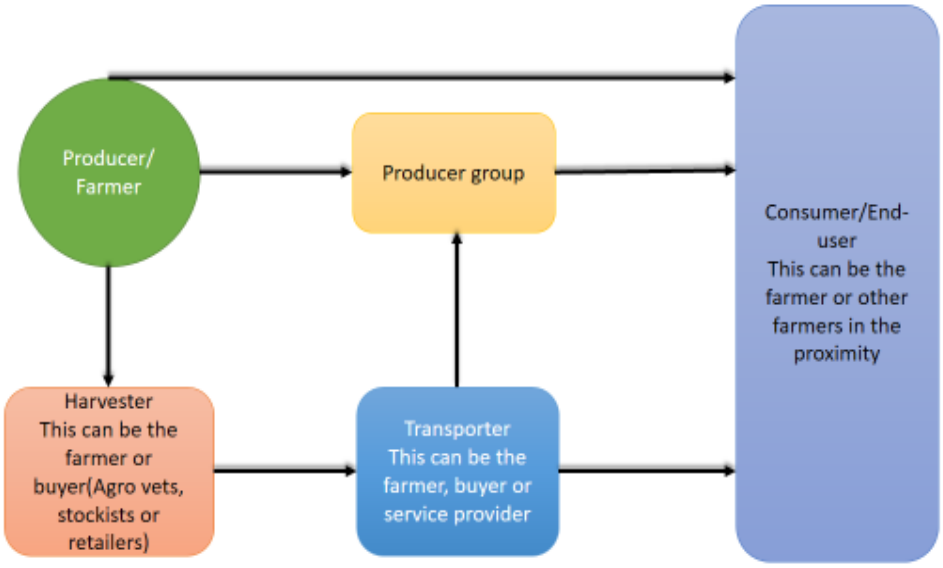

Figure 3. 5 Napier grass value chain in Nyatike sub-county, Migory County Kenya

Table 3. 6 Brachiaria Gross Margin – Chamgiwadu Farmers' Cooperative, Migori County

Items	No	Unit Cost (KES)	Total Cost (KES)	Remarks
Land preparation	1	300	300	Use of animal draft power
Harrowing	1	300	300	
Labor for nursery prep (MD)	1	150	150	
Cost of seeds (0.5 Kgs)	0.5	4300	2,150	
Labor for transplanting	1	400	400	
Fertilizer DAP	12	125	1,500	
Fertilizer CAN	12	95	1,140	
Labor for fertilizer application	2	150	300	
Labour for harvesting @1500 per cutting	3	1500	4,500	1500/cutting
Total variable cost	4	10,740	42,960/acre	
Yield (670kg/harvest X3 price 15/Kg	2010	15	30,150	120,600/acre
Gross margin/0.25 acres per year	4	19,410	77,640/acre	
Gross margin (%)	180			
Cost of production in the subsequent year				
Alternative pricing (KES 250/bale; 45 bales	135	250	33,750	Labor for baling not considered
Cost of leasing land KES 30,000 per year because of competition with sugarcane production				

Source: Auma et al., 2018

Table 3. 7 Gross Margin of TMR (Maize Stover) - Case Study of a Farmer in Rongo, Migori

Items	No.	Unit Cost	Total	Remarks
Harvesting labour (supporting harvesting of another farmers' maize)	3	300	900	Equivalent to cosit of raw material
Labor for harvesting maize stovers	3	300	900	
Transportation using a lorry - two trips	2	1500	3,000	
Storage labor	4	300	1,200	
Fuel cost (KES 500 worth of fuel crush six bags-45 bags for HB)	7.5	500	3,750	Hybrid maize produces 42 local 32 bags per acre -50 bags,
Engine oil cost or crushing 45 bags (1200 for three months)	1	250	250	
Labour for crushing (45 bags crushed in 7.5 days@ 50/bag	45	50	2,250	1 month of 26 days crush 156 Bags
Cost of other ingredients in TMR (Desmodium, Boma Rhodes, etc.)	45	50	2,250	
Total variable cost	14,500			
Sales of TMR (45 bags; KES 400-500/bag).	45	450	20,250	
Gross margins.	5,750			
Gross margin (%)	40			

Source: Auma *et al*., 2018

Key stakeholders/actors in the fodder value chain

Table 3.8 shows the critical stakeholders recorded to be active in Migori County, especially the Nyatike sub-county, during the scoping study. For example, in the livestock development and extension sector, the State Department of Livestock and Migori County Livestock Directorate is the key stakeholder. These stakeholders' role is to provide a policy framework and guidance on the livestock production sector nationally and in the county. The Directorate at County government does support the fodder value chains at different production levels and extension services to the farmers but has limited staffing. The National government also has provided milk coolers and feed inventorization. In Migori county, there is the National Agricultural and Rural Inclusive Growth Project (NARIGP). Among other roles, NARIGP aims to help increase agricultural productivity and profitability among selected smallholder farming communities, including fodder and milk production in Migori County. The Agriculture Sector Development Support Program (ASDSP) also supports food, nutrition security, and income generation. The East African Breweries Ltd is also an essential player in the area. It collaborates with Kenya's Government to implement structured, forward-contract-based supply chains for white sorghum and other beer-making crops. This arrangement can transform farmer yields and guarantee the supply of high-quality output using the crop residues as fodder from sorghum by-products.

Stakeholders mentioned international research centres such as ICIPE, ILRI, other partners, and national research institute (KALRO) to be good collaborators supporting livestock production, including fodder value chain in parts of Nyatike Sub- County as shown in Table 8. Farmers also receive technical support from KEPHIS, Kenya Dairy Board (KDB) and Agriculture and

Food Authority (AFA). Several "Jua kali artisans" engaged in fabricating quality low-cost machinery for fooder production and processing in the study area. Farm input stockists are also found in towns and marketplaces that provide valuable services to livestock farmers. From this scoping study, we observe an excellent opportunity to introduce, promote and adopt high yielding and improved fodder species in Nyatike Sub- County and Migori County in general. The various research activities demonstrate these opportunities, but more data needed to ensure sustained production, promotion, preservation/conservation and utilization of such fodder by smallholder farmers in the study area. For example, *Brachiaria* with high biomass can be grown and used for hay and silage production in the Nyatike sub-county. This will help bring more land under natural pastures and increase volumes of improved fodder for feeding livestock. We also observed that there is still low commercialisation of fodder in the area leading to a low desire to grow such valuable fodder. This leads to a low yield of fodder per unit area due to the planting of inappropriate species and poor fodder management. Nyatike Sub- County is characterized by vast degraded rangeland areas, which can be rehabilitated through reseeding with suitable natural pastures. This may more than double the smallholder farmers' benefits by providing increased feed and environmental protection.

Table 3. 8 Key stakeholders in the fodder value chain

Sector	Stakeholder	Details and potential areas of collaboration
Extension	County Livestock Production and State Department of Livestock Production	✓ support the fodder value chains through the Department of Livestock Production ✓ providing extension services to the farmers. ✓ Supports farmers with inputs such as seeds of improved fodder either through donor-funded programmes or counties own programmes. ✓ The County plans to establish a modern feed manufacturing factory.
	National Agricultural and Rural Inclusive Growth Project (NARIGP)	Support & funds increased agricultural productivity and profitability for smallholder farmers e.g. ✓ fodder production ✓ milk production.
	Agriculture Sector Development Support Program (ASDSP)	Supports food, nutrition security and income generation to farmers
	Farmers	Own the land and produce the fodder
Subsidy and policy formulation	National Government	Milk coolers and feed inventorization
	East African Breweries Ltd	EABL collaborates with Kenya's Government to implement ✓ agricultural infrastructured, ✓ support forward-contract-based supply chains for white sorghum and other beer-making crops. ✓ Works to transform farmer yields and guarantee the supply of high-quality output. ✓ Support use of crop residues to provide fodder from sorghum and other technologies.
Improved fodder technologies and inputs	Research organizations; ICIPE ILRI and partners, KALRO	✓ ICIPE promotes Napier and Desmodium production under its push-pull technology project & encourages Brachiaria (Mulato) production by smallholder farmers. ✓ ILRI promotes some animal feeding technologies, fodder planting materials & provides farmer training. The main fodder crops promoted are Boma Rhodes, *Brachiaria* and *Napier* species that are tolerant to diseases and pests. ✓ KALRO promoted improved fodder and natural pasture management and seed collection & supply, harvesting, treatment, storage, and marketing.

Sector	Stakeholder	Details and potential areas of collaboration
	Jua kali artisans	✓ Fabrication of quality low-cost machinery for fooder production and processing
Regulatory	KEPHIS	✓ Provides a science-based regulatory service by assuring the quality of agricultural inputs and produce, promoting food security and sustainable development.
	Kenya Dairy Board (KDB)	✓ Regulates, promotes and develops the dairy industry. ✓ Ensures adoption of measures and best practices are promoted to the highest efficiency.
	Agriculture and Food Authority (AFA)	✓ responsible for enhancing synergies between the various actors. ✓ Ensures standardization and quality assurance of agricultural products ✓ Enhances positive competitiveness in the sector
Sale of grass seeds and other inputs	Kenya Seed Company Limited	✓ responsible for bulking of quality fodder seeds ✓ sells fodder/grass seeds to farmers.
	Input stockists e, g. Agrovets	✓ Sell farm inputs required for fodder and livestock production

Source: ScaleWAYS Scoping Study 2020

Table 3. 9 Summary of key opportunities for intervention in feed and fodder production

Activities	Challenges	Opportunities for Intervention
Fodder production and utilisation	• High demand for fodder amidst reducing land sizes and competing farm enterprises • Knowledge gap – information on fodder production and proper feeding practices • Certification process for grass seeds as outlined by KEPHIS regulations is a challenge to smallholder seed producers	1. Adopt varieties of high yielding improved fodder species availed by research in suitable areas 2. Testing and implementing viable commercial seed/splits production models 3. Testing and implementing viable commercial fodder production models 4. Extension and training on production and feeding 5. Support farmers' groups to develop useful feeds plan and put it into use – planning to ensure an adequate supply of fodder at the time of scarcity

3.10 National policies and institutional frameworks

3.10.1 The legal framework

This consists of legislation that empowers the relevant institutes to carry out their mandate. The main Acts of Parliament that shape Kenya's feed industries are the Fertilizers and Animal Foodstuff Act [Cap. 345], the Standards Act [Cap. 496], the Animal Disease Control Act [Cap. 364], Customs and Excise Act [Cap. 472], Public Health Act [Cap.242], Plant Protection Act [Cap. 324], Weight and Measures Act [Cap 513], and the Trade Descriptions Act [Cap. 505]. Some legislation regulating animal feeds are old, and these include:

- The Fertilizers and Animal Food Stuff Act Cap 345 (1967).
- The Standards Act Cap 496.
- The Animal Disease Act Cap 364.

The Animal Feedstuff Bill, 2016, is under review and aims to repeal the Fertilizers and Animal Foodstuffs Act, Cap 345, by bridging some existing gaps. The Animal Feedstuff Bill, 2016 has no legal framework that facilitates engagement between the Ministry and the industry players and does not provide a framework for governing and controlling the country's sub-standard or

counterfeited animal feedstuff. As such, most small-scale livestock keepers are at a disadvantage as the Law of the land does not adequately support them.

There are some Acts relevant (directly or indirectly) to the animal feed industry, which include:

- ✓ The Fertilizers and Animal foodstuff Act [Cap. 345] regulates the importation, manufacture, and sale of agricultural fertilizers and animal foodstuffs and animal origin substances intended to manufacture fertilizers and foodstuffs. It was first published in 1967 has been reviewed twice by Session papers of 1983 and recently 2008. There is a need to separate the Act from Fertilizers and Animal feedstuff and review penalty fees to approximate today's living standards.
- ✓ Standards Act [Cap. 496] empowers the Kenya Bureau of Standards to set and control standards or codes of practice for commodities produced or imported into Kenya and protects three dimensions: public health safety, environmental safety, and industrial safety. The Act provides powers to inspectors to check processing operations, specify both input and output of the production line, and issue the relevant standardization mark of quality about the feed manufacturing industry. Some complaints about feed quality warrant an informed approach to reform KEBS weak feed regulatory framework.
- ✓ The Animal Disease Control Act [Cap. 364] regulates animal disease control mechanisms. Under L.N.326/1996, the Animal Disease Control Act empowers government livestock officers and veterinary officers to inspect/prohibit importation of meat and bone meal and their products. Kenya has few rendering plants; however, the existence of zoonotic diseases such as scrapie, Bovine spongiform encephalopathy (BSE), and avian influenza requires that a trace-and-tracking system, surveillance, and monitoring framework is in place.
- ✓ Customs and Excise Act [Cap. 472] provides rules of thumb for the management, assessment, and administration of customs and duty. Kenya feed millers, in part, rely on international markets to meet their input requirements in feed manufacturing. Therefore, the amount of duty charged on raw materials for the feed manufacturing industry and the end products implies consumer prices and the industry's overall competitiveness.
- ✓ Public Health Act, [Cap.242] is responsible for making provisions to ensure public health and food safety. There is a need for better networking between this department, the Ministry of Livestock and Development, Ministry of Industrialization to ensure that feed quality and safety mandates are assigned and not duplicated. Weight and Measures Act [Cap.513] amends and consolidates the law relating to the use, manufacture, and sale of weights and measures and provides the introduction of the International System of Units (SI) connected purposes.
- ✓ Plant Protection Act [Cap.324] lays down guidelines for preventing disease's introduction and spread to plants. This includes screening the imported plants and plant materials or being moved from one country to another. The Act confers power to enforce the legislation to the Minister for Agriculture.
- ✓ Trade Descriptions Act [Cap. 505] establishes a system of measurement units, controls weighing and measuring equipment in use for trade, controls transactions in some goods, and protects the public against false trade descriptions—the Act advocates for compulsory verification of new and repaired weighing equipment as well as periodical checks.
- ✓ The Livestock Identification and Traceability System Regulations, 2019 form part of the Animal Health Act, 2019, and provide strict guidelines on identifying and tracing

livestock and sources their products in the market. Each county director of veterinary service is expected to keep accurate, up-to-date, and reliable animals' data. The county veterinary chief must register all establishments, farm holdings, or premises where animals are kept and issue animal identification numbers consisting of not more than 15 digits.

3.10.2 Long-term policies and strategies

Policy and legal reform areas of interventions include National Livestock Policy, Poultry Policy, Livestock Breeding Policy, Animal Disease Control Policy, Animal Welfare Policy, Apiculture Policy, Dairy Development Policy, Animal Feedstuff Policy, and National Veterinary Pharmaceuticals Policy

a. The Kenya vision 2030- The Kenya vision 2030 – implemented through a series of Medium Terms Plans (MTP 2008/12, MTP II 2013/17 and MTP III 2018/22) – aims to transform Kenya into an industrialised middle-income country ensuring high-quality life to all its citizens. Over and above the current MTP III, the President's Big 4 priority agenda (2019/22) focuses on enhancing food security, affordable housing, manufacturing and universal health, modelled around Public-Private Partnerships (PPP). The Third Medium Term Plan (MTP III) is a nationwide multi-sectoral document that outlines the central policies, legal and institutional reforms, and programs and projects that the Government plans to implement during the period 2018-2022. Eight priority Sectors have been identified to drive economic growth. These are (1) Agriculture and Livestock; (2) Manufacturing; (3) Tourism; (4) Trade; (5) Business Process Outsourcing; (6) Financial Services; (7) Oil, Gas and Mineral Resources; and (8) the Blue Economy. To help eliminate hunger and food insecurity, the main proposals of the MPT III are (i) irrigate 1.2 million acres, (ii) expand the area under crop production; (iii) reduction of food prices and support value addition (iv) subsidize fertilizer under the fertilizer cost reduction program; (v) promotion of food and nutrition security, and generation of income vi) expand the Strategic Food Reserve Trust Fund (vii) establish livestock disease-free zones and strategic feed reserves built to improve the availability of fodder in Arid and Semi-Arid Land (ASAL) areas during drought, and (viii) implement programs and projects to address the twin challenges of climate change and drought. The Vision 2030 document envisages to make agriculture, forestry and fisheries more productive and sustainable through (ii) improving access, affordability, and suitability of fertilizers; (iii) development and adoption of new crop varieties iv) increasing land under irrigation (v) strengthening the adoption of agricultural mechanization (vi) supporting farmers to access agriculture insurance, and (vii) develop research and capacity building programs. Rural poverty would mainly be reduced through water projects in urban and rural areas to increase the number of people connected to safe piped water, including drilling new boreholes and providing safe, reliable and sustainable water to public schools and health institutions.

   Furthermore, the objectives of agricultural development are all aimed at achieving rural poverty reduction. To enable more inclusive and sustainable food and agriculture systems the document seeks to achieve the following (i) build retail markets to facilitate trade; (ii) increase gender equality, empowerment of women, youth, and persons living with disability and other vulnerable groups; (iii) increase the number of women trained on entrepreneurship skills; (iv) develop subsidized inputs for smallholder farmers; (v) promote measures for exports of agricultural and livestock products in the regional and international markets; (vi) create sustainable and gainful self-employment for the youth and women through their participatory engagement in agriculture; (vii) offer incentives for integration of youth and women into agribusiness value chains including market

guarantees, incubation training and scholarships in agribusiness to produce high value horticultural crops; and (viii) enhance market access by providing an enabling environment through policy, legislation and regulations, model guidelines for improved market infrastructure and enhanced access to information. The resilience of livelihoods to disasters shall be increased through (i) enhancing governance, coordination and financing of climate change-related activities in all sectors of the economy through the National Climate Change Council, development of subsidiary legislation, and resource mobilization; (ii) promotion of a low carbon climate resilient and green growth development through strengthening climate change governance and coordination, climate change monitoring, reporting and verification, capacity building and public awareness, and formulation and implementation of Green Economy Strategy and the National Climate Change Action Plan; (iii) an integrated Disaster Risk Management System to focus on preventing or reducing the risk of disasters, mitigating the severity of disasters, enhancing preparedness, rapid and effective response and post-disaster recovery; and (iv) strengthening the capacities of pastoral communities and stakeholders on the use of insurance products for reduction of weather-related risks and rebuilding of livelihood support systems in drought-prone areas by expanding crop insurance programs.

b. The Agriculture Sector Development Strategy (ASDS – 2010/20), the Food and Nutrition Security Policy (2011). It aims at enhancing sustainable agricultural productivity for food and nutrition security through innovative, commercially oriented and modern agriculture. The sector's overall development and growth are anchored in two strategic thrusts: increasing productivity, commercialization and competitiveness of agricultural commodities and enterprises and developing and managing critical production factors.

c. Kenya Climate Smart Agriculture Implementation Framework (2018/27) guides the agriculture sector's growth and transformation. It also aims at enhancing sustainable agricultural productivity for food and nutrition security. The Framework explores smart climate practices relating to sustainable intensification of crops, agroforestry, livestock and fisheries production; adaptation and mitigation practices in livestock production systems; efficient management of agricultural commodity value chains; opportunities to leverage climate finance for CSA; knowledge sharing and practical learning; strengthening key institutions and systems for CSA initiatives; and mainstreaming CSA elements into national policies and development planning process (KCSAI Framework-2018-2027).

d. The Agriculture Sector Transformation and Growth Strategy (ASTGS-2019/29) emphasises the importance of modernizing agriculture and shifting towards more value to attain 100 per cent food and nutrition security. The ASTGS prioritizes three anchors to drive the 10-year transformation, with specific targets set for the first five years. Anchor 1 seeks to increase small-scale farmer, pastoralist and fisherfolk incomes by raising the average annual small-scale farmer incomes by approximately 40% from KES 465/day to 625/day (about 35% increase) and benefit about 3.3 million Kenyan farming households Directly. Anchor 2 seeks to increase agricultural output and value add and expand agricultural GDP from KES 2.9 trillion to approximately KES 3.9

trillion (6% CAGR[1])and growing contribution of agro-processing to GDP by approximately KES 130 billion over five years (about 50% from KES 261 billion today). Anchor 3 seeks to increase household food resilience by reducing the number of food-insecure Kenyans in the ASAL regions from 2.7 million on average to zero[2] while lowering the cost of food, improving nutrition, and protecting households against environmental and fiscal shocks.

e. The National Livestock Policy (revised 2019) is the overarching framework that guides Kenya's livestock sector development. The policy aims at supporting a transformation of the sector from subsistence to commercial undertaking to improve the livelihoods of smallholder farmers and pastoralists, enhance food and nutrition security for all Kenyans, and contribute to increased agro-industrialization and inclusive economic growth through the generation of employment opportunities along the livestock value chain. The Livestock Policy (2019) covers critical issues relating to farm animal genetic resources, livestock feeds and nutrition, inputs, animal diseases and pests, livestock marketing, research and extension, and food security. The new livestock sector policy replaces the old policy of Sessional Paper No 2 of 2008. Livestock services were governed by the Crop production and Livestock Act, Cap.321 (1926), which was repealed by the Crops Act 2013. The new law did not include issues on livestock services. There is, therefore, an urgent need for a legal framework for livestock production services and to entrench the crucial institutions such as Kenya veterinary vaccines production Institute, Kenya tsetse and trypanosomiasis eradiation council, Kenya animal genetics resources centre, and Animal health and training institutes into law.

f. Fodder Policy- Gaps in the policy include:

- ✓ the lack of the role of fodder production in enhancing the resilience of livestock production.
- ✓ Support for promoting traditional range use and grazing management does not consider changes in culture and land.
- ✓ The absence of a policy statement specific to the fodder value chain in ASAL counties hampers investment to spur its production and conservation.
- ✓ Lack of a favourable environment for private investment in commercial fodder production or support the fodder value chain in ASALs.

3.10.3 Institutional frameworks

The Ministry of Livestock Development (MoLD), through its Department of Livestock Production and Department of Veterinary Services, the KEBS for laboratory testing of feeds, and the Kenya Plant Health Inspectorate Services (KEPHIS), are responsible for quality fodder planting materials, production and trade on seeds. The Department of Livestock Production functions is primarily in animal breeding, nutrition, husbandry, and marketing. The Department

[1] Compound annual growth rate (CAGR) is the rate of return that would be required for an investment to grow from its beginning balance to its ending balance, assuming the profits were reinvested at the end of each year of the investment's lifespan.

[2] Currently, ~1.5mn Kenyans are chronically food-insecure, including 1.3mn in ASALs. During emergencies, the most severe of which are droughts historically, number rises to ~3.4-3.7mn total, so this is an average of ~2.7mn chronically and in-emergency food-insecure. The. ASTGS assumes that in the aspirational case, 100% coverage of the average food-insecure population (taking % of population that is food-insecure from 2008-2017 and extrapolating to the 2022 population); conservative case is full coverage of chronic food-insecure population in ASALs of ~1.3 million

of Veterinary Services is responsible for disease control, regulatory management, and quality control of inputs, livestock, livestock products, and by-products, including livestock feeds. The certification process for grass seeds, although outlined by KEPHIS, is a challenge to smallholder seed producers. Natural pasture seeds with massive demand within and outside the country need attention during multiplication and management. Other regulatory organizations connected to this process at different stages are the National Environment Management Authority (NEMA), Kenya Revenue Authority (KRA) and the National Bio-Safety Authority (NBA). There is also some conflict in the Livestock Production Department's responsibility and that of Veterinary Services on who should be responsible for fodder value chain management. We found that in Nyatike Sub- County, several factors constrain the livestock development sector, especially fodder value chain i.e.

- ✓ Recurrent droughts that lead to massive livestock losses and livelihoods for the pastoralists constitute a significant concern.
- ✓ Lack of reliable markets undermines dedicated livestock and fodder development efforts.
- ✓ The liberalisation of domestic agricultural products marketing has reduced the roles of the Kenya Meat Commission (KMC) and Kenya Cooperative Creameries (KCC). The marketing of livestock and livestock products left to the private sector
- ✓ The poor state of infrastructure, which increases the marketing costs and aggravates the marketing problem.
- ✓ Some conflicting National and County government Policies, a regulatory framework, and institutional arrangements do not support a robust fodder value chain.
- ✓ Lack of a policy framework or enforcement mechanisms to grow fodder development.

Table 3. 10 Summary of livestock feed laws and regulatory framework in Kenya

Legislation and regulations	Enforcing agencies	Comment
Fertilizers and Animal foodstuff Act [Cap. 345],	MoLD: ✓ Dept. of Livestock Development ✓ Dept of Veterinary Services.	
Standards Act [Cap. 496]	Kenya Bureau of Standards	Some of Animal Feeds Standards include ✓ KS CAC/RCP 54-2009 on Practice on Good Animal Feeding ✓ KS 1647:2001 on animal feed production, processing, storage and distribution.
Animal Disease Control Act [Cap. 364] Revised Edition 2012 [1989]	MoLD: ✓ Dept. of Livestock Development ✓ Dept of Veterinary Services.	✓ Measures to be taken by public bodies and holders of animals for the control of an animal
Seed and Plant Varieties Act (CAP 326) Revised Edition 2012 [1991]	Kenya Plant Health Inspectorate Service (KEPHIS)	Phytosanitary regulations for the importation of grains and other crop used in feed processing
The Public Health Act (Cap 242)	Ministry of Health	✓ protection of public health in Kenya. ✓ provides rules relative to food hygiene and safety of foodstuffs, the keeping of animals, ✓ protection of public water supplies, the prevention ✓ destruction of mosquitos and the abatement of nuisances arising from sewerage.
The Environmental Management and Coordination Act (Cap 8)	National Environment Management Authority NEMA	✓ There is the National Environment Council for policy direction

Source: ABS TCM LTD. (2013)

3.11 Sources of pasture seeds and planting material

In Kenya, fodder seeds sourcing and delivery pose a significant challenge in both formal and informal sectors since the latter sources have to comply with the requirements of KEPHIS and need to be from approved fodder/grass seeds varieties. This process entails the National Performance Trial (NPT), Distinctiveness, Uniformity, and Stability (DUS) tests. KEPHIS conducts both NTB and DUS to confirm the particular variety's descriptor. The informal channel involves seeds, mainly forages, propagated vegetatively do not have to pass through the regulations unless the materials are procured outside the country. But they require quarantine to ascertain pest disease-free status (Mwendia et al., 2016). Some farmers in the study area were aware of fodder varieties that were being promoted by several companies such as Advanta Seeds Company (ASC) from India, Tropical Seeds Company (TSC), Kenya Seed Company (KSC), Pannar Seed companies (PSC). The informal seed system is driven mainly by farmers (KALRO) and Agricultural Training Centers (ATC). The informal seed exchange and delivery are through farmer-to-farmer arrangements or from the government and local and international NGOs such as USAID-KAVES Project. Table 3.11 shows the seed companies in Kenya and type forage seed sold to farmers in Migori county, while Figure 3. 7 Formal and informal sources of seeds and planting material for forages in Kenya's ASALs.

Table 3. 11 Seed companies in Kenya and type forage seed sold to farmers in Migori county

	Company	Forage seed	Headquarters
1	Simlaw Seeds Company	Lucerne, Boma Rhodes, Elmba Rhodes	Kijabe Street, Nairobi, Kenya, Phone: 0722 200545 www.simlaw.co.ke
2	Pannar Seed(K) Ltd	Dual-purpose sorghum	PANNAR HSE, Kipkenyo, Kitondo St, Eldoret Phone: 053 2060240
3	Pioneer Hi-Bred K Ltd	Lucerne	DuPont Pioneer Zambia Limited, Plot No 35283 Mwembeshi Road, Heavy Industrial Area, P.O. Box 33282, Lusaka Tel: +260 211 846 299, +260 211 846 318, info.zambia@pioneer.com
4	Kenya Seed Company	Lucerne, Boma Rhodes, Elmba Rhodes	P.O. Box 553 – 30200, Mbegu Plaza, Kijana Wamalwa Street next to NCPB Safaricom Line: +254 722 205 144 or +254 726 141 856, Airtel Line: +254 739 480 663 729, Email: info@kenyaseed.co.ke
5	Western Seed Company	Desmodium, Lucerne	49464, 00100 Nairobi GPO, Nairobi, Kenya Phone (254) 20 - 891868
6	Hygrotech EA Ltd	Lucerne, Kowkandy	Tigoni Centre, Limuru Rd, Karuri, P.O. Box: 41446-00100 Nairobi Phone: +254-202053916 Fax: +254-502053921
7	Leldet Kenya Ltd	Fodder sorghum	Nakuru-Rajwera Farm, P.O. Box 16065, Nakuru 20100, Kenya, leldet@leakeygroups.co.ke For Sales: (+254) 0723 469007
8	Tropical Seeds	Brachiaria	Daniel Gor Nambiok (0711489550) C/O John Okelo Olual (0724737139) Dr Charles Wasonga cjw56c@gmail.com (254729152473) Awendo General Stores, Homabay County, Kenya
9	Advanta	Fodder sorghum (non-genetically modified imidazolinone herbicide tolerance sorghum trait, igrowth).	KIPRO CENTER, 2ND Floor, Westlands, Sports Road P.O Box 1035 - 00100 Nairobi, Kenya, Phone number +254724314614 mobile +254709186000 Email info@advantasms.com

Source: ScaleWAYS Scoping Study 2020

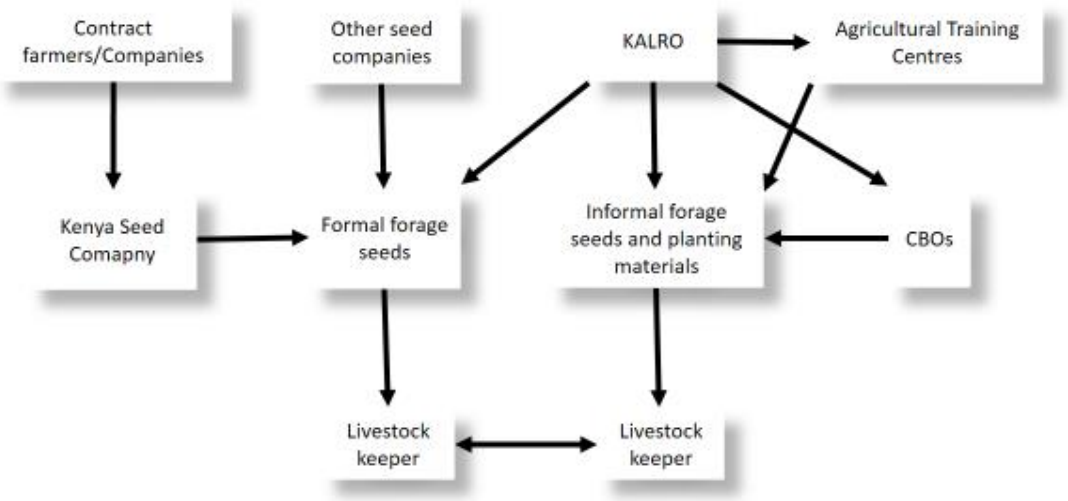

Figure 3. 6 Formal and informal sources of seeds and planting material for forages in Kenya's ASALs. Adapted from Mwendia et al. 2016

3.12 Uptake, adoption and marketing of pasture and fodder improvement technologies

Fodder can be sold green, as hay or in the form of silage, provided it has the right dry matter (DM) content and quality. Despite there being a tiny sale of fodder and seeds, there is much potential in Nyatike. For example, the African foxtail (Cenchrus ciliaris) grass is grown mainly for its straws that make hay and seed. Farmers bale the grass and sell it to local livestock keepers. Unlike other crops such as maize, grass regenerates every time it rains. According to Priscah, you can hardly go wrong with grass farming (WFP, 2018). In Nyatike, there is very little practice of pasture technologies other than deferred feeding. Manyeki et al., 2013, reported that the adoption and uptake of pasture technologies are highly dependent on the age and education level of the household head, land ownerships, and affiliation to farmers groups. This is similar to the case of Nyatike, where young people are adopting *Bracharia* sp. Other factors include a lack of farmer participation in on-farm trials, farming experience, and land ownership. More awareness needs to be done by the different actors to hasten the process and progress of adopting technologies, especially with the prevailing social, ecological, and economic conditions since uptake is still not desired. Despite the research carried out in pastures, utilisation of crop residues, and even supplementation, livestock's poor nutrition is a significant challenge to Kenya's productivity, especially Nyatike Sub- County. Actors along the pasture and fodder value chains in Migori County perceive feed availability as one of the significant issues facing livestock productivity in Kenya's ASALs. The increased frequency of drought in the Nyatike sub-county further exacerbates the problem due to dependence on natural pastures as fodders, which are quickly depleted. Supplementation is minimal except where cows are sick or being milked. There is a need to empower communities to deal with the changing climatic and weather conditions, particularly drought, for increased livestock productivity. In Nyatike, the respondents during the FGDs and The KII reported that rainfall variability, seed scarcity, the high cost of inputs, and lack of fodder management skills were

mentioned as the respondents' main constraints. Table 3.12 shows the limitations faced by livestock keepers in Nyatike and possible solutions.

Table 3. 12 Constraints faced by livestock keepers in Nyatike and possible solutions

Constraint	Possible solution
Harsh climate and weather variability	Introduction of irrigation technology
Lack of quality planting materials for fodder species	Introduction of quality planting materials.
Lack of knowledge on fodder management technologies	Capacity building
Lack of awareness of fodder varieties	Capacity building
The high cost of inputs, e, g, seed, inoculant, among others	Subsidy
Lack of certified seed	Research and bulking of seed

Source: ScaleWAYS Scoping Study 2020

3.13 Strategies for improving fodder production and quality in Nyatike, Migori county

Sustainable fodder production requires the use of technologies, which ensure maximum fodder production in a limited area all year round. Some of the models for sustainable fodder production are:

- ✓ Fodder production on bunds- Bunds are laid around fields to check run-off losses. This would be used in the rice-growing areas to maintain the bunds and reduce repairing bunds annually. A combination of mixed hedges of leguminous family and forage grasses can enhance the production of fodder. Brachiaria *sp* and *Panicum maximum* can grow, produce fodder, and conserve soil and moisture.
- ✓ Year-round fodder production- The combination of multi-purpose tree sp., shrubs, grasses, and legume can play a vital role in improving fodder production and assured availability round the year. The biomass, energetics of three-tier silvopastoral systems have been reported to be more productive than the natural pastures. Research at Indian Grassland and Fodder Research Institute (IGFRI) have shown that 2.9-7.9 t/ha dry forage could be produced under the silvopastoral systems without affecting the growth of associated trees (Singh and Roy, 1991). The system has proved to be successful in the areas receiving less than 800 mm rainfall with nine months of the dry season.

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4 RWANDA

4.1 Livestock production systems in Rwanda

Generally, there are two types of feeding constraints: quantitative and qualitative. Quantitatively, the mountain and medium-altitude pastureland has been overgrazed, leading to soil degradation (invasion by woody shrubs, ginger grass and other weeds which are not edible for cattle). Generally, forage shortage during the dry season is an annual occurrence and very significant over the country. This leads to a considerable decline in milk production when the demand increases in consumption centres and to a substantial increase in deaths, particularly cattle. Qualitatively, animal nutrition in Rwanda experiences a big protein gap.

On the one hand, because of the degradation of grazing land and the relative weakness of the only available fodder grass, pastures' feed value can be qualified as low in most cases. As for planted fodder, which is not available in sufficient quantities, they are cut belatedly at the state of shrubs and are rarely associated with leguminous plants. On the other hand, commercial concentrates are unbalanced, but their high price seriously affects the farms' yields where they are used. Besides, there is poor adoption of fodder conservation techniques (silage or haymaking) which could help out during the dry season. There is a relative overproduction of fodder during the rainy season and the opposite in the dry season. This could be useful, except that the quantities produced are not enough for most family farms to make silage possible for most family farms. But haymaking can be done everywhere. Breeders are aware of the importance of nutrition for livestock productivity. Still, their resources are limited while prices have soared at the same rhythm as foodstuffs used as raw materials for making concentrates.

With the introduction of improved cattle, quality feed requirements have increased. For example, a cow with the potential to produce milk should be fed with a balanced diet on high-quality fodder and concentrate and sufficient quantity for it to give its full yield. Breeders should, therefore, improve their natural pastureland where necessary and develop fodder crops according to research guidelines. On the other hand, they should use balanced concentrates to supplement the feeding requirements of their animals. Therefore, the manufacturing of animal feeds should be developed in parallel with an increase in milk production. At the moment, there is no industrial plant for producing these feeds. Those available are made here, and there is an almost cottage manner, which negatively influences their quantity and quality.

4.2 Livestock production systems and key areas/ecosystems

4.2.1 Extensive Livestock Production

The extensive production system is mainly practised in the Eastern Province, especially in Nyagatare and Gatsibo (North-Eastern part of Rwanda in Eastern Province) and Gishwati area (Northern part of the Western Province). The cattle feed nearly always by grazing on individual farms. The stocking rates per hectare per cow are often higher than the recommended capacity. This overgrazing of prairies leads to land overexploitation and the introduction of exotic and undesirable plant species. This overgrazing has reached dangerous levels and constitutes a severe threat to the environment, with animals squeezed in small areas, while cattle productivity leaves much to be desired.

4.2.2 Agriculture and livestock mixed system

The agriculture and livestock mixed system a system run mainly practised by households or enterprises where agriculture and livestock are more or less integrated components of the same farm. The most integrated systems are characterized by interdependence between agricultural and livestock activities. Generally, this system offers more opportunities to check the adverse effects of livestock on the environment and strengthen its positive impact, soil fertility conservation using farm manure and effective crop/herding rotations. But still, this depends on the farming objective: food plant cropping vis-à-vis cattle production.

4.2.3 Stalling with basic feeding based on cut fodder from outside the farm

This is a system where the fodder is made up mainly of grass grown on owners or hired land and carried home for the cattle enclosed on the farm or near the farm. Most of the fodder is cut from outside the farm. The system is characterized by land scarcity, and the cattle in a stall is fed with the grass cut on riverbanks or roadsides and everywhere where green grass is found in abundance near crop farms. It has been, since recently, adopted in most parts of the country. The remains of harvests and household residues are extensively used but are insufficient to meet all the needs.
In some cases, concentrate feeds are provided. Concentrates feeding is preferably more used in Kigali city and grouped settlements. This system is intensely used in rural areas in high agricultural potential areas, particularly around valleys and the hills' dips. In these areas, cattle wandering is no longer authorized. This system is practised by farmers who generally own small farms. Their fields are cultivated intensively to produce mainly for the subsistence needs of their families. Generally, the households are poor, earning low incomes mostly from tilling the land. These farmers encounter difficulties related to access to resources and a lack of knowledge and training in cattle management to ensure productivity. Those families are currently encouraged to keep other livestock (e.g., sheep and goats).

4.2.4 Dairy livestock on ranches or big farms

This system is rarely used due to insufficient vast grazing land. A few farms are found predominantly in the Eastern Province, around Kigali City, and the Government farms at Songa and Rubona (branches with Rwanda Agricultural Board's site offices). Generally, this system requires much investment and can be more cost-effective while requiring fewer human resources. Nonetheless, it has been observed that in many cases, the owners of these farms are not professional breeders who monitor daily the management concerns of their farms. On the other hand, these are people who have different occupations, leaving it to the herdsmen to manage their farms to the detriment of efficiency.

4.2.5 Livestock breeds and products

Table 4. 1 Evolution of Cattle Population in Different Rwanda Production Zones from 2008 to 2020

Production Zone	Year / Breed	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Ngoma Dairy Farming Area (Eastern part of Rwanda – Eastern Province)	Cattle Population													
	Local	103,873	100,946	90,328	85,577	81,154	77,083	73,174	69,462	65,939	62,595	59,573	56,665	53,898
	Crosses	14,802	34,754	61,161	75,953	82,296	89,196	96,674	104,779	113,564	123,085	133,625	145,112	157,586
	Pure	5,188	11,669	24,959	36,792	39,865	43,207	46,830	50,756	55,011	59,623	64,729	70,294	76,336
	Total	123,863	147,368	176,448	198,322	203,315	209,486	216,677	224,997	234,514	245,303	257,927	272,070	287,821
	Lactating Cows													
	Local	31,422	30 793	28 890	27,370	25,956	24,614	23,366	22,181	21,056	19,988	18,992	18,065	17,183
	Crosses	5,329	11 062	20 296	25,205	27,264	29,550	32,028	34,713	37,623	40,777	44,196	47,995	52,121
	Pure	2,023	3 872	8 282	12,209	13,207	14,314	15,514	16,815	18,225	19,753	21,409	23,249	25,248
	Total	38,774	45 728	57 468	64,784	66,427	68,478	70,908	73,708	76,904	80,518	84,598	89,310	94,552
Nyirangarama Dairy Farming Area (Northern part of Rwanda, Northern Province)	Cattle Population													
	Local	52,118	50,649	45,322	42,938	40,719	38,676	36,715	34,852	33,085	31,407	29,891	28,431	27,043
	Crosses	5,643	24,913	52,163	66,219	71,749	77,764	84,284	91,350	99,009	107,310	116,500	126,514	137,390
	Pure	1,400	7,439	21,237	32,766	35,503	38,479	41,705	45,202	48,992	53,099	57,646	62,602	67,983
	Total	59,161	83,002	118,722	141,923	147,971	154,920	162,704	171,405	181,086	191,816	204,037	217,548	232,417
	Lactating Cows													
	Local	15,766	15,450	14,495	13,733	13,023	12,350	11,724	11,129	10,565	10,029	9,529	9,064	8,622
	Crosses	2,031	7,930	17,310	21,974	23,770	25,763	27,923	30,264	32,801	35,551	38,532	41,844	45,441
	Pure	546	2,469	7,047	10,873	11,762	12,748	13,817	14,975	16,231	17,591	19,066	20,705	22,485
	Total	18,343	25,849	38,853	46,581	48,555	50,861	53,463	56,368	59,597	63,172	67,128	71,614	76,548
Karongi Dairy Farming Area (North-Western part of Rwanda, Western Province)	Cattle Population													
	Local	36,188	35,168	31,469	29,814	28,273	26,855	25,493	24,200	22,972	21,807	20,754	19,741	18,777
	Crosses	3,586	22,703	50,142	64,033	69,380	75,197	81,501	88,335	95,741	103,767	112,654	122,338	132,854
	Pure	396	6,318	20,251	31,699	34,347	37,226	40,347	43,730	47,396	51,370	55,769	60,563	65,769
	Total	40,170	64,189	101,861	125,546	132,000	139,278	147,342	156,264	166,109	176,945	189,177	202,642	217,401
	Lactating Cows													
	Local	10,947	10,728	10,065	9,535	9,043	8,575	8,140	7,727	7,335	6,963	6,617	6,294	5,986
	Crosses	1,291	7,226	16,639	21,249	22,985	24,912	27,001	29,265	31,718	34,378	37,260	40,463	43,941
	Pure	154	2,097	6,720	10,519	11,379	12,333	13,367	14,488	15,702	17,019	18,445	20,031	21,753
	Total	12,392	20,051	33,424	41,303	43,407	45,820	48,508	51,480	54,756	58,360	62,322	66,788	71,681
	Cattle Population													

Production Zone	Year / Breed	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Rusizi Dairy Farming Area (South-Western part of Rwanda, Western Province)	Local	33,736	32,785	29,337	27,794	26,357	25,035	23,765	22,560	21,416	20,330	19,348	18,404	17,505
	Crosses	4,417	23,596	50,958	64,916	70,337	76,234	82,626	89,553	97,061	105,199	114,207	124,025	134,687
	Pure	1,013	7,007	20,857	32,355	35,057	37,996	41,182	44,635	48,377	52,433	56,923	61,816	67,130
	Total	39,166	63,388	101,152	125,065	131,752	139,266	147,573	156,748	166,854	177,961	190,478	204,245	219,322
	Lactating Cows													
	Local	10,205	10,001	9,383	8,889	8,430	7,994	7,589	7,204	6,838	6,492	6,168	5,867	5,581
	Crosses	1,590	7,511	16,910	21,542	23,302	25,256	27,373	29,668	32,156	34,852	37,774	41,021	44,547
	Pure	395	2,325	6,921	10,737	11,614	12,588	13,643	14,787	16,027	17,371	18,827	20,445	22,203
	Total	12 ,190	19,837	33,214	41,168	43,346	45,838	48,606	51,659	55,021	58,714	62,769	67,334	72,331

4.3 Fodder production systems in Rwanda

Fodder supply has already been identified as a weak and critical link for the Rwandan dairy sector. The use of premixes or fortified animal feed is limited. No import duty or VAT is levied on production inputs or feed components. However, a foreign exchange premium causes market distortion, and other obstacles include farmers' access to high-quality animal feed. Firstly, awareness regarding the balanced rations required to keep cows productive and healthy is low. In collaboration with RAB and cooperatives, feed mills and feed dealers could improve feed quality and feeding by giving more information about the quality and rations. It should be strongly emphasized that roughage will keep cows healthy and productive while reducing feed costs. Secondly, animal feed costs are too high for most farmers: forage is scarce, and concentrates are expensive. A lack of land constrains the production of fodder and fodder conservation. Many dairy farmers cannot afford to buy concentrate or fortified feed for their cattle. Agriterra has collected data during field visits to farmer cooperatives in 2019. The results have been summarized in the following Table 4.2.

Table 4. 2 Prices for Concentrate or Fortified Feed (Source: TRAIDE, 2019)

Prices used in calculations	Unit	RWF	Euro
Concentrates for mature and lactating cows	Price/kg	267.03	0.26
Concentrates for young stock	Price/kg	275.00	0.27
Additives (salt licks) 5 kg block = 5000 RWF	Price/kg	1,000.00	0.99
Napier grass (500 kg = ± 5500)	Price/kg DM	43.52	0.04
Sweet potato vines (100 kg = 4000 RWF)	Price/kg DM	131.87	0.13
Maize bran	Price/kg DM	197.80	0.20

Furthermore, farmers are suspicious of the quality of concentrates available on the market. The quality of concentrates is generally poor due to the feed industry's lack of quality control regulation. Most farmers - 196 (54.5%) who were interviewed- reported feeding their animals solely on pastures without supplementation. Planted pastures were being adopted as 151 (41.9%) of the farmers used natural and cultivated pastures. Only 3.6% of farmers practised supplement feeding. Napier grass (Pennisetum purpureum) was the primary planted forage reported 151 (93.2%), followed by Chloris gayana (3.1%) and Brachiara. Significantly few farmers also said leguminous forages such as Calliandra, Leucaena leucocephala, Desmodium species, Lablab and Mucuna. Maize and rice brans were the primary feedstuffs used in supplementary feeding, especially for lactating cows. However, crop residues of maize, beans, rice, and purchased hay were reported to be used in dry season supplementary feeding (46.1%).

4.4 Livestock production policies and strategies

The National Dairy Strategy (NDS)

The NDS is a roadmap to identify potential roadblocks and to prepare for removing then, and it recognizes the following challenges that face the dairy subsector: Increase of improved dairy cattle, with existing potentials of the production of 650,000 mt of milk per year (which would have been achieved by 2017 without NDS interventions); An adequate supply of feed and the

knowledge of how to prepare feed rations are challenges to improving productivity for dairy producers; Costs of production (COP) of milk in Rwanda are higher than in neighbouring Kenya and Uganda, where production and processing benefits from economies of scale and the farm to consumer cold chain is better developed; The marketing costs beyond the farm gate to final domestic consumers are also high, where farmers' share of the final retail price is low (less than 30% for milk sold through the alternative milk sector (AMS) to less than 20% if farmers' milk is sold through the formal sector) when compared to international standards of 50 percent; On the demand side, consumer demand for both raw and processed milk is not increasing fast enough to clear the projected supplies of raw milk because of affordability, accessibility and availability of milk; Milk quality is an issue of concern for the majority of milk marketed through the AMS and this limits domestic and export market opportunities; The retail price of processed dairy products is high compared to milk in the AMS, which impacts demand and diverts consumers to purchasing "loose" milk (unpasteurized); The government of Rwanda does not currently have a dairy policy, and private stakeholders in the dairy subsector are not organized or able to effectively advocate for needed regulations and investments.

Master Plan of the Milk Chain in Rwanda

The master plan of the milk chain in Rwanda has set forth strategies and plan to ensure that by 2020, Rwanda would achieve the following objectives:

- ✓ Stock farming would avail 6 g of proteins/head/day, representing 10% of protein
- ✓ requirements of the population as a contribution to food security.
- ✓ The contribution of stock farming to GDP would be 8% at least.
- ✓ The subsector will contribute to foreign exchange earnings by exporting animals and animal products, particularly milk and dairy products.

For the above targets to be achieved, the following objectives have to be executed, as per the master plan:

- ✓ To organize, train and equip grassroots producers to enable them to participate in the implementation and internalizing of the project.
- ✓ To improve the genetic potential of the local cattle through crossing with high performing breeds to improve productivity.
- ✓ To provide appropriate veterinary services.
- ✓ To improve livestock nutrition and the rational management of grazing land.
- ✓ To build and operationalize infrastructure for the collection, cooling and trading of milk and dairy products.
- ✓ To build capacity for national departments involved in the implementation of the project

4.5 Institutional and policy frameworks

4.5.1 Rwanda's Vision 2050

Rwanda's Vision 2050 is aimed at ensuring high standards of living for all Rwandans. The main areas of focus for Vision 2050 include: a) Quality of Life, b) Modern Infrastructure and livelihoods, c) Transformation for prosperity, d) Enhancing Rwandans Core Values, and e) International cooperation and positioning. Specifically, in the third main area (c)- Transformation

for prosperity, the country aims at increased productivity and competitiveness while providing jobs for Rwandans; this goal will be achieved through advancing the following areas:

- ✓ Agro-processing: advanced food industry, technology-intensive agriculture with a commercial focus.
- ✓ Diversified tourism.
- ✓ High value IT and tech services/industry: e.g., electronics
- ✓ Business and financial services
- ✓ Logistics and aviation: airline, airport, drones, ports, etc.
- ✓ Scientific and technological innovations: e.g., nanotechnology and biotechnology
- ✓ Construction industry, e.g., housing, local materials development and expansion)
- ✓ Extractive industries (mining, oil and gas): with a focus on value addition

4.5.2 National Strategy for Transformation 1 – NST 1 (2017 – 2024)

NST 1 has been developed with expectations to lay the foundations for decades of sustained growth and transformation that will accelerate the move towards achieving high standards of living for all Rwandans. It builds on lessons learned, successes and challenges encountered in previous medium-term development strategies and entails interventions to enable the transformation journey towards achieving Vision 2050 aspirations. The economic transformation pillar of the strategy aims at "accelerating inclusive economic growth and development founded on the Private Sector, knowledge and Rwanda's Natural Resources", which is planned to be implemented through 5 specific objectives: Creating decent jobs for economic development and poverty reduction; Accelerating urbanization to facilitate economic growth; Promoting industrial development, export promotion and expansion of trade-related infrastructure; Developing and promoting a service-led and knowledge-based economy; Increasing agriculture and livestock quality, productivity and production; and Sustainably exploiting natural resources and protect the environment. Specifically, the fifth specific objective of the economic transformation pillar on "Increasing agriculture and livestock quality, productivity and production" lays a foundation for the Priority Area 6 of "Modernizing and increasing the productivity of Agriculture and livestock", which has been developed to be implemented through 12 key strategic interventions:

- ✓ Strengthen the commercialization of crop and animal resource value chains
- ✓ Work with the private sector to increase the surface of consolidated and irrigated land and promote agricultural mechanization
- ✓ Promote new models of irrigation scheme management
- ✓ Increases the land area covered by terraces and ensure their optimal use
- ✓ Enhance farmers' access to improved seeds
- ✓ Promote Research and develop new seed varieties
- ✓ The average productivity of key crops measured in tonnes per hectare will be increased between 2017 and 2024
- ✓ Work with the private sector to build post-harvest handling and storage facilities across the country and to add value to agricultural produce (processing)
- ✓ Scale up the production of high-value crops
- ✓ Establish a program to improve livestock farmers' professionalisation and increase their output in quality, volume, and productivity.
- ✓ Attract private sector and farmers to invest in flagship projects in the livestock sub-sector

- ✓ Put in place mechanisms to increase access to finance for farmers

4.5.3 Strategic Plan for Agriculture Transformation (2018 – 2024)

Rwanda's Strategic Plan for Agriculture Transformation phase 4 (PSTA 4) indicates priority investments in agriculture and estimates required resources for the agriculture sector for 2018 – 2024. The National Agricultural Policy (NAP) implementation plan represents the agriculture sector's strategic document under Rwanda's National Strategy for Transformation (NST 1). This strategy builds on the achievements of the PSTA 3 while envisaging a transformation of agriculture from a subsistence sector to a knowledge-based value-creating sector that contributes to the national economy and ensures food and nutrition security. Throughout the PSTA 4, there is a strong focus on private investments, as it recognizes that investments of private actors must drive agriculture growth. Therefore, the strategy emphasizes a more substantial role of the private sector, including farmers, with the government becoming a market enabler rather than a market actor. For example, the strategic plans that the direct government involvement in production, processing and marketing should be reduced. Besides creating an enabling environment, the government will provide public goods, otherwise undersupplied by the private sector, including infrastructure, research, social protection, and emergency response. To achieve the envisioned impact, PSTA 4 is structured around 4 Priority Areas: 1) Innovation and Extension, focusing on improving agronomic knowledge and technology in terms of basic research and innovation, primarily aimed at developing improved varieties and breeds. 2) Productivity and Resilience, focusing on promoting sustainable and resilient production systems for crops and animal resources. 3) Inclusive markets and value addition, seeking to improve markets and linkages between productions and processing. 4) Enabling Environment and Responsive Institutions, providing the regulatory framework by defining and coordinating public sector involvement.

4.5.4 The National Agriculture Policy

The National agricultural policy envisions Rwanda to become "a nation that enjoys food security, nutritional health and sustainable agricultural growth from a productive, green and market-led agricultural sector." This is to be achieved in a mission "to ensure food and nutrition security, modern agribusiness technologies professionalizing farmers in terms of production, commercialization of the outputs, and creating a competitive agriculture sector". The policy outlines four main objectives: 1) Increased contribution to wealth creation, 2) economic opportunities and prosperity, 3) improved food security and nutrition, and 4) increased resilience and sustainability. The policy actions are organized under four broad policy pillars: 1) Enabling environment and responsive institutions (recommending avital action to attract investments from the private sector, to driving sector toward commercialization, in recognition of the fact that turning the agricultural sector around will require substantial investment while public finances are getting scarce); 2) Technological Upgrading and Skills Development (the pillar presents a research agenda for closing Rwanda's agriculture technology and skills gap, thus making more people employable, in recognition of the fact that technological upgrading should be at the crux of productivity growth); 3) Productivity and Sustainability (emphasizing on the fact that agricultural production must increase accordingly in order to meet socio-economic and food and nutrition security issues); 4) Inclusive Markets and Off-Farm Opportunities (the pillar promotes improved productivity and inclusiveness of agricultural market systems and increased off-farm opportunities of diversified for agricultural products for domestic, regional, and international markets, in

recognition of the fact that efficiently working market systems are deciding factors for consumers, producers, processors, and traders alike).

4.5.5 Strategic and Investment Plan to Strengthen the Animal Genetic Improvement

It builds on the fact that livestock production improvement can only be achieved if and when simultaneously, both the genetic composition of animals and management kept are improved. But only genetic modification will not bring the required productivity and increased farmers' income. The development of value chains and final markets is also essential to add value to the primary product and ensure market demands. Thus, the country should develop an integrated animal production development strategy. Genetic improvement is only one part of an all-compassing vision and strategy to uplift the livestock sector and indicated in the SWOT analysis as per the plan in Table 4.3.

Table 4. 3. SWOT analysis for Genetics Improvement in Rwanda:

Strength	**Weaknesses**
- Livestock keepers have a great affinity with their livestock - Presence of an animal population, which genotype is well adapted to prevailing conditions - Highly motivated government professionals at the service of farmers - Government conscious of the importance of genetic improvement and ready to further invest in it - Existing infrastructure and capacity for selection and reproductive work	- No underpinning of genetic improvement work with result monitoring and economic parameters - Little to no involvement of the private sector in genetic improvement - Poor animal identification system and no performance testing - Poorly developed value chains in the livestock sector, preventing specialization among farmers and private investment in trade and processing due to the high level of "informal trading." - No clear link between genetic improvement work on the station and the realities in the field
Opportunities	**Threats**
- Interest and involve livestock keepers to do animal selection and genetic improvement themselves - Involve the private sector in animal genetic improvement and breeding as gene fond - Develop an animal registration system linked to performance testing and selection - Develop integrated value-chain development plans in which genetic improvement is part of a larger total improvement plan to increase impact and returns	- The narrow genetic base of the genetically improved animals due to "loss" in crossbreeding and lack of registration and recording - Environmental limitations (esp. animal nutrition) hindering the expression of genetic potential - Too little economic benefits for the national economy and farmers from the current genetic improvement programme to justify the investments - Introduction of new breeds/varieties before these have been thoroughly tested for suitability under Rwandan farming conditions

4.5.6 Strategic Plan for Animal Nutrition Improvement Programme for Rwanda

The strategic plan starts informing about the current situation of animal nutrition in Rwanda. The livestock development subsector in Rwanda contributes about 12% of the country's GDP and approximately 30% of Agricultural GDP (the agricultural sector contributes about 33% of the national GDP). Moreover, it informs that the subsector has undergone significant transformation in recent years by introducing improved dairy breeds in the country, followed by an ambitious genetic improvement programme of upgrading the local cattle breeds. Furthermore, the strategic plan recognizes that there have been a few challenges in enhancing livestock productivity, particularly for the improved dairy cows, with the key being poor animal nutrition caused by

multiple factors associated with lack of adequate quantity and quality of feed. It is against the background mentioned above that the livestock nutrition policy calls for strategic measures in dry season preparedness for livestock feeding, which are well elaborated in this strategy. This strategic plan recommends highlight the need to conserve the surplus wet season forage to provide for dry season feed and even outfeed availability throughout the year. The proposed simplest and most effective method nationally would be the conservation of high-quality forage at the right stage of growth to hay. The advantages of hay originate from its high dry matter and nutrient content hence the lower weight required to meet livestock requirements and the ease of transporting it across the country to areas experiencing feed shortage. Farmers can only undertake the improved fodder production and conservation practices if they have appropriate seed, knowledge and skills. The strategic plans urge MINAGRI to liaise with the Rwanda Standards Board (RSB) on enforcement and compliance of feed millers' feed standards to ensure quality compound feeds. Furthermore, the strategic plan proposes seven strategic areas that must be addressed for improved animal nutrition and feeding performance, categorised into three different areas based on the required time frame and resources for implementation, ease of execution, and envisaged impact. The categories (and recommended strategic actions) are i) Overall strategic actions (forages/fodder and feed development; Compounded feed industry and quality assurance; Water development; Research and development; Extension, training and information; Institutional, policy and legal framework; and Technological, financial, marketing and socio-economic environment). ii) Priority programme actions (Production, utilization and conservation of grass/legume fodder and other types of forage and countrywide distribution of fodder seed; Research capacity to effectively deliver in production of multispecies fodder and dissemination on the establishment, utilization and conservation; Capacity for useful extension and information service delivery to end-users on animal nutrition, feeds and integrated feeding techniques; Development of commercial poultry and pig industries to meet the increasing demand for products and enhance the growth of the compounded feed industry; Production, distribution and utilization of non-forage feeds mainly single feedstuff concentrates; Production, distribution and utilization of high quality compounded feeds). iii) Immediate quick actions (mostly call for disseminating useful information currently not well known by farmers regarding simple feeding technologies and water provision. It is also crucial to release and distribute more fodder seed to farmers through farmer organizations).

4.5.7 National Fertilizer Policy

The national fertiliser policy starts with a piece of background information, informing that Rwanda targets agricultural growth of 8.5% per annum as a critical contributory driver to economic growth and poverty reduction in the country. This growth hinges on agricultural intensification. Nevertheless, Rwanda is characterized by low soil productivity due to nutrient depletion arising from over-cultivation and soil erosion; hence, increased and judicious use of fertilizers must be adopted to achieve agricultural intensification. In this regard, Rwanda targets that fertilizer use of 45Kg/Ha, which translates to 55,000MT of fertilizers, is adopted, which still is below the target as contained in the Abuja Declaration on Fertilizer for an Agricultural Green Revolution of 50Kg/Ha. The policy outlines seven critical challenges that the agricultural sector is still facing: 1. Low fertilizer use (compared to other countries), resulting in Low yields; Low farm incomes; 2. Inadequate economic returns to fertilizer use due to a narrow range of formulations; 3. Nutrient use inefficiency at the farm level; 4. Lack of sustainable availability and access to fertilizers (a. Not enough companies involved in imports, b. Limited competition); 5. Lack of effective quality control and regulation in fertilizer marketing and use; 6. Government-led input programs are

expensive and not easy for private companies (a. Government cost per ton too high to support expanded use and require heavy subsidies, b. Subsidies directed to a few companies, products, c. Strengthen quality control to accommodate more importers, products); 7—lack of utilization of locally available raw materials for fertilizer production. The fertilizer policy covers the following aspects to address the challenges mentioned above: 1. Fertilizer Production; 2. Imports and Exports; 3. Fertilizer Trade and Marketing; 4. Promotion of fertilizer use (i. Extension, ii. Subsidies, iii. Agriculture and Rural Finance); 5. Research and Development (Updating recommendations, Soil surveys); 6. Regulation and Quality Control (standards etc.); 7. Environmental Considerations (Increase fertilizer use efficiency (briquettes etc.), Synchronized applications: timing of applications and split applications); 8. Gender focus; and 9. Governance and Institutional linkages.

4.5.8 Strategic and Investment Plan to Strengthen Meat Industry in Rwanda

The strategic plans aim to develop a plan to improve the quality and availability of meat and meat products in Rwanda and create a sovereign meat market in Rwanda and profitable outside Rwanda. The corresponding strategic diagnosis has revealed the following main observation: the institutional framework is favourable to animal husbandry development in Rwanda. Nevertheless, challenges have been identified and are the poor animal nutrition, the poor control of disease situation, the small size of the national herd, the lack of slaughter facilities to meet food quality standards, the lack of value-adding step (cutting and processing), and the low control of the quality Hygiene of meat marketed. In this line, the strategic plan establishes a guide to allow the development of the meat industry to allow the public authorities to meet five significant challenges: Ensuring meat security in Rwanda; Becoming a considerable asset in malnutrition and poverty-fighting; Promoting the development of proper and responsible meat industry processing, Developing Rwandan competitiveness in Livestock in Eastern Africa; and developing foreign exchange.

4.5.9 Gender and Youth Mainstreaming Strategy

The strategy was developed by the Ministry of Agriculture and Animal Resources and is aligned with the Fourth Strategic Plan for Agriculture Transformation (PSTA4). This comprising strategic intervention to increase youth capacity and tap their potentials as the PASTA4 is being implemented. The strategy indicates, by background, that agriculture contributes 31% of Rwanda's GDP and accounts for almost 80% of the female labour force, with the majority undertaking subsistence farming. Farming accounts for 33% of all new jobs created in the Rwandan economy. There are high expectations for agriculture to employ a growing rural population and generate higher-quality jobs to reduce poverty.

The strategy draws out the concerns and experiences for women, men, and youth. It pays particular attention to women due to the historical exclusion, the impact of cultural norms and attitudes, and marginalization that women have faced. On average female-managed farms are estimated to be 12% less productive than male-managed farms. This has been attributed to differential access to and returns from abundant and financial resources and the gender-based differences in the returns that accrued to those abundant resources. Closing the 12% gender agricultural productivity gap would create an estimated increase in GDP of USD 418 million and lift a significant number of Rwandans out of poverty. The gap is most evident in off-farm employment (with fewer women accessing these jobs), work in implementing agencies (where women are outnumbered by almost 50%); financial services; and access to land and agricultural inputs. Other key factors that drive

inequality include farm size (farms managed by women are 10.5% smaller than farms operated by men); lower expenditure on fertilisers and insecticides (female farm managers spend 35% less on these inputs compared to farms managed by men); household size (farms operated by women tend to have larger households and a higher dependency ratio); lower prices for agro-produce (compared to prices achieved by men); and time spent in formal education.

4.5.10 Knowledge Management and Communication Strategy for the Agricultural Sector

The purpose of the knowledge and communication strategy is to build relationships between the various actors in the agricultural sector, both within and outside MNAGRI, through experience and information sharing. It is intended to empower MINAGRI to communicate the agricultural transformation issues in a more innovative and integrative manner through awareness building, knowledge sharing, and training to facilitate the adoption of best-bet practices, technologies, and approaches and contribute to policy decision making processes. The strategy plans that the increasing knowledge and awareness of agricultural transformation to a broader audience will be achieved through the following activities: The development of targeted knowledge and information sharing materials to promote dialogue and discourse among development partners and the general public on various aspects of agricultural transformation; The promotion of public debates on various issues related to the strategic plan for change among the stakeholders in the agricultural sector; Engaging media through training to increase their level of awareness and reporting on various issues related to agricultural transformation to the targeted stakeholders and general public; and developing the capacity of farmers, private sector and other development partners to enable them better participate in the process of agricultural transformation and thus integrate key issues about the change into their plans.

4.5.11 Nutrition-Sensitive Agriculture Mainstreaming Guideline

The guideline starts by recognising that Rwandan farmers link their agricultural activities with their food requirements and nutritional needs. They rely on agriculture for their livelihoods as well as their direct source of daily food. The guideline aims to build on what farming households do intuitively by integrating nutrition sensitivity into policies, programmes, and plans by implementing the following approaches: a). Seasonal and or chronic dietary gaps and related health problems should be drivers for agriculture supply chain upgrading; b. Value chain interventions need first to use a “do no harm” framework to ensure existing cropping systems and their corresponding dietary diversity and gender roles are valued, preserved and improved; c). Agriculture project resources have to be programmed to meet both nutrition and income goals.

4.5.12 Law N°005/2016 of 05/04/2016 Governing Seeds and Plant Varieties in Rwanda

The Law governs seeds and plant varieties in Rwanda, and elaborates on plant variety evaluation, certification and registration Committee; Procedures for assessment, certification, registration and withdrawal of a plant variety from the national plant variety list; national plant variety list (previsioning that each year, certified plant varieties are registered on a list provided for that purpose which the Minister publishes in the Official Gazette); Quality seed production, processing and marketing; Requirements for quality seed producer, conditioner and dealer; Recognized Seed categories (pre-basic seed, basic seed, certified seed, and quality declared seed), among other provisions.

4.5.13 Strategy and Investment Plan for Small Animal Industry in Rwanda

The strategy starts by highlighting the strategic diagnosis indicating the potentialities of the small Animal Industry in Rwanda, which include: A favourable framework, reflecting the will and the involvement of the public authorities to achieve the goals concerning the development of the sector; The relevance of the choice of small animals given the specific context of Rwanda: high population density inducing a lack of land for ranching (hence the "Zero Grazing"), the suitability of small animals breeding to a low-input system, faster return to investment for low-resource poor farmers; Commercial opportunities in the regional and international markets for live animals and livestock by-products such as wool and skins. Nevertheless, to fully maximize this potential, significant constraints should be lifted: Genetic issues: lack of good quality breeding stock; Nutritional matters: the absence of animal feed factories, low-quality roughages, scarcity and high prices of crop residue; and Animal health.

4.5.14 Ongoing policy and strategy reviews for fodder production systems and related aspects

The increasing population pressure on available land and water resources has led to their degradation and resulted in the loss of productivity of arable lands and increased food insecurity. The response of Rwanda's farmers to the pressure on land and the associated decline in productivity has been to expand their agricultural activities into the fragile wetlands. Rwanda's total area of wetlands is approximately 278,000 ha, of which about 55% is used for cultivation. This accounts for 12% of the entire cultivated land in the country. In Rwanda, water management highlights the relatively dense hydrological network and linked "wetland" and "water bodies (Lakes and constructed (multi-purpose) dams). As competition for water intensifies, the need to plan for equitable resources is growing in step. For Rwanda, which targets middle-income status by 2035 and then high-income status by 2050, water management's integrated approach will prove critical for achieving their aspirations.

- ✓ Fast facts: (i) Soil erosion costs Rwanda 20-200% of GDP annually, and (ii) Agriculture (largely rain-fed) employs 90% of the workforce.
- ✓ Challenges: (i) With its green hills and valleys, and relatively high average rainfall, Rwanda could be mistaken for a water-rich country, while precipitation is not evenly distributed over the country and Water infrastructure isn't sited strategically to address this imbalance; (ii) Climate change is contributing to increasingly short and more intense rainy seasons, which brings flooding and then drought. Overall, water availability per capita (on average, 670 m3/person/annum) remains low, and Rwanda ranks amongst the world's water-scarce countries.
- ✓ Solution: Development and implementation of an integrated approach to water management (IWRM), with three Es: equitable, efficient and environmentally sustainable water resources. The system-initiated water governance at the catchment level.
- ✓ Progress: Development of catchment plans for 30% of the country's surface area, including detailed water allocation plans mapped out across different time horizons up to 2050. The ministry of Environment now knows precisely how much water can be allocated to irrigation, industry, livestock, domestic water supplies, and the environment. This quantitative information illustrates the looming water scarcity and the need to revise the irrigation masterplan and food production policy. A new Water Resources Board will manage water allocation to prevent disputes, improve water quality, restore catchment areas, control erosion and plan for floods and droughts, and be staffed since a few weeks ago.

4.6 Intensification options for fodder productions and trade-offs

Rwanda's government has initiated a programme known as "*One cow per every poor household*" that intends to distribute dairy cows throughout the country, particularly in impoverished areas. This will significantly contribute to the increase of the cattle population in the country. According to available data for 2008, Eastern Province has the highest cattle population, followed by Western, Northern, Southern and Kigali City. Tables 4.4 and 4.5 cattle population per province by the end of 2008 and the cattle population per production zone. Table 4.6 summarises livestock farming opportunities in Rwanda, Table 4. 7 looks at the advances and changes related to water management issues. Table 4. 8 shows the types of anti-erosion activities undertaken in Rwanda by stratum (%) from 2017 to 2020.

Table 4. 4 Cattle population per province by the end of 2008

Province	Local breed	Crosses	Pure breed	Total	Total (%)
East	376,566	61,823	27,694	466,083	39
West	123,615	43,014	15,322	335,462	28
North	138,142	22,870	7,794	181,951	15
South	260,170	61,777	13,514	168,806	14
Kigali City	22,984	9,086	10,523	42,593	4
Grand Total	**921,477**	**198,571**	**74,847**	**1,194,895**	**100**
Grand Total (%)	**77**	**17**	**6**	**100**	

Source: MINAGRI, 2009

Table 4. 5 Cattle Population per Production Zone

Cattle Production Zone	Local Breed		Crosses		Pure Breed		Total	
	Number	%	Number	%	Number	%	Number	%
Nyagatare	218,309	24	40,419	20	17,543	23	276,271	23
Nyanza	198,438	22	50,138	25	10,986	15	259,562	22
Inyange	163,812	18	33,682	17	21,538	29	219,032	18
Gishwati	115,003	12	45,884	23	16,783	22	177,670	15
Ngoma	103,873	11	14,802	7	5,188	7	123,863	10
Nyirangarama	52,118	6	5,643	3	1,400	2	59,161	5
Karongi	36,188	4	3,586	2	396	1	40,170	3
Rusizi	33,736	4	4,417	2	1,013	1	39,166	3
Grand Total	921,477	100	198,571	100	74 847	100	1,194,895	100

Table 4. 6 Opportunities in livestock farming in Rwanda

Main challenge No. 1: Low Milk Production per Cow at Farm Level.	
Specific Challenge	**Opportunity (Intervention Needed)**
Poor animal nutrition, shortage of feed and low ration.	- Increase and diversify local production of forage: grass, maize and other fodder crops - Increase local production of maize for corn - Optimize the use of by-products and crop-residues

	- The lower price of concentrate or increased cost of raw milk, which is 350 RWF/kg at the farm level: almost twice the price of milk - Improve quality control on compound feed to prevent the sales
Shortage of land and fodder	- Focus on crossbreeding to reduce the number of low productive, indigenous cow breeds in a country with scarce land - Enhance production of fodder crops, including irrigation and conservation
Low awareness of farmers regarding needs for improved cow breeds	- Training for farmers regarding cow management: feeding, health and housing
Seasonal fluctuations in milk production resulting in surpluses and shortages	- Increase UHT processing of milk to meet demand during the dry season with processed surplus milk from the wet season - Improved feeding practices during the dry season with concentrates and fodder to mitigate fluctuations - Allow milk prices to rise during the dry season to cover increased production costs of farmers
Main challenge No. 2: Poor Quality of the Raw Milk	
Specific Challenge	**Opportunity (Intervention Needed)**
Toxic/ high antibiotic levels in milk	- Bring down aflatoxin levels in cow feed by an improvement of post-harvest handling of maize - Increase testing of individual milk batches - Test on antibiotics and combine penalty system with advice on the use of antibiotics
Poor milk handling at the farm	- More hygiene during milking, storage and transport - Use of stainless-steel buckets for milking and cans for transport (or acceptable alternatives!) - Stimulate the use of filters and chilling - Continue with Farmer Field School approach
The long duration between milking and cooling	- Promote the use of cooling equipment and transport facilities in a reliable and affordable way - Increase the number of Milk Collection Centres (MCCs), creating a decentralised network - Increase the availability of small cooling equipment on dairy farms - Improve electricity provision at MCCs: milk cannot be adequately cooled during power cuts affecting milk quality or use alternatives that require a more flexible approach
Lacking awareness and incentives to improve quality	- Implement a quality-based payment system based on factors such as fat and protein content, biological quality - Promote the use of extra laboratory quality checks - Provide training to farmers to improve quality
Main Challenge No. 3: Limited Access to Extension & animal health Services (<30% farmers)	
Specific Challenge	**Opportunity (Intervention Needed)**
On an annual basis, dairy farmer visited only 2.5 times by a public or private extension agent	- Strengthen the knowledge and technical expertise of farm advisors - Increase coverage of extension services through private actors or public-private partnerships - Improve the low extension agent to dairy farmer ratio to enable vets to do more farm visits and enhance the access of farmers
Limited access to animal health services resulting in high young and adult stock mortality	- Proceed with the privatization of veterinary services - Develop and enforce quality requirements for veterinary services - Improved training of vets and para-vets to meet quality requirements - Raise awareness regarding diseases and utilization of drugs but also regarding potential resistance of diseases to drugs (drug resistance)
Limited access to Artificial Insemination (AI) services.	- Improve access to input supply (semen and liquid nitrogen) and increase the number of AI technicians

	- Assess the feasibility of providing high-quality exotic semen with estrus synchronization in dairy production - Develop a breeding policy consistent with farm management conditions - Monitor performance for public and private AI services - Continue to privatize the market for AI services
Main Challenge No. 4: Lack of Organizational Structures for Farmers cause poor milk Marketing & in access to inputs/Services	
Specific Challenge	**Opportunity (Intervention Needed)**
There is an unfair sharing of gross margins as the farm-gate price is about 16% of the consumer price	- Establish direct links between cooperatives or farmers and distributors/markets - Increase the number of MCCs, so farmers do not have to rely on traders for transportation who currently collect most milk for direct sales or delivery to MCCs - Create networks, sector-platforms and umbrella organisations for better exchange of interests and to build mutual trust - Make cost-price calculation for raw milk production and processed products to assess price structures, margins and efficiency problems in the dairy chain
Dairy cooperatives do not have business expertise	- Create economies of scale by collaboration between smallholders through coops for sales, inputs and service provision - Training in entrepreneurship and making business plans for farms
A limited number of coops provides inputs and services	- Stimulate collaboration between cooperatives for investment in (chilled) transport - Assess the viability for cooperatives to invest in feed production to ensure quality and supply for their members - Strengthen the advisory, AI and health services to suppliers of the cooperative MCCs - Raise awareness on alternative finance models for inputs and services provided by cooperatives to their members

Table 4. 7 Advances and changes related to water management issues

		Season A									Season B								
		Rainfall	Rain- harvesting Water	WASAC water (Water Treatment)	Underground water	Lake water	Stream water	Recycled water	Water catchment/Dam	Other sources	Rainfall	Rain- harvesting water	WASAC water (Water Treatment)	Underground water	Lake water	Stream water	Recycled water	Water catchment/Dam	Other sources
2017	Intensive cropland on hillsides	4.4	0.9	7.0	36.8	7.0	32.5	0.9		10.5	1.1	6.3	4.2	22.1	6.3	56.8	1.1		2.1
	Intensive cropland in marshlands	2.4	7.5	-	42.1	0.7	44.9	0.9		1.4	0.9	1.5	-	28.0	4.7	58.6	0.4		6.0
	Rangelands	-	-	-	-	-	100	-		-									
	LSF	1.3	2.2	22.8	42.4	28.1	3.1	-		-	4.3	2.8	-	17.1	22.8	51.2	-		1.9
2018	SSF	0.4		5.02	28.1	57.14		-	9.07	0.4	0		1.7	27.3	60.3		-	10.2	0.4
	LSF	6.16		1.9	14.22	61.14		-	15.64	0.95	2.5		1.5	17.9	57.7		-	13.4	7.0
2019		0.9		3.2	27.6	54.3		-	13.9	0.2	1.5		2.6	28.5	57.6		-	9.6	0.3
2020		2.53		5.15	47.21	43.16		-	1.94	-									

Table 4. 8 Type of anti-erosion activities by stratum (%) from 2017 to 2020

		Season A									Season B								
		Ditches	Trees / Wind break/ Shelterbelt	Bench terraces	Progressive terraces	Cover plants/grasses	Water drainage	Mulching	Beds/ridges	Others	Ditches	Trees / Wind break/ Shelterbelt	Bench terraces	Progressive terraces	Cover plants/grasses	Water drainage	Mulching	Beds/ridges	Others
2017	Intensive cropland on hillsides	13.6	2.9	4.5	9.7	59.2	0.8	3.7	5.3	0.4	11.6	2.5	4.5	11.0	57.4	0.8	4.5	6.9	0.8
	Intensive cropland in marshlands	7.8	1.2	0.2	1.1	22.4	45.3	0.4	20.5	1.1	4.3	0.5	0.3	0.6	18.6	48.1	1.2	25.4	1.0
	Rangelands	24.5	16.3	-	5.4	34.0	0.7	17.7	0.7	0.7	40.7	6.7	3.7	4.4	34.1	0.7	8.2	1.5	-
	LSF	27.7	5.5	5.1	2.7	18.4	28.2	6.7	4.5	1.3	22.4	8.4	6.4	0.5	23.1	24.4	6.7	3.0	5.0
2018	SSF	12.2	2.6	4.2	7.7	51.6	8.9	2.5	10.3	0.0	11.4	2.5	3.7	8.6	52.0	9.4	3.3	9.2	0.0
	LSF	29.4	5.7	3.1	0.4	32.5	18.5	4.7	5.4	0.3	22.1	8.0	5.0	2.0	28.4	23.4	5.5	5.7	
2019		10	3.3	4.8	9.3	51.5	7.5	3.2	10.4	0.1	6.6	3.1	11.9	4.6	54.4	7	4.1	8.2	0.1
2020		6.5	6.0	4.6	9.3	58.5	0.5	1.5	5.6	7.6									

Source: (NISR, 2018a; NISR, 2018b; NISR 2019; NISR, 2020)

4.7 Key market structures connected to fodder and livestock

There are three market categories:

1) domestic market, which is dominated by food crops, and it remains a priority that the domestic agro-food system meets the dietary needs of the population. Improving aggregation and consumer markets (infrastructure, logistics, and market information) is vital for food consumers and producers. There is a limited but growing market for higher-value niche products in urban supermarkets, restaurants, and hotels. Therefore, standards certification of food products will play an increasingly important role.
2) The regional market is also primarily dominated by basic food. Currently, DRC is the leading market for Rwanda's cross-border trade - especially livestock, potatoes, dairy, flour, and edible oils. Within the EAC, continued market integration will expand the Rwanda regional market and tailored products to EAC consumers will be prioritised. There is a growing urban market in regional cities, and Rwanda's opportunity may be in selling higher quality products.
3) International markets have traditionally been concentrated on exports of different coffee and tea. In these traditional value chains, the focus is on improving branding and quality such that the products can fetch higher prices on the global market. Besides, horticultural exports are growing, the primary market being Europe. However, opportunities have been identified elsewhere – especially in West Africa. The emphasis for horticulture will be to improve aggregation, standards compliance, and logistics in the supply chain's domestic segment. Animal products are the subsequent emerging export sector. Here, there is a need for ensuring animal health to meet standards. For example, a tagging system and livestock database will be required to access larger international markets.

4.8 Key stakeholders in fodder production and their roles

4.8.1 Unions (or Federations) and Farmers Cooperatives

The agricultural sector has the highest number of registered cooperatives (27% of all cooperatives) as well as the highest number of people (297,996 farmers) operating with cooperatives (Rwanda Cooperatives Agency, 2016), as per 2016. The following table presents the distribution of cooperatives according to economic activity at the national level (Table 4.9)

A list of unions (or federations) and cooperatives and their contacts in rice farming and fodder /dairy production in Rwanda is presented in Annex 4.1

Table 4. 9 Cooperatives Operating in Rwanda in Different Business Activities

Economic Activity	No. of Cooperatives	Membership					Share Capital (RFw)
		Male (no.)	Male (%)	Female (no)	Female (%)	Total	
Agriculture	2,433	179,510	60	118,486	40	297,996	4,878,087,148
Livestock	1,652	46,834	51	44,923	49	91,757	3,991,748,925
Trading	1,207	29,507	53	26,609	47	56,116	8,310,857,882
Service	908	23,077	63	13,534	37	36,611	2,010,426,884
Transport	542	21,912	89	2,731	11	24,643	1,764,398,500
Handicraft	979	14,113	47	16,179	53	30,292	1,894,282,580
Transformation	98	3,920	60	2,648	40	6,568	745,505,500
Mining	121	1,971	80	500	20	2,471	602,246,100
Fishing	94	3,540	77	1,080	23	4,620	162,422,000
Housing	160	4,930	71	2,053	29	6,983	4,803,614,000
Other	198	5,096	63	3,047	37	8,143	498,431800
Sub-Total	8,391	334,410	59	231,790	41	566,200	29,662,021,319
SACCOs	448	1,795,295	55	1,455,096	45	3,250,391	14,403,218,733
Unions	141						193,166,100
Federations	15						61,020,000
Grand Total	8,995	2,129,705	56	1,686,886	44	3,816,591	44,319,426,452

4.8.2 NGOs and Civil Society

Local and international NGOs are not only funds providers but also service providers for local communities (agricultural inputs supply, marketing and processing of agricultural production, counselling, facilitation in problem and solutions identification, facilitation in farmer's organisations in commodity chain, capacity building of farmer's organisations, lobbying and plea for local communities etc.). NGOs and Civil society will have to provide feedback through stakeholders' platforms at different levels. Being service providers, they will have to sign contracts with public and private institutions funding in the agricultural sector.

4.8.3 Private sector and Financial Institutions

The private sector is active in all commodity chain steps starting from inputs supply, production, marketing, processing and commercialisation of a processed or unprocessed product. Its role in decentralised agricultural extension will need to be reinforced to better ensuring the linkage between production and markets.

Despite its importance, the agricultural sector is not financed by grants from commercial and development banks, comparatively with other economic sectors. That is why public sector funding is predominant in this sector through development projects, agricultural guarantee funds, Fertilisers Funds and other programs. This tendency will still be maintained for a specific time, but essential efforts will be deployed to encourage local microfinance institutions to participate in the agricultural financing sector.

4.8.4 Higher Agricultural Education Institutions

Higher Agricultural Education Institutions play an indispensable role in the regular review of their curricula so that they train qualified staff responding to the profile of the new extension strategy, i.e., equipped with skills to work in rural areas, autonomously take initiatives, analyse complex situations of agricultural development, having competences in management and entrepreneurship, play advocacy & lobbying role whenever necessary. Higher Agricultural Education Institutions are part of stakeholders' platforms at different levels. Moreover, the higher learning institutions participate in initiating and leading vital research projects from which great benefits are obtained by the government and the farmers in different farming aspects.

4.9 Water resource management and fodder production

The growth of the Rwandan dairy sector is constrained by a lack of feed, fodder and water. The quantity and quality of inputs hold back the expansion of dairy farms and production per cow. Firstly, feed is scarce and expensive due to the low availability of raw materials such as maize. The lack of animal feed supply is a significant constraint for all livestock industries in Rwanda. In Rwanda, Napier grass and banana pseudo-stem are the most common feed items, followed by weeds and cereal straws. Many cows depend on grazing for feed, and hence, they often receive too little. In a zero-grazing system, average daily rations on dairy farms are estimated to contain a ratio of Napier grass (7kg/day), sweet potato vines (1kg/day) and maize bran (0.5 kg/day). The usage of concentrates or feed additives is not widespread because the market price of concentrates is higher than milk's price. Hence, farmers are reluctant to invest in concentrates unless the extra feed results in a significant increase in milk yields.

Secondly, farmers need to provide their cattle with a sufficient amount of (clean) drinking water Farmers can try to save money by cutting back on water expenses. Seasonal influences play a significant role in the dairy sector. The wet season is the period with the highest milk production because more feed (grass) and water are available. During the dry season running from June till September, there is often a shortage of feed and water. Cattle are provided with less water, less nutritious feed, and consequently, milk production drops. Especially in the Eastern Province, dairy farmers experience severe feed shortages, and cattle mortalities shoot up. Fluctuations in milk production are enormous: the Inyange processing plant in Nyagatare District reported that they receive about 50,000 litres per day during the rainy season while receiving about 3,000 litres per day during a drought.

4.10 Gender aspects in fodder production systems

MINAGRI has shown that about 52% of Rwandan farmers are women, playing a very significant role in the agricultural production of Rwanda (MINAGRI, 2011). It has been noted that women in the age group of 15-60 years spend one-third of their time in agriculture, while men spend only 19% of their time in agriculture and 54% of their time in diverse leisure activities and on paid work, against 18% of women's time in this last category. By 2001, rice growers comprised 20,208 women (45%) and 24,699 men (55%), although women are not present in the processing and wholesale sub-sectors. They are predominantly represented in the retail sub-sector (60%).

4.11 Selected pilot: Nyavyamo Watershed

4.11.1 Overview

This low rainfall, low altitude livestock production zone: 800-1000 mm and 1450 to 1500 meters asl is the zone highly potential for fodder production. It covers the eastern savanna and the eastern plateau of Rwanda predominantly. Table 4.10 indicates the livestock systems by species in the zone.

Table 4. 10 Livestock systems in the low rainfall low altitude zone

No.	Livestock systems by species	Livestock production systems
1	Cattle system	Local breed
		Family dairy (Crossbreed)
		Family dairy (Crossbreed)
2	Sheep system	Local Breed
		Crossbreed
3	Goats systems	Local Breed
		Crossbreed
4	Chicken systems	Family
5	Pigs systems	Family

The following table 4.11 presents the challenges and proposed interventions in the livestock systems in the low rainfall, low altitude livestock production zone of Rwanda.

Table 4. 11 Challenges and proposed interventions to advance the livestock system in the LRLA production zone

Challenges	Proposed interventions
a. Fodder/ Feed	
▪ Limited access to land for production of forage seed and forage. ▪ Unable to meet the fodder demand that is required at commercial feedlots ▪ Poor access to quality concentrate fodder; and inadequate concentrate available ▪ Lack of effective feed quality control: standards and mechanisms of enforcement missing	▪ Making land available to forage production investors. ▪ Promoting the production of forage for commercial feedlots. ▪ Promoting the establishment of flour mills to make more concentrates available. ▪ Strengthening the feed quality control authority to expand its operations ▪ Promoting the establishment of agro-industries for increased availability of by-products that could be used as feed supplements.
b. Animal Health	
▪ Poor animal health extension advice. ▪ Inefficient animal health services. ▪ Inadequate supplies of drugs. ▪ Poor quality control of drugs and supplies. ▪ Poor disease surveillance. ▪ A lack of traceability and identification; and ▪ Inadequate quality control in abattoirs.	Strengthening the animal health regulatory capacity under the coordination of the Livestock Sector Ministry is the main thrust.
c. Marketing and processing	
▪ Absence of quality-based pricing. ▪ Lack of holding area and feedlot space.	▪ Building the capacity of meat technology training staff at the TMB. ▪ Increasing training of meat processing staff.

▪ Lack of knowledge and skill on meat-cutting and –grading; and ▪ Poor links to export abattoirs.	▪ Promoting forward contracting of feedlots and abattoirs; and ▪ Investing in export infrastructure for animal holding and quarantine and programs to ensure food safety and animal health through disease surveillance, monitoring of abattoirs, animal identification and traceability, etc.
d. Policy	
▪ A lack of meat quality standards controls and enforcement, grading, and pricing policies. ▪ The policy on breeding not fully implemented. ▪ A need to strengthen feed production and land acquisition for feedlot investment. ▪ Inadequate feed quality monitoring and control. ▪ Need for further incentives to establish GAKO type feedlots (including land access in appropriate locations conducive to feed production, linkages with the export market, and infrastructure – road access, power and water supply).	▪ Development of appropriate standards for meat quality ▪ Development guidelines on feed quality monitoring ▪ Capacity building on quality control

The most dominant fodder varieties grown in this production zone include *Brachiaria spp*. *Kikuyu grass* (*Pennisetum clandestinum*), *Digitaria spp*., and *Napier grass*.

4.11.2 Technical and socio-economic drivers or limitations of fodder production

Rwanda's main limiting production factor is land. Agriculture growth requires an increase in profits per hectare and the capture of productivity gains along the value chain. To raise profits per hectare means increasing agricultural yields and switching to higher-value agricultural commodities. Rwanda's government (through PSTA 4) currently focuses on facilitating private sector investment in crop production by upgrading the provision of quality standards and supporting the demonstration of better technologies such as greenhouses, hydroponics, and other small-scale irrigation solutions. Furthermore, infrastructure development has remained problematic for Rwanda due to limited financial capacities and relevant technical knowledge and little investment from the private sector. Therefore, a significant proportion of Rwanda's rural population lacks access to transport facilities, including feeder roads. In 2015, only 13,350 km of roads were in excellent or passable condition, but Rwanda targets 30,000 km of passable roads by 2028. Additionally, the outreach and capacity of service providers remain limited.

4.11.3 Map of the selected sites for intensification

The following maps in Figures 4.1 and 4.2 indicate that the North-Eastern part of Rwanda is one of the country's regions with the highest livestock intensity; hence, the highest potential for the largest fodder production.

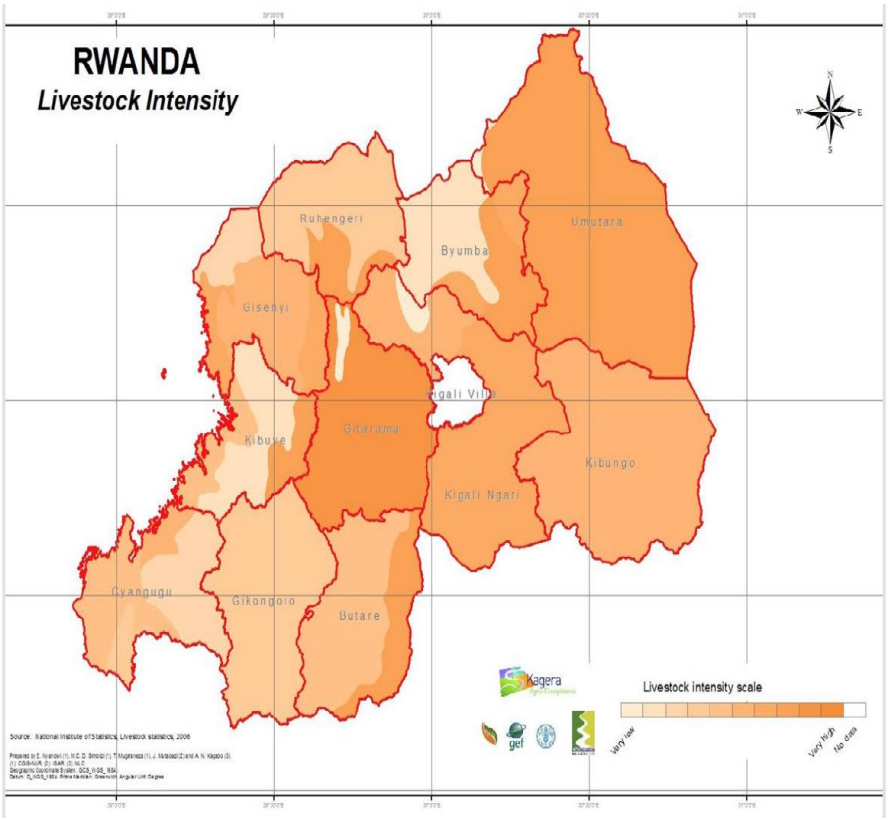

Figure 4. 1 Livestock intensity in Rwanda

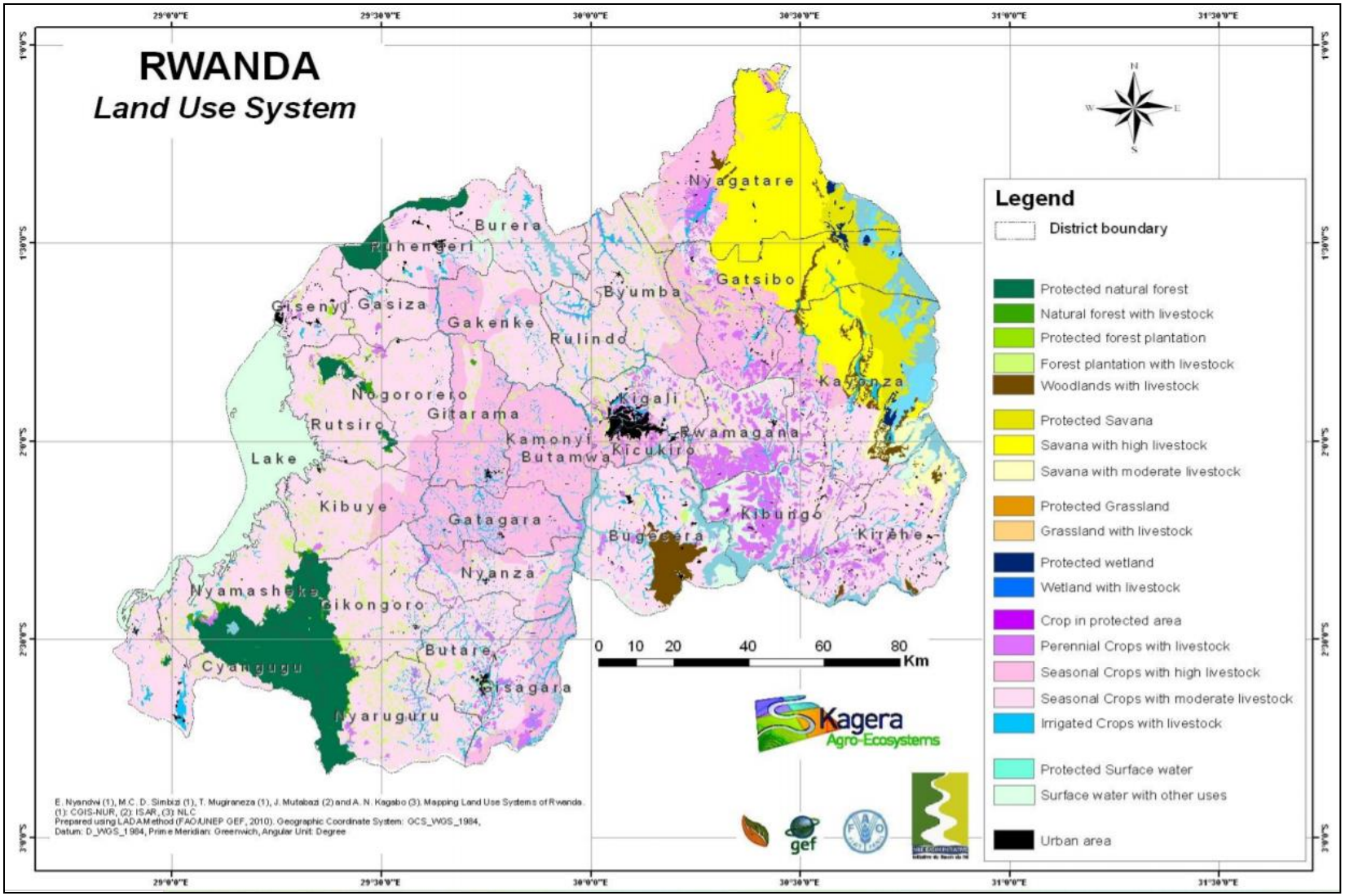

Figure 4. 2 Land Use Types in Rwanda - with Livestock dominating in North-Eastern Part

Source: FAO, 2010

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5 Unite Republic of TANZANIA

5.1 Introduction

The Tanzania Ministry of Agriculture and Livestock (MALF) 2016/2017 baseline report shows that livestock in the country includes 28.4 million cattle, 16.7 million goats and 5 million sheep, 2 million pigs and 37.4 million local chickens and 34.5 million improved chickens. Beef accounts for 82% of the red meat product. To close the current demand/consumption of red meat in Tanzania, any development focus on increasing the amount of red meat must include cattle. However, the national herd is dominated by indigenous cattle that currently show low productivity, although they can improve if well feed, health, and breed improved. The Tanzania Shorthorn Zebu (TSHZ) and the Longhorn Cattle (LHC), such as the Ankole and the Boran, are the main breeds for beef. There are adequate natural resources in Tanzania to support livestock development, such as extensive rangelands, diverse natural vegetation, and diversely resilient livestock breeds, even as the livestock sector performs rather poorly. However, with additional investments and policy changes, these animal resources' productivity and production can feed the rapidly growing Tanzania's population, income, and demand for ASFs. At the moment, livestock activities contribute only 7.4% to the country's GDP. The annual growth rate of the sector is low at 2.6%, a situation that reflects an increase in livestock numbers rather than productivity gains which, according to TLMI (2015), is caused by constraints such as low livestock reproductive rates, high mortality and high disease prevalence, and lack of feed. Thus, combining combined technology and policy (reducing poverty, achieving food security and nutrition, contributing to economic growth, contributing to exports, and contributing to industrialization), livestock production is already on its path to improvement. In Tanzania, the following are priority interventions to modernize the livestock sector**.**

- ✓ Improving the quality and quantity of livestock feed resources by introducing improved forage crops and enhanced animal feed management practices, and increased access to existing lands appropriate for grazing
- ✓ Improving the productivity of indigenous livestock by changing the genetic composition through breed selection by crossbreeding, introducing pure exotic breeds where feasible and through improved animal husbandry interventions
- ✓ Increasing the quality and quantity of animal health services and livestock producers' access to these services through private and private-public partnerships decreases YASM.
- ✓ Design and implement policies and institutional interventions that enable private and private-public investment interventions in animal feed, genetics, animal feed, and animal husbandry.

Studies in Tanzania show that the livestock sector is desirable and can significantly impact household incomes (Table 1), food and nutrition security, and the national economy, as presented in Table 1. The nutritional implications were also assessed in terms of the percentage change in livestock contribution to calories and protein. The percentage change in protein contribution varied from 1% for small-scale improved pigs to 105% for medium- to large-scale improved traditional cattle. Meanwhile, urban and peri-urban dairy cattle, medium- to large-scale (in all zones), also significantly contribute to household nutritional security (again assuming the meat is consumed in the household

and not sold). However, it is still evident that with the current level of dairy investments, there will always be a production-consumption gap/deficit of 5.8 million litres in 15 years, which will be driven by a high human population, increased incomes, urbanization, and income elasticity of demand, leading to very high projected growth in consumption of animal-source foods. Thus, additional investment in the LSA for each priority livestock value chain is red meat, white meat, meat, and cow dairy**.** The main results and conclusions of the livestock sector analysis, among others, are:

- ✓ Significantly increasing poultry production and consumption is vital for growing animal-source foods' contribution to achieving more significant household and national food security.
- ✓ The projected gap in milk demand could be closed and a surplus produced using artificial insemination, hormone synchronization, multiple ovulations, and embryo transfer for breed improvement, combined with feed and health interventions addressing YASM.
- ✓ Livestock genetic improvement priorities should focus on dairy crossbreeds and exotic chicken pure breeds for both family and large-scale investment.
- ✓ Animal health interventions for YASM (vaccinations, parasite control) are critical to ensure improved productivity, increasing animal and product off-take of meat and dairy.
- ✓ Feed is the biggest constraint to animal productivity improvement. Challenges of access to land appropriate for grazing and land for feed production need to be addressed to overcome the current animal feed deficit.
- ✓ Land allocation and ownership policies need to change to favour the investments required to increase meat and milk production feed.
- ✓ The policy priority should create a more conducive environment for commercial meat and milk production and processing investment.
- ✓ The vast projected deficit in red meat consumption is driven by an increasing human population and urbanization, and rapid income growth.
- ✓ Emphasis on improving cattle off-take needs to focus on increasing beef production from on-farm fattening and commercial feedlots.
- ✓ Red meat production cannot be expected to increase much over time and or to help significantly in closing the projected 'all meat' production-consumption gap due to the present limited access to land for feed production and grazing, the need to expand animal health services, and the low genetic potential of local cattle breeds and small ruminants.
- ✓ Animal health services need to expand dramatically, especially in remote areas where pastoralists predominate. Public-private partnerships could be used where private investments are risky and the returns are low.
- ✓ Pork is prone to African swine fever, and its demand is limited; hence it cannot be a priority solution for closing the meat supply gap; and
- ✓ Investing in chicken production has the most potential to close the meat production-consumption gap and could enable the export of ruminant animals and red meat. However, domestic consumer

preferences for white meat and chicken meat would need significant investment and effort to change consumer preferences for red meat, especially beef and goat meat.

The milk production is expected to increase from 2,159 million litres in the base year to 3,816 million litres in 2021/22, an increase of about 77% over five years, mainly due to the expected improvement and increased production by dairy cows and milk from the cattle meant for red meat production that will also contribute to milk production. Dairy cows production system will result in a 31% increase in annual milk productivity, and traditional and improved family dairy will provide milk increase by 26%. Thus, over five years (2016/17–2021/22), it is estimated that individual milk production per cow will increase from 179 litres to 254 litres annually (Table s5.1-5.5). Due to dairy and red meat improvement interventions, milk's GDP contribution at the national level is expected to increase from TZS 808,342 million in 2016/17 to TZS 1,415,671 in 2021/22, a 75% increase (Table 5.5).

5.2 Livestock Production Systems

In Tanzania, the dairy production system can be divided into three, i.e., traditional cow meat-milk; not specialized on a single commodity and milk and meat are essential products, improved family dairy, and commercial specialized dairy subsystems where milk is a priority commodity (Nell et al. 2014). Both subsystems use crossbred/pure temperate dairy breeds (Nell et al., 2014). The level of input by farmers for the improved family dairy subsystem is lower than the commercial specialized dairy subsystem. In contrast, the enhanced family dairy subsystem's input level depends on marketing opportunities and income from milk sale. Cattle are kept under the semi and zero-grazing settings with cultivated fodder, crop residue, and the grass cut from communal land. Most of the feed and milk are either sold directly to consumer and milk collection centres. The commercial specialized dairy subsystem requires higher feeds input and animal health services than the improved family dairy subsystem. It is worth noting that farmers in the medium commercial and specialized dairy subsystem own larger herds of cattle, often more than 100 cows, with a national average of 450 animals and are government or privately-owned farms with their input delivery systems. The milk produced in these farms is sold directly to milk processing plants or processed within the farms (Table 5.6). The development of the dairy cow system in Tanzania aims to improve and expand family dairy subsystems in coastal, lake and highlands zones and the country's commercial specialised dairy sector. Table 5.7. provides key Challenges and Strategies related to Improved Family Dairy Production. Based on the strategies, all production zones in the country will gain from the dairy planned interventions provided the selected vital criteria such as feed availability, climatic condition (temperature), and prevalence of endemic diseases like trypanosomiasis, existing experience in dairying, product marketing infrastructure, and comparative advantage of each zone for dairy are considered and properly managed and provided the interventions will not have a higher cost of feed and veterinary services. Further at the national level, the dairy improvement interventions will increase the number of hybrid dairy cows and milk production in the family dairy subsystem, as shown in Table 5.8 and 5.9. Table 5.10 shows the projected annualized milk production of a cow in the Coastal, Lake and Highlands Zones by 2020-2021.

It is worth noting that investments in cow dairy cattle development in the different Tanzania zones may be categorized into six major groups, i.e., improvements in feed supply, breeding, improved health, useful extension, relevant research, and marketing. In the case of feed improvement, the main issues include improving pasture and forage and concentrate feed production and marketing. These

can be done by growing commercial animal feed plants, modifying existing feed, and foraging seed quality control facilities. Animal health improvements of dairy cows may also help other livestock breeds control acute and common diseases such as East Coastal Fever, Contagious Bovine Pleuropneumonia, Foot-and-Mouth Disease, Rift Valley Fever, and Brucellosis. This will require an improved capacity of veterinary centres and services. Improving cattle breeds requires strengthening existing national and zonal artificial insemination centres and investing more in research infrastructure. Investment to enhance milk marketing and processing is vital in the various regions of the country.

Therefore, the crucial aspects of the dairy improvement interventions and success requirements are:

- ✓ Plan and carry out extensive crossbreeding/breeding schemes in selected areas using artificial insemination, artificial insemination with hormone synchronizing and the bull of dairy cattle breeds, multiple ovulations, and embryo transfer.
- ✓ Improve the efficiency of existing artificial insemination, artificial insemination with hormone synchronizing and bull crossbreeding/breeding, multiple ovulations, and embryo transfer services.
- ✓ Reduce cumbersome procedures to ease land availability for local and foreign investors in feed and dairy production and processing.
- ✓ Encourage the establishment of heifers' multiplication centres.
- ✓ Provide continuous training and refresher courses to artificial insemination technicians.
- ✓ Strengthen the extension service and training to dairy cattle owners in dairy cattle farming and milk and milk products.
- ✓ Improve animal health service.
- ✓ Enforce forages, concentrate feeds, and forage seed quality standards and create a conducive environment for production and marketing of feeds and feed seeds; and
- ✓ Enforce milk quality standards and support the establishment/functioning of milk processing plants.

However, many of the improved family dairy section's challenges and strategies are pertinent to commercial specialized dairy production and only specific challenges. The interventions to achieve targets under commercial specialized dairy production are presented in Table 5.1. The major ones are feed /fodder improvement, especially its production, marketing, and processing, increasing the number of hybrid dairy cattle and commercial specialized dairy farms, encouraging private artificial insemination, health service providers, and improving milk marketing and milk products. Tables 2-12 below show various aspects of livestock production and products in Tanzania, such as the current and projected number of crossbred cattle by production zone and milk production, challenges and strategies related to improved dairy production and interventions to achieve targets under commercial specialized dairy production.

Table 5. 1 Profitability, GDP, and Nutritional Impacts of Investment in the Livestock Sector by the year 2031

No.	Value chain and production zone	Internal rate of return – IRR	Increase in GDP contribution from additional investments in livestock by 2031 by production system and zone		% Change in nutrition contribution	
			In comparison with base year 2015/16	In comparison with the without additional investment in 2031	Calories	Protein
1	Improved traditional cattle small-scale (central)	34%	87%	8%	8	22
2	Improved traditional cattle medium-to large-scale (central)	18%			10	49
3	Ranch cattle (central)	39%			NA	NA
4	Improved traditional cattle—small-scale (coastal and lake)	77%	131%	57%	5	15
5	Improved traditional cattle medium-to large-scale (Coastal and lake)	58%			35	105
6	Ranch cattle (coastal and lake)	6.6%				
7	Improved traditional cattle—small-scale (highlands)	18%	196%	48%	2	5
8	Improved traditional cattle—large-scale (highlands)	15%				25
9	Ranch cattle (highlands)	73%			NA	NA
10	Urban and peri-urban dairy cattle small-scale (all zones)	35%	1,748%	958%	2	42
11	Urban and peri-urban dairy cattle medium- to largescale (all zones)	73%			14	114
12	Cattle fattening (all zones)	72%	4,696%	1,187%	NA	NA
13	Improved traditional pigs small-scale (all zones)	86%	651%	165%	3	1
14	Improved traditional pigs— medium- to large-scale (all zones)	17%			8	5
15	Specialized pig operation (all zones)	22%			1	2

Table 5. 2 Current and Projected Number of Crossbred Cattle by Production Zone in Tanzania

Improved family dairy	**Livestock production zone**	**Number of hybrid cattle in improved family dairy and specialized commercial dairy**						**% Change**
		Base year (2016/17)	**2017/18**	**2018/19**	**2019/20**	**2020/21**	**2021/22**	
	Coastal and lake	156,857	339,596	568,881	842,297	1,162,868	1,394,338	789
	Highlands	375,337	460,801	556,671	665,979	790,043	930,286	148
	Total in improved family dairy	532,194	800,397	1,125,552	1,508,276	1,952,911	2,324,624	337
Commercial specialized dairy	Commercial specialized	250,800	304,348	369,330	448,185	543,877	660,000	163
National number of crossbreeds		782,995	1,104,745	1,494,882	1,956,462	2,496,788	2,984,624	281

Source: LSIPT livestock sector analysis (2016), MLF

Table 5. 3 Current and Projected Milk Production in Tanzania

Livestock production zone	**National and production system milk production (thousand litres)**						**% Change**
	Base year (2016/17)	**2017/18**	**2018/19**	**2019/20**	**2020/21**	**2021/22**	
Central	848,140	884,466	922,348	961,853	1,003,049	1,046,010	23
Coastal and lake	751,923	841,687	942,166	1,054,641	1,180,542	1,321,474	76
Highlands	344,186	401,149	467,541	544,920	635,106	740,219	115
Commercial specialized dairy	214,885	272,832	346,405	439,819	558,423	709,011	230
Total milk production	**2,159,134**	**2,400,134**	**2,678,461**	**3,001,233**	**3,377,121**	**3,816,714**	**77**

Source: LSIPT Livestock Sector Analysis (2017), MLF

Table 5. 4 Annualized Milk Productivity of Cows in Traditional and Improved Family Dairy and Commercial Specialized Dairy Subsystems

Livestock production Category	**Milk production per reproductive female per year (litre)**						**% Change**
	Base year (2016/17)	**2017/18**	**2018/19**	**2019/20**	**2020/21**	**2021/22**	
Traditional and improved family dairy	165	174	184	194	205	216	31
Commercial specialized dairy	1,757	1,839	1,925	2,015	2,108	2,207	26
National	**179**	**192**	**206**	**221**	**237**	**254**	**42**

Source: LSIPT Livestock Sector Analysis (2017), MLF

Table 5. 5 GDP Contribution of Milk at National Level

Livestock product	GDP contribution by commodity (TZS million)						% Change
	Base year (2016/17)	2017/18	2018/19	2019/20	2020/21	2021/22	
Milk	808,342	904,209	1,011,445	1,131,399	1,265,578	1,415,671	75

Source: LSIPT Livestock Sector Analysis (2017), MLF

Table 5. 6 Dairy Production Sub-systems in Tanzania

Dairy subsystems	Herd size	Classified under	Average milk production (litre/day)	Average lactation length (days)	Parturition rate
Improved family dairy	1-5	Crop-livestock mixed agriculture	6–8	250–270	0.7
Commercial specialized dairy	5-100 (small) >100 (medium)	Urban and peri-urban specialized dairy	10–12	310	0.75–0.8

Source: LSIPT Livestock Sector Analysis (2017), MLF

Table 5. 7 Key Challenges and Strategies Related to Improved Family Dairy Production

SN	Key challenges	Strategies
1	**Feed availability and quality**	
	• Erratic supply of feed quality and quantity • Limited availability and high cost of forage feed, and little supplementation • Limited access to land for grazing, production of forage and forage seed due to an unclear land tenure system • Mineral deficiencies in most of the forage	• Strengthening the extension service and training on forage production, conservation and feeding • Policy interventions to make land available for investors for forage seed and forage production • Enforcing feed and forage seed quality standards • Using appropriate fertilizers in forage production.
2	**Low genetic potential of indigenous animals for milk production**	
	Inadequate and inefficient artificial insemination services	• Providing training support and incentives to livestock farmers to work as artificial insemination technicians. • Establishing and strengthening dairy heifer multiplication farms through private, public, and private-public joint ventures. • Promoting, expanding, and strengthening privatization of artificial insemination, hormone synchronization, multiple ovulations, and embryo transfer services
3	**Animal health services**	
	• High calf mortality • Inefficient animal health services • Inadequate supply of drugs • Poor quality control of drugs and supplies • High prevalence of transboundary diseases and trypanosomiasis	• Rationalizing and strengthening the animal health regulatory capacity at the national and local government authorities (LGAs) levels under the coordination of the MLF • Improving availability and quality control of vaccines and drugs
4	**Marketing and processing**	
	• Unreliable transport system	• Promote investment in long shelf-life milk products such as UHT and powdered milk

SN	Key challenges	Strategies
	• Narrow product range which is concentrated on short shelf-life products, i.e., liquid, and fermented milk • Poor milk marketing and low price of milk • Fluctuations in milk supply due to seasonality (dry and wet seasons) • An absence of quality-based pricing incentives • Poor milk quality control and enforcement mechanisms • The existing informal trade of raw milk poses a threat to spreading zoonoses • Limited promotion of dairy-product consumption	• Introduction of quality-based standards and pricing to encourage quality milk supply • Strengthen enforcement of milk and milk products quality standards • Formalize milk trade by training and licensing milk traders • Scale-up school-milk feeding program to promote milk consumption
5	**Policy**	
	• Pricing policies have disincentive effects on milk processing • Overregulation of the dairy industry resulting in multiple taxes, which is a burden to investors	• Introduction of a protective trade policy that includes increasing import tariffs or bans and subsidies for domestically produced milk products to enable competition with imports • Put in place indicative prices for milk products • Reduce bureaucracy and facilitate investment in the dairy industry.

Table 5. 8 Increase in Milk Production due to Cow Dairy Improvement in Family Dairy Subsystem of Coastal, Lake and Highlands Zones

Livestock production zone	Milk production in the improved family dairy subsystem (thousand litres)						% Change
	Base year (2016/17)	2017/18	2018/19	2019/20	2020/21	2021/22	
Coastal and lake	751,923	841,687	942,166	1,054,641	1,180,542	1,321,474	76
Highlands	344,186	401,149	467,541	544,920	635,106	740,219	115
Total milk production	**1,096,109**	**1,242,836**	**1,409,707**	**1,599,561**	**1,815,648**	**2,061,693**	**88**

Source: LSIPT Livestock Sector Analysis (2017), MLF

Table 5. 9 Average daily milk production change per cow in coastal and lake, and highlands zones due to cow dairy improvement interventions in an improved family dairy subsystem

Livestock production zone	Average daily milk production per reproductive female (litre)						% Change
	Base year (2016/17)	2017/18	2018/19	2019/20	2020/21	2021/22	
Coastal and lake	1.50	1.62	1.74	1.88	2.02	2.18	45
Highlands	2.00	2.14	2.30	2.47	2.65	2.84	42

Source: LSIPT Livestock Sector Analysis (2017), MLF

Table 5. 10 Annualized Milk Production of Cow in Coastal and Lake and Highlands Zones

Livestock production zone	Milk production per reproductive female per year						% Change
	Base year (2016/17)	2017/18	2018/19	2019/20	2020/21	2021/22	

Coastal and lake	157	171	186	202	220	240	53
Highlands	215	236	259	285	313	343	59

Source: LSIPT Livestock Sector Analysis (2017), MLF

Table 5. 11 Key Strategies and Challenges in Commercial Dairy Production

SN	Key challenges	Strategies to address challenges
1	**Feed availability and quality**	
	• Cumbersome procedures of owning land for commercial forage production • Underutilized public farms • Shortage of concentrate feed and roughage (both in quality and quantity) • Lack of effective feed quality control and standards enforcement mechanisms	• Making land available for commercial forage production by investors • Employ PPP arrangement to increase public farms production efficiency • Promoting and enforcing outsourcing contracts to produce forage for specialized dairy • Enforcing feed quality standards, quality monitoring and control • Promoting the establishment of flour mills and oil processing plants will make more concentrate feed ingredients available, i.e., wheat bran, wheat short and seed cakes
2	**Marketing and processing**	
	• Lack of diversity of dairy products and packaging that meets the consumption needs of different consumers • Shortage of dairy technologists	• Promoting investment in UHT milk, powdered milk production, and other value-added products like yoghurt, ice cream and cheese, etc. • Building the capacity of the dairy technology training institute(s)
3	**Policy and investment support**	
	• Poor milk quality control and enforcement mechanisms • Few commercial specialized dairy farms and milk processing plants	• A need for milk-quality standards controls and enforcement, as well as grading and pricing policies • There is a need for an effective land acquisition policy for dairy investments (preferential treatment for accessing land for specialized dairy production, milk processing, and feed production). • A need for incentives for investors to establish dairy processing plants and specialized dairy farms

Table 5. 12 Main activities for interventions to achieve targets under commercial specialized dairy production in Tanzania

SN	Intervention area	Initiatives
1	Feed improvement interventions	• Make land accessible for forage production for the commercial specialized dairy farms and forage producers. • Strengthen the existing forage/forage seed/ quality control laboratories

SN	Intervention area	Initiatives
2	Increasing the number of commercial specialized dairy farms	• Provide incentives to investors and ease the bureaucracy in establishing commercial specialized dairy farms. • The number of crossbreed dairy cattle and commercial specialized dairy farms in the commercial specialized dairy subsystem is expected to increase by 120-163% and 164%, respectively. • The number of commercial specialized dairy farms is targeted to increase from 159,000 to 420,000 in small and 204–400 farms in medium commercial specialized dairy subsystems. • The number of mixed dairy cattle will increase from 159,000 in 2015/56 to 420,000 in 2020/21 in small commercial specialized dairy farms and from 250,800 in 2015/16 to 660,000 in 2020/21 in the medium ones.
3	Animal health interventions	• Improve the availability of drugs, vaccines, and medical equipment and support to enhance private health service providers' effectiveness. • Improve the availability of vaccines for Foot and Mouth Disease, Rift Valley Fever, Contagious Bovine Pleuropneumonia, East Coastal Fever and Brucellosis.
4	Genetic improvement interventions	• Encourage private artificial insemination service providers
5	Improving marketing and processing of milk and milk products	• Interventions proposed to improve marketing and processing of milk and milk products in improved family dairy subsystems equally work for commercial specialized dairy subsystems.

5.3 Animal Feed, Water and Health in Tanzania

Given that crop and livestock production provide livelihoods, incomes, and employment to more than 75% of Tanzania's population, existing data show that feed and water are the most critical resource constraint in the livestock sector despite that fact that the country is endowed with pasture and water resources that can serve the country's millions of livestock more sustainably. The primary constraint that humper increased, and sustained livestock productivity are seasonal variations in forage quality and quantity. The country also produces substantial amounts of cereals and root crops, whose residues are valuable livestock feeds. Still, such crops are grown primarily for human consumption, and some are in short supply. Moreover, natural pasture and crop residues are inferior in quality and, according to Daniel (1990), provide inadequate nutrients and hardly meet the nutrient cattle requirements for growth and reproduction. However, proper pasture management can significantly reduce costs and improve livestock performance (Abadi *et al*., 2017)., pastureland management practice needs to be improved. Sustainable management of the land can improve agricultural management, such as planting Nitrogen-fixing legumes (Nebi, 2018) and other quality forage pasture crops to increase feed resources availability (Peyraud *et al*., 2009). For example, growing legumes provide many benefits to as pasture system and do not need any nitrogen fertilization but improve the seasonal distribution of dry forage matter by boosting production and overall fodder digestibility, especially in rainy periods (Alemayehu, 2002). However, the livestock feed deficit is often aggravated by climate change in feed quantity and quality. For instance, extended dry seasons, frequent droughts, erratic rainfall, and rainfall patterns and temperatures can drastically reduce the availability of both feed roughages

and concentrates. In many parts of Tanzania, pasture and water shortages have also led to overgrazing and resource conflicts between livestock keepers and other land users.

Although most (> 75%) of rural Tanzanians live in rural areas, about 37% keep livestock mainly under traditional smallholder systems. Animal health services remain one of the main constraints of livestock production and productivity, feed and genetics. As such, the control and prevention of animal diseases is a recurring and costly burden to livestock keepers and others who deal in the livestock value chain and transboundary cases concerning animal health. Inadequate resources, including funds, skilled personnel, and logistics, have also weakened national veterinary services' ability to reduce the impact of reported transboundary and zoonotic diseases and pests outbreaks. Such factors and several others hinder effective livestock breeding and selection programs in many areas in Tanzania. Transboundary livestock, livestock product, and product trade are critical elements of traders' livelihood systems, pastoral and agro-pastoral populations in Tanzania. A regional cross border trade network supports these, and the responsible ministry has the mandate to enforce related laws, rules, and regulation on livestock trade. Despite the government's well-stipulated role of creating a conducive environment to attract investments in the livestock sector, some of the challenges to be addressed are some unnecessary disturbances to the investors by the many regulatory organs that often cause, unfair competition inconvenience in both public and private livestock production sectors. This study observed several challenges in the livestock value chain sectors such as availability of long-term capitals, which has a low-interest rate, failure by some businessperson to pay back the loan, uncontrolled sales of milk which leads to loss of revenue, black market milk imports (>20%) and lack of access to raw milk as raw materials to industries and lack of cold chain

5.4 The pasture resource and types of natural pasture in Tanzania

Natural pasture provides over 90% of the feed requirements of ruminant livestock, especially cattle in Tanzania. According to TSAP (1978.), the range is very diverse due to its wide variety of ecological variations. The five main ecological zones identified in the country, semi-arid to sub-humid grazing land, cover nearly 30% of the grazing area. This mainly occurs in the central plains and includes pastoral systems of Arusha, Dodoma, Shinyanga, and Singida that host about 40% of the national cattle herd. Common fodder trees are *Brachystegia* or *Combretum* spp, with the most typical grasses being *Chloris gayana*, *Cenchrus ciliaris*, *Brachiaria brizantha*, *Cynodon spp*. and *Andropogon gayanus*. *Sporobolus spp* dominates in overgrazed areas. The humid plateau lands also represent another 30% of the grazing area and support nearly 50% of the cattle. This is found in the agropastoral zones of Mwanza, Mara, and Mbeya. These grazing areas represent 60% of the area and carry 90% of the stock. The most common legumes found in this zone are *Desmodium spp*., *Clitoria ternatea*, *Macroptilium atropurpureum*., *Neonotonia wightii* and *Stylosanthes guianensis*. Dominant grasses are *Chloris gayana*, *Pennisetum purpureum* and *Setaria sphacelata.* The Humid lowland represents 20% of the grazing, but only about 2% of the livestock occur here. The regions with the most potential are Mtwara and Lindi. Species commonly found include *Hyparrhenia spp.* and *Cynodon spp.* The Very humid highlands covering some 9% of the gazing area and support only 5% of the cattle and found in parts of Kilimanjaro, Mbeya, Ruvuma and Kagera. Most cattle found here

are exotic and crossbred cattle. This is potentially forested or intensive agriculture, including pyrethrum, coffee, and tea. The natural grassland responds to intensive management and can support one stock unit on less than one hectare. Grasses found in the zone are *Cenchrus ciliaris*, *Setaria sphacelata* var. *splendida*, *Panicum spp*., *Pennisetum purpureum*, and legumes *Centrosema pubescens*, *Desmodium intortum*, *Neonotonia wightii* and *Medicago sativa*. The Very humid lowlands are a limited area, restricted to the Tanga region, but livestock, mostly crossbred dairy stock, is increasing. Grass species commonly found are *Panicum spp*., *Pennisetum purpureum*, and *Chloris gayana*. *Neonotonia wightii* and *Centrosema pubescens* are the major legumes. The main types of pasture in Tanzania are reported in FAO (1960); they are summarized below.

- ✓ *Chloris* grassland is associated with a tree or bush steppe in which Comephorid, Acacia and Adansonia are the main trees. It is found between 450 and 1 140 meters under rainfalls of 380–640 mm. Dense bush usually reduces grazing capacity considerably, but bushes and shrubs contribute largely to stock feed in the dry season. Carrying capacity is low, and lack of water and tsetse infestation limit access in some areas. The primary grasses are *Chloris roxburghiana*, *Latipes senegalensis*, *Enteropogon macrostachyus*, *Tetrapogon spp*., *Cenchrus ciliaris* and in parts *Cymbopogon aucheri* and *Aristida ascensionis*.
- ✓ *Eragrostis* grassland is an open, almost treeless savanna derived from intense cultivation; it occurs along sandstone ridges on low fertility soil. The grass cover is mostly secondary. It happens at an altitude of 1400 meters under relatively high rainfalls, 1500–1800 mm. Grasses soon become coarse and unpalatable. It is typical of the Bukoba sandstone areas where the carrying capacity at 3.25 ha per head is relatively high. The primary grasses are *Eragrostis blepharoglumis*, *E. milbraedii*, *Hyparrhenia spp*., *Cymbopogon sp*. and *Setaria spp*.
- ✓ *Hyperthelia dissoluta* grassland is chiefly composed of tall grasses usually associated with Brachystegia woodlands or a more open Commiphora woodland or Acacia spp. Soils are generally poor, sandy, and derived from granite. It occurs between 450 and 1500 meters, with rainfall of 760–1 200 mm falling between November and May. Most grasses are palatable when young but, if not heavily grazed, soon become woody, especially Hyparrhenia and Andropogon. This type is characteristic of large western Tanzania areas and parts of the east and south used mainly for mixed farming. The primary grasses are *Hyperthelia dissoluta, Hyparrhenia filipendula, Pennisetum polystachyon, Eragrostis chaplieri, E. patens, Setaria sphacelata* and *Chloris gayana.*
- ✓ *Hyparrhenia rufa* - *Bothriochloa insculpta* type is an edaphic grassland maintained by periodic flooding and frequent burning. Soils are variable but fertile; it occurs from sea level to above 1200 meters with rainfalls of 760–1140 mm between November and June. It is typical of the coastal belt and is suitable for mixed farming. The primary grasses are *Hyparrhenia rufa, Bothriochloa glabra, Andropogon schirensis, Pennisetum polystachyon, Setaria sphacelata, S. marginatus, Ischaemum afrum, Chloris gayana* and *Hyparrhenia filipendula*. Echinochloa pyramidalis, Leersia hexandra, Phragmites communis and Imperata cylindrica are common in more permanently wet areas.

- ✓ *Panicum - Hyparrhenia* grassland is associated with the woodland of varying density associated with Acacia spp. (A. nigrescens is common). It occurs along the coast with a rainfall of 1000 mm between November and June. This type is also found at higher altitudes up to about 670 metres in high soil fertility areas, but this is much used for cropping. Under good management, its carrying capacity is about five hectares per head. The primary grasses are *Panicum maximum, Hyparrhenia rufa, Pennisetum purpureum, Cymbopogon excavatus, Brachiaria mutica, Bothriochloa glabra, Echinochloa pyramidalis* and *Chloris gayana*.
- ✓ *Panicum - Cenchrus* grassland consists of patches within the scrub, comprised mainly of Combretum, Grewia, Maerua, Boscia, and Acacia. It occurs between 750 and 1350 metres with a rainfall of 380–760 mm between December and April. It is very palatable and contains many browse plants relished by both stock and game. This type is characteristic of large areas of the central plateau. The primary grasses are *Panicum maximum, Cenchrus ciliaris, Bothriochloa insculpta, Brachiaria brizantha and Cynodon nlemfuensis.* Many annuals are present in the early stages of succession after clearing and persist long afterwards, including *Chloris virgata, C. pycnothrix, Setaria pallida-fusca, Dactyloctaenium aegyptium and Urochloa panicoides.*
- ✓ *Pennisetum clandestinum* (often associated with *Themeda triandra* and *Pennisetum schimperi*) grassland is open with grass 45–90 cm high or sometimes short, dense, and associated with *Trifolium semipilosum*; dominance depends on fire, soil fertility and grazing intensity. It occurs at medium to high altitudes, 1500–2 400 m, under bimodal rainfalls of 750–1 500 mm. This is excellent pasture, but much has been put under crop because it is in a high agricultural potential area. The main species are *Pennisetum clandestinum, P. schimperi, Themeda triandra, Exotheca abyssinica, Pennisetum catabasis, Panicum trichocladum, Andropogon pratensis, Digitaria scalarum and Eleusine jaegeri*. In cultivated areas, Digitaria scalarum can be a serious pest.
- ✓ *Themeda - Loudetia* grassland is derived from the forest in highland areas, often on deep red loam above 1400 m with rainfall over 760 mm distributed from December to June. The quality of the grazing is good, but this land has a high potential for crops. The primary grasses are *Themeda trianda, Loudetia simplex, Hyparrhenia nyassae, H. hirta, Melinis minutiflora, Trachypogon spicatus, Eragrostis racemosa* and *Elyonurus argenteus.*
- ✓ An open, often almost treeless savanna with scattered trees of *Acacia drepanolobium* occurs on red and black soils and some flood-plain areas between 450–1200 m under rainfalls of 640–900 mm. It provides good grazing if well managed. The primary grasses are *Themeda triandra, Bothriochloa insculpta, Heteropogon contortus, Hyperthelia dissoluta, Cynodon nlemfuensis* and, *Pennisetum mezianum.*

5.5 Pasture utilization systems and opportunities for improving pasture resources

Three central grazing systems can be identified in Tanzania. Nomadism occurs in semi-arid areas where stock owners move with their animals in search of forage. This happens mainly in Maasai land.

There is also Semi-nomadism where cattle owners permanently settled but trekking their animals to distant grazing and watering areas. The third system is Ranching, and dairying done by land-owning groups, villagers, corporations, or private individuals. According to Kidunda *et al*. (1990), this system can allow successful pasture innovations to be introduced.
Further, it is possible and quite common to obtain forage from farming systems that can include natural herbs, crop residues, cereals, root crops, milling by-products and oil-press residues, molasses, meals from animal by-products, Fish meal and minerals. There is a diversity of natural herbage species available that form the primary feed resource of Tanzania. According to Kidunda *et al*. (1990), grazing lands cover about 51% of the total land area on which both wild and domesticated ruminant continue to graze for many years to come. But they must be well managed and have good nutritional value if they have to meet a growing livestock industry's need in a sustained manner. However, this source is an essential source of high-quality feed due to the extensive grazing areas and its considerable contribution to the maintenance of dietary quality, especially in the dry season and especially for about 99% of ruminants which depend on this traditional pasture management system (Kidunda et al., 1990). Crop residues such as rice, maize, sorghum, millets, and beans account for about 8% of the livestock. There are also residues from other crops such as wheat, cassava, groundnuts, bananas and further processing such as sugar, coffee, sisal, and cashew, which are essential locally as cattle feed. Although cereals are used for human food, the low-quality grain is usually fed to dairy cattle, and with increased crop production, additional feed sources will be available. Supplementary feeding from concentrates is common, especially when dairy cows are in-calf and to mulch cows. These include minerals and vitamins mix, brewers' wastes from Arusha, Kilimanjaro, and Mbeya commonly used by smallholders as supplementary feeds from maize bran, cottonseed cake sunflower cake as primary concentrates. Seasonal variations affect the availability and quality of these feeds. Therefore, livestock keepers sometimes do long travel distances in search of fodder. They also sometimes buy hay from large stock farms and small-scale entrepreneurs. Traditional farming only involved subsistence and cash crops but often ignored and even abused the large trucks of natural grassland as evidenced by mismanagement such as frequently seen in overgrazed, eroded grassland and often bush encroachment. Over time, the agriculture pattern is slowly changing, with farmers realizing the value of their grasslands. There is increased awareness of the importance of pasture and fodder among small commercial dairy farmers. As milk prices rise, farmers also tend to look for cheaper concentrates which are often hard to get. But according to Ekern (1990), pasture, if adequately utilized, is the most affordable feed for ruminants.

The improvement of natural pasture by manipulation of grazing pressure, use of appropriate species (including mixed herds), controlled burning and clearing and control of woody weeds forms the foundation for better yields; and this can only be done effectively under controlled land management as demonstrated by various research efforts in Tanzania. In Tanzania, sown pasture **or** fodder is not crucial in farming systems, although it has been widely used elsewhere in East Africa, notably Kenya. Sown pasture, however, has not become vital since it is unsuitable for smallholder agriculture. Fencing and large fields are required for proper management; similarly, reseeding common grazing lands is impracticable unless there is agreed and organized management and control of stocking rates. Material initially selected in Tanzania has had a much more widespread use outside the country. The two standard features of natural grasslands in Tanzania are dominated by quick flowering and rapidly

lignifying grasses with high fibre contents, low protein, minerals, and digestibility, and (2) herbaceous legumes unimportant in the pasture. Many attempts have been made to introduce legumes into East Africa's ranges, both for "improvement" of natural grassland and mixed, sown swards. Whichever the case, the level of crude protein in pasture should be kept above 7% to avoid a decline in feed intake by stock and maintain increased live weight. So far, pasture improvement is the most economical method of ensuring that stock has access to adequate supplies of energy, protein, vitamins, and minerals.

Several large, indigenous types of grass are widely cultivated throughout East Africa as cut-and-carry fodder. These include Elephant Grass (*Pennisetum purpureum*), the most popular, although Guinea Grass, Panicum maximum and the giant Setaria, Setaria sphacelata var *splendida* can also be used. These grasses have been used in Tanzania for many years. They are well suited to smallholdings as supplementary feed for dairy stock because they are vegetatively propagated and easy to harvest and feed.

Over-seeding natural pasture is also an essential system for pasture improvement**.** *Desmodium intortum* over sown into natural pastures produced an increased yield over natural pasture alone (Kusekwa et al., 1990). Also, the nutritive value of two legumes (*Macroptilium atropurpureum* and *Clitoria ternatea*) over sown in Hyparrhenia dominated grassland averaged 13.4% CP and 69% in vitro dry matter digestibility (IVDMD) after eight weeks, compared to 5.3% CP and 47.1% IVDMD for the grass alone (Mkonyi, 1977). Although different results from applying fertilizers to natural swards have produced variable results and responses, vary with species, but generally, all responded to fertilizer.

In Tanzania, coconut is among the main cash crops produced in the coastal belt. According to Njau (2000), a sustainable way to improve coconut plantations is to intercrop them with food crops or integrate grazing livestock. Livestock provides manure, milk and meat and control weed growth. More livestock integration into coconut production is good since livestock enterprises increased on the coast due to the high demand and a good road network to the market centres. However, investigation on the productivity and quality of pastures under coconut plantations has received little attention in Tanzania. Njau (2000) has shown that ranges under coconut shade have low dry matter yield and nutritional value leading to low livestock productivity. Livestock depending on grazing under coconuts in Tanzania, will not reach their production potential without pasture improvement. Some sown forages like *Brachiaria decumbens* and *Brachiaria miliiformis* disappear when pastures under coconut are overgrazed, so a mixed sward should be maintained with a favourable balance between legumes and grasses ((Njau, 2000). A decline in the legume fraction affects the overall efficiency of herbage utilization.

The growth rate and dry matter yield of pastures under coconut are reduced, and therefore, the growth rate and dry matter yield are reduced (Njau, 2000). The growth and dry matter yield of some pasture species are less affected by shade; therefore, the need to screen shade resistant pastures ((Njau, 2000). Some shade resistant forages include grasses *Ischaemum indicum, Brachiaria spp* and legumes *Desmodium heterophyllum, Mimosa pudica* and *Centrosema pubescens*. To effectively utilize the land under coconut and get more income, farmers are advised to integrate livestock with coconut plantations or intercrop in fertile soil (Njau, 2000). In Tanzania, grazing under coconuts was proposed

by Sethi (1953, cited in Njau, 2000) in Tanga and later by Childs and Groom (1964). Some benefits of grazing cattle under coconuts are increased farm income by selling the nuts and livestock products, reduced weed competition and weed control costs, better land use and fertility recycling.

5.6 Research and development organizations and personnel

Most research on forage and pastures is done by parastatal organisations and research centres under the Ministry of Agriculture and Corporation (MOAC)located in different ecological zones in the country such as Mpwapwa Livestock Production Research Institute, Kongwa Pasture Research station, West Kilimanjaro Research Centre, Malya Research Centre, Tanga Livestock Research Centre. Sokoine University of Agriculture (SUA), Tengeru Livestock Training Institute and Uyole Agricultural Centre.

The following research projects are undertaken at Tengeru livestock training Institute: ILCA pasture research, the FAO project on pasture seed production, and the ICRAF agroforestry research project. The institute also has an agroforestry project established in cooperation with the U.K. Leominster community. Legume forages incorporation with fodder grasses for smallholder dairy farmers in the Kilimanjaro highlands. Dairy feeding systems using crop residues in the Kilimanjaro highlands. There is also research on nutritional value, treatment, utilization, and transportation costs of crop residues.

Mpwapwa Livestock Training Institute and research in Central zone conduct research on introducing and evaluating pasture species for oversowing in natural pastures and undersowing with cereal crops in the semi-arid areas of central Tanzania. The initial screening is done on-station and later on-farm for the most promising species. It also established intensive feed gardens (participatory farmer research), improvement of livestock feeds by the introduction of dual-purpose legumes (Intercropping cereals with dual-purpose legumes in Berege village), oversowing of legumes into natural pastures in central Tanzania as a method of pasture improvement and improved grasses and legumes as feed resources for central Tanzania. Browse leaves and pods as ruminant feed in central Tanzania. There are also studies conducted on legume forage conservation in the Singida region. At Uyole Agricultural Research Station and southern highlands zone pasture activities include pasture seed production, Leucaena forage in farming systems, forage utilization by livestock, screening of temperate and sub-tropical and multipurpose browse species for adaptation to southern highland conditions for on-farm integration with cereals and range monitoring, improvement by sod seeding, grazing management and bush control methods at Kongwa Pasture Research Station.

5.7 Constraints limiting pasture research in Tanzania

Despite a great deal of effort made in pasture research over the years, there has been little progress due to some constraints in this sector, such as

- ✓ Insufficient qualified and competent extension staff needed to advise farmers on pasture development and grazing management. Where there has been extension staff, their interaction with pasture research has been minimal.
- ✓ Shortage of pasture seed has been a significant limitation to sown pasture in Tanzania. Several research stations and parastatal livestock farms have been producing uncertified pasture seed

- ✓ Lack of funds to develop and expand the vital seed production activity
- ✓ There is insufficient demand to support commercial production.

5.8 Livestock sector policy and institutional arrangements in Tanzania

Tanzania is a low-income rural economy where livestock contributes 30% to agricultural value-added and 7% to GDP. And most livestock are kept by poor small farmers and pastoralists. In the medium to long-term, livestock is expected to continue playing a central role in its rural economy. Its enhanced development will improve economic growth and reduce poverty, especially in rural areas. The country's current development objective is to create an enabling and conducive market environment for improving agriculture and livestock profitability to improve incomes and reduce rural poverty. The main concerns are that the liberalization emphasis seems to bypass the poor livestock keepers. There is a lack of credit and extension services in most rural areas.

Tanzania's Livestock Sector Development Strategy (2014/15 -2018/2019) aims to contribute to overall GDP growth, national and household incomes and growth in export earnings based on the Tanzania Development Vision (TDV) 2025 and with a mission to "ensure that livestock resource is developed and managed sustainably for economic growth and improved livelihoods". Therefore, the Livestock Sector Development Strategy (LSDS) aims to develop a competitive and more efficient livestock industry that contributes to improving the livelihoods of all livestock keepers and the national economy. The specific objectives of strategy (as in the National Livestock Policy (NLP) are:

- ✓ Contribute towards national food security through increased production, processing, and marketing of livestock products to meet national nutritional requirements.
- ✓ Improve the living standards of the people engaged in the livestock industry through increased income generation from livestock.
- ✓ Increase the quantity and quality of livestock and livestock products as raw materials for local industry and export.
- ✓ Promote integrated and sustainable use and management of natural resources related to livestock production to achieve environmental sustainability.
- ✓ Promote the production of safe and quality foods of animal origin to safeguard the health of consumers.

The Ministry responsible for livestock industry development has demonstrated the Government's resolve to give this sector to contribute to poverty alleviation and the national economy in general. But several structural, regulatory, and institutional gaps still exist and need to be addressed. There are many laws and regulations, some outdated and need to be harmonized or updated. Some need to be enacted, such as the Dairy Industry Act no 8, 2004; the Veterinary Act, No 16, 2003; the Meat Industry Act, No. 6 of 2006, The Grazing-land and Animal Feed Resources Act, 2010; and The Livestock Identification, Registration and Traceability Act, 2010). Some regulatory institutions (e.g., the Dairy Board, Meat Board) are not yet fully operational. The Central Government and its various institutions and employees, Local government authorities and the private sectors in the livestock sector's implementation need to be reviewed to ensure clarity. Public-Private Sector Partnerships should be effectively and efficiently implemented and related to control of transboundary diseases,

zoonoses, animal genetic resources improvement and conservation. Several issues on regulatory frameworks for monitoring are still weak and problematic and need improvements. Tanzania's Grazing-Land and Animal Feed Resources Act of 2010, which provides for the management and control of grazing-lands, animal feed resources, has no related regulations and institutional structures, guiding forage production and trading business recognized by local or national governments. There is no licensing and regulatory body needed to develop relevant guidelines for enforcing forage quality and compliance and appropriate mechanisms for advocacy and lobbying platforms on forage issues.

5.9 Cross-Cutting and Cross-Sectoral Issues

Many factors outside the Ministry of Livestock and Fisheries Development jurisdiction influence livestock development in Tanzania. Several cross-cutting and cross-sectoral issues should be mainstreamed in livestock development plans. These issues include land tenure, environment, gender and Human Immune-deficiency Virus and Acquired Immunodeficiency Syndrome (HIV and AIDS). Land tenure problems have caused low land productivity since there is little incentive to invest in land development for livestock production. The problems point to lack of land for livestock production, lack of technical expertise in land surveying, lack of awareness of the importance of legal land ownership, and title deed acquisition issues. Other problems are related to overgrazing, uncontrolled movements of many livestock, which threaten rangelands and cannot guarantee sustainable livestock development, and proper utilization and management of the environment in a manner that ensures livestock and fodder value chain. It can also be stated that the gender balance does play out it the livestock and fodder value chain much more against women than men. While the latter are key actors at the various stages of the value chains, their access to resources and role in the decision process is limited mainly by social and cultural factors. Further, diseases such as HIV/AIDS and malaria and some traditions and cultural factors hinder livestock keeping communities regarding risks related to interactions associated with transporting livestock and livestock products. Such adverse impacts are constrained by the social, economic and cultural factors, low awareness amongst livestock keepers, livestock traders and other stakeholders, inadequate health infrastructure and facilities and insufficient expertise.

Figure 5. 1 Map of Tanzania

5.10 Selected pilot: Rorya District, Mara Region

5.10.1 Overview

Mara Region is one of Tanzania's 31 administrative regions. The regional capital is the municipality of Musoma. According to the 2012 national census, the region had 1,743,830 inhabitants, which was lower than the pre-census projection of 1,963,460. For 2002–2012, the region's 2.5 per cent average annual population growth rate was the thirteenth highest in the country. It was also the twelfth most densely populated region with 80 people per square kilometre. Livestock production in Mara Region is a significant livelihood and economic resource. The observed low productivity of livestock in the region and other parts of the country is mainly due to poor nutrition caused by the shortage and low quality of forage. There are three central livestock production systems in the country, namely (i) traditional extensive production system which comprises agro-pastoralism and pastoralism and is the

dominant production system (96%) in Mara Region, (ii) intensive or commercialized system (4%), and (iii) semi-intensive production system- mostly in large-scale ranches and dairy farms.

5.10.2 Status and availability of fodder and forage

In this area, the ruminant livestock producers meet their feed requirements through a combination of mainly grazing, crop residues (i.e., legume and cereal residues) and some planted forage and collected feed plants as weeds, free leaves, banana pseudostem and tubers. Some farmers also use concentrates and feed supplements and crop byproduct ingredients purchased off-farm. But the availability of and access to quality feed, including forage, is still a significant challenge for the intensification of livestock production in this region which is complicated by adverse effects of climate change and seasonal variations in quantity and quality forage. The result is that livestock, especially those for dairy, are poorly fed; hence their production potentials cannot be fully realized. The district forage is often abundant in wet seasons but in short supply in the dry season leading to fluctuating seasonal milk availability and prices that mainly affect smallholder farmers' incomes. The fluctuating availability of pasture also causes seasonal, temporary movement or migration of herders and livestock to areas along the Mara River Basin and the lake with better range and water, especially in dry periods. It is worth noting that viability for smallholder dairy farmers in Mara Region is adversely affected mainly by the losses incurred during forage scarcity and may not fully be offset during forage abundance, leading to unpredictable milk supplies and prices. As such, the government and other development partners are keen on research and development and have put TALIRI to ensure, among others, forage productivity and production through research, technology development, and dissemination through its seven research centres.

5.10.3 Fodder/Forage Production systems in Rorya district (Mara Region)

Forage production requires a wide range of critical inputs, including seeds, fertilizers, farm machinery/equipment and water. Extension services are relevant and necessary as well. Recently in Tanzania, forage seeds are supplied primarily by public institutions such as Vikuge Pasture Farms, Langwira Pasture Farm, TALIRI and LITA. International organizations like Heifer International, International Centre for Tropical Agriculture (CIAT) and International Livestock Research Institute (ILRI) import improved forage seeds mainly from Kenya for their projects. Our study observes that these interventions are still rare and hardly reach livestock keepers in Mara Region. Some smallholder dairy farmers benefit from such initiatives and therefore have access to improved forage seeds during the relevant season. Available information shows that in 2016/17, only 3,717.1 and 731.5 kilograms of improved grasses and legume seeds were produced by government pasture farms and sold to forage producers. This was grossly insufficient, and no records are available for the Mara Region. Additional effort is necessary to establish a sustainable forage seed map and reliable and cost-effective input supplies in the region. We noted that forage production in the country is mainly rain-fed and is predominantly by large scale producers. Still, only a few small-scale producers (>5acres) produce forage Mara Region.

The trend of private pasture farms' development in recent years across the country is promising since many forages traded across the country. The commonly established grass species found in the region and many parts of the country are Napier, Rhodes, Buffel, Guatemala, Setaria, Guines/Panicum maximum, Cenchrus cilliaris and Brachiaria spp. Some common forage legumes found during the

study include Lablab, Alfalfa, Desmodium spp, Centrosema, Siratro, Stylo, Tropical kudzu, Clitoria ternatea, Calopo, Sunnhemp, Phaseolus bean and Glycine (Table 5.19). However, forage legumes with higher feed quality than natural grasses are rare and poorly distributed in the Region, and availability depends on seasonality. Silage, a preserved forage with high moisture content made from a green crop, is useful for feeding livestock, especially during the dry season during the scarcity of natural grass. Still, many farmers rarely adopt this in Mara Region and Tanzania. Although Napier and maize silage are now recognized and used in some regions in Tanzania, especially Tanga, Morogoro, Arusha and Kilimanjaro, they are hardly used by livestock farmers in Mara Region.
In the Mara region and most regions in Tanzania, forage trading is dominated by small forage vendors who more often harvest free of charge forage from unutilized open public and private land such as in crop field, roadsides and in wetlands areas along the rivers and sell it to traders and consumers mainly smallholder dairy farmers in urban and peri-urban areas. This may have implications on the quality of forage traded. Dry forage predominantly from crops residues and hay market supply chain, traders dominate the business, although many of them hardly keep livestock. Therefore, some people trade forage as a business, a critical enterprise and a good income source. Traders undertake bulking and aggregation of dry forage (i.e., hay) mostly directly from producers and transport them depending on their financial capability, the quantity of forage and the distance, but by the head, bicycles, trucks, tractors, motorcycles, and hand carts are the most common. Most consumers buy fresh forage daily, once or twice a week from producers, small forage vendors, and traders. Dry forage such as hay and crop residues are usually purchased in large quantities and stored in sheds. During this study, it was noted that dairy farmers mainly applied various strategies to enhance the intake of the purchased forage, such as chopping and feeding, which is the most common method. In dry fodder, some farmers chop and sprinkle salted water.

In contrast, others use molasses., most farmers mix the forage with commercial concentrates or brewers' yeast/waste for lactating animals, and dairy farmers also feed maize bran and sunflower and cotton seedcake. There is an increasing demand for forage in urban and peri-urban areas in the Mara Region. The markets demand in some rural areas are emerging due to scarcity of land and climate change. Some producers and traders were found to export fodder to countries outside Tanzania, suggesting a tremendous potential in fodder trade if there are a well-structured trading policy and activities. In Mara Region and indeed in Tanzania, the forage value chain's significant resources are people's skills and knowledge, land, water, capital inputs, and service delivery. The quality and quantity of these resources are critical to the performance of forage activities.

Although dominant, forage commercialisation practices in regions such as Southern Highlands, Northern Highlands, and Kagera regions are still rare in the Mara region, where extensive grazing is prevalent. In the area, inadequate supply of forage and inferior nutritional quality is the major constraint leading to low productivity levels. Generally, forage is purchased on a cash and carry basis, but some consumers make prior reservations with traders who have developed a working relationship during scarcity. Traders also selectively make reservations with some producers. During the rainy season, producers offer the forage on credit instead of leaving it to rot. In some instances, consumers gave manure to crop farmers in exchange for forage or/and crop residues. However, some systemic constraints are associated with the availability, accessibility, and affordability of forage/fodder in the

Mara region and many parts of the country. These include adverse effects of **c**limate change, small and insufficient grazing and forage production, lack of certified forage seed, inadequate extension services, relatively high capital investments in pasture seed production and maintenance and inadequate market development. It is worth concluding that forage production is an essential component of Tanzania's livestock sub-sector and need to be supported and improved for better dairy farming and trading in the Mara region and the entire country.

Further, forage producers should be encouraged to use irrigation facilities for fodder production, wherever available and forage preservation in hay and silage should be encouraged and enhanced. Possible land reallocation should consider more land for grazing and forage production. The availability of sufficient high-quality feed is key to improving the sector's productivity, such as milk yields and income for smallholders by intensifying smallholder dairy systems (Delgado *et al*., 1999; Gerosa and Skoet, 2012).

It is worth noting that feed scarcity has two main dimensions: temporal or seasonal and spatial, and both are somewhat mitigated through conservation, storage, and marketing of feeds. At the moment, there is a rapid growth of smallholder dairy farming despite the shrinking land sizes and due to increasing human population leading to pressure on land and food, a situation set to be more pronounced as producers shift towards more intensive systems of dairy production and focus on the need to be competitive in the livestock product market (Manyawu et al., 2013). Recent studies Nangole *et al*. (2011) show that fodder marketing occurs at different levels (e.g., village and district) and involves various actors and fodder types. Further, providing market information to producers and buyers is vital to enhancing and improving feed marketing systems. Still, the most available information is about manufactured feed rather than roughages (Jabbar, 2008).

5.10.4 The main actors/stakeholders in the fodder value chain

The fodder value chain involves the three broad categories of actors: producers, traders, and consumers, but within these categories are sub-groups, as shown in Table 5.14. Most producers are small-scale farmers with less than five acres of land allocated to fodder production. Institutions comprised public and private institutional farms such as a university, prison, and company farms. Which mainly produced Rhodes grass for hay. Large scale-farms include farmers producing grass hay for sale and crop residue (primarily rice and maize). Wholesale traders are the least in terms of numbers in the value chain. Most of the traders are neither engaged in fodder production, nor do they do dairy farming. They only sell fodder, which may indicate the importance of fodder marketing as a source of livelihood. Table 5.15 presents a list of stakeholders/participants and their distribution by category of actors in Tanzania's fodder value chain.

Table 5. 13 Categories of key actors in fodder market value chain in Tanzania, including in Mara Region

Actor	Components
Producers	• Institutions (Private, public) • Large-scale farmers • Small-scale farmers

Traders	• Gatherers • Retails traders • Wholesale traders
Consumers	• Buy to supplement • Depend on purchased fodder only

Table 5. 14 Distribution of participants by category of actors

Region	Producers	Traders	Consumers	Total
Arusha	2	4	15	21
Dar es Salaam	0	32	60	92
Morogoro	10	20	7	37
Moshi	0	15	26	41
Mwanza	0	10	19	29
Tanga	6	10	15	31
Total	**18**	**90**	**143**	**251**

5.10.5 Gender and Age distribution along the fodder value chain in Mara region (Rorya District)

The majority of Morogoro and Arusha producers were male, but in Tanga, the number of males was about the same as that of females. The majority of traders in all sites except Moshi and Tanga were males. In Moshi, fodder trading was viewed as a women job, with which men did not wish to be associated. A livestock officer working with farmers in Moshi observed that women are mostly involved in fodder marketing since they are the primary family caregivers while men are primarily engaged in non-profitable social activities. In Tanga, the main fodder traded by women was dried *Leucaena* leaves which men view as a woman's job due to the drying and threshing activity. Tanga area has been cited as the only area in sub-Saharan Africa where *Leucaena* leaf meal is widely marketed (Franzel *et a*l., 2007). Except in Moshi, women consumers were dominant in most sites since they were also mainly responsible for managing the dairy enterprise.

It was found that the majority of participants were over 45 years old, but some differences occurred among various actor categories. Other producers and consumers fell in the age group of between 26 -35 years old (Table 5.16), indicating that fodder trade also attracts the youth who may not have adequate resources such as land and start-up capital. Most of the traders reported that they did not need any money to start the fodder business. They need "only a sickle and you." All participants except five traders had gone through formal education, with the majority (60%) completing the primary level. The participants who had secondary and tertiary education were mainly consumers (Table 5.17), indicating that fodder marketing and trade are potentially an alternative form of employment to the less educated.

Almost all the consumers (99%) and 75% of the producers had dairy cattle, which initially motivated them to plant fodder (Table 5.18). The producers who did not have dairy cows were mainly crop farmers who sold crop residues after harvest and a few farmers who planted fodder for sale. Some traders did not have dairy cattle and carried out fodder trading purely as a business.

Table 5. 15 Distribution in % of fodder market actors by age group across all regions

Actor type	Below 18 yrs		18 to 25 yrs		26 to 35 yrs.		36 to 45 yrs.		Above 45 yrs.	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Producers	0	0	0.4 (1)	0	1 (2)	0.4 (1)	1 (3)	0.4 (1)	4 (9)	1 (3)
Traders	0	0	4 (9)	0.4 (1)	12 30)	4 (9)	4 (9)	1 (3)	7 (17)	5 (12)
Consumers	0.4 (1)	0	2 (4)	0.4 (1)	3 (8)	5 (13	6 (15)	8 (20)	12 (31)	19 (49)
Total	0 (1)	0	6 (14)	1 (2)	16 40)	9 (23)	11 (27)	9 (24)	23 (57)	25 (64)

*Values in parenthesis represent numbers.

Table 5. 16 Distribution in % of fodder market actors by education level across regions

Actor type	None		Primary		Secondary		Tertiary	
	Male	Female	Male	Female	Male	Female	Male	Female
Producers	0	0	3 (8)	0.4 (1)	1 (3)	1 (3)	2 (4)	0.4 (1)
Traders	2 (5)	0	17 (43)	7 (18	5 (12)	2 (6)	2 (5)	0.4 (1)
Consumers	0	0.4 (1)	12 (31)	19 (49)	6 (16)	10 (26)	5 (12)	3 (7)
Total	2 (5)	0.4 (1)	33 (82)	27 (68)	12 (31)	14 (35)	8 (21)	4 (9)

*Values in parenthesis represent numbers.

Table 5. 17 Proportion of farmers with dairy cattle among the different actors across regions

Actor type	% With dairy cattle	% Without dairy cattle	N
Producers	75	25	20
Traders	28	72	90
Consumers	99	1	142

Table 5. 18 Fodder types traded (√) across all regions

Fodder type	Moshi	Arusha	Tanga	Morogoro	Mara (Rorya district)	Mwanza
Natural grass mixture	√	√	√	√	√	√
Rhodes grass (hay)	√	√	√	√	√	√
Rice straw	√	√	√	√	√	√
Bean haulms	√	√	√	√	√	√
Dry Maize stover	√	√	√	√	√	√
Napier grass		√	√	√		
Leucaena			√	√		
Natural Elephant grass (magugu)				√	√	√
Matembele pori (vines)				√		√
Mlonge (moringa)				√		√
Vegetable waste				√		√
Banana leaves/stems					√	

5.10.6 Fodder quality and nutritional value in Mara Region

Quality forage/fodder is required in feeding dairy cows to maintain and increase high milk production and better farm income. A practical assessment for forage or feed quality is based on animal performance which is useful when comparing forages given to growing or lactating animals. It may also mean that the farmer has already incurred the cost of feed. During this study, the participants assessed fodder quality mainly from its physical appearance and in some instances from the smell and characteristics such as Color, stage of maturity, leaf to stem ratio, tenderness of the leaves, well preserved, lack of undesirable types of plants (e.g., poisonous, unappealing/unpalatable to the animal), fodder type and effect on milk yield. We noted that checking feed quality is more than merely containing its physical characteristics. The nutritional content should be of concern, i.e., the energy, protein content, etc. The results of the analysis can be used to select and cost the feed in terms of individual nutrients, e.g., cost per unit metabolizable energy (ME) and crude protein (CP) versus alternative meals (the two significant nutrients that determine the milk production potential of a feed) and to develop feed quality indices. Based on nutritional attributes, the Relative feed value (RFV) index and Relative Feed Quality (RFQ) have been widely used to determine the quality of forages (Moore and Undersander, 2002) and therefore add some objectivity to determining a market value. It should be known that most of the natural grass marketed are collected from open areas leading to a wide variation in species with medium quality. Soils that have not been degraded give good quality pasture depending on species, stage at harvest and storage. During the study, respondents at the FGD reported that they lacked skills and knowledge on various fodder production systems, management, and utilization and depended on natural grass availability for fodder all year round. But they agreed that interventions that improve fodder quality and availability to smallholder dairy farms and consumers are necessary. Further studies are required to validate existing data based on temporal and spatial variability.

5.10.7 Challenges, coping strategies, and possible solutions

Although each group of actors had unique challenges, a few were similar across all actor groups and sites. Among the most critical challenges were lack of technical knowledge, insufficient land for fodder production, fodder availability and capital. The challenges, coping strategies and possible solutions cited by each actor type are presented (Table 5.18).

Table 5. 19 Challenges, coping strategies and possible solution cited by actor groups in the Mara region

Producers	**Constraint**	**Coping strategy**	**Suggested solution**
	Scarcity of land	Utilize available land	Rent more land, Government to set aside land for fodder producers, Producers should form cooperatives to be heard by the government
	Lack of capital	Produce on a small scale	Form self-help groups Government to set up credit schemes
	Inadequate inputs & services	Obtain the service wherever it can be found	Government to set up service points for farmers
	High cost or lack of farm machinery/equipment for production	Produce at a low scale	Government to exempt taxes on farm machinery, Government to set up institutions that give credit, Formation of farmers groups/association for increased joint purchasing power
	Lack of technical knowledge	Seek information from neighbours/fellow farmers	Research institutions and government to conduct training for farmers Farmers to seek information through other means, e.g., agricultural show, media, radios, and special TV sessions There is a need to create awareness of available channels
	Long duration required to establish planted fodder (e.g., Napier grass)	Plant what is available	Research to come up with varieties that take a shorter time
	Changing weather patterns	Harvest when weather conditions are favourable	Practice irrigation to produce fodder year-round
	Pests and diseases that affect fodder	Plant fodder not affected Seek information from experienced farmers, media	Research institutions to come up with new varieties
	Cost of transporting fodder from farm to market	Meet the cost as they come and try to bargain	Collective action
	The low purchasing power of consumers	Sell to those who can buy Store what one is unable to sell	Buyers should organize themselves into groups
Consumers	Constraint	Coping strategy	Suggested solution
	Scarcity of fodder, particularly during dry season hence: Move long distance to sources of fodder The high cost of transport	Feed what is available Feed rationing so that what is there can last longer Buy crop residues and store	Produce sufficient fodder on-farm Conserve fodder when in plenty
	Lack of market for milk	Produce little milk	Farmers to form cooperative Government to set up milk plants Government to invite foreign buyers
	Poor milk prices	Produce little milk	Farmers form cooperatives

Producers	**Constraint**	**Coping strategy**	**Suggested solution**
			Government to set the price of milk
	Lack of government support to dairy farming	Produce little milk	Farmers to form cooperatives
	Inadequate labour supply	Treat labourer like family members	Pay high for labour
	Too many responsibilities on women	Do what they can	Sensitize men on the importance of sharing responsibilities
Traders	Constraint	Coping strategy	Suggested solution
	Lack of recognition for fodder trade	Self-confidence	Create awareness and provide technical information to help traders carry out the business in a professional way.
	Change in weather pattern (supply of fodder)	Plant of drought-tolerant varieties Irrigation	Tree planting Government to set up policies that prevent environmental degradation
	Seasonal variation in fodder availability	Search for fodder far-off	Avail capital to enable year-round fodder availability
	Long-distance to sources of fodder during dry weather hence the high cost of transport	Sell available quantities	Traders can form groups and use pooled transport
	Security of homestead while away searching for fodder	Identify culprits secretly	Government to improve security
	Risk of being attacked by dangerous animals, e.g., snakes	Walk/search for fodder with caution	
	Levies on fodder for sale	Sometimes traders evade the council by getting fodder very early in the morning	The government should recognize fodder trade and extend services, e.g., build sheds for traders
	Lack of officially designated marketplace	Sell by the roadside	The government should set aside a marketplace for fodder
	Market fluctuations (buyers and prices)	Try to maintain customers' loyalty Reduce the amount of fodder for sale when there are few customers	Conserve fodder when in excess
	Defaulting customers	Try not to sell on credit	
	Low quality of fodder, especially during the dry season	Search for fodder far away Sell at a low price	Practice fodder conservation
	Lack of knowledge on fodder (type, quality, production, and management)	Use experience or indigenous knowledge	The government should provide training: Extension workers, Institutions, e.g., TALIRI, LITA, SUA, etc.
	Poor working equipment	Use simple, cheap equipment	Take loans to buy equipment
	Lack of efficient means of transport	Make use of cheap means or hire	Government to provide credit scheme where traders can take loans
	Lack of capital	Borrow money informally from each other	Traders should form groups that can assist in accessing credit

5.10.8 Opportunities in fodder production and marketing in Mara Region (Rorya District)

The fodder market presents an opportunity for improving the livelihoods of rural and urban poor due to the following observations:

- ✓ Rising demand for fodder, especially in urban areas
- ✓ Presence of actors along the fodder value chain: there is potential to organize the actors and set up structures to grow fodder businesses in rural and urban areas
- ✓ There is enormous potential for fodder value addition along the fodder market value chain
- ✓ There is a huge opportunity to streamline policy and institutional support structures and services for fodder businesses in Tanzania
- ✓ There is an opportunity to build the capacity of all fodder market actors along the value chain to grow businesses

5.10.9 Suggested areas of intervention for fodder production utilization and marketing in Mara Region (Rorya district)

The following suggested areas of intervention:

- ✓ Dissemination of improved fodder technologies: Improved access to quality forage seeds and technical information on fodder production, management, and utilization.
- ✓ Fodder conservation: This should be enhanced both at the farm and market level.
- ✓ Utilization options to improve fodder quality and intake; integration of grass-legumes mixtures.
- ✓ Provision of the market and technical information relevant to the whole fodder value chain.
- ✓ Collective action: This can achieve economies of scale and efficiency in marketing and service acquisition and delivery.
- ✓ Expand fodder production by private and government institutions: Utilize their expansive land optimally to address rising fodder demand.
- ✓ Fodder irrigation: As a mitigation strategy to the scarcity of fodder during the dry spells

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6 UGANDA

6.1 Overview of the livestock sub-sector in Uganda

Currently, agriculture contributes about 26.2% to GDP, whereas the livestock sub-sector contributes 1.7% to GPD and accounts for about 6.7% of agricultural value-added (NPA, 2020). About 58% of Uganda households depend on livestock for their livelihoods, 92% of them being small-scale subsistence farmers (FAO, 2019). This livestock, especially cattle, provide income, food, draft power, insurance and savings, social capital, employment, social status, and others to the livestock farmers. In 2017, the per capita consumption of meat and milk in Uganda was estimated at 14 kg and 36 litres per year (FAO, 2019).

Figure 6.1 and Table 6.1 shows the population of cattle, goats, sheep and pigs in Uganda. In 2018, there were 14.6 million cattle, 16.1 million goats, 2.7 million pigs and 2.1 million sheep (UBOS, 2020). Indigenous breeds continue to dominate the livestock sector over exotic species in Uganda, as shown in Table 6.1 for cattle and goats from 2013 to 2018 (UBOS, 2019; UBOS, 2020). In 2017, 11.9 million cattle out of the 14.2 million were raised for meat (FAO, 2019). Trends of Livestock production (beef, goat meat, sheep meat and pig meat) are as shown in Figure 6.2. In 2018, Uganda produced 217,065, 41,098, 129, 195 and 10,115 tonnes of cattle, goat, pig and sheep meat, respectively.

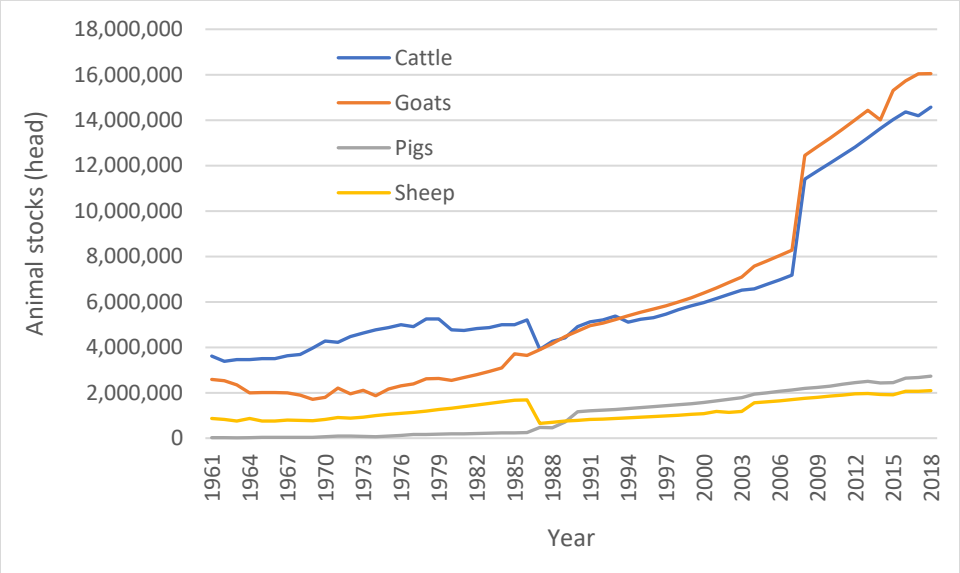

Figure 6. 1 Trends of stocks of cattle, goats, sheep and pigs in Uganda

Table 6. 1 Cattle and goat numbers ('000s) for the years 2013 to 2018 by breed

	Cattle		Goats	
Year	Indigenous	Exotic	Indigenous	Exotic
2013	12,339	730	14,245	188
2014	12,709	887	13,829	182
2015	13,090	914	15,113	199
2016	13,377	991	15,521	204
2017	13,271	918	15,826	208
2018	13,629	943	15,455	593

Source: UBOS, 2019; UBOS, 2020

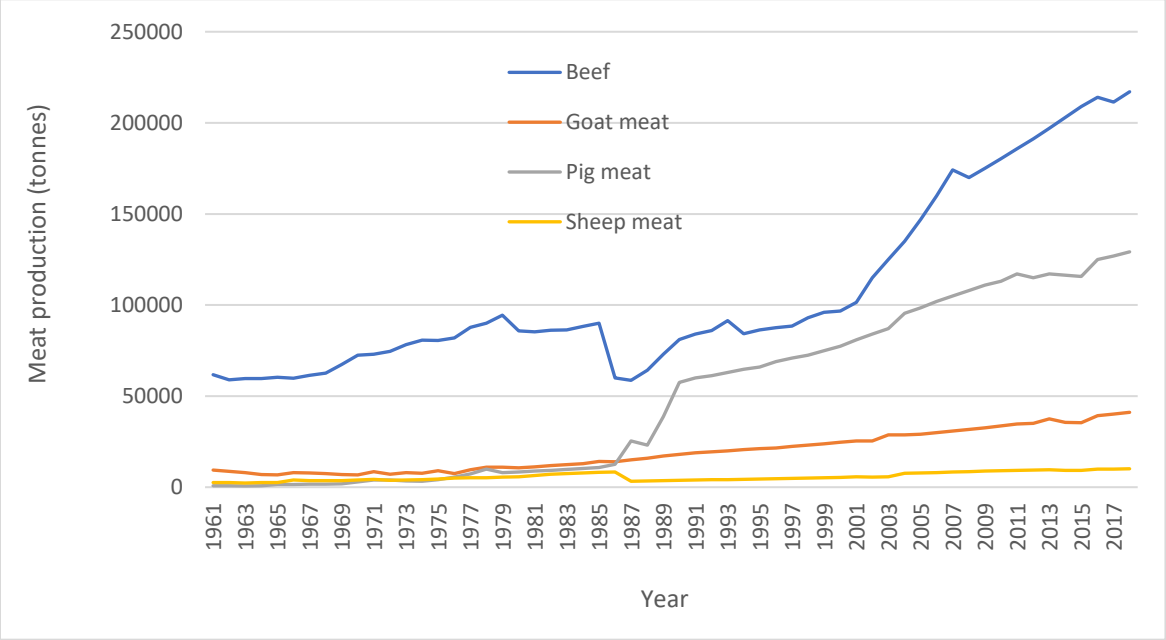

Figure 6. 2 Trends of meat production in Uganda

Total milk production was estimated at 2.04 billion litres in 2018 (UBOS, 2020), an increase from 1.46 billion litres in 2012 (UBOS, 2019) (Table 2). About 80% of the total national milk is sold, whereas farming households consume 20%. Of the total volume of milk sold in Uganda, 33% is processed, while 67% is sold as raw milk (MAAIF, 2012). Uganda is divided into six (6) milk sheds based on geographical agro-ecological characteristics, market dynamics and cattle population. These milk sheds include South-western, Mid-western, Central, Eastern, Northern and Karamoja, each contributing 25, 12, 24, 21, 11 and 7% of the total milk production, respectively (Figure 3) (DDA, 2020). This report's case study areas are the Karamoja sub-region located in the Karamoja milk shed and the Mbarara district situated in the South-western milk shed.

Table 6. 2 Uganda's milk production from 2012 to 2018

Year	Milk production (million litres)
2012	1,460
2013	1,504
2014	1,549
2015	1,596
2016	1,634
2017	1,614
2018	2,040

Source: UBOS, 2019; UBOS, 2020

Figure 6. 3 The six (6) milk sheds in Uganda

Most of the cattle in Uganda are in the 'Cattle Corridor', which stretches diagonally from the Ankole sub-region in Southwestern Uganda to the Karamoja sub-region in the Northeast (Figure 6.4). The pastoral areas of Karamoja have the highest concentration of cattle (i.e., head/km^2) (Figure 6.5), and cattle are the primary source of livelihoods for the people in these areas (FAO, 2019).

Uganda has four cattle production systems: commercial ranching, pastoral, agro-pastoral and semi-intensive production systems (Figure 6.5) (FAO, 2019).

- ✓ The pastoral or free grazing production system is dominant in the Northeastern sub-region (Kotido, Moroto, Soroti and Kumi districts), in the Southwest sub-region (Ntungamo and Mbarara districts) and in Central Uganda (Masaka, Lwengo, Sembabule, Rakai, Luwero and Kiboga Districts). Under the pastoral production systems, cattle keepers move from one place to another, looking for pastures and water. The land is owned communally; Farmers have no control over the feed resources available to their cattle as cattle feed mostly on natural pastures. They keep native breeds (local zebu) mainly for beef, milk, blood, hides, manure and horns. The herd size ranges from just a few cattle to about 100 heads (FAO, 2019). Pastoralists have little access to animal health services; their cattle may only be vaccinated during government vaccination campaigns (FAO, 2018).
- ✓ The agro-pastoral or mixed crop-cattle production system dominates the livestock production landscape in Uganda. This system is expected in Eastern, Central 2 (Buikwe, Buvuma, Kayunga, Kiboga, Kyankwanzi, Luwero, Mityana, Mubende, Mukono, Nakaseke, Nakasongola), Western, Northern, and West Nile sub-regions (FAO, 2019). In this system, cattle graze on pastures on both private and public lands. The cattle also feed on crop by-products. The cattle are mainly indigenous breeds (local zebu and Ankole cattle) with some crossbreeds (FAO, 2018). Cattle produce beef, milk, hides, manure, horns and provide draft power. Agro-pastoralists invest limited resources in on-farm infrastructure and animal health.
- ✓ Commercial ranching is market-oriented beef production with milk as a by-product. Commercial ranching is found in the Southwestern and Central 2 sub-regions. In this system, farmers keep large herds of cattle, ranging from 500 to about 3000 heads of cattle per household. The cattle kept here are indigenous, cross- and exotic breeds. Cattle graze from private fenced areas during the day and are customarily paddocked at night. Cattle are fed on natural and improved pastures. Some ranches may provide supplementary feeds to the cattle in the forms of mineral salts, maize bran, maizes silage and molasses (FAO, 2018). In this system, farmers make investments both in animal health (such as vaccinations and deworming) and infrastructure (such as feed and water troughs, spray races, dip tanks etc.) to improve the productivity of their cattle (FAO, 2018).
- ✓ The semi-intensive production system is where farmers keep mostly cross-bred cattle in kraals, paddocks, barns or stalls, and feed them with high-quality feed, including forage, compound feed and crop residues when available (FAO, 2019; FAO, 2018). Herd sizes vary from 1 to 20 cows for small to large farms. These farmers make significant investments in their animals' health, such as regular vaccination and deworming. Farmers keep cattle for mainly producing milk; beef production originates from cows no longer productive (FAO, 2018). Some of these dairy farmers have planted legumes, Napier grass and alfalfa in fodder gardens (). Such farmers are mainly found in Central 1 (districts of Butambala, Gomba, Mpigi, Bukomansimbi, Kalangala, Kalungu, Lwengo, Lyantonde, Masaka, Rakai, Sembabule, Wakiso, and Kyotera) and Central 2 sub-regions, the Southwest sub-region, and peri-urban areas (FAO, 2019). Peri-urban farmers also feed their livestock on pasture from wetlands.

Of the 11.9 million heads of cattle raised for meat in 2015, 49% were in the agro-pastoral system, 41% in the pastoral system, 8% in commercial ranching and 2% in the semi-intensive production system (FAO, 2019). Integrating livestock production with crops would be ideal for Uganda's agricultural production systems. Farmers can feed their animals with crop residues that would otherwise be wasted, and the animal dung can be used as manure in crop fields.

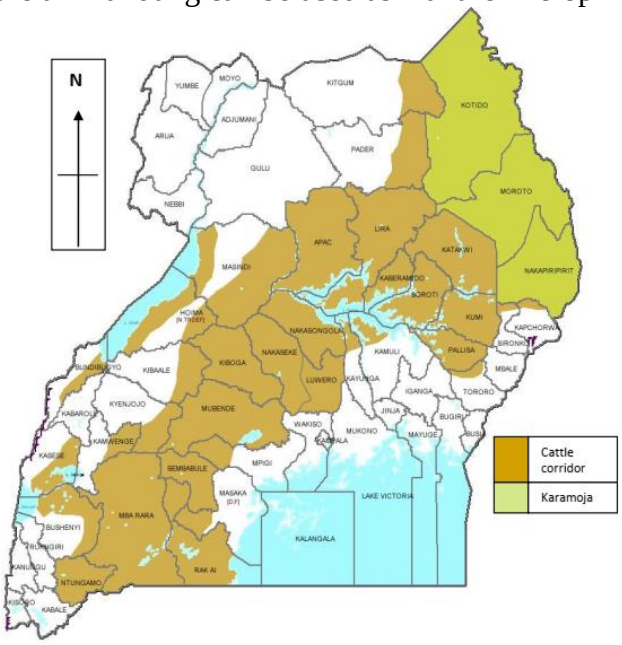

Figure 6. 4 The cattle-corridor of Uganda

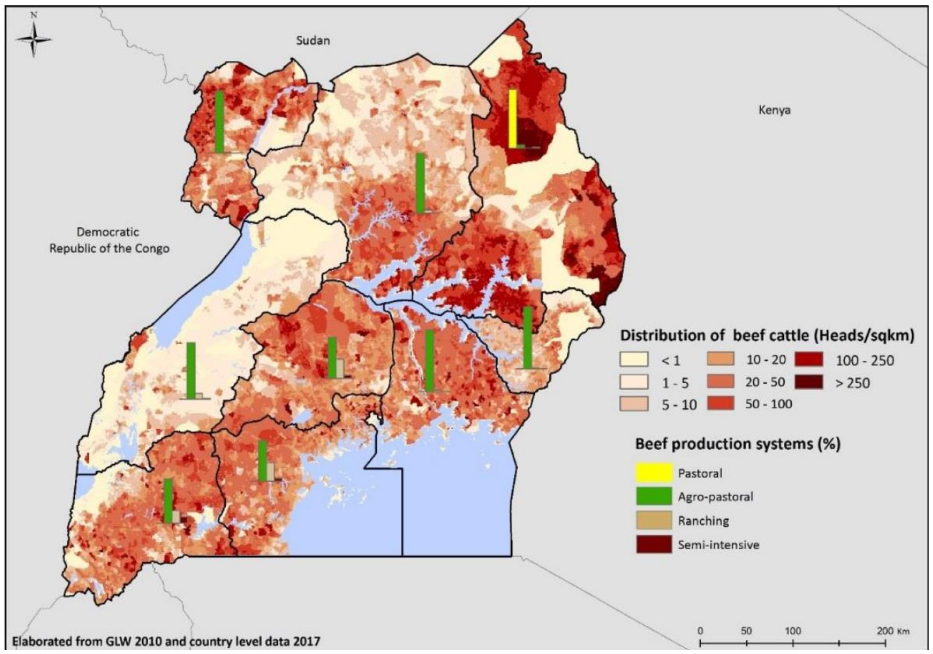

Figure 6. 5 Distribution of production systems and beef cattle in Uganda

Source: FAO, 2018

6.2 Fodder growing in Uganda

Cattle in Uganda is mostly fed on natural pastures that are unreliable and unsustainable in quantity and quality. The natural ranges are abundant during the wet season but become scarce in the dry season when the available ranges are also low quality (Roschinsky et al., 2011). NPA (2020) reported that beef and dairy production in Uganda is constrained by breeds' quality, livestock numbers, water shortages and scarcity of feeds during the drought. Feeding animals on crop residues is also a common practice among livestock keepers. Some of the crop residues and agro-industrial by-products used include maize (straw, cobs and bran), banana (leaves, peels, flower and stem), sweet potato (vines), cassava (leaves and peels), brewers' waste, sunflower (seed and cake/meal), bean (haulms), jack fruit residues, yam (leaves), cotton (seed cake), wheat (straw and pollard), soya bean (straw, seed cake), sorghum (straw and grain) and molasses. The National Livestock Resources Research Institute (NaLIRRI) of the National Agricultural Research Organization (NARO) has developed pelleted supplements from locally available crop residues, leguminous forages and agro-industrial by-products (SNV, 2017). To cope with natural pastures' seasonality, a few farmers make hay by drying herbage from grasses and legumes to a moisture content of less than 15% and storing it away from direct sunlight to be fed to cattle during periods of fresh pasture scarcities. Also, the practice of making silage is currently being taught and promoted to livestock farmers. When making silage, fresh forage, crop residues or agricultural and industrial by-products are preserved by acids that are either added or produced by natural fermentation. These materials are preserved if they stay under airtight storage. Farmers who make silage mostly use Napier grass and fresh stover of maize.

In 2008, it was reported that only 2.4% of the 4.5 million households that rear livestock in Uganda planted pasture (MAAIF & UBOS, 2009). Natural grazing areas are rapidly declining because of their conversion to cropland and settlement lands. Consequently, the demand for fresh fodder, hay and silage is high in Uganda. Feeds are reported to contribute to over 62 to 70% of the variable costs in dairy production systems (Kabirizi, 2020). Growing fodder to ensure all-year-round feed, especially dairy cattle, has been suggested as one of the significant ways to reduce animal production costs (Kabirizi, 2020). Therefore, the need for cultivating fodder is urgent; to provide animal feeds in adequate quantities and adequate nutritional quality if an increase in livestock production is to be assured for the increasing demand for livestock products. Some organizations promote the practice of planting improved pasture species that are high yielding, fast-growing and drought tolerant (SNV, 2017). Some livestock farmers, especially dairy farmers and especially those from Southwestern Uganda, are adopting the practice.

6.2.1 Fodder types used in Uganda

Fodder types used in Uganda are as shown in Table 6.3.

Table 6. 3 Major fodder types (both local (indigenous) and introduced (exotic)) used by livestock farmers in Uganda

Scientific name	Local/commonly used name	Characteristics
Pennisetum purpureum Schumach.	Elephant grass/Napier grass/Bisagazi/Ekibingo	- Napier grass is the most used forage in Uganda - Napier is an indigenous grass but has varieties that have been improved over the years - It is available in different varieties such as NARO 1, NARO 2, NARO 3, Bana grass, Kakamega 1, Kakamega 2, Clone 13, sugar Napier, etc. - It is easy to propagate - It has a soft stem that is easy to cut - Its roots can grow deep, and thus fairly drought resistant - The young leaves and stems are tender and very palatable for livestock. The older stems and leaves are less palatable for livestock - Napier grass grows very fast. It is a basal feed; has high carbohydrate content but is low in its protein content to sustain adequate milk production - Animals can browse Napier; it can also be fed animals through the cut and carry - It is used to make hay and silage - Napier grass is an aggressive plant that spreads through rhizomes under the ground. If it is not controlled, it can invade crop fields and become a weed - Napier stunt and smut diseases constitute a significant threat to the use of Napier grass fodder.
Calliandra calothyrsus Meissn.	Calliandra/kaliandra/ kaliyandra	- It is the most planted fodder tree in Uganda - It is an exotic fodder tree - It is a fast-growing, nitrogen-fixing, protein-rich fodder tree that can be used both as a supplement to increase milk production and as a substitute for the expensive dairy meal concentrates - The tree is tolerant of frequent pruning and droughts - The tree is susceptible to pest and diseases, especially "die-back" disease that causes a reduction in the biomass yields of the trees
Lablab purpureus (L.) Sweet.	Lablab/labu labu	- It is a forage legume with a high protein content - It is easy to establish - It is suitable for cut and carry and not cattle browsing - It is very palatable to animals - It is grown as an annual crop - However, it suppresses grass pastures, and thus it cannot be integrated with grass pastures
Sesbania sesban (L.) Merr.	Sesbania	- It is an indigenous fodder tree - It grows slowly and has a low fodder yield
Tithonia diversifolia	Mexican Sunflower	- It is a quick-growing short legume shrub used to supplement low-quality forage grasses and crop residues due to its high protein content
Morus alba	Mulberry/Nkenene	- It is an indigenous fodder tree that grows slowly and has low fodder yields
Gliricidia sepium	Gliricidia	- It is a nitrogen-fixing exotic fodder shrub used to supplement low-quality forage grasses and crop residues

Scientific name	Local/commonly used name	Characteristics
Stylosanthes gulanensis	Stylo	- It is a small shrub legume - It is very palatable - It is tolerant to droughts - It can be used as a cover crop - It can be integrated into grass pastures - However, seed collection is tiresome - Seeds are costly; 1 kg costs 300,000 UGX
Chloris gayana	Rhodes grass	- It is among the most used forage by livestock keepers in Uganda - Is easily established - Spreads by runners - It is both a drought-resistant and disease resistant grass - It has good salt tolerance - It tolerates heavy grazing - It is ideal for horse pastures (no oxalate problems) - It has good seed production - It is a good competitor for weeds such as spiny burr grass - However, its fluffy seed is difficult to sow - It is not adapted to acidic and infertile soils. It requires high fertility to persist - Its quality drops rapidly with the onset of seeding - Rhodes grass has low shade tolerance - It also has a low tolerance to waterlogging
Panicum maximum	Guinea grass	- Guinea grass is very leafy - It is a high-quality feed - It has high production potential - All stock readily eats it - It is suited to grazing and cutting - Guinea grass is drought tolerant - It allows for early season growth in some lines - However, it requires fertile soils - It is intolerant to waterlogging - It is intolerant to heavy grazing - It becomes stemmy if not cut or grazed frequently
Medicago sativa	Lucerne/Alfalfa	- Alfalfa is the “Queen” of forages with a protein content of over 35% - Alfalfa can be ideal on farms where it can be used for hay, silage, or grazing - With proper grazing management, alfalfa’s high yield potential can be converted to high levels of animal production per acre - It adds nitrogen to the soil - Live weight gains per acre are relatively high for grazing beef cattle, with total season gains of 500 to 800 pounds per acre in research trials and on-farm demonstrations

Scientific name	Local/commonly used name	Characteristics
		- However, alfalfa needs considerable amounts of water to grow. It can't survive without irrigation
Microptilium atropurpureum	Siratro	- It is a forage legume - It is palatable to animals - It is tolerant to droughts - It can be used as a cover crop
Brachiaria brizatha	Signal grass	- Signal grass is well-adapted to acidic and neutral soils of moderate to low fertility - It is very persistent, even under seasonally dry conditions - It is productive, and it is capable of sustaining high stocking rates and grazing pressures - It has a high nutritional value for ruminants - It maintains green leaf of relatively high nutritional value into seasonally dry periods - Signal grass responds well to nitrogen fertilizer - However, its low seed production may limit the availability - It is slow to establish if dormant seed is sown - It grows densely, meaning careful management is needed to maintain companion legumes
Pennisetum clandestinum	Kikuyu grass	- It is a high-quality forage if managed correctly - It has a long growing season - It is highly persistent - It survives long dry periods - It responds well to nitrogen fertilizer in the warm season - It is tolerant of heavy grazing. - It has better frost tolerance than some warm-season grasses - It is beneficial for erosion control - It has a rapid summer growth rate with high yield potential - Very competitive; suppresses weeds - However, it requires good management to maintain feed quality - It becomes rank and unpalatable if ungrazed - It requires high fertility for sustained production - It has low winter growth. - It is challenging to maintain a legume in this pasture - It may become a weed in food crop cultivation
Brachiaria hybrid cv. Mulato	Brachiaria/Congo signal grass/Kifuta/Ekijubwe	- Grass with a high biomass yield that tolerates prolonged droughts and poor soils - It matures quickly and regrows very quickly - It is ideal for cut- and- carry feeding - However, termites eat it during the dry season
Centrosema pubescens	Centro	- It is a forage legume - It is palatable to animals - It is tolerant to droughts - It can be used as a cover crop - It can be integrated into grass pastures

Scientific name	Local/commonly used name	Characteristics
Cenchrus ciliaris	Buffelgrass or African foxtail grass	- Buffelgrass is suitable for beef cattle - It is persistent - It is very drought tolerant - It quickly responds after rain - It is widely adapted - However, it needs high fertility for production - Its establishment is difficult on clay soils - It will not survive prolonged flooding or waterlogging - It can cause 'big head' in horses - The "fluffy" seed is difficult to sow - It is a threat to certain sub-humid to arid environments
Setaria sephacelata	Golden timothy	- It gives good biomass - It requires rain to survive - It is self-cooling; it sucks in water during the day and releases it in the evening - It is fed to only dairy cattle
Zea mays	Maize (fresh and dry)	- It can be fed to both dairy and beef cattle - Maize fodder crop gives highly succulent and nutritionally rich fodder - Maize is a rich source of starch, protein and edible oil - Maize produces good quality herbaceous fodder with high palatability - On average, it contains 9-10% crude protein on a dry matter basis when harvested at milk to early-dough stage - Three (3) maize plants are said to give 1 litre of milk
Sorghum bicolor (L.) Moench	Sorghum	- (**See section 6.2.5 below**)

Source: Nyeko et al., 2004; Fraser and Wambugu, 2007; Fraser et al., 2014; Kabirizi et al., 2014; Buyinza et al., 2015; SNV, 2017; Key informant interviews, 2020

Fodder trees and shrubs like calliandra and Mexican sunflower are low cost to produce, easy to use, effective in raising milk yields. They are available for use as a substitute for expensive dairy feed concentrates. Fodder trees and shrubs are fed to both dairy and beef cattle. Fodder trees and shrubs have higher biomass yields, better resistance to mismanagement and a capacity to retain high-quality foliage under stress conditions than herbaceous pasture legumes. Fodder shrubs and trees usually are integrated into existing cropping systems rather than in monoculture fields. They are typically planted in hedges around the farm. The cultivation of these trees requires minimal cash investments - to purchase seeds and raise seedlings in a nursery, and they do not take away land for producing other crops. Fodder trees have numerous by-products and often supply feed within a year after planting. Key challenges constraining fodder trees' uptake include limited species appropriate to different agro-ecological zones, shortages in seed, and lack of knowledge and skills needed to grow them by farmers.

Forage legumes produce high-quality forage, thus fed to both dairy and beef cattle. They improve animal performance compared to grass monocultures. They also enhance the seasonal distribution of forage production to complement perennial grasses. They serve as cover crops to conserves soil moisture and control weeds. They reduce the risk of groundwater contamination when used as an alternative to nitrogen fertilizer. Legumes are susceptible to pests due to their palatability. Farmers in Uganda, however, rarely have forage legumes on their farms. Those who have them have them as small plots of pure stands of one or more species (Creemers and Aranguiz, 2019).

6.2.2 Fodder seeds and planting materials

On-farm availability of fodder seeds and planting materials is generally low in Uganda; one reason why development and adoption of improved fodder production and technology have remained low. The majority of forage seed production and availability is through informal on-farm reproduction and channels for sharing seeds or planting materials (Creemers and Aranguiz, 2019). Large-scale forage seed multiplication (certified and non-certified) is limited to NARO, government farms, and private farms (Creemers and Aranguiz, 2019). There are a few companies like Simlaw seeds and Victoria seed company that deals in pasture seeds like Rhodes grass, Nutri-feed (forage millet), sugar graze (forage sorghum), Alfalfa (Lucern), and Desmodium. Fodder tree seeds and seedlings are available at the National Forestry Authority (NFA) offices in Namanve, Kampala-Jinja Road, and at the National Forestry Resources Research Institute Mukono district. Government agencies like the National Agriculture Advisory Services (NAADS), the Dairy Development Authority (DDA) supply seeds to livestock farmers. Also, non-governmental organizations like Heifer Project International and SNV provide fodder seeds to farmers in their projects.

6.2.3 Fodder agronomic practices and Markets in Uganda

Agronomic practices depend on the type of fodder. The production of fodder in Uganda is majorly rain-fed. Inorganic fertilizers are not commonly used in fodder growing in Uganda. Livestock farmers instead use animal waste and biogas slurry in their fodder fields. Table 6.4 shows the recommended agronomic practices for fodder legumes, grasses and trees.

Although there is a demand for fodder across the country, commercial fodder production in Uganda is not common (Creemers and Aranguiz, 2019). The forage markets are informal and opportunistic; demand and perception of the quality drive the market. There are

no standards in place. Fodder trade increases or decreases depending on the season (Creemers and Aranguiz, 2019). Small traders are often seen cutting grass from swampy areas and along roadsides and selling it along roadsides.

Table 6. 4 Recommended agronomic practices of fodder crops

Fodder crop	Recommended agronomic practices
Forage legumes and fodder trees	• Testing soil for nutrients • Proper seedbed preparation • Selecting fodder species adapted to the specific agro-ecological zones • Using quality fodder seed • Applying pre-planting seed treatment (heat treatment, scarification and inoculation) • Using recommended seed rates, sowing methods and sowing depth) • Using pest and disease control • Using weed control • Applying recommended rates of fertilizer
Fodder grasses	• Testing soil for nutrients • Proper seedbed preparation • Selecting pasture species adapted to the specific agro-ecological zones • Using quality pasture seed • Using recommended seed rates, sowing methods and sowing depth) • Using pest and disease control • Using weed control • Applying recommended rates of fertilizer

6.2.4 Sorghum for livestock production

Sorghum ((*Sorghum bicolor* (L.) Moench) is a significant staple cereal food crop in Uganda. It is mainly used for food, making beer and as livestock feed. In 2018, the crop was occupying 446,039 ha with an annual production of 298,252 tonnes (FAO, 2020). Uganda's northern region is the highest sorghum producer, followed by the eastern part and then south-western Uganda (Awori et al., 2015). Sorghum is a significant income and food security crop in the drought-prone areas in the country. It requires relatively little water to grow and survive in harsh environments and conditions like poor soils, pests, and diseases, where other crops might not increase. It is therefore regarded as a food security crop because of its adaptability to harsh conditions. That is why it occupies more than 80% of the total crop acreage in Karamoja. It is also an income crop due to its use in making beer.

Sorghum grain is an energy source in formulating livestock feed rations; the animals will therefore require other protein, energy, and mineral supplements (Kabirizi, 2020b). For optimal digestibility, sorghum grain should be ground.

Sorghum can be used in several ways. It can be used as (i) green chop where freshly cut sorghum is dried first to prevent the formation of Hydrogen Cyanide whose levels might be poisonous to the animal, (ii) stover, (iii) silage where sweet sorghum that is used for silage is cut before seeds mature, and (iv) brewers' spent grain a significant by-product of the brewing industry (Kabirizi, 2020b).
Sorghum regrows after being cut; thus, it has a higher annual herbage yield per unit area. Depending on how the crop is managed, a farmer can get two or more ratoons. The ratoons also provide fodder reserve during the dry season when soil moisture to enable reseeding is minimal (Kabirizi, 2020b).
Sorghum varieties grown in Uganda are as shown in Table 6.5.

Table 6. 5 Sorghum varieties grown by farmers in Uganda

Sorghum variety	Year of release	Days to maturity	Yield under sound management (kg/ha)	Grain colour	Characteristics
NAROSORG-1	2017	110-120	3000-3200	Cream white	Has medium maturity and is excellent for brewing
NAROSORG-2	2017	100-110	2700-3000	Red	It is suitable for yeast and is not so much attacked by birds
NAROSORG-3	2017	110-120	3000	Chalky white	Is midge resistant
NAROSORG-4	2017	110-120	2300-2500	Brown	It is suitable for food and is not so much attacked by birds
SESO-1	2011	90	3000	White	It is early maturing, is suitable for brewing and is grown solely for grain
SESO-2	2011	100	2500	White	Gives more forage and is resistant to lodging
SESO-3	2011	95	3000	Brown	It is suitable for food when mixed with cassava and is not much attacked by birds
Epuripur	1995	110	2500-3000	White	It has excellent brewing qualities. It is resistant to shoot fly and stem borers. It is susceptible to bird damage. Grains are sweet and can be used for food, baking and brewing.
Sekedo	1995	100	4000-5000	Brown	Is resistant to stem borers, shoot flies and midges. It is recommended for food and animal feeds. It is used to feed broiler chicks for quick maturity.

Sorghum variety	Year of release	Days to maturity	Yield under sound management (kg/ha)	Grain colour	Characteristics
Sugargraze (*Sorghum bicolor x S. bicolour*)					Is a late flowering sorghum cultivar that has high sugar content that improves its ensilage quality. It has increased palatability hence minimal feed wastage. It produces high quality silage. It produces much more forage.

Source: Lubade et al., 2019; Infonet-Biovision, 2020

6.3 Policies and strategies related to fodder production in Uganda

Livestock sector development in Uganda is fundamental to support the social, environmental, and public health transformation of the country in a sustainable way. As such, livestock sector development can only be achieved through understanding livestock production systems and value chains, especially understanding of trends in production, consumption and productivity of various animal feeds, not only to guide investments, but also to inform actions that decision makers can take to make Ugandan livestock systems more robust and resilient to future shocks.

The Dairy Master Plan was developed in 1993 and made three major recommendations. These included: (i) to have the dairy sector liberalized; (ii) to create a Dairy Board to oversee the liberalized industry; and (iii) to restructure Dairy Corporation into a commercial company and to have the company divested. The Dairy Industry Act of 1998 was enacted to operationalize the Dairy Master Plan. As such the Dairy Development Authority (DDA), a statutory body under the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) was created with the mandate to develop and regulate the dairy industry in a sustainable manner.

The National Animal Breeding Policy 1997 guides stakeholders in the improvement and conservation of animal genetic resources. The policy is backed up by the Animal Breeding Act 2001; "an Act to establish the National Animal Genetic Resources Centre and Data Bank, to provide for the promotion, regulation and control, marketing, import and export, and quality assurance of animal and fish genetic materials and generally to provide for the implementation of the national breeding policy in Uganda; to repeal and replace the Branding of Stock Act; and to provide for other matters connected with the preceding" (GoU, 2001).

There is an increasing demand for animal feeds in Uganda due to rapidly increasing commercial livestock production because of the growing demand for livestock products. The rising demand for animal feeds has encouraged informal small-scale feed producers (Kilimo Trust, 2017). The main objective of the National Animal Feeds Policy, 2005, is to promote, support and guide the manufacture and marketing of animal feeds. The specific goals of the policy are: to stimulate increased feed production and availability; to ensure quality animal feeds on the market and protect end-users against improperly formulated, contaminated, decomposed and deceptively packaged or labelled feeds; to put in place strategies for reducing production costs and ensure that producers cater for their interests as well as

those of livestock farmers concerning feed prices and profitability; and to build capacity among private and public sector for the development of the animal feeds industry (MAAIF, 2005).

To ensure sustainable growth and transformation of the livestock sector, Uganda's government in the Agriculture Sector Strategic Plan (ASSP) 2015/16 – 2019/20 prioritized investments in beef and dairy cattle (MAAIF, 2015). The plan targeted to produce 3.35 billion litres of milk annually and to increase annual exports from milk and related products to approximately US$92 million by 2020. The above targets would be achieved through (i) implementation of the Presidential directive to provide one heifer per household; (ii) support dairy extension services; (iii) establish dairy herd information system; (iv) support increased dairy regulation and inspection; (v) establish mobile and regional laboratories; (vi) build capacity in conserved feed production, marketing, on-farm water harvesting infrastructure and pasture and rangeland improvement in the national milk sheds establishment; and (vii) increase efforts to improve dairy market access and value addition (MAAIF, 2012). The plan also targeted to increase beef production to 360,000 tonnes, pork to 139,185 tonnes, mutton and goat meat to 39,775 tonnes, and poultry to 63,647 tonnes by the year 2020 through (i) control of vectors and diseases through vaccinations, disease surveillance and construction of infrastructure for disease control; (ii) pasture development; (iii) provision of adequate water for livestock production through the construction of valley dams; (iv) provision of high genetic materials; (v) promotion of labour-saving technologies; (vi) creating a buffer stock/animal handling grounds to support beef processing (MAAIF, 2020).

6.4 Fodder production in the Karamoja sub-region

The Karamoja sub-region lies between 1°.4‘– 4.24°N and 33°50‘– 35°E) and located in North Eastern Uganda. It borders South Sudan in the north and Kenya in the east. The sub-region comprises seven administrative districts: Kotido, Moroto, Kaabong, Abim, Napak, Nakapiripirit and Amudat (Figure 6.3). Agro-pastoralism is the most dominant economic activity and livelihood in the sub-region, followed by pastoralism in the east and agriculture in the west (Jordaan, 2014). Other activities such as mining, selling charcoal, firewood and food products are becoming common as a primary source of income or as a survival strategy during droughts. FAO (2013) classifies the Karamoja sub-region into three livelihood zones regarding the degree of aridity and the level of dependency on livestock. The zones include: “(1) Pastoral – semi-arid zone characterized by a prolonged dry season and erratic rainfall. It runs along the eastern border with Kenya, comprising parts of Kaabong, Moroto and Amudat districts. Livestock production is the main economic activity supplemented by opportunistic farming; 2) Agro-pastoral – with an average annual rainfall of 500 – 800mm, stretches through the central part of Karamoja sub-region from the border with South Sudan covering Kotido and parts of Kaabong, Moroto, Napak, Amudat and Nakapiripirit districts. The zone is highly dependent on livestock production and rain-fed crop production of mainly sorghum, maize, groundnuts, sesame and beans (Jordaan, 2014); and 3) Agricultural – running along the western side of Karamoja with an average annual rainfall of 700 – 1000 mm, capable of supporting most tropical food crops.” According to FSNA (2018), the five mainly cultivated crops in the Karamoja sub-region include sorghum (77%), maize (40%) and beans (22%), potatoes (11%) and millet (5%) at 77, 40, 22, 11 and 5 % respectively. The pastoralists’ seasonal calendar is shown in Table 6.6, and the cropping calendar is shown in Table 6.7.

Table 6. 6 Pastoralists' seasonal calendar

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Seasons	Dry			Rain		Dry	Rain			Dry		
Pastures	Scarce			Surplus					Available			Scarce
Water	Scarce			Limited	Plenty					Limited		Scarce
Dodoth, Jie, Bokora, Matheniko Pian	Settled in dry season grazing areas – western districts		Return to wet season areas: Eastern districts	Grazing restricted to around settlements. Family involved in agricultural activities as well				Grazing in own district. Community dialogues. Scouts sent to look for grazing for coming dry season		Migration Migration completed Settle in dry season grazing areas		
Pokot	Settle in dry season grazing		Return to wet season grazing	Grazing within wet grazing areas						Migration		Settle in dry season grazing areas

Source: Jordaan, 2014

Table 6. 7 Crop production calendar

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainy season	Dry		Rain			Dry spells		Rain		Dry		
Sorghum	C	C	LP	LP/S	S/W	W	W	H	H	G	G	C
Maize	C	C	LP	S	W	W	GC	GC	H	H	G	C
Beans	C	C	LP	S	W	W	GC	H	G	G	G	C
Sesame	C	C	LP	S	S	W	W	H	H	G	G	C
Millet	C	C	C	LP	S	S	W	W	H	G	G	C
Groundnuts	C	C	LP	S	W	W	W	H	H	G	G	C

C = Cleaning of fields or gardens by burning or cutting surplus plant material that is usually dry and unpalatable by animals; LP = Land preparation; S = Sowing; W = Weeding; H = Harvesting; G = Fields/gardens are under fallow, and animals are allowed to graze freely
Source: Jordaan, 2014

Cattle are the primary source of livelihood for the Karamojong pastoralists; they keep large herds of cattle in addition to goats, sheep and poultry (Waiswa, 2016). The Karamoja sub-region is the significant cattle supplier to Eastern Uganda, extending from Teso to Jinja (Aklilu, 2016). Until recently, the pastoralist way of life was to move frequently with their animals in their vast communal rangelands, looking for water and pasture. The pastoralists seasonal calendar is as shown in Figure 6.6. Over the past few years, government policies

in the sub-region, including the disarmament programme that started in 2006 and ended in 2011, have promoted increasing crop production to improve food security in the sub-region and encourage settlement of the Karamojong pastoralists. The disarmament programme included a "protected kraal system" that assembled large livestock numbers in confined spaces (kraals), limited livestock grazing to a few hours a day in specific areas. It transferred the management of the herd to army units (Aklilu, 2016). Some of the rangelands were gazette for wildlife in game parks and game reserves and mining (Aklilu, 2016; Waiswa, 2016). Women are now more engaged in crop farming while the men go out to graze animals (Waiswa, 2016). The current limitations in movements of the pastoralists and their animals, cattle raids by neighbouring communities in Kenya and South Sudan and the associated insecurity, and the rampant livestock diseases in the sub-region have led to a dramatic decline of livestock numbers in the sub-region since 2008 (Waiswa, 2016; Jordaan, 2014; Levine, 2010).

Seasonal pasture shortages in Karamoja occur because: (i) available pastures around the *manyattas* (homesteads) are grazed throughout the year by resident livestock, (ii) during the dry season; several herders congregate around open water sources to access water for the animals; the animals graze the pastures around the water points, (iii) limited mobility of herders and their animals due to security concerns exacerbates pasture shortages in the safely accessible grazing areas, and (iv) of the increasing expansion of farmlands in the sub-region (Egeru et al., 2014; Aklilu, 2016). In a study whose objective was to understand drivers of pasture management strategies and their implications in the transitional pastoral system of semi-arid Karamoja sub-region, ten (10) native pastures in Table 6.8 below were classified by Karamojong farmers as desirable pastures concerning palatability, availability, biomass yield and resilience against droughts/floods (Atuhaire et al., 2018). Ranges in Table 6.9 were undesirable species because some are poisonous to livestock, cause diarrhoea, have low biomass yield and are invasive (Atuhaire et al., 2018).

Table 6. 8 Forages considered desirable by farmers in Karamoja

Local name	Scientific name	Qualities described
Nyesilot	*Setaria sphacelata*	• Drought resistant • Highly palatable • Cows produce concentrated milk • Fattens animals
Erereng	*Hyparrhenia rufa*	• Drought resistant • Highly palatable • Cows produce concentrated milk • Fattens animals • Abundant in the dry and wet season
Emaa	*Hyparrhenia newtonii*	• Highly palatable • Fattens animals • Cows produce concentrated and sweet milk

Local name	Scientific name	Qualities described
Ekutukutachwe	*Brachiaria decumbens*	• High biomass yield • Increases milk production • Stimulates growth rate • Highly palatable • High herbage yield • Resilient to drought
Elet	*Brachiaria brizantha*	• Increases milk production • Stimulates growth rate • High biomass yield in the dry season • Prone to drought • High biomass yield
Lomurio	*Cenchrus ciliaris*	• Highly nutritious • Fertilizes the soil • Fattens animals • Increases milk production • Fattens animals
Ngiletio	*Eragrostis pilosa*	• Abundant in the dry and wet season • Palatable • Fattens animals • Drought resistant
Neymuria	*Cynodon dactylon*	• Palatable • Fattens animals • Increases milk production
Ekode	*Chloris pycnothrix*	• Abundant in the dry and wet season • Palatable • Fattens animals • Sprouts very fast after rains
Losaricoo	*Panicum maximum*	Abundant in the wet season • Palatable • Fattens livestock

Source: Atuhaire et al., 2018

Table 6. 9 Pastures considered as desirable by Karamajong herders

Local name	Scientific name	Characteristics
Edomeo	*Acacia aspera*	• Invasive in nature • Drought resistant • Nutritious

Local name	Scientific name	Characteristics
Eiring	*Cadaba farinose*	• Invasive in nature • Drought resistant • Nutritious • Causes diarrhoea
Epeet	*Acacia oerfota*	• Invasive in nature • Drought resistant • Nutritious
Ethiloit/Ajanet	*Sporobolus pyramidalis*	• Hard to chew • Neck meat becomes harder • Out-competes good species
Alolot-Eligo	*Hibiscus abyssinica*	• Hard to chew
Ekwanyaro	*Triumfetta anua*	• Invasive
Ekadele	*Cymbopogon africana*	• Causes injuries to cattle lips/mouths • Out-competes good species • Harbors eco-parasites
Edupamal	*Hibiscus micrantha*	• Poisonous • Out-competes good species • Causes injuries to cattle

Source: Atuhaire et al., 2018

It is reported that herders lead their livestock to grazing areas and watering points following their perception and interpretation of the forage qualities. Although native pastures are said to supply adequate nutrients to livestock through the year, pasture quality fluctuates seasonally, with poor pastures dominating in the dry season because of prolonged droughts, over-grazing and poor pasture management (Atuhaire et al., 2018). Waiswa (2016) notes that "the most common pasture management practices by Karamojong people include: i) movements from kraal to kraal as areas become grazed to a point when further use becomes destructive; ii) daily travel of up to 12-14 km per day from the kraal to grazing areas for the more able/older or more conscientious herder, with earlier morning departures and later evening returns than the less able/often very young or less conscientious herder; iii) combination stocking (mixtures of numbers of cattle, sheep and goats) adjusted to match browse and grass type availability at the preferred sites; iv) changing watering regimes adjusted to account for water availability and the water content of grasses eaten at different times of the year; and the physiological state and associated requirements of the animals in the herd/flock; v) controlled and timely burning of pasture (only if it is expected that the burner will profit from the highly digestible re-growth and expected control of vectors and parasites); vi) shaking high protein pods and leaves/lopping branches/pollarding browse trees for feeding in situ or dragging back to the kraal and vi) regular visits to mineral-rich areas included in the round."

Due to lack of range improvement interventions, over-grazing and unfavourable climatic conditions, highly palatable and productive perennial pasture species are replaced by unpalatable, low quality annual species (Atuhaire et al., 2018). The native pastures classified by farmers in Table 6.8 were low in crude protein during the dry season, implying that livestock in the sub-region are subjected to poor quality pastures during the dry season. Despite the sub-region having abundant grass species, leguminous plant species were scarce or absent in most grazing areas (Egeru et al., 2014; Atuhaire et al., 2018). Crude protein and mineral limitations are reported to hinder livestock growth and cattle meat and milk yield. This might explain the low livestock productivity witnessed in the sub-region.
The Nabuin Zonal Agricultural Research and Development Institute (ZARDI) station located in Lorengedwat, Nakapiripirit District "is engaged in fodder research with the objective of "improving the rangelands for animals to acquire the minimum nutritional requirements." Funded by the World Bank and initiated in 2013, the program has focused on evaluating five grass and five legume species. Of the few species brought for trials, the Centre learnt later that *Chloris guayana* (Rhodes grass) and local varieties thrived well in Karamoja. Regardless of the ten varieties observed under trial, three legumes (Centrocena, Ciratro, and Glyciene) and three grass species (*Chloris gayana*, Brachiaria, and giant Panicum) were selected based on dry matter and gross energy. The Centre now plans to conduct trials on feed intake, digestibility, and average daily weight gains in bulls that are 6–9 months old. Besides, households owning crossbred cows have started purchasing hay from the Centre, which is also multiplying grass cuttings to distribute to households with mixed heifers from the Government. Some farmers have also enrolled in the "*Chloris* Platform" to promote the cultivation of the species as fodder" (Aklilu, 2016).

Specific to the Karamoja sub-region, improving animal health services is critical to improving livestock production, followed by feed improvement (Aklilu, 2016). Feed improvement would necessitate:

- ✓ improving rangeland and grazing management,
- ✓ promotion of cultivation of fodder to compensate for the decrease in pasture yields during the dry season but also because some fodder trees and shrubs may be able to tap water and nutrients from deeper soil profiles to withstand water-scarce periods,
- ✓ incorporation of legumes that are drought tolerant in grazing areas to improve feed quality,
- ✓ training of herders in conservation practices of desirable (good) pastures such as making hay and silage, to be utilized during periods of feed scarcity is highly recommended, and
- ✓ promotion of supplementary feeding.

A Rangeland Management and Pastoralism Policy has been in draft for many years now. It needs to be finalized and plans for its implementation developed.

6.5 Selected pilot: Mbarara district

6.5.1 Overview

Mbarara district, located in South-western Uganda, lies between 1250–1525 m above sea level and is part of the Ankole sub-region, and is subdivided into Mbarara city and 13 sub-counties. In 2017, the district had an estimated 121,318 exotic and high-grade cross cattle, 88,499 local breed and low-grade cross cattle, including the Ankole cattle, 217,583 goats, 11,482 sheep and 6871 pigs (Mbarara District Local Government and UBOS, 2017). Farmers interviewed during the field visit to the Mbarara district mentioned keeping majorly Friesian crosses and Ankole cattle for milk production. The Friesian crosses produce milk ranging from 15 to 25 litres per day, whereas the Ankole dairy cow gives on average 5 litres of milk in a day. Only one farmer out of the farmers visited keeps the Ayrshire and Jersey breeds for milk production. Due to the high demand for livestock products, especially milk and meat, farmers in the Southwestern sub-region are gradually transforming their herds from local breeds of low productivity to higher grade cattle especially crosses between local breeds and the Holstein Friesian (Ntakyo et al., 2020). As such, farmers' demand for improved pastures that can sustain production throughout the year has increased.

To limit overgrazing and rangeland resource-use conflicts in the sub-region, in the late 1980s, land in the past communally grazed was subdivided into smaller land parcels by the government re-allocated to individual pastoralists (Sserunkuuma and Olson, 1998). Communal rangeland tenure has since been phased out of the sub-region. Farmers in the Mbarara district were classified into five (5) categories. These include: "(i) the Ranchers (22 %), who own crossbred and Ankole cattle in the pastoral zone which are mainly bred for meat production, they are non-transhumant, and milk is a by-product of the farm; (ii) the Settlers (26 %), with Ankole cattle who live in the pastoral area where they were recently settled, dairy cattle performances are deficient, and these extensive farmers have no other source of income than those from cattle; (iii) the Multipurpose farmers (15 %) are sedentary, they breed crossbred or Ankole cattle and produce some coffee, milk productivity is higher than in the Settlers' farms; (iv) the Crop-livestock integrated farmers (33 %) constitute an intermediate between the Settlers and the Multipurpose farmers, they are sedentary in the pastoral zone, cattle breeding (crossbred and Ankole) is as important as crop production; and finally, (v) the Modern farmers (3 %) who breed high potential Holstein-Friesian cattle" (Grimaud et al., 2004).

Wangalwa et al. (2016) reported that the central grazing systems for dairy cattle in the Mbarara district are using paddocks (i.e., rotational grazing) (49.3%) and free grazing (or open grazing) (40.3%). Only 5.8% and 4.6% of dairy farmers in Mbarara use zero-grazing and semi-zero grazing (i.e., open grazing with a few night paddocks). Naturally growing pastures are usually used in the open -, semi-zero- and rotational grazing systems (Ntakyo et al., 2020).

6.5.2 Fodder species, naturally growing and planted and agronomic practices

Livestock farmers in the Mbarara district use several fodder species to feed their cattle. These include but not limited to mixed natural grass; Napier grass; maize; Brachiaria species; Rhodes grass; Kikuyu grass; star grass; Siratro; Centrocema; Stylo; lablab; Guinea grass; Calliandra; banana leaves, flower, stem; sweet potato vines and sorghum. Ntakyo et al. (2020) analyzed some fodder species' nutrient

composition in the Southwestern sub-region. Fodder growing in the Mbarara district is rain-fed, as is the case with the rest of the country. Government agencies and non-governmental agencies promoting improved fodder species in the country teach livestock farmers to plant fodder species in rows for easier weeding. Inorganic fertilizers are rarely applied in fodder growing in Mbarara. Farmers interviewed mentioned only using Diammonium phosphate (DAP) to plant some fodder species at demonstration plots on their farmers. DAP was given to the farmers by SNV under one of their projects demonstrating and promoting fodder growing in the sub-region (Tables 6.10, 6.11 and 6.12). Farmers on their own apply animal manure and biogas slurry (for those that have biogas production units) as the only sources of fertilization for their fodder fields. The Southwestern region of the district experiences drought for at least 183 days in a year (Ntakyo et al., 2020), with adverse effects of low animal productivity. In exacerbated instances, cattle deaths have occurred. Since most livestock farmers depend on naturally growing mixed pastures, droughts' occurrences affect pasture growth and nutrient composition. As a result, pasture lands are usually overgrazed, leading to land degradation, weeds, and invasive plant infestations. These pasture effects consequently lead to inadequate animal feed resources in terms of quantity and quality. Some of the remedies to the seasonality of pastures that livestock farmers in the Mbarara district are employing include:

- Rehabilitation of degraded pastures through the removal of invasive plants and planting pastures desirable to animals
- Planting of improved pastures, especially *Chloris gayana, Brachiaria Mulato* and Napier grass
- Use of fodder crops, especially maize and Napier grass, for making silage
- Feed conservation through making hay from planted pastures
- Reducing stocking rates through acquiring improved cattle breeds
- Supplementary feeding by use of crop residues
- Supplementary feeding with agro-industrial by-products such as brewers' spent grain
- Fencing of pasture fields and practising rotational grazing

NARO's Mbarara ZARDI and other non-governmental agencies like SNV, CIAT, Heifer Project International, etc., are promoting the practice of planting improved fodder species with some livestock farmers in the district. The growing of fodder crops in the Mbarara district is majorly rain-fed. Fodder irrigation would need to be done to bridge the gap of feed scarcity during the dry seasons. However, water sources used for irrigation need to be developed first since the current sources are not sufficient for many farmers.
Making hay and silage is currently being practised by a few farmers in the district. These farmers are using makeshift wooden balers (see pictures in the annexe) to make hay bales. Silage is placed in plastic sheets to keep it airtight in stack or pit silos (see photos in the annexe). In addition to the promotion of irrigation, the rise of feed conservation practices is needed for livestock farmers to cope with natural pastures' seasonality.

6.5.3 The market structure for fodder

There are no formal markets for fodder in the Mbarara district. Farmers purchase fodder from other farmers. Livestock farmers in communities have formed WhatsApp groups on which information on fresh grass and hay for sale, their prices and the available

quantities are shared. Some of the fodder prices that livestock farmers in the Mbarara district mentioned are shown in Table 13. The prices shown in Figure 6.13 do not include transportation costs of the fodder or hay from the seller's premises to the buyer's premises.

6.5.4 Sources and prices of fodder seeds and planting materials

Livestock farmers that plant fodder mentioned that they mostly buy fodder seeds and planting materials from fellow farmers. Farmers share information on the type of fodder seed and planting materials available, their prices and available quantities. Farmers can also purchase fodder seed and planting materials from Mbarara ZARDI. However, the demand for fodder seed and planting materials greatly exceeds their production at the Institute. Other government agencies like NAADS and DDA and non-governmental organizations like SNV give out seeds to farmers engaged in their projects. A kilogram of *Chloris gayana* seeds costs 30,000 UGX, a kilogram of Mexican sunflower seeds is 35,000 UGX, and a kilogram of *Stylosanthes gulanensis* costs 300,000 UGX.

Table 6. 10 Cost of some cattle feeds

Feeds	Price
Hay	5000 – 6000 UGX* per bale†
Brewers' spent grain	100,000 UGX per tonne
Fresh maize straw	25,000 UGX per 1 tonne pickup
Calliandra	20,000 UGX per 1 tonne pickup

* 1 UGX = 0.00027 USD

† A bale weighs about 18 kg

Table 6.10: Nutrient composition of pasture grasses

Nutrient	Pasture species (pure stand)						
	Brachiaria brizantha	*Brachiaria ruziziensis*	*Brachiaria mulato*	*Pennisetum purpureum* 0	*Pennisetum purpureum* 1	*Pennisetum purpureum* 2	*Pennisetum purpureum* 3
Energy (MJ/Kg)	8.00	8.15	9.25	8.60	8.50	9.00	9.60
Protein (%)	11.5	13.0	17.6	13.3	12.9	15.6	20.9
Fibre (%)	27.2	25.8	19.9	26.9	27.5	25.0	22.0
Oil (%)	2.80	2.98	3.52	3.16	3.20	3.31	3.65
Ash (%)	8.08	9.07	9.7	7.51	7.01	9.11	10.9
Starch (%)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Acid Detergent Fibre (ADF) (%)	37.6	36.5	30.7	35.3	36.8	33.5	30.2
Neutral Detergent Fibre (NDF) (%)	61.3	55.6	44.5	58.8	60.5	54.8	51.0
Sugar (%)	<0.50	0.98	2.17	<0.50	<0.50	0.52	<0.50
Digestibility (NCGD) (%)	51.2	52.9	58.8	54.9	54.3	57.8	60.7
Dry Matter	-	86.4	87.1	-	91.0	89.0	92.8

Source: Ntakyo et al., 2020

Table 6. 11 Nutrient composition of pasture grasses (continued)

Nutrient	Pasture species (pure stand)					
	Tripsacum andersonii	*Setaria sphacelata*	*Pennisetum clandestinum*	*Hyparrlenia rufa*	*Themeda triandra*	*Cynodon dactylon*
Energy (MJ/Kg)	8.60	8.60	8.2	8.10	7.20	8.30
Protein (%)	16.8	12.3	14.0	11.8	9.56	21.4
Fibre (%)	25.8	29.3	24.1	28.9	31.8	20.6
Oil (%)	3.02	3.52	2.20	3.09	2.18	3.29
Ash (%)	7.93	9.66	10.8	7.09	6.86	8.53
Starch (%)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Acid Detergent Fibre (ADF) (%)	36.7	38.7	34.8	41.4	42.6	32.1
Neutral Detergent Fibre (NDF) (%)	58.9	60.8	54.2	61.5	69.6	49.3
Sugar (%)	<0.50	0.55	2.32	<0.50	<0.50	3.44
Digestibility (NCGD) (%)	55.3	54.0	54.2	51.9	46.8	52.6
Dry Matter		87.4	81.8	89.4	90.3	87.9

Source: Ntakyo et al., 2020

Table 6. 12 Nutrient composition of forage legumes and some mixed pasture species

Nutrient	Legume pasture species				Pasture species (mixed stand)	
	Greenleaf desmodium	Alfalfa	*Silverleaf desmodium*	Grass-legume mixture	Mixed grass pastures	*Chloris gayana* + Centrosema
Energy (MJ/Kg)	10.3	11.1	10.8	9.30	8.90	9.30
Protein (%)	18.2	24.2	18.3	19.8	13.3	16.5
Fibre (%)	22.1	14.5	19.7	20.6	26.9	23.5
Oil (%)	4.57	5.51	4.98	3.72	3.32	3.81
Ash (%)	5.99	9.22	7.24	6.48	9.12	8.28
Starch (%)	<0.10	<0.10	0.79	<0.10	<0.10	<0.10
Acid Detergent Fibre (ADF) (%)	38.8	24.6	30.8	33.8	36.1	31.9
Neutral Detergent Fibre (NDF) (%)	50.8	28.8	44.3	43.1	56.8	53.3
Sugar (%)	<0.50	7.21	0.58	4.22	1.78	2.25
Digestibility (NCGD) (%)	64.2	67.4	67.0	58.4	56.9	58.8
Dry Matter	88.3	82.5	89.4	87.8	88.6	88.8

Source: Ntakyo et al., 2020

6.5.5 Gender dimensions in fodder production

In the Mbarara district, the household head decides whether to grow fodder or not. The decision depends on the herd's size, the grade of the cattle, size of land available, labour availability and the commercial gain the household head hopes to gain from the enterprise. Women and youths are mainly involved in livestock production activities and fodder production activities when herds are small, e.g., 1 to 3 dairy cattle and small ruminants and calves. Men's involvement comes when monetary transactions and crisis situations are demanding external assistance, such as calling for veterinary assistance or transporting livestock. When the herds are immense, typically, men undertake all the decision making and the enterprises' management. Women are the key players in planting fodder, weeding, manure/fertilizer, and milking when men have off-farm activities.

Field observations have shown that where women are the key players and no hired labour is used, the fodder fields' management is poor. This is because women have to carry out other household activities and not have time to produce sufficient fodder quantities. Therefore, the overall management of animals is lacking. In urban and peri-urban areas, boys and girls below 13 years are rarely involved in fodder production. Older boys help their fathers to plant, weed, collect and chop fodder, manure/fertilize the fields, clean the stalls, milk and sell dairy products, but they have no control over the revenue.

6.5.6 Challenges in fodder production in Mbarara and Uganda in general

Several challenges in the production of fodder were mentioned by stakeholders interviewed. These challenges include:

- ✓ Although the demand is high, there is inadequate quality fodder seed and planting materials in terms of availability and access
- ✓ The cost of quality fodder seed and planting materials, concentrates and agro-industrial by-products is high, e.g., as mentioned above, 1 kg of *Chloris gayana* seeds costs 30,000 UGX
- ✓ The costs of producing conserved feeds, including hay, haylage and silage, are high, thus hampering farmer adaptability
- ✓ Fodder markets are informal and opportunistic
- ✓ Land shortages as a result of increasing urbanization and competing uses of land have exacerbated fodder production in the country
- ✓ The low level of mechanization in fodder production activities contributes to low farm output. There is inadequate machinery for fodder production activities in terms of tractors and related implements. Farmers lack access to forage harvesters, including forage slasher, chopper and hay balers
- ✓ Some farmers are comfortable with traditional grazing practices of open grazing of animals on natural pastures and are not willing to use part of their lands to grow fodder
- ✓ Introduction, promotion and expansion of improved forage production are inadequate and slow. Several farmers lack knowledge and awareness on improved fodder species and their benefits. Feed testing on quality and production is rarely done. There is, therefore, a lack of understanding of the links between the nutritional value of fodder species and animal production.
- ✓ Several farmers are unable to grow and preserve enough quantities of fodder on their farms because they own small land sizes, and they also lack the knowledge and skills to do so
- ✓ Extension services on fodder production in the country are minimal
- ✓ Since fodder in the country is majorly rain-fed, changing weather patterns have not helped the seasonality in the production of forage
- ✓ Water for production is minimal in most of the major livestock production areas. The dry season further exacerbates the water scarcity issue, thus hampering fodder irrigation plans
- ✓ Fluctuating prices of milk have affected investments in commercial fodder production
- ✓ For some farmers, there is an inadequate storage capacity of fodder, mostly hay
- ✓ Several pests and diseases, as indicated in Table 3, affect the production of the various fodder species
- ✓ Since most of the fields that farmers use for growing fodder were previously open grazing grounds facing land degradation issues over the years, these fields often have poor soils that do not produce good yields of planted fodder. Soil fertilization is low and used only when there are leftover animal manure and biogas slurry that has not been applied in fields used for growing food crops
- ✓ The smothering effects of forage legumes on pasture grasses limits the integration of legumes in pasture grasses in the open- and rotational grazing fields
- ✓ Farmers often do not follow the recommended agronomic practices for growing various fodder species; as such, yields are affected
- ✓ Fodder production and livestock production activities are very trying. These activities are often constrained when labour is not inadequate in terms of quantity, quality and cost.

6.5.7 Opportunities for intensification of fodder production in Mbarara & Uganda in General

Several opportunities exist to intensify fodder production in the country. Some of these opportunities include:

- ✓ Increasing access to affordable quality pasture seeds and planting materials by supporting the commercialization of certified seed production and supporting research institutions. The private sector should be facilitated to engage in commercial fodder seed and planting material production
- ✓ Technologies are needed that integrate fodder production more closely into the different agro-ecologies and different farm activities, including food crop production. More practices integrating livestock and food crop production should be encouraged
- ✓ Increasing access to farm machinery especially harvesting implements
- ✓ There is a need to support commercial fodder production and create linkages with research institutions, dairy farms and feedlots
- ✓ Milk market development needs to be reinforced as the main driver to encourage improving fodder growing
- ✓ There is a need to create awareness of the importance of improved fodder species in milk production. Emphasis also needs to be put on sensitizing farmers on the fodder species' management practices during land preparation, growth, harvesting, storage and feeding.
- ✓ There is a need to introduce a compatible grass-legume forage mix to improve protein production and soil conservation
- ✓ There is also a need to improve and promote new feed preservation practices such as Complete feed Block technology (see pictures in the Annex) in addition to hay and silage
- ✓ Investments in the forage sub-sector need to be supported, especially by incentivizing youth service providers to create businesses specialized in different forage chain steps (seed multiplication and supply, forage contracting services, sales and maintenance of scaled machinery, etc.)
- ✓ Forage production needs to be included in student education, farmer training and extension programs
- ✓ There is a need to rehabilitate and conserve rangelands and other communal grazing lands
- ✓ Water source development is needed in significant livestock producing areas to foster irrigation of fodder, thus intensifying fodder production
- ✓ There is also a need to improve soil and water management and use, focused on increasing productivity and sustainable use of resources
- ✓ Interventions in forage markets are needed through setting up strategic feed reserves in areas prone to droughts and climate shocks
- ✓ Cultivation of dual-purpose feed/food crops such as sorghum needs to be promoted, especially during the dry season where there is a protein shortage in the available pastures to boost the productivity of animals

Since the allocation of land for the cultivation of fodder is a major limiting factor, hydroponic technology can be an alternative to the conventional fodder growing method. Hydroponics technology is such that plants are grown in water rich in mineral nutrients instead of growing plants in soil. Hydroponic fodder can currently be grown in low-cost structures. Maize, rice, wheat and barley can be produced using hydroponics technology. Hydroponic fodder is a good alternative because it grows fast, contains a high nutrient value, and is liked by animals (Kabirizi, 2020c).

6.5.8 Stakeholders in fodder production in Uganda

Stakeholders in the fodder production sub-sector are as shown in Table 6.13 below.

Table 6. 13 Stakeholders in the fodder production sub-sector in Uganda

Stakeholder	Role	Contacts
Ministry of Agriculture Animal Industry and Fisheries (MAAIF)	MAAIF is charged with creating an enabling environment in the Agricultural Sector. The Ministry formulates, reviews, and implements national policies, plans, strategies, regulations, and standards and enforces laws, regulations, and standards along the value chain of crops, livestock, and fisheries. MAAIF comprises four Directorates including the Directorate of Crop Resources, Directorate of Animal Resources, Directorate of Agricultural Extension Services and the Directorate of Fisheries Resources, each with Departments, Divisions and Partnership Projects. The Ministry is also made up of seven Agencies, including the National Agricultural Research Organisation (NARO), the National Agricultural Advisory Services (NAADS), Dairy Development Authority (DDA), and the National Animal Genetic Resources Centre and Databank (NAGRC&DB), among others. The Directorate of Crop Production is the national authority to regulate the seed industry, with the National Seed Certification Services (NSCS) responsible for seed certification. NARO is the leading producer of pasture seeds in the country. It undertakes initiatives to develop pasture varieties suitable for certain Agro-ecological zones in the country. It also carries out pasture seed multiplication for distribution to farmers and seed producers. NARO is also piloting the commercialization of fodder production and conservation. It also carries out farmers and extension workers' training in selected areas of the country on fodder production and conservation. NARO researches pastures and legume seeds and maintains a mother bank of forage seeds and planting material distributed for seed multiplication at government farms and farmers' farms. National Livestock Resource Research Institute (NaLIRRI under NARO) research efforts focus on bridging the nutrient deficiency gap, conserving year-round farm feeds and improving the efficiency of local feed resources.	• Dr. James Kakungulu, Principal Animal Nutritionist, MAAIF, jameskakun@gmail.com, +256-772-590746 • Dr. Halid Kirunda, Director of Research, Mbarara Zonal Agricultural Research and Development Institute (Mbarara ZARDI), National Agricultural Research Organization (NARO), halidkirunda@gmail.com, +256-772-927430 • Christine Nakkazi, Animal Production Scientist, Mbarara ZARDI, NARO, kristex6@gmail.com, +256-777-200272 • Gershom Tugume, Animal Production Technician, Mbarara ZARDI, NARO, tugume2012@gmail.com, +256-782-961659 • Paul Boma, Research Officer, Nabuin Zonal Agricultural Research and Development Institute (Nabuin ZARDI), NARO, bomapaul@gmail.com, +256-781-558819 • Dr. Andrew Sekitoleko, Dairy Development Authority, sekitolekoa@hotmail.com, +256-772-437218 • Dr. Annuciate Nakiganda, Research Officer, NARO, aknakiganda@yahoo.co.uk, +256-782-901687

Stakeholder	Role	Contacts
Ministry of Water and Environment (MWE)	The Directorate of Water Development (DWD) of the MWE is a regulatory and supervisory agency for water resources management activities. Its activities are executed through four Departments – Rural Water Development, Urban and Institutional Water Development, Inspection and Support Services and Water Resources Management.	Dr Callist Tindimugaya, Commissioner, Water Resources Planning and Regulation, callist_tindimugaya@yahoo.co.uk, +256-772-521413
Makerere University	Makerere University has three mandates: teaching, research and outreach	Dr Denis Mpairwe, Associate Professor, Department of Agricultural Production, dmpairwe@caes.mak.ac.ug, +256-772-439372 Fred Kabi, Associate Professor, College of Agricultural and Environmental Sciences, fred.kabi@gmail.com, +256-701-262559
Livestock Development Forum	It brings together various stakeholders in the livestock sub-sector	Ben Twine, Chairperson
Karamoja Development Forum	The group aims to cause changes in Karamoja	karamojadf@gmail.com, +256776775775
NGOs: - SNV Uganda	SNV is a not-for-profit international development organization working in Agriculture, Energy, and Water, Sanitation & Hygiene (WASH). Since October 2015, SNV Uganda has been implementing The Inclusive Dairy Enterprise (TIDE) project aimed at improving dairy farm incomes for 20,000 farmers in the districts of Bushenyi, Isingiro, Kiruhura, Mbarara, Ntungamo and Sheema by addressing the following: Improving farm productivity through the establishment of practical dairy training farms, support on-farm investments, strengthen cooperatives and improve dairy services to farmers; improving milk quality through the introduction and promotion of quality-based payment systems; improving regulation and investment facilitation; and improving household nutrition by supporting the introduction of milk in schools and promoting dietary diversity at the household level. AgriProFocus is an initiative originating from the Netherlands that creates opportunities for multi-stakeholder action and learning to enhance farmer entrepreneurship. The partnership currently consists of 35 member organizations and is operational in 13 countries in Africa and Indonesia. AgriProFocus operates the dairy learning lab, a network approach to boost the exchange	Dr Paul Kimbugwe, +256-752-441146 James Muhangi, +256-775-561802

Stakeholder	Role	Contacts
- AgriProFocus Uganda - Heifer International	and learn between dairy practitioners and professionals who support farmer entrepreneurs. Heifer Project International is one of many non-governmental organizations involved in rural development around the world. It works at the grassroots by providing animals and training to organized local groups that request assistance	Sylvia Natukunda Mwesigwa, Agribusiness Linkage Facilitator, snatukunda@agriprofocus.com; +256-782-551473 heifer@heiferuganda.org, +256-414-231828
Dairy Farmers Co-operative Societies	Farmers' co-operatives deal in collective milk marketing, tractor and agricultural extension services to member farmers	Bukaka Dairy Farmers Co-operative society, based in Mbarara, +256-772-415184
Uganda Meat Producers Cooperative Union	The Union was established in 2008 under the guidance of MAAIF. It brings together beef farmers, provides them with a platform to enhance beef production, productivity and quality assurance.	Eng. Robert Ssenozi, Chairman, +256-786-504495
Private sector	They are involved in various commercial activities in livestock and fodder production	Dr Jolly Kabirizi, Senior Principal Research Officer/Livestock Consultant, The Green Elephant Uganda, jmkabirizi@gmail.com, +256-777-912716
Livestock/fodder farmers	These farmers are involved in fodder production in the Mbarara district	Enoch Rukidi / Edridad Mutahunga (farmer manager), +256-751-594919. This farmer irrigates his fodder using sprinkler irrigation. Philomena Nshangano, Executive Director, Rubyerwa Dairy Investments, +256-772-417666 Dr Lewis Barigye, former District Veterinary Officer, Mbarara District, +256-772-554994 Prof. Kenneth Kagame, +256-702-415184 Rev. Polly Musiime, musiimep@gmail.com, +256-772-407199 Moses Mwebaze Kabunduguza, +256-772-603725

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7 ANNEXES

7.1 Annexes for Kenya

Appendix 1: List of participants and their contacts

Administrative location	Ward	Name of respondent	Telephone contact of respondent
Kakelo Kakoth	North Kadem	Gideon Okoth	0725502128
Kakelo Kakoth	North Kadem	Rusalia Akinyi	0704766696
Kakelo Kakoth	North Kadem	Everline Odoyo	0702589578
Kakelo Kakoth	North Kadem	Ruth Achieng	0790638954
Kakelo Kakoth	North Kadem	Irine Otolo	0725584888
Kakelo Kakoth	North Kadem	Petra Awuor	0721550976
Lower Karapolo	North Kadem	John Olawo	0713779262
Lower Karapolo	North Kadem	Dismas Bala	0727091328
Lower Karapolo	North Kadem	Mary Akinyi	0791676434
Lower Karapolo	North Kadem	Caren John	0725003810
Lower Karapolo	North Kadem	Peter Otieno	0792039272
Lower Karapolo	North Kadem	Charles Otieno	07248664603
Lower Karapolo	North Kadem	Farida Okoth	0719791501
Agenga Sub-location	North Kadem	Rahel Ogiro	0703438850
Agenga Sub-location	North Kadem	Jane Kasuku	0701827444
Agenga Sub-location	North Kadem	Tobias Mutese	0742933244
Agenga Sub-location	North Kadem	Jack Nyawanda	
Agenga Sub-location	North Kadem	Everline Atieno	0705810842
East Kanyuor	North Kadem	Nancy Achieng	0742059327
East Kanyuor	North Kadem	Kevin Oloo	0798528611
East Kanyuor	North Kadem	Gideon Otieno	0729643120
East Kanyour	North Kadem	Mercy Atieno	0742727725
East Kanyuor	North Kadem	Judith Atieno	0703247783
East Kanyuor	North Kadem	Velma Achieng	0703247783
Lowers Central Kadem	North Kadem	Philip Odero	0725745888
Lowers Central Kadem	North Kadem	Jackeline Adhiambo	0703588609

Administrative location	Ward	Name of respondent	Telephone contact of respondent
Lowers Central Kadem	North Kadem	Agnes Otieno	0704446739
Lower Central Kadem	North Kadem	Martin Okoth	0720444438
Lower Central Kadem	North Kadem	Morice Otieno	0708855766
Lower Central Kadem	North Kadem	Martin Okello	0725888013
Bala Central	North Kadem	John Otieno	0728168159
Bala Central	North Kadem	Grace Akeyo	0728168179
Bala Central	North Kadem	Elizabeth Adhiambo	0769073566
Bala Central	North Kadem	Sila Polo	0711716574
Bala Central	North Kadem	Elija Apolo	0792056077

7.2 Annexes For Rwanda

Annexe 4.1. Unions and cooperatives in rice farming and dairy production in Rwanda

1. FEDERATION OF DAIRY (NDFR)				
Name of Union	**District of Operation**	**Activity**	**Contact Person and Phone Number for the Union**	**Names of Farmers Cooperatives (members of the Union)**
NDFU	Nyagatare District (Eastern Province, Northeast Part of the country)	Dairy	Name: Baguma Anony Contact Phone: +250788531113	Terimbere Mworozi
				NDMCS
				KKZCO
				BNRT
				ABARWANASHYAKA MILK Supply Ruhuha
				ZIRAHUMUJE
				RDFCO
				MATWOKI – CO
				KAMIRWA
				KAMDAMACO
				KAFCO
				IGG
				HOK
				GIRAMATA

				COEVMM
				BCRKDC
KDCU	Kayonza District (Eastern Province, Eastern Central Part of Rwanda)	Dairy	Name: Nzaramba Contact Phone: +250788652792	Gahini farmers
				MUFCOS
				KOPABIKA GIRAMATA
				KAFACO
				Jyambere mu Kwiyubaka
				Giramata – Kayonza - KGK
				Gikaya Farmers Cooperatives
				COABONDE
				Abakoranabushake ba Gahini
GDFU	Gatsibo District (Eastern Province, Northeast Part of the country)	Dairy	Name: Nkuranga Peter Phone: +250788670359	MUDACOS
				Uruhimbi Kiramuruzi
				Koperative Tubanyeneza Gatsibo
				KOPABOAKA
				KFC
				KDC
				Girinka Munyarwanda
				ELPRORU
				CODEN Jyambere Mworozi
				CILSCF
				Canira Inka
RWALU	Rwamagana District (Eastern Province, Central Eastern part of Rwanda)	Dairy	Name: Nkusi Casmir Phone: +250788305365	CFAER
				UBUDEHE
				KOPAKI MWULIRE
				KOAMUSHA
				KAMIRABOSE
				INDENGABAGANIZI
				DUKUNDAMATUNGO
				DUFACO
				CYURAMASHYO
				COOPAG
				CECOLA-ZIKAKAMWA
				AKIRINKONI
IAKI	Kirehe District (Eastern Province, Eastern south-east part of Rwanda	Dairy	Name: Hakuziyaremye Justus Phone: +250788556420	COABMA (ABOROZI BA MAHAMA)
				MFC
				INDAKEMWA
				COTGA
		Dairy		KOPAKAMAB)

UCEVABU - HURANINKA	Bugesera District (Eastern Province, Eastern South-West part of Rwanda		Name: Gasirabo Gervas Phone: +250788462092	KOINDAMU
				ZIRAKAMWA - RUHUHA
				MURAMA
				KOPEGIMA
				KOGIRINYA
				KOBUZI
				KAJ
				IGICANIRO
				DUSANGIRE MU MAJYAMBERE
				COOPEM
				COEDIBU
KFCU	Kamonyi District (Southern Province, North-Eastern Part of the Southern Province)	Dairy	Name: Nzabarinda Martin Phone: +250788876788	URUHIMBI RWIZIHIYE RUKOMA
				UMUSHUMBA MWIZA KAMONYI
				KOPAIKA-KARAMA
				KOPABOKI
				KABOKA
				COOPEKA
				COEMU
				CODEAM-BENINKUYO
				CODAPR
				COALFKA
				AMIZERO Y….
MCFU	Muhanga District (Southern Province, North-Western part of the Southern Province)	Dairy	Phone: +250783353766	GIRUMUSARURO
				GIRAMATA KABACUZI
				COPAEMR
				COEPROMU-ZIRAKAMWA
				TWITEZIMBERE MUBUGA
NFCU	Nyanza District (Southern Province, Central Eastern Part of the Southern Province)	Dairy	Name: Kabirigi Charles	GIRAMATA MWOROZI
				COODENYA
				ABISHYIZEHAMWE-KANKIMA
				TWIYORORERE KIJYAMBERE
				KOANYABU
				GWIZUMUKAMO - BUSORO
RUDAUGO	Ruhango District (Southern Province, Central part of the Southern Province)	Dairy	Name: Uwamariya Alevera Phone: +250784446442	KOTUA
				KOAGIB
				KOPAGIKI (KOPERATIVE AGIRAGITEREKA - KINAZI)
				RUZICO
				COEGA
		Dairy		KOPERATIVE INGABO NZIZA RAMBURA

UPROCENYA	Nyabihu District (Western Province, North-Western Part of the Western Province)		Name: Teger Gadi Phone: +2500781035131	KOPERATIVE IMBABAZI
				COTMRU
				KABAGA
				VUMERA
				TWIRWANEHO INDAMUTSA(KOTI)
				KOPETA (TWITE KU BUZIMA ARUSHA)
				TWESE IMIHIGO KARAGO
				KODTUBI
				COIMBA
				KOIR (INTWARI ZA RWANTOBO)
				KORUDU RAMBURA
				KOI (IBIHOGO)
				UTERIMBERE
				KOTEWO - JOMBA
				NZIRAKURUTWA ZA RAMBURA-KIRA
				INKOMEZAMIRYANGO
				IMBERABAHIZI
				DUKORE BASUMBA
				DUFATANYE
				COPEVL
				COPDEGI
				COEBOMO
				CEZONYI
				CEMO
LARU	Rubavu District (Western Province, North-Western part of the Western Province)	Dairy	Name: Uwamwezi Dativa Phone: +25078593646	CODERU
				COFTZ
				KOPERATIVE URUGERO II
				DUHURIZEHAMWE KANAMA
				KOGAM (GIRA AGACIRO MWOROZI)
				ZIRAKAMWA BISIZI
				DUTERIMBERE MU BIKORWA KANAMA
				TUZAMURANE MURARA
				KOPABOMA KANAMA
				KOBANKO (ABAGANWA BA NKOMANE)
				COODEKA IMANZI
				KOABAGI (ABATANGANA BA GITWA)
				KOAGI DUKOREREHAMWE (KOPERATIVE Y'ABOROZI BA GISHWATI)
				COODAPPE (COOPERATIVE POUR LE DEVELOPPEMENT AGRO-PASTORALE ET DE LA PROTECTION ENVIRONNEMENTALE)
				KOTWIBUYU (TWIBUMBE YUNGWE)

				CCDT
				TUJYEMBERE- MUHIRA
				KORUM
				KAMU-ZIRAKAGWIRA
				CODAMIN
URUKUNDO	Rutsiro District	Dairy	Name: Niyonteze Jonathan Phone: +250788713045	KOTUBOMU
				INDINGANIRE ZA BUSUKU
				KOAIGI ABAGANJE
				INTWARI TUZAMUKE TWESE
				INZIRAGUHINYUKA ZA NGONGO
				KOAI RUTSIRO
				AMAGAJU
				COE ABADAHEMUKA
				TWONGERUMUSARURO IWACU NGOMA
				INYAMAMARE NYABIRASI
				MBABAZABAHINZI BA NYABIRASI
				ABAHUJUMUGAMBI W'UBWOROZI
				ABIYEMEJE NYABIRASI
				MBABAZI NYABIRASI
				COTEMBI
				COPEM NYABIRASI
				INTARUTWA ZA NYABIRASI
				IMBONERA
				GIRINKA NAWE
				IMBONEZA
				TWITEKUBWOROZI
				ABAKUNDIMANA BA BUSUKU
				KODUIBU
				INZIRAKURUTWA ZA NGONGO
				DUFATANYE MU BIKORWA
				ABASHAKAMAJYAMBERE
				KANYANA
				TWISUNGANE NYABIRASI
				ABARESHYA BA NGONGO
				NGABO NZIZA
				URUHIMBI
				KOHUWOKI
				KOGIM-MANIHIRA
				KOAIKI - KIGEYO
				KOABAGA

				JYAMBERE MWOROZI
				INKUMBURWA KABONA
				IMBONERABARESHYI NYABIRASI
				COPROCEKI
				COEGB - IMANZI
				CODECO - URUNANA
				ABAKUNDAMATUNGO
IABU	BURERA	DAIRY	Name: HAKUZIMANA ALOYS Phone: +250783294647	DUHUZIMBARAGA ZACU
				UBUZIMA BURAHENDA
				TWUNGUBUMWE - KIRAMBO
				URENGERUBUZIMA - KIRAMBO
				KUNDINKA - RWERERE
				GIRA UBUKIRE GAHUNGA
				COPAEBU
				COEVAL
				COEPEVA
				CEPTL
				ABATIGANDA BA GAHUNGA
IAMU	MUSANZE	DAIRY	Name: RYAMUKURU INNOCENT Phone: +250784365132	AGIRAGITEREKA KINIGI
				KINIGIAYERA DAIRY MUHOZA
				KOPIZI
				TUZAMURANE NYAGASAMBU
				ABAHARANIRAMAHORO
				COAPEBM
				CDCEMU
				BUMBATIRUBUZIMA
UEG	GAKENKE	DAIRY	Name: BARAME MATHIEU +250788679272	TWIYUNGURE
				KOPIU - KAGOMA
				KOGIMU
				COOTAG
				COOPAEMO
UPROCEBRU	RURINDO	DAIRY	Name: RWAGASORE VENUSTE Phone: +250788777581	CODAE
				ABISHYIZEHAMWE TUMBA
				ZIRAKAMWA - NTARABANA (KOZINTA)
				NKUNDAMATUNGO
				KODUMUSA-SHYO
				KOARWA - RULINDO
				KIM
				CODEBU
				CAGITU

				AKOKI
				ABIZERANYE TUMBA
				ABIKI
				ABESAMIHIGO
				ABATERANINKUNGA CYOHOHA
				ABAHUJICYANSI
GILICU	GICUMBI	DAIRY	Name: BAJYINAMA Joseph Mukasa	KOTBUKA
				TUZAMURANE NYANKENKE
				HAGURUKUKORE RUVUNE
				ITEZIMBERE MWOROZI
				AMAHIRWE KIGABIRO
				ABIZEYEKUBAHO RWESERO
				ITERAMBERE RWESERO
				INKA ZIWACU
				DUTERIMBERE GATOBOTOBO
				TWITEZIMBERE BUKURE
				TUREBEJO MUREHE
				TUZAMURANE KARENGE
				ABADAHIGWA BA MUTETE
				TWISUNGANE RWESERO
				ABUNZUBUMWE KIGABIRO
				DUFATANYE KARENGE
				TUJYIMBERE NYARUTARAMA
				TUGANEHEZA NGONDORE
				COEKI
				ABATIGANDIRAMAJYAMBERE
				KOBASHA (BATUREBEREHO)
				KOTWIASHA
				ABAHUJUMUTIMA
				TURWUBAKE SHANGASHA
				ABISHYIZEHAMWE MUHAMBO
				ZIRAKAMWA NYANKENKE
				ABESAMIHIGO - CYUMBA
				TWITEGANYIRIZE RWANKONJO
				TWIZERANE DUKORA
				NKUNDICYANSI
				URUHONGORE
				KUNDINKA - MUKONO
				KOIIBU
				KOGIAGI

				IKODM
				KOARU
				KIARU
				KAMA
				IAKIB
				DUKOMEZUMUGAMBI
				ABUMVIKANA - SHANGASHA

7.3 Annexes for Uganda

Annexe 6. Livestock and fodder production in Uganda

Annexe 6.1: Trends of stocks of cattle, goats, pigs, and sheep in Uganda (source: FAO, 2020; UBOS, 2019; UBOS, 2020)

Year	Cattle	Goats	Pigs	Sheep
1961	3,618,000	2,592,000	16,000	865,000
1962	3,382,762	2,532,953	16,069	832,219
1963	3,464,603	2,339,920	14,751	760,016
1964	3,463,937	1,990,915	18,738	861,362
1965	3,496,797	2,013,597	31,729	754,833
1966	3,496,797	2,013,597	31,729	755,000
1967	3,626,643	1,997,713	37,280	790,933
1968	3,682,325	1,900,426	37,358	783,750
1969	3,971,000	1,710,000	42,546	775,000
1970	4,280,500	1,801,400	63,500	827,500
1971	4,223,900	2,211,800	87,500	915,000
1972	4,472,600	1,953,000	88,200	887,900
1973	4,628,700	2,100,800	74,600	921,300
1974	4,773,300	1,872,800	71,500	996,500
1975	4,867,900	2,168,700	93,100	1,051,000
1976	4,989,500	2,299,700	122,000	1,097,000
1977	4,911,100	2,384,800	161,200	1,138,900
1978	5,245,600	2,609,100	169,200	1,195,800
1979	5,242,200	2,624,300	177,200	1,255,600
1980	4,770,600	2,543,600	186,600	1,318,400
1981	4,745,400	2,670,800	195,900	1,384,300
1982	4,821,100	2,804,300	205,700	1,453,500
1983	4,871,300	2,944,000	215,993	1,526,000
1984	4,993,100	3,091,000	226,793	1,602,000
1985	5,000,000	3,710,000	238,133	1,674,000
1986	5,200,000	3,640,000	250,000	1,680,000
1987	3,905,200	3,900,000	470,400	650,000
1988	4,259,800	4,170,000	452,300	700,000
1989	4,416,500	4,480,000	716,400	750,000
1990	4,913,200	4,710,000	1,160,000	780,000
1991	5,121,000	4,950,000	1,210,000	820,000
1992	5,209,000	5,070,000	1,228,000	845,000
1993	5,370,000	5,227,000	1,266,000	871,000
1994	5,106,000	5,383,000	1,304,000	897,000
1995	5,233,000	5,545,000	1,343,000	924,000
1996	5,301,000	5,684,000	1,383,000	951,000
1997	5,460,000	5,825,000	1,425,000	980,000
1998	5,651,000	5,999,000	1,475,000	1,014,000
1999	5,820,000	6,180,000	1,520,000	1,044,000

2000	5,965,500	6,396,000	1,573,000	1,081,000
2001	6,144,000	6,620,000	1,644,000	1,180,000
2002	6,328,000	6,851,800	1,709,800	1,140,800
2003	6,519,000	7,092,000	1,778,000	1,175,000
2004	6,567,000	7,566,000	1,940,000	1,552,000
2005	6,770,000	7,800,000	2,000,000	1,600,000
2006	6,973,100	8,034,000	2,060,000	1,648,000
2007	7,182,293	8,275,020	2,122,000	1,697,440
2008	11,408,740	12,449,656	2,186,000	1,748,000
2009	11,751,002	12,823,146	2,229,000	1,800,000
2010	12,103,532	13,207,840	2,297,000	1,847,000
2011	12,466,638	13,604,075	2,377,280	1,902,220
2012	12,805,900	14,012,198	2,439,100	1,959,000
2013	13,226,000	14,433,000	2,497,600	1,968,000
2014	13,623,000	14,011,000	2,437,100	1,921,000
2015	14,031,000	15,312,000	2,449,566	1,914,183
2016	14,368,000	15,725,000	2,645,503	2,069,449
2017	14,189,000	16,034,000	2,675,435	2,063,727
2018	14,572,000	16,048,000	2,730,847	2,094,426

Annexe 6.2: Trends of meat production in Uganda (source: FAO, 2020; UBOS, 2019; UBOS, 2020)

Year	Meat, cattle (tonnes)	Meat, goat (tonnes)	Meat, pigs (tonnes)	Meat, sheep (tonnes)
1961	61770	9420	720	2592
1962	59000	8700	720	2496
1963	59720	8070	664	2280
1964	59700	6920	843	2580
1965	60390	6810	1428	2616
1966	59790	7940	1428	4030
1967	61340	7890	1678	3590
1968	62570	7540	1680	3580
1969	67320	6860	1915	3610
1970	72440	6740	2855	3890
1971	72960	8520	3935	4280
1972	74580	7090	3970	3790
1973	78330	7944	3360	3894
1974	80690	7632	3215	4210
1975	80519	9110	4190	4420
1976	81884	7388	5490	4919
1977	87803	9505	7250	5250
1978	90000	10960	9910	5240
1979	94370	11020	8000	5450
1980	85880	10680	8400	5720
1981	85350	11220	8810	6400
1982	86120	11780	9257	7122
1983	86400	12360	9720	7478
1984	88200	12980	10205	7852
1985	90000	14160	10716	8245
1986	60000	13980	12600	8260
1987	58650	15000	25400	3178
1988	64130	15960	23100	3430
1989	73050	17160	38700	3640
1990	81150	18000	57600	3822
1991	84000	18960	60000	3990
1992	86000	19440	61200	4130
1993	91500	20000	63000	4200
1994	84300	20650	64800	4382
1995	86400	21250	66000	4522
1996	87500	21600	69000	4620
1997	88500	22320	70800	4802
1998	93000	23040	72540	4970

1999	96000	23760	75000	5110
2000	96750	24600	77400	5320
2001	101400	25440	80880	5782
2002	115000	25344	84000	5600
2003	125000	28800	87000	5754
2004	135000	28800	95400	7602
2005	147000	29000	98400	7840
2006	160000	29870	102000	8064
2007	174150	30766	105000	8316
2008	169950	31689	108000	8568
2009	175049	32640	111000	8820
2010	180300	33619	113100	9072
2011	185709	34627	117000	9300
2012	191280	35100	115000	9400
2013	197019	37500	117000	9520
2014	202929	35567	116321	9300
2015	209017	35420	115715	9231
2016	214033	39222	125063	10003
2017	211358	40058	126857	9973
2018	217065	41098	129195	10115