



Ministry of Agriculture,
Animal Industry and Fisheries



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NATIONALLY APPROPRIATE
MITIGATION ACTION ON

CLIMATE-SMART DAIRY LIVESTOCK VALUE CHAINS IN UGANDA

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ABBREVIATIONS AND ACRONYMS

AgDevCo	Africa Agricultural Development Company
DDA	Dairy Development Authority
EADD	East Africa Dairy Development
ESCO	Energy Service Companies
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GHG	Greenhouse Gases
ICEIDA	Icelandic International Development Agency
IPCC	Intergovernmental Panel on Climate Change
MAAIF	Ministry of Agriculture, Animal Industry, and Fisheries
MRV	Monitoring, Reporting, and Verification
NAMA	Nationally Appropriate Mitigation Actions
NDC	Nationally Determined Contributions
NDP	National Development Plan
PEAP	Poverty Eradication Action Plan
PCP	Pearl Capital Partners
PMA	Plan for Modernisation of Agriculture
RDS	Rural Development Strategy
ROU	Republic of Uganda
SDG	Sustainable Development Goals
UBOS	Uganda Bureau of Statistics
UNFCCC	United Nations Framework Convention on Climate Change
Yield	Yield Uganda Investment Fund

1

COUNTRY BACKGROUND

Uganda, in East Africa, is bordered on the east by Kenya, on the north by South Sudan, on the west by the Democratic Republic of the Congo, on the southwest by Rwanda, and on the south by Tanzania and Lake Victoria. It has a total land area of 241,548 km² and is divided into 117 administrative districts (Figure 1).

The country lies astride the Equator, between latitudes 4° 12' N and 1° 29' S and longitudes 29° 34' W, and 35° 0' E. The average daily temperatures range from 15°-30° C. More than two-thirds of the country is a plateau, lying between 1,000 and 1,500 metres above sea level. Based on topography, Uganda has been divided into four relief regions:

- Above 2,000 metres: 2 percent of the land area
- 1,500 – 2,000 metres: 5 percent of the land area
- 900 – 1,500 metres: 84 percent of the land area
- Below 900 metres: 9 percent of the land area (Mwebaze, 2006)

More than 75 percent of the country has an equatorial climate that is modified by the high altitude. Precipitation is fairly reliable, varying from 600 to 1,000 mm in Karamoja in the northeast received in a single rainy season and from 1,000 to 1,500 mm in the high rainfall areas on the shores of Lake Victoria, in the highlands around Mt. Elgon in the east, the Ruwenzori mountains in the south-west and some parts of Masindi and Gulu received in two rainy seasons. Rainfall distribution has generally been categorized as:

- High: Over 1,750 mm per annum, 4 percent of the land area
- Moderate: 1,000-1,750 mm per annum, 70 percent of the land area
- Low: Under 1,000 mm per annum, 26 percent of the land area (Mwebaze, 2006)

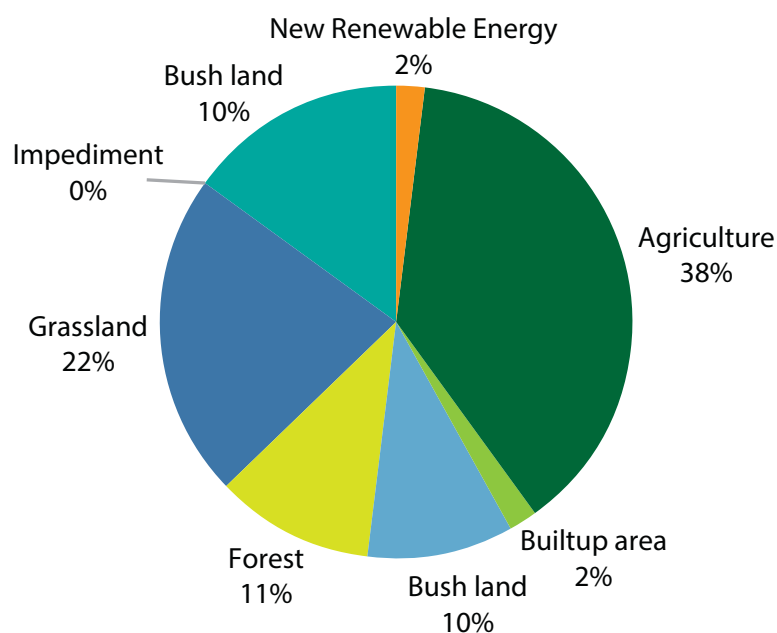
Figure 1: Map of Uganda



Source: United Nations Geospatial Information Section¹

About 80 percent of the country's total land area is arable, although it is estimated that only slightly over 30 percent is productively utilized. The vegetation is mainly composed of savannah grasslands, woodlands, bush land and tropical rain forest (UBOS, 2012; MAAIF, 2010; UBOS, 2015) (Figure 2). Perennial crops that include coffee and green bananas dominate the southern parts of Uganda, while livestock farming is dominant in the drier areas northern and western parts of the country. Other crops grown include cotton, tobacco, tea, maize, beans and flowers. Coffee is the most important export commodity, accounting for 18.5 percent of total exports in 2011, followed by fish and fish products, which accounted for 5.6 percent (ICEIDA, 2014).

1 The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 2: Land Cover and Use in Uganda 2010

Source: UBOS 2015.

Uganda has an estimated population of 35.6 million and an estimated population growth rate of around 3 percent per year, making it one of the fastest growing populations in the world. Around 85 percent of the population lives in rural areas, depending mostly on subsistence farming. Uganda has a very young population, with an estimated 55.3 percent being below the age of 18 in 2010 (ICEIDA, 2014; UBOS, 2015).

The Ugandan economy is dominated by three main sectors: services, agriculture and industry. The agricultural sector employs most of the country's population, the majority of whom are poor. The services sector is the biggest contributor to gross domestic product (GDP) growth rates, growing by 4.0 percent in 2005/06 while agriculture and industry grew by 0.1 percent and 0.9 percent respectively in the same period (ROU, 2007).

2 DAIRY SECTOR OVERVIEW

2.1. Agricultural Sector in Uganda

Agriculture is the most important sector of the Ugandan economy as apart from the direct provision of food, it provides employment, accounts for nearly 20 percent of the value of nominal GDP, accounts for 48 percent of the value of export commodities, and provides a large proportion of the raw materials for industry. Food processing alone accounts for 40 percent of total manufacturing industry. The sector employs 73 percent of the population (MAAIF, 2010). During the Population and Housing Census 2002, about 81 percent of the female and 67 percent of the male work force was employed in agriculture, making it the dominant economic activity at that time (UBOS, 2012).

The agricultural sector of Uganda is one of the main emitters of greenhouse gases (GHG) in the country. Table 1 lists the four main sources of greenhouse gas emissions from the agricultural sector in Uganda, and thereby, its mitigation potential.

Table 1: Main emission sources from the agriculture sector in Uganda

Emission sources from agriculture	2010 greenhouse gas emission (tCO ₂ e/year)
Indirect N ₂ O emissions from managed soils	15.7
CH ₄ emissions from enteric fermentation	4.8
CH ₄ emissions from manure management	0.5
CH ₄ emissions from rice cultivation	0.5
Total	21.6

Source: UNFCCC.²

2 Ministry of Water and Environment, Uganda Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC).

The agriculture sector, which is mainly subsistence, comprises the food and cash crops production, livestock, forestry and fishing sub-sectors. The most important cash crops are coffee, tea, cotton, tobacco, and cocoa, with coffee being the principal export crop. Plantains, cassava, sweet potato and maize are the primary food crops, produced mainly for subsistence. The north-eastern part of Uganda is dominated by pastoralism (cattle farming) and wherever there is crop production, it is normally a mixture known as ‘agro-pastoralism’ (integrated cattle and crop farming). It is estimated that there are approximately 3.95 million small and medium agricultural households who own an average farmland area of 2.5 ha, with a population of 19.3m persons (60 percent of Uganda’s population), producing the bulk (over 95 percent) of the food and cash crops.

Livestock Production

Livestock production is an important sub-sector of agriculture contributing about 7.5 percent to total GDP or 17 percent to agricultural GDP. The major livestock species in Uganda include cattle, sheep, goats, pigs, rabbits and poultry. It is estimated that mixed farming small holders and pastoralists own over 90 percent of the cattle herd and all of the small ruminants and non-ruminant stock and in addition, they produce the bulk of domestic milk and slaughter animals. Cattle are the most important livestock, followed by goats and sheep. Pig and chicken meat production are also important. In 2014 livestock population was estimated as 13.6 million cattle, 14 million goats, 3.8 million sheep, 3.6 million pigs and 44.7 million chickens (UBOS, 2015). The indigenous breeds of most of the livestock continue to be dominant over the exotic ones. Households that include livestock in their enterprise mix tend to be less poor.

2.2. Dairy Sector in Uganda

The Uganda Government has identified milk as one of the 10 commodities of focus for the accelerated development of the agricultural sector (Agriterria, 2012). The dairy industry is estimated to contribute 40 to 50 percent of livestock-related GDP (Balikowa, 2011). From a livelihoods perspective, the sector provides perhaps the one commodity—milk—that is available most of the year as a source of income for the rural poor. The dairy sector is already a specific area of interest for several stakeholders.

This sector is growing at an annual rate of 8-10 percent per annum. This growth is even faster within the processed milk category, estimated at about 11 percent per annum. Growth is driven by a robust and unfulfilled level of demand for milk products in the country and the region. The per capita consumption of milk products is a mere 58 liters/person/year, far lower than the 100 liters/person/year in neighboring Kenya or the 200 liters/person/year recommended by the Food and Agriculture Organization (FAO). The market has the potential to consume more milk (Agriterria, 2012; Balikowa, 2011).

Ugandan milk production is largely dominated by small-scale farmers who own over 90 percent of the national cattle population (MAAIF and UBOS, 2009). Out of 1.7 million households owning cattle, 165,997 households (10 percent) keep improved dairy breeds. The majority (98.4 percent) of the households keeping improved dairy cattle, equivalent to 163,395 households, are found in the eastern, central and south western regions.

2.3. Dairy Livestock Feed Resources

Natural Pastures

Uganda has six major natural grassland communities which are associated with the farming systems and agro ecological zones. The natural pastures are fairly productive and contain many desirable grasses and browse plants but little or no legume component. This, together with lack well-articulated management guidelines leads to low dry matter yields and poor nutritive value for the greater part of the year (Mwebaze, 2006).

The common grasses in the traditional cattle corridor include *Panicum maximum*, *Brachiaria decumbens*, *Chloris gayana*, *Hyparrhenia rufa*, *Pennisetum clandestinum*, *Setaria anceps*, with *Pennisetum purpureum* as the only indigenous fodder grass. However, most of the milk in Uganda is produced by smallholder farmers, who rely on rain-fed natural pastures. During the dry season, there is always a severe decline in the quantity and quality of pastures and overgrazing of the palatable species. This often leads to widespread invasion of unpalatable grasses, as well as bush encroachment. A small number of households keeping improved cattle have planted improved pastures, but it is not enough to meet the fodder requirements of their herds throughout the year. In addition, there is progressive shrinking of grazing land, becoming a serious constraint to dairy farming (Balikowa, 2011).

Although about 25 percent of the households in south western Uganda have been reported to grow fodder crops (mainly Napier and various legume species), only a small proportion (5 percent) of the farms, preserve fodder for dry season feeding (Balikowa, 2011). The result is that most farms frequently experience severe a shortage of forage during the dry season.

Napier grass is the most important source of forage on smallholder farms keeping improved dairy cattle and is found in about 53 percent of the farms (EADD, 2010). Other forage species that are gaining popularity include grasses such as *Panicum maximum*, *Pennisetum clandestinum*, *Chloris gayana*, *Brachiaria brizantha*; herbaceous legumes such as lab lab (*Dolichos lablab*), centro (*Centrosema pubescens*), *Desmodium* spp, stylo (*Stylosanthes guianensis*), siratro (*Macroptilium atropurpureum*), alfalfa or lucern (*Medicago sativa*), *Chamaecrista rotundifolia*; tree legumes mainly calliandra (*Calliandra calothyrsus*), leucena (*Leucaena leucocephala*), and gliricidia (*Gliricidia sepium*) as well as bulk forages, mainly Napier, Guatemala grass, Giant setaria, forage sorghum and maize. If well managed, these forage species can be produced during the rainy seasons well above the farmers' herd requirements and conserved to meet the deficit experienced during the dry season, or sold to earn extra income. In many tropical countries, fodder marketing is becoming an important component smallholder dairy farming, particularly under urban and peri-urban environments. In Uganda fodder selling has been reported in the Masaka and Mukono dairy hubs. This trend in fodder trade is likely to grow due to inadequate feed supply on farm and increased market orientation (EADD, 2010)

Concentrate Feeds

Concentrate use in Uganda has been reported to be low, with fewer than 4 percent of cattle keepers using concentrates feeds, which may be contributing to low milk production on farms. Of those using concentrates, 33 percent feed commercial dairy meal while nearly 56 percent use feed ingredients, such as maize bran and rice bran as straights (EADD, 2010). Uganda is faced with serious problems related to availability of well formulated and balanced rations for adequate dairy cattle feeding. Despite an abundance of cereal grains and their by-products such as maize and maize bran, sorghum, millet, rice bran and root

crops (e.g. cassava) as energy concentrates as well as protein concentrates such as soybean, sunflower cakes, cottonseed cakes, peas and groundnuts, farmers have continued to cite high prices and poor quality of commercial feeds as a major challenge in dairy farming (Nakiganda and others (2005), quoted by Lukuyu and others, 2012a).

Although 44 percent of feed suppliers in Uganda are feed companies, small scale feed producers control a significant share of the feed market in the value chain; highlighting the important role they play in these chains to improve feed access to smallholder livestock producers. This contribution is also significant in the context of feed quality concerns in particular and broader feed production issues in general. In addition, small scale feed producers are dominant players in the concentrate feed value chain in terms of their strong influence on prices of raw materials and their ability to compound feeds of varying composition in accordance with consumer demand regardless of the quality (Lukuyu and others, 2012a)

The apparent 'liberalization' of the feed market has allowed many small processors to penetrate the market supplying the concentrate cattle feeds to farmers, with the result that over the past few years the number of large and medium scale livestock feed producers has been reducing and the number of small scale 'backyard' feed mixers increasing. Whereas this provides small producers with opportunities for business, it has introduced new challenges, especially quality control, into the concentrate feeds value chain.

The concentrate feed value chains in Uganda comprise a longer, more complex formal large-scale value chains and a shorter informal (backyard) value chain. The large-scale value chain includes a range of actors with wholesalers, distributors and large scale farmers being more dominant. In this chain, concentrate feeds are traded within and also across counties and even regions. Most (80–90 percent) of the feed produced goes through rural distributors, wholesalers and retail traders who then sell directly to farmers. A small proportion also goes directly to dairy cooperative societies, institutions and large scale farmers. The small-scale value chain is rather simple in that feed is sold where it is produced in quantities as demanded by the consumer with little regard for quality control. However, more and more small-scale traders are opening outlets in neighbouring towns.

The large-scale feed producers source raw materials from large-scale grain millers, agro-industrial processors, traders and importers of premixes and mineral supplements, while small-scale feed producers buy most of the raw materials direct from producers and the rest from stockists and other cheaper sources, some of which is sold direct to farmers as 'straight' feeds while the rest is mixed into compounded feeds. This serves to diversify the product range to meet the needs of a large number of farmers, while on the other hand it reduces the transaction costs. Feed mixing in large scale production is by large mechanical and/or automatic feed mixers while small scale feed producers only use shovels or horizontal drum mixers where all feed mixing is often done by hand (Lukuyu and others, 2012a) This raises the question of consistency in quality of feed in the small scale value chain.

The increasing demand for livestock products such as milk, meat and eggs in Uganda offers livelihood opportunities to livestock farmers. However, in order to meet this demand there is a need for farmers to supplement their livestock with concentrates in order to improve their productivity. Currently there is no feed quality regulation and certification policy in Uganda and this has resulted in the supply of poor quality feeds to livestock farmers and consequently low productivity. Another consequence is that farmers have resorted to formulating homemade feeds despite a glaring lack of knowledge about feed formulation and animal requirements.

There is great potential for use of concentrate feeds in Uganda. To enhance this, there is a need to put in place the necessary technical, policy and institutional structures to ensure access to and high quality of affordable feed concentrates.

2.4. Milk Production and Marketing

Milkshed areas

There are five distinct milksheds (regions producing milk) along the cattle corridor extending from Mbale in the east to Kabarole in the west and stretching down to Kabale in the south-west. The western region has the highest number of milked cows estimated to be 0.41 million while the northern region has the least number of milked cows, estimated to be 0.16 million. It is estimated that about 80 percent of all milk produced is marketed through informal channels and less than 20 percent is marketed through formal ones. The various milksheds are:

- **Western region:** has 22.3 percent of the cattle population but produces the highest volume (37 percent) of milk in the country. The region has a relatively higher level of improved breeds and a higher level of infrastructure in terms of cold storage milk bulking points.
- **Central region:** has the highest milk productivity of about 9.8 liters per cow/week and a higher population of the more productive exotic and crossbreeds. Farmers in the central region benefit from higher consumer prices due to their proximity to large urban centers (Kampala and Entebbe). Hence, some have invested in fodder banks, improved pastures and use of concentrate feeds bought from formal and informal animal feed processors.
- **Eastern region:** This is a milk deficit area, producing 21 percent of the total production. The dairy sector in this region is less organized, but production has been growing steadily.
- **Northern region:** This region is undergoing resettlement and livelihood development programmes, progressively recovering from the effects of civil war.
- **Karamoja (Northeast) region:** This is arid land with very limited pastures for grazing. It is estimated to produce only 7 percent of the national milk production, in spite of holding 20 percent of the national herd. The low productivity may be attributed to the fact that over 98 percent of the herd comprise indigenous animals, which have to walk very long distances in search of pasture and water. Most of the milk produced in this region is consumed locally (Agriterro, 2012).

Milk Production Systems

In Uganda, milk is produced under three systems; the first is the pastoral system where farms have more than 50 indigenous cattle grazing on unimproved pasture throughout the year with no supplementary feeding. This system relies mostly on family labour, and has low input and output levels. The cattle in this system are generally kept for multiple objectives. The second system consists of peri-urban small-scale mixed crop and livestock farms that keep, on average, fewer than 10 mixed dairy cows. The third system consists of commercial dairy farms (above 200 acres in size) that keep 20 to 100 pure and crossbred dairy cows, depending mainly on planted pastures supplemented with concentrate feeds. This system heavily relies on hired labour and on a greater range of purchased inputs and services (Balikowa, 2011; Makoni and others, 2013).

The dairy systems may also be categorized according to the level of intensification, with semi-zero grazing and zero grazing being the most intensive dairy production systems. Zero-grazing is gaining more popularity due to increasing milk demand which is driving dairy farms to intensify so as to increase output per animal/unit land and hence increase household returns. At least 20 percent of low income households in the Ankole sub-region in Western Uganda have received a zero grazing cow from either government or other institution (Ekou, 2014). In an effort to improve productivity, there has been an increase in cross breeding of indigenous stock with pure dairy breeds, particularly the Friesian, through use of Artificial Insemination (AI) and exotic bulls. A small but growing number of farmers are breeding their animals to calve down in the dry season, taking advantage of higher milk prices in the dry seasons. Supplementary feeding is increasingly practised among these particular farmers. Typically, these farmers, most of whom are women, keep between one and three dairy cows in a stall on a zero-grazing regime (Agriterra, 2012).

Milk Marketing

There are two distinct milk retail channels in Uganda: the (i) formal and (ii) informal market segments (Figure 3) and both are important in the subsector: It is estimated that 65 to 70 percent of all milk produced is offered for sale to the market. The formal segment deals with the processed milk, and includes various products such as: pasteurized milk; UHT; yoghurt; ice cream; powder milk and cheese and is concentrated in the major urban centres, particularly Kampala, Entebbe and Jinja. Only about 10 percent of the milk traded in Uganda goes through the formal (processed) channel but this market segment is showing a faster rate of growth with a recent study by World Bank indicating an 11 percent year on year growth (Balikowa, 2011; Agriterra, 2012).

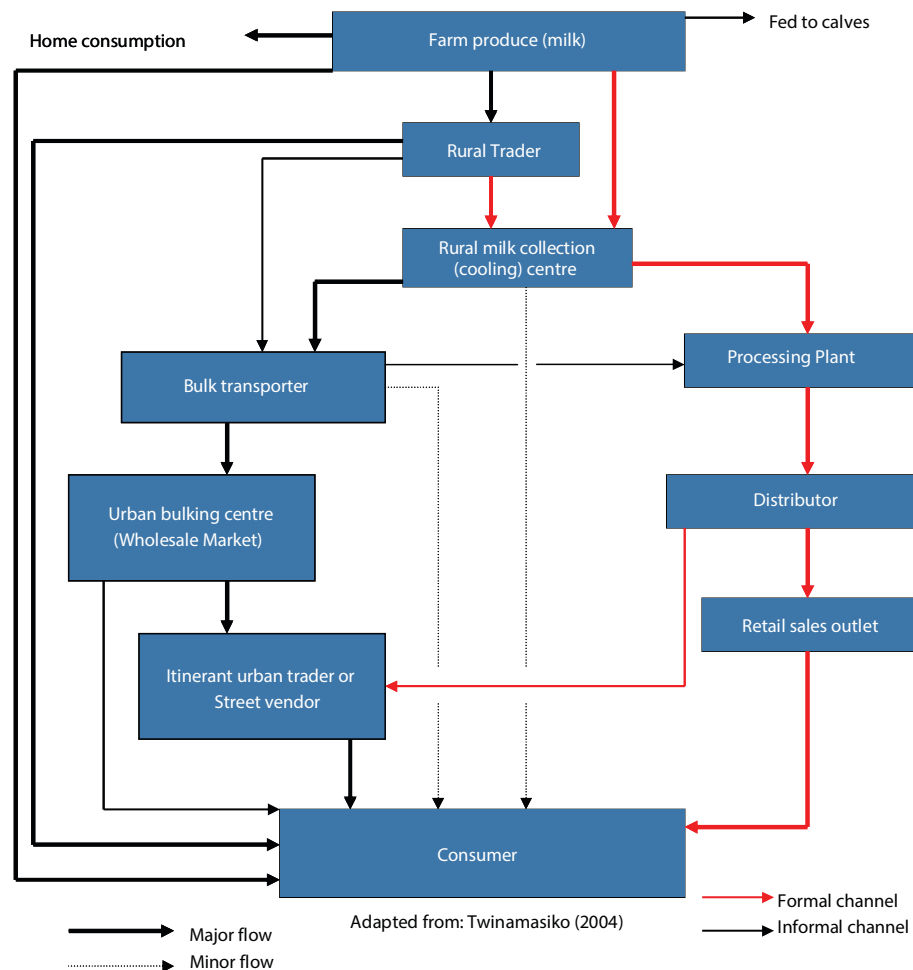
The informal sector on the other hand deals primarily with the sale of raw milk. Up to 90 percent of all marketed milk is channelled through this large and vibrant 'loose' milk segment, making unprocessed milk the most commonly consumed dairy product. This implies that consideration of this segment is extremely critical for any interventions targeted at stimulating productivity within the entire dairy value chain. This segment also presents significant opportunities for increased value addition (Agriterra, 2012). Recent developments in the informal segment include regularization of businesses through registration of limited liability companies, licensing and adoption of the use of appropriate technologies. The informal segment is of great significance because it ensures that milk is readily available and cheap, thereby meeting the needs of most low income households. In addition, there are hundreds of homestead and backyard processors of various products including ghee, cheese, and chilled raw milk. However, a growing number of cottage industry actors have formalized their status and are now registered with the Dairy Development Authority (DDA). These actors who are increasingly adopting appropriate technology present extremely attractive opportunities for trade (Balikowa, 2011).

Liberalization of the dairy industry has resulted in a competitive marketing environment and an improvement in households' ability to market raw milk. In addition, farmer attitudes towards dairying changed from subsistence to commercial, causing a general shift from local to cross breeds. Increase in quantity and an improvement in quality of milk produced at the farm level has also been reported. However, there are regional differences in market access, with greater improvement reported in the central and eastern regions than in the northern and western regions. Political instability and chronic milk shortages in the northern region may explain the lack of improvement in the ability to market raw milk. Market prices (farm gate, trader and local markets) are lowest in the milk surplus western region and highest in the milk deficit northern region. It has also been reported that prices severely fluctuate between the peak and lean seasons in the western region. The relative difference in prices between regions is a demonstration that regional raw milk markets are not well integrated and structurally separated. Therefore milk producers face prices squarely determined by forces of demand and supply within regions of their operation (Mbowa, Shinyekwa and Lwanga, 2012).

The eastern, mid-western, northern and Karamoja regions lack the necessary infrastructure to support organized milk bulking and marketing, hence most farmers market their milk individually through the informal market. In the central region, many farmers continued to sell their milk through the informal market until recently when development partners, particularly Heifer International through the East Africa Dairy Development Project, began to assist registered farmer groups to set up their own milk cooling plants. There was also assistance from Sameer Agriculture and Livestock Ltd., the largest milk processor, to farmer groups to set up milk cooling plants by providing the necessary equipment on a rental basis. The volume of milk entering the formal market in the central region has increasing steadily, going through the two major milk processing companies, namely Sameer Agriculture and Livestock Ltd. and Jesa Farm Dairy.

The southwestern region has well developed infrastructure for milk bulking and transportation. However, there is significant surplus of marketable milk particularly in the wet season which results in a low farm gate price. Most farmers are organized in cooperatives and market their milk through the cooperative structure. In order to address the problem of surplus milk, particularly in the wet season, dairy farmers in south western Uganda through their umbrella organization, Uganda Crane Creameries Cooperative Unions, raised capital which they are using to set up a milk processing plant which will be able to process at least 50,000 liters of milk per day (Balikowa, 2011).

Figure 3: Milk Flow through the Formal and Informal Marketing Channels



Source: Balikowa 2011.

2.5. Key Actors in the Dairy Value Chain

Key Actors

The key actors in the dairy value chain include:

- i. Large scale processors: There are thirteen registered processors in the dairy value chain, operating at varying levels of capacity but a combined installed capacity of 821,000 litres per day
- ii. Small processors/cottage industry: There are numerous small-scale/cottage milk processors but only 35 are registered and licensed by the DDA. The exact number of these actors is not known as many operate in the 'backyard' and hence are not licensed by the DDA.
- iii. Transport chain actors: These include by the bicycle trader, the collection/bulking point trader and the insulated milk tanker operators.
- iv. Farmers: This undoubtedly, is the most important category of dairy industry player, the majority being smallholder farmers for whom sale of milk is the major and often the only source of regular income
- v. Input service providers: They include suppliers of:
 - Seed, animal feed and animal health products
 - Processing ingredients
 - Packing materials
 - Equipment
 - Artificial Insemination, veterinary, extension and business development services.
- vi. Regulators: Although the Ministry of Agriculture, Animal Industry & Fisheries (MAAIF) is responsible for the regulation of the dairy industry it is spearheaded by the semi- autonomous DDA.
- vii. Other support agencies: These include agencies giving support to the dairy industry in the form of financial services, advocacy, advisory services etc. They include civil-society organizations supporting rural development in the agricultural sector, public sector organizations such as universities, and private organizations offering services such as feed and veterinary laboratories (Agriterro, 2012; Makoni and others, 2013).

Government Agencies

Whereas MAAIF is responsible for all functions in the agriculture and livestock sub-sectors, there are several agencies/organizations playing different roles that govern the dairy sector:

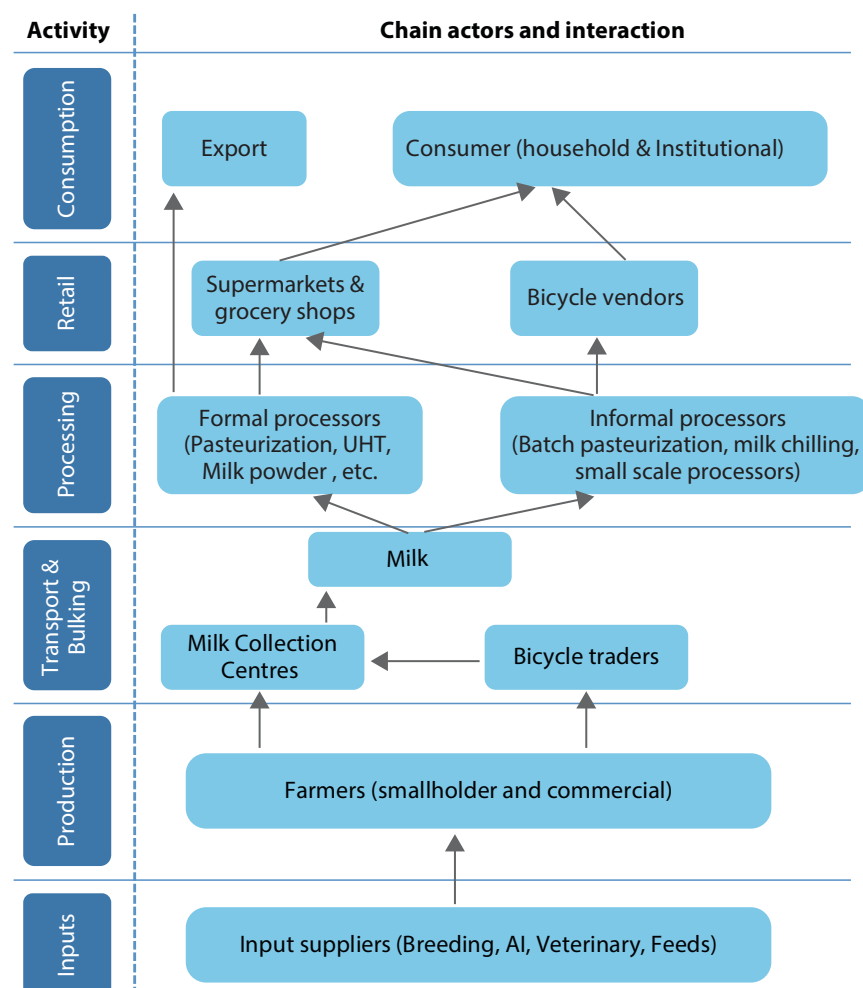
- The Dairy Development Authority (DDA): established as a semi-agency of MAAIF under the revised Dairy Industry Act in 2000, it has a mandate to regulate, coordinate, and harmonize the liberalized sector in order to achieve and maintain self-sufficiency in milk production and dairy products.
- The National Animal Genetic Resources Centre and Data Bank: responsible for the promotion, regulation and control of import, export and market animal genetic material, including quality assurance.
- The National Agricultural Advisory Services: established in 2001, is a government agency mandated to implement the transition from the funded to private sector funded agricultural advisory/extension services.

- The National Agricultural Research Organization: established in 1990, this is a semi-autonomous public sector national agricultural research organization mandated to undertake, promote and coordinate research on all aspects of crops, livestock, fisheries and forestry.
- The Uganda National Bureau of Standards: mandated to develop and promote standards, and undertake quality assurance, laboratory testing and metrology.
- The Uganda Bureau of Statistic (UBOS): established in 1998, it is a semi- autonomous government agency responsible for coordinating, monitoring and supervising the national statistical system. In collaboration with MAAIF, UBOS regularly collects and analyses data on the livestock industry and publishes the findings.

There is still little incentive for most smallholders to supply the formal market as opposed to the informal market, the main reason being low milk prices. This is especially the case in the southwestern region where milk surpluses are common. While the informal market is hard to regulate, the best option for Uganda is a deliberate government effort to provide an enabling policy framework to formalize the informal sector (Makoni and others, 2013).

Figure 4: The Uganda Dairy Value Chain Map

Source: Agritterra 2012.



2.6. Barriers and Constraints (Summary)

The preceding sections provided a brief overview of the dairy production sector and its barriers and constraints. The sector is one of the fastest growing agricultural sub-sectors, but also one that contributes most to greenhouse gas emissions. The following major barriers to the sectoral growth and transformation were identified in the detailed analysis above:

1. Low animal productivity due to poor feeding and animal health;
2. Low level of commercialization and lack of regulation of hay and concentrated feed production;
3. Low adoption of improved management practices and technologies;
4. Infrastructure for collection, storage and chilling of milk is extremely limited across the entire country;
5. Limited incentives for smallholders and informal milk traders to participate in the formal segment;
6. No quality control for milk production.

It is impossible to address any of these factors separately and without creating sufficient commercial incentives to guarantee the long term sustainability of the sector. Therefore, this Nationally Appropriate Mitigation Action (NAMA) as described in the ensuing sections, will address all these issues by designing commercially viable business models for the different parts of the dairy value chain, which will eventually also lead to significant GHG emission reductions.

3

AGRICULTURAL SECTOR POLICIES

This chapter briefly summarizes existing policy in the agricultural sector in Uganda.

Agricultural Policy of Uganda

The policy with respect to agriculture that has been in force since 2001 was formulated against the backdrop of the Plan for Modernisation of Agriculture (PMA) which was a multi-sectoral policy framework for agriculture and rural development. The PMA was part of the wider planning framework for the country—the Poverty Eradication Action Plan (PEAP)—which was first drawn up in 1995 and expired in 2008 (ROU, MAAIF, 2011). Before the formulation of the PMA, agricultural interventions were scattered and there was no comprehensive policy framework to guide the sector (ROU, MAAIF 2011). The most significant policy reform undertaken between the late 1980s and the to mid 1990s was the liberalization of crop marketing for key agricultural commodities by dismantling state controlled marketing boards (coffee, lint, and produce marketing boards), creating opportunities for the private sector to perform the marketing function much more efficiently than government parastatals.

Policy Gaps

The Plan for Modernization of Agriculture, as well as the subsequent policies, did not recognize the need for a holistic approach in modernizing agriculture, as well as the interconnection among the various sectoral stakeholders. The lack of a holistic approach has been a characteristic of all subsequent agricultural policies, programmes, and plans. Finally, the PMA does not recognize the need for commercialization of various agricultural activities, as well as the necessity to bring farmers to markets.

The NAMA will address this gap by proposing a holistic approach to transforming a specific subsector of agriculture, namely the dairy sector, through measures and interventions including the commercialization of activities along the dairy value chain, introduction of policy support measures and incentives, capacity-building, and awareness-raising. The combination of these mitigation and resilience activities will contribute to the overall sectoral adaptation to climate change.

National Development Plan

The PEAP was replaced by the National Development Plan (NDP) (2010/11 – 2014/15) under the theme, 'Growth, Employment and Socio-Economic Transformation for Prosperity', whose focus is on restoration of agricultural growth as an engine for employment creation, poverty reduction and industrialization. The objectives of NDP are to:

- i. Increase household incomes;
- ii. Enhance the quality and availability of gainful employment;
- iii. Improve the stock and quality of economic and trade infrastructure;
- iv. Increase access to quality social services;
- v. Promote innovation and industrial competitiveness;
- vi. Harness natural resources and the environment for sustainable development;
- vii. Strengthen good governance and improve human security (MAAIF, 2010)

The NDP recognizes agriculture as among the key productive sectors driving the economy and hence the need for the Government to give it extra attention. Most Ugandans are self-employed, mainly in agriculture, so any plan to develop the economy and reduce poverty will have to be carried out in the agricultural sector and through agricultural sector growth. Focal points for agricultural growth have been identified as the following:

- i. Development and adoption of high-yielding technology.
- ii. Expansion of the acreage under cultivation.
- iii. Diversification of agricultural exports.
- iv. Efficient and competitive system for processing and marketing of agricultural commodities.
- v. Development of rural finance markets (EC, 2000).

Policy Gaps

The National Development Plan looks at the possible new technologies for agricultural development and their financing mechanisms, but it does not look at the development of viable business models that can bring Ugandan farmers beyond subsistence agriculture.

The NAMA will address this gap by providing concrete business models along with concrete financing vehicles for agricultural development. The business models are localized and reflect conditions in Uganda. The NAMA will also propose standards, labelling, and regulation in the animal feed production industry to promote a healthier business environment.

Plan for Modernisation of Agriculture

Since 2001, investments in the agricultural sector have been guided by the Plan for Modernisation of Agriculture (PMA) whose main objective was poverty reduction through agricultural commercialization. The PMA adopted a multi-sectoral approach to agricultural development, giving it the breadth that agriculture needs to move forward, and as such had seven key pillars (research and technology development, national agricultural advisory services, rural finance, agro-processing and marketing, agricultural education, physical infrastructure, and sustainable natural resource utilization and management), whose implementation mandates spread across 13 ministries and agencies. The PMA recognized that some of the investments needed to make a difference in agriculture, for instance roads, financial services, energy, natural resource management and agricultural education lie outside the mandate of MAAIF.

A PMA evaluation in 2005 found that the concept was still valid, but implementation of the framework was a challenge, the major one being coordinating the activities of some 13 ministries and agencies. In addition, government and development partners provided financial support and institutional development to two of the PMA pillars in particular: agricultural research and technology development through the National Agricultural Research Organization; and National Agricultural Advisory Services: hence the other PMA pillars lagged behind. There were two glaring gaps: (i) The need to provide financial services to farmers to enable them to purchase agricultural inputs; and (ii) The need for farmers to add value to their products as well as to improve access to markets.

To respond to the gaps in PMA implementation the Ministry of Finance, Planning and Economic Development, in 2005, formulated the Rural Development Strategy (RDS) with the overall objective of raising household incomes, like the PMA, but proposing a more focused approach to supporting farmers. The main objectives of RDS were:

- i. Increasing farm productivity of selected commodities;
- ii. Increasing household output of selected agricultural products;
- iii. Adding value and ensuring a stable market for agricultural products.

Support to farmers was through input provision and formation of cooperative societies. The focus of RDS was the sub-county, and this led to the development of the Sub-County Development Model. Hence, the RDS was intended to give them more focus and to generate more public sector support than did the PMA.

Policy Gaps

The weakest part of the PMA is the lack of a working implementation structure with clear roles for all actors and the lack of well designed monitoring and feedback mechanisms, that will allow the policy adjustment over time based on the outputs of its implementation.

The NAMA will address this gap by providing a detailed implementation structure with clear roles for the stakeholders involved. The NAMA's monitoring, reporting, and verification (MRV) system will also provide the necessary data for evaluating the outcomes of implementation and its effectiveness.

The National Agricultural Policy

As of 2010, MAAIF is developing a new agricultural sector policy for Uganda. MAAIF will be guided by six principles that are derived from the country's experiences, with lessons learned from implementing the PEAP,

the PMA, and from implementation of decentralized governance through the Local Government Act of 1997:

- i. Fostering a private-sector led and market-oriented economy and in so doing encouraging the private sector to invest more in agriculture.
- ii. Adopting a zoning strategy according to the agricultural production zones. Commodities that are best suited for each zone will receive extra public sector support. Efforts will be made to support the value chain development of selected strategic commodities in the different zones in order to create viable agro-industrial centres.
- iii. Provision of agricultural development services to all farmer categories as individuals or in groups, ensuring gender equity.
- iv. Provision of agricultural development services will continue to be through the decentralized system of government and efforts will be made to strengthen it.
- v. Government interventions will pursue growth and equity; hence balance agricultural interventions across regions, agricultural zones and by gender.
- vi. Sustainable use and management of key agricultural resources including soils and water for agricultural production

The overall objective of the agriculture policy is to achieve food and nutrition security and improve household incomes through coordinated interventions that focus on enhancing sustainable agricultural productivity and value addition; providing employment opportunities; and promoting domestic and international trade (ROU, MAAIF, 2013). To achieve the objectives of the National Agricultural Policy, the government will work closely with all stakeholders in agriculture, including central government ministries, departments and agencies, local governments, private sector, civil society, farmers, and development partners.

Policy Gaps

This is the most comprehensive agricultural policy as of now and the first to target explicitly the sustainable management of agricultural resources. The policy also looks at a holistic approach for the agricultural sector, but does not provide specific policies for individual sub-sectors, such as dairy production.

The NAMA will address this gap by providing a tailor made solution for the dairy sector that will allow the adequate involvement of various stakeholders participating in the dairy value chain.

Other Policy and Regulatory Gaps

In addition to the above gaps, it should be emphasized that there are currently no standards or labelling for animal feeds and milk. The lack of such standards prevents informed decision on the side of the consumers: farmers (for concentrated feeds); and milk processing facilities (for milk).

The NAMA will address this gap by introducing standards, labelling, and regulations for animal feeds and milk production. Also, while hay can be used as a quality feed supply to livestock, especially during the dry season, this has not been addressed by current policies and regulation. This will be addressed by the NAMA, which will include hay production as one of the proposed interventions.

4

PROPOSED NAMA INTERVENTIONS

4.1. Objectives of the NAMA

The Ministry of Agriculture, Animal Industry & Fisheries emphasizes that while climate is the main motivation behind climate finance, it is financial returns, climate resilience, resource security, production, and productivity that drive change at the farm level. The proposed NAMA should address these particular drivers and will be centered on them.

The objective of this NAMA is to trigger resilient low-carbon development in the dairy sector through the introduction of climate-smart agricultural practices and to bring the dairy production sector of Uganda onto a low carbon and more resilient path. The NAMA focuses on a set of interventions and measures related to policy development, technical assistance, and access to finance that will be integrated within sustainable commercial oriented investment activities that contribute to enhanced agriculture productivity, climate change mitigation and adaptation, improved food security, and increased incomes.

Climate-smart agriculture in the dairy sector combines three objectives, namely, (i) sustainably increasing agricultural milk productivity and incomes; (ii) adapting and building resilience to climate change along the milk production value chain; and (iii) reducing greenhouse gas emissions. Mitigation measures which will be considered under climate-smart resilient agriculture are those that reduce emissions from enteric fermentation and animal manure management. Brief descriptions of the measures are provided below.

1. Feeding strategies that increase productivity while at the same time reduce methane emissions from enteric fermentation. Efforts will be centered on strategies that have shown promise elsewhere including feeding livestock on improved forages, and improving the quality of feeds by using feed supplements and feed additives. This will involve screening tanniferous herbaceous forages and agroforestry tree species for methane reducing potentials; supplementation using agro-industrial by-products including oilcakes; use of feed additives including plant extracts (condensed tannins, saponins, essential oils) and rumen modifiers (yeast, bacterial direct fed microbials, and enzymes), which reduce

methane emissions from enteric fermentation; and integrating these options strategically in ruminant feeding systems or incorporating grain with pastures.

2. Alternative supply to feeds. The production of hay and its use as supply of quality feeds to livestock during the dry season when commercial feeds are in high demand. In addition to meeting dry season nutrient demands, hay production also improves soil quality by preventing soil erosion.
3. Improved manure management. Examples of improved manure management are the use of biodigesters where animal waste manure is properly treated and produce biogas and sludge as by-product. The biogas can be used for cooking or as a source of energy for the processing of agricultural products. The sludge can be applied as fertilizer.

Table 2 in Chapter 2 showed the most recent data for emissions from enteric fermentation and manure management; however, the future emission reduction potential is considered to be much larger as the sector is one of the fastest growing ones. Table 2 also does not show how emissions are expected to grow in the business-as-usual scenario. For example, continued growth in livestock numbers is expected to triple methane emissions in Uganda by 2035.

One of the main objectives of a NAMA is to have a transformational effect. It should permanently reduce greenhouse gas emissions, improve climate resilience, be scalable, and propose economically feasible changes in agricultural practices. The latter also means that the NAMA should be able to stand on its own after the sources of NAMA funding have been used up. The proposed NAMA aims to combine all of these objectives.

4.2. Approach of the NAMA

The previous chapters provided an overview of the dairy sector in Uganda and the existing relevant policies for this sector. In this process, the following observations were made:

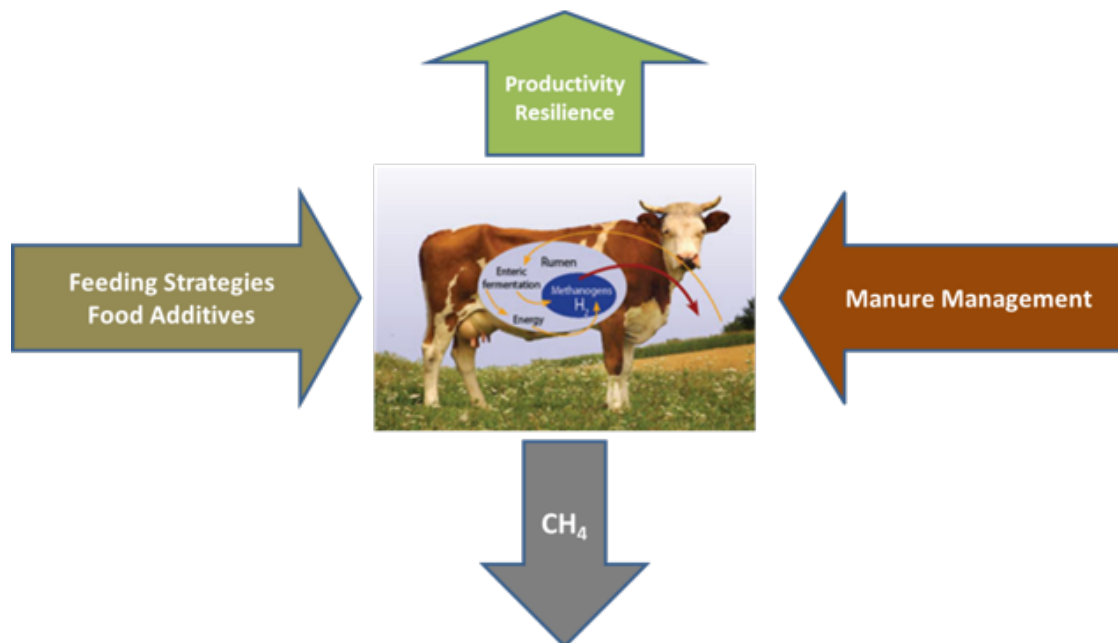
1. Dairy production is a major source of GHG emissions, mainly resulting from enteric fermentation and manure management.
2. The dairy sector is the sector with strongest exposure to markets and one of the fastest growing agricultural sub-sectors due to the growing demand for milk and milk products.
3. The dairy sector has strong exposure to the effects of climate change, especially during the dry season when in some parts of Uganda lack of water and animal feed has resulted in increased dairy stock mortality. As the effects of climate change are expected to get stronger, it is crucial to increase the resilience of the sector to guarantee its long-term sustainability and the food security of Uganda.
4. The existing agricultural policies do not address sufficiently the issues related to the quality of animal feed, and no standards have been developed in that area. This prevents the successful implementation of any wide-scale measures related to the improvement of animal health and nutrition, as well as to increase of dairy sector productivity.
5. Hay production has also not been adequately addressed despite the fact that it can be an easy to achieve solution for supplying quality feed to animals and securing fodder during the dry season. Additionally, hay production can prevent soil erosion, thus having a significant climate change adaptation effect.

The above issues have been partially addressed in pilot projects, however, the lack of a holistic sectoral approach has prevented the implementation of any sustainable solution. This NAMA proposes a model for transformation of the dairy sector by addressing various issues existing along the milk supply chain, starting from feed production all the way to milk processing, holistically with a set of policy measures and commercialized solutions.

The interventions proposed under the NAMA (details in Chapter 4.3) include measures such as improving feeding strategies, including targeted hay production and using food additives in feed production, which are expected to improve the animal health and nutrition and improve the quality and quantity of milk produced as well as increase the resilience of the dairy sector, especially during the dry season. This translates to Ugandans consuming better quality milk and thus having a positive impact on human health and farmers increasing their incomes. As part of the NAMA's holistic approach, interventions will include the improved treatment of livestock manure that could generate additional energy sources for electricity or heat, and produce by-product to fertilize soil.

These interventions aim to address the various issues identified above while at the same time result in the mitigation of greenhouse gas emissions within the sector, namely, methane emissions from enteric fermentation and from manure management.

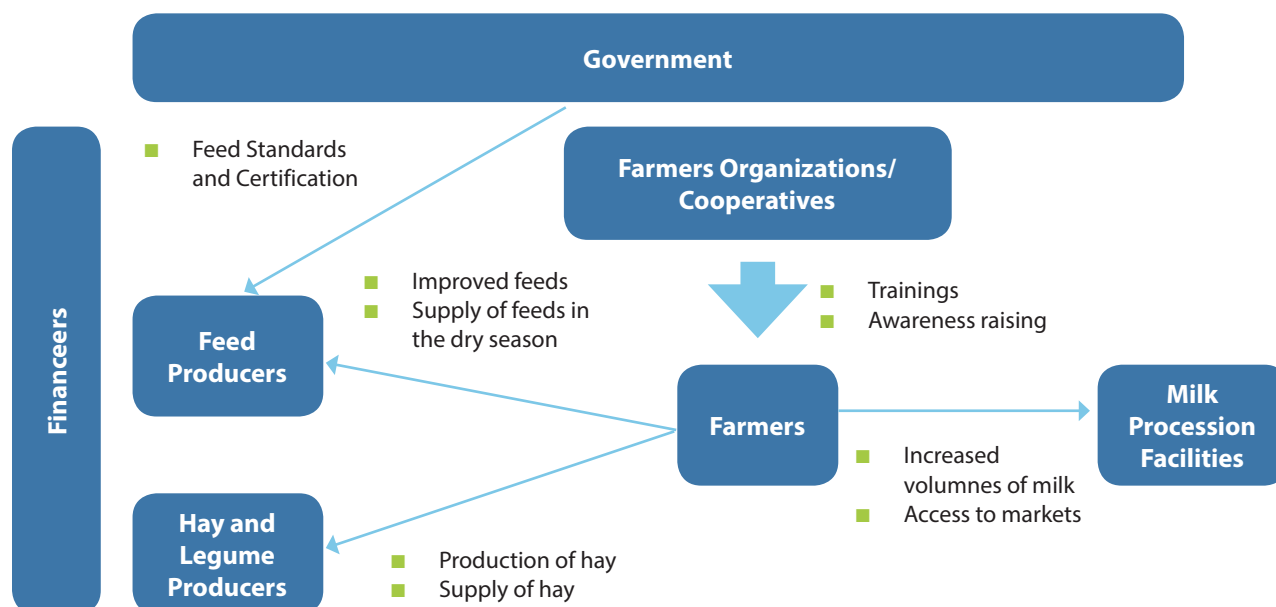
Figure 5: NAMA Approach in the Dairy Sector of Uganda



4.3. NAMA Interventions

The prototype of the NAMA measures and interventions is described below.

Figure 6: NAMA Concept and Prototype



The NAMA targets the increase of climate resilience, resource security, production, and productivity in the dairy sector of Uganda by improving the dairy value chain. The NAMA will introduce interventions that will create a market for quality dairy production to improve production, quantity and quality of products, thereby increasing the financial return for farmers, while eventually leading to a reduction of methane emissions in the agricultural sector.

Policy Measures

Introduction of Feed Standards and Certification System

The NAMA aims to introduce a Feed Standards and Certification system that will ensure the quality of the feeds being supplied to the market. These standards will cover the quality control of the existing feed mixture as well as the development of new feeds with and without additives that can suppress enteric fermentation and the generation of methane emission.

Introduction of a Labelling System

The NAMA will introduce a certification and labelling system for dairy products. Through this system, milk processing facilities will be able to easily identify and source high quality milk. This way, milk processing facilities will be assured of the quality of raw materials they are procuring and be able to produce higher quality consumer products. On the other hand, farmers producing the quality milk may be able to earn a premium price, thereby increasing further their potential for higher revenues.

Business Solutions

Production of Improved Animal Feed

The feed intake of dairy cattle determines its health, as well as the amount and quality of milk produced. Improving the quality of the livestock feed increases the content of dry matter and total digestible nutrients in their intake, leading to increased dairy productivity, as well as reduces methane emissions from enteric fermentation.

This component will also concentrate on integrating the informal sector in the production of high quality feeds. This will guarantee, on one hand, the steady supply of feeds to the market, while also allowing the population engaged in informal feed production to be successfully transferred to the formal sector. For that purpose, the proposed trainings will also cover a special module for training of informal sector producers.

Production and Supply of Hay

All year productivity has always been a challenge to Uganda's dairy livestock mainly due to the scarcity of pasture and feeds during the dry season. Using hay is a cost-effective source of nutrients for livestock especially during the dry season when feed supply is not enough. It can be made from grass and legumes which are abundant during the rainy season. The NAMA aims to promote the production and supply of hay for the farmers to utilize during shortages in feed supply, mainly during the dry season. This ensures the productivity of the dairy livestock all year round.

Establishment of Milk Collection and Storage Points

The measures and interventions proposed under the NAMA is expected to improve the quality and quantity of milk produced. To ensure that the end users and consumers of the milk receives the highest possible quality state of the product being at the end of the dairy value chain, milk collection and storage points will be established. Cooling, storage, and testing facilities will be established to ensure that the quality of the milk products is retained. Milk purchase points will also be established and serve as places for attracting certified milk producers and consumers, as well as support to individual farmers having access to its market.

Livestock manure management and biogas production

In consideration of the NAMA's holistic approach, it will also aim to address the proper treatment of livestock manure. This will be done by introducing the use of anaerobic biodigesters to treat animal waste from livestock operations. Using closed-type anaerobic digesters allows for the collection of its by-products, biogas and sludge. The collected biogas serves as an additional source of fuel which can be used by farmers to replace their existing fossil-fuel based needs such as for drying, electricity, cooking, and others. The sludge can be used or sold as fertilizer.

4.4. Individual Business Cases: Modules

This NAMA is expected to consist of individual commercially driven business modules implemented by individual farmers and cooperatives, as well as private sector participants. The standardized business modules are described below.

Table 2: Business Modules of the NAMA

Module 1	Feed production
Activities	Production of commercial feeds/use of additives
Recipient/implementer	Feed Producers, including farmers cooperatives
Fiscal Support	Income tax deduction for the first three years after obtaining certification
Capacity Development Support	Trainings for the production of certified commercial feeds and compliance with certification requirements
Funding source	Uganda Yield Fund
Required investments	In case of established facilities, mainly for training and compliance Purchase of mixers Purchase of weighing machines Purchase of testing equipment Purchase of packaging machines
Business case	Sale of certified and labelled feeds. The main market will be farmers aiming at getting milk certification. As a result of the awareness campaign for quality feed under this NAMA, the market is expected to grow and include small-scale and individual farmers. As the use of the improved feeds will lead to increase in milk production, and certification will allow access to big milk processing facilities, steady demand is expected to exist.
Module 2	Hay production
Activities	Commercial production and marketing of hay
Recipient/Implementer	Crop Farmers/land owners/cooperatives
Fiscal Support	Income tax deduction for the first three years of operations
Capacity Development Support	Awareness-raising about the benefits of the use of hay Marketing support to access individual farmers Training of production of hay
Funding Source	Agdevco, Yield Uganda
Required investments	Partial support for land purchase Training on hay production and drying Partial support for construction of storage facilities Partial support for purchase of transport vehicles (trucks)
Business case	Sale of hay to individual farmers or cooperatives. The main market will be farmers in dry areas. As a result of the awareness campaign for quality feed and hay, the market is expected to grow and include other farmers.
Module 3	Purchase of certified milk from farmers
Activities	Establishment of milk collection and storage points. Construction of cooling facilities. Establishment of testing facilities.
Recipient/Implementer	Farmers cooperatives/milk market intermediaries (companies)
Fiscal support	Income tax deduction for the first three years of operations

Module 3	Purchase of certified milk from farmers
Capacity development support	Support in establishment of the milk purchase points as the places for attracting certified milk producers Marketing support to access individual farmers
Funding Source	Uganda Yield, Agdevco
Required investments	Partial support for land purchase Partial support for facility construction Storage facilities Testing facilities Partial support for the purchase of transport vehicles (trucks)
Business case	The storage facilities will be either be operated directly by milk processing plants or will have exclusive agreements with them. The facilities will be the only places to purchase certified milk. The purchase price will be publicly announced. The facilities will be the only places that will purchase certified milk at preferential prices. The prices will be set at a level that will provide incentives for farmers to certify their milk and to stimulate the movement to overall national milk certification.
Module 4	Biodigester Business
Activities	Sale, installation and maintenance of biodigesters (includes production of heat and/or electricity from biogas, and production/sale of fertilizers from sludge by-product)
Recipient/Implementer	Individual farmers/farmer cooperatives
Fiscal support	VAT discount for the purchase of biodigesters
Other donor support	Support of the establishment of preferential lending facilities
Capacity Development Support	Awareness raising Marketing support to access individual farmers Energy service companies (ESCOs) capacity development
Funding Source	Uganda Yield, Agdevco
Required investments	Support for warehouse construction Support for transport vehicles (trucks) Support for establishment of maintenance facilities
Business case	Farmers throughout the country will be targeted. Major marketing targets will be large-scale and medium scale farms where the use of biodigesters can be applied for meeting the heat and electricity needs as well as produce and sell fertilizers (sludge by-product), while the model will be further modified to incorporate small-scale farmers. The payments can follow an ESCO scheme wherein payments will be made against the reduced electricity and heat bills.

4.5. Required Policy and Regulatory Support

The major policy support instruments require grant support and fiscal support in order to complement the already existing policy framework, an Animal Feed Standards Framework and a Mild Quality Standards and Labelling Framework.

4.5.1 Animal Feed Standards Framework

As explained in the preceding sections, there are currently no standards for animal feeds produced in Uganda. Therefore, it is crucial that the Bureau of Standards of Uganda together with the Ministry of Agriculture, Animal Industry and Fisheries develop a set of animal feed mixtures that will aim at improving the animal health and reduce enteric fermentation. The feed mixtures and the possible use of additives will be designed together with an animal nutritionist.

In addition, a system for certifying and labelling of feeds and certification of feed producers will be designed. To make this system effective, the Uganda Bureau of Standards and MAAIF will offer support and trainings for feed producers who are willing to obtain certification, in this way allowing the informal sector to transform and be integrated into the formal feed production value chain.

Finally, the animal feed standards and quality labelling will be connected to the milk quality labelling by making the use of certified feeds a precondition for milk quality certification. In this way, such a type of animal feed standards is expected to spread gradually and become the norm in the country. The budget for the development of the animal feed standards framework and its supporting activities is provided below.

As part of the standards framework development, feed producers will be provided the necessary technical skills to formulate and produce quality feeds using appropriate feed supplements and additives that result in increased digestible nutrients in the feeds. In addition, training and awareness raising to ensure the quality of the feed does not deteriorate from production source to the end user will be provided. This includes the proper mode of transport, handling during transport, and storage, as well as avoidance of feed adulteration during transit and repackaging by traders. The establishment of feed producers' association(s) will also be considered so that all efforts in ensuring the quality of production are well coordinated.

Hay producers will be provided with the necessary knowledge and skills to produce high quality hay. This includes the multiple steps involved in its production, harvest, and storage, as well as matching hay quality with the nutrient requirements of livestock in the country or region.

Table 3: Costs for Animal Feed Standards Framework

#	Item	Budget (US\$)
1.	Development of standards and animal feed mixtures	60,000
2.	Development and execution of training programmes for hay production	60,000
3.	Development of a certification and labelling system	40,000
4.	Awareness campaign	50,000
5.	Trainings	30,000
	TOTAL	240,000

4.5.2 Development of Milk Quality Standards

In addition to the feed quality standards, milk quality standards also need to be developed. The milk standards will be developed together with nutritionists and will be combined with a certification system for producers, as well as a labelling and certification system for milk products. The standards will be implemented under the guidance of an animal nutritionist.

Milk processing facilities will be provided with the necessary knowledge and awareness regarding the merits of improving their quality of products by using quality raw materials in the dairy value chain. This would pave the way for a quality dairy market.

The costs for this policy support are summarized below.

Table 4: Costs for Development of Milk Quality Standards

#	Item	Budget (USD)
1.	Development of standards for milk and milk products	50,000
2.	Development of a certification and labeling system	40,000
3.	Awareness campaign	50,000
	TOTAL	140,000

4.5.3 Capacity-building and Awareness-raising

The NAMA will undertake a train-the-trainers approach and will need support for the necessary training, capacity-building, and awareness-raising among key stakeholders. The trainings would involve topics such as proper feeding strategies, use of quality feeds, and use of hay, and ensure that the trainers are properly equipped with the skills and knowledge to disseminate this information to their targeted audience, the participating farmers. In addition, a reference manual will be developed for the participating farmers and serve as a supplement information source after training is received. Furthermore, a helpdesk will be established which will serve as an information centre for farmers.

The costs for this policy support are summarized below.

Table 5: Costs for Capacity-Building and Awareness-Raising

#	Item	Budget (USD)
1.	Trainings	50,000
2.	Development of a reference manual	50,000
3.	Establishment of a helpdesk	50,000
	TOTAL	150,000

5 NAMA BASELINE

The baseline scenario describes how the current situation would have evolved in the absence of the proposed NAMA interventions. For Uganda's agriculture sector, the baseline scenario represents the continuation of the current agricultural practices.

5.1. GHG Baseline

The GHG baseline assumes the continuation of the current agricultural practices in Uganda. According to Uganda's Second National Communications to the UNFCCC, enteric fermentation and animal manure management was the most significant emitter of methane in the agriculture sector which generated 241.23 Gg of CH₄ in 2000. Its Nationally Determined Contribution (NDC) indicates that this is projected to increase four times by 2030.

Baseline emissions from enteric fermentation and animal manure management are calculated based from the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories. In the absence of sufficient disaggregated data for a more detailed calculation, the Tier 1 method using default emission factors is used.

$$BE_y = BE_{Enteric,y} + BE_{Manure,y}$$

Where:

BE_y	Baseline emissions in the year y (tCO ₂ e)
$BE_{Enteric,y}$	Baseline emissions from enteric fermentation in the year y (tCO ₂ e)
$BE_{Manure,y}$	Baseline emissions from manure management in the year y (tCO ₂ e)

Baseline emissions from enteric fermentation of livestock are calculated using a simplified method requiring only readily available animal population data and IPCC default emission factors.

$$BE_{Enteric,y} + \sum_T (N_{T,y} \times EF_{BLEnteric,T} \times 10^{-3} \times GWP_{CH4})$$

Where:

$BE_{Enteric,y}$	Baseline emissions from enteric fermentation in the year y (tCO ₂ e)
$N_{T,y}$	Number of head of livestock species / category T (head)
$EF_{BLEnteric,T}$	Enteric fermentation methane emission factor for the defined livestock population T in the baseline scenario (kgCH ₄ /head/yr)
GWP_{CH4}	Global warming potential of CH ₄ (tCO ₂ e/tCH ₄ , use value of 25)
T	Species / category of livestock

The NAMA focuses on the dairy sector therefore, the species and category of livestock considered for baseline determination are specific to dairy cattle. The number of dairy cattle population in Uganda was obtained from the Food and Agriculture Organization of the United Nations (FAO) food and agricultural data statistics page, FAOSTAT.³ The most recent available data shows that dairy cattle population is 3,500,000 heads in 2014. Default methane emission factor for enteric fermentation for dairy cattle (46 kgCH₄/head/yr) was obtained from Table 10.11 of the IPCC Guidelines. Using these available data, baseline emissions from enteric fermentation amounts to 4,025,000 tCO₂e/yr.

Baseline emissions from animal manure management are calculated using a simplified method that uses IPCC default emission factors and only requires livestock population data by animal species/category.

$$BE_{Manure,y} + \sum_T (N_{T,y} \times EF_{BLManure,T} \times 10^{-3} \times GWP_{CH4})$$

Where:

$BE_{Manure,y}$	Baseline emissions from manure management in the year y (tCO ₂ e)
$N_{T,y}$	Number of head of livestock species / category T (head)
$EF_{BLManure,T}$	Manure management methane emission factor for the defined livestock population T in the baseline scenario (kgCH ₄ /head/yr)
GWP_{CH4}	Global warming potential of CH ₄ (tCO ₂ e/tCH ₄ , use value of 25)
T	Species / category of livestock

3 <http://www.fao.org/faostat/en/#home>.

The default methane emission factor by average annual temperature for animal manure management for the dairy cow category ($1 \text{ kgCH}_4/\text{heat}/\text{yr}$) was obtained from Table 10.14 of the IPCC Guidelines. Using the same animal population data obtained from FAOSTAT used in the enteric fermentation baseline calculation, baseline emissions from animal manure management amount to $87,500 \text{ tCO}_2\text{e}/\text{yr}$.

Therefore, the total baseline emissions for the dairy sector covered by the NAMA amount to $4,112,500 \text{ tCO}_2\text{e}/\text{yr}$.

5.2. Sustainable Development Baseline

The sustainable development baseline represents the continuation of the current agricultural practices in Uganda. The country's sustainable development goals as defined in the publication, Uganda, Our Constitution, Our Vision, Our SDGs.⁴ The publication describes critical milestones in Uganda's development landscape which coincide with the shaping of the global development agenda. This was evident in the 1995 constitution which has many elements of the Sustainable Development Goals (SDG). This NAMA contributes to the country's constitution and sustainable development goals through the following national objectives and directive principles:

- The right to development
- Food security and nutrition
- Recognition of the role of women in society
- Balanced and equitable development
- General social and economic objectives
- Provision of adequate resources for organs of government, role of people in development, role of the state in development, foreign policy objectives, duties of a citizen

4 United Nations, Uganda. Uganda, Our Constitution, Our Vision, Our SDGs. <http://www.un-ug.org/sites/default/files/reports/Ourper cent20SDGspers cent20Uganda.pdf>.

6

NAMA IMPLEMENTATION STRUCTURE

The NAMA implementation will consist of two components, technical assistance flows and financial assistance flows.

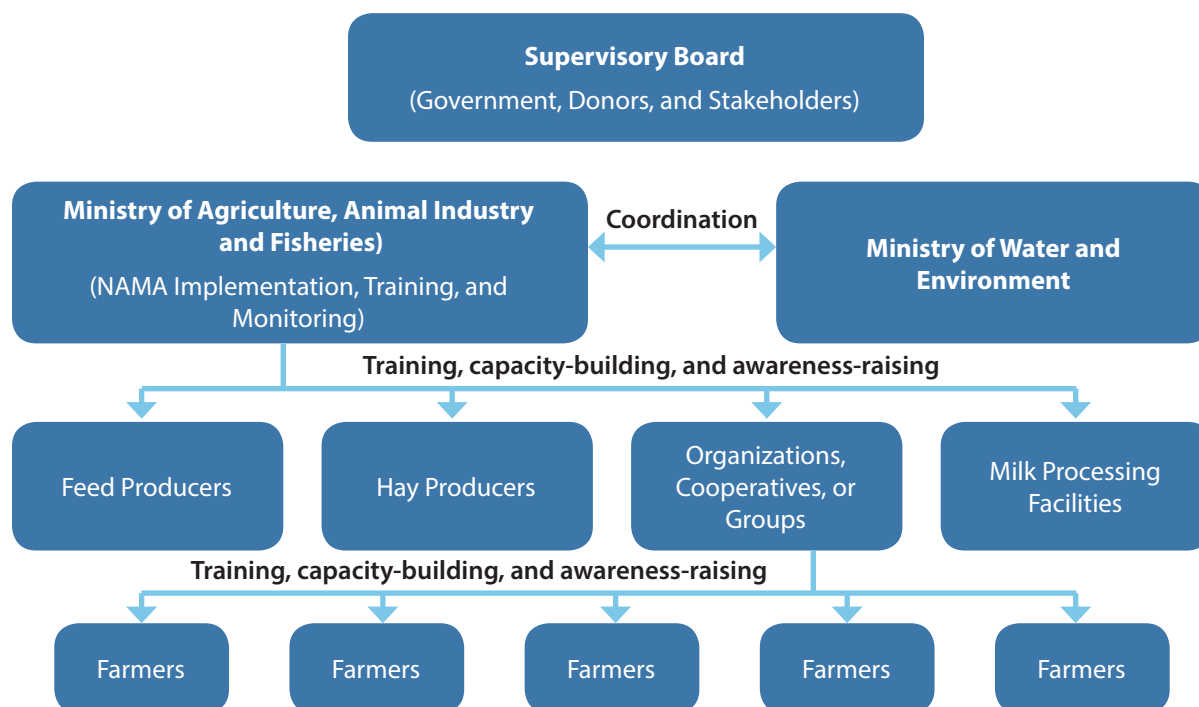
6.1. Technical Assistance Flows

The technical assistance will be channeled through the MAAIF, the NAMA Implementer. The content of the technical assistance will be agreed with the NAMA Supervisory Board and will be fine-tuned in regular consultations with stakeholders.

The NAMA Implementer will provide the necessary training, capacity-building, and awareness-raising to key stakeholders such as cooperatives in a train-the-trainers approach to allow for scale and replicability of the NAMA interventions.

Farmers' organizations, cooperatives, or groups will be provided with the knowledge and skills to train the individual participating farmers of the NAMA. This will be a train-the-trainers activity for proper feeding strategies, use of quality feeds, diet manipulation, and use of hay, among others. The organizations, cooperatives, or groups will be tasked to disseminate awareness to farmers about the economic benefits of participating in the NAMA.

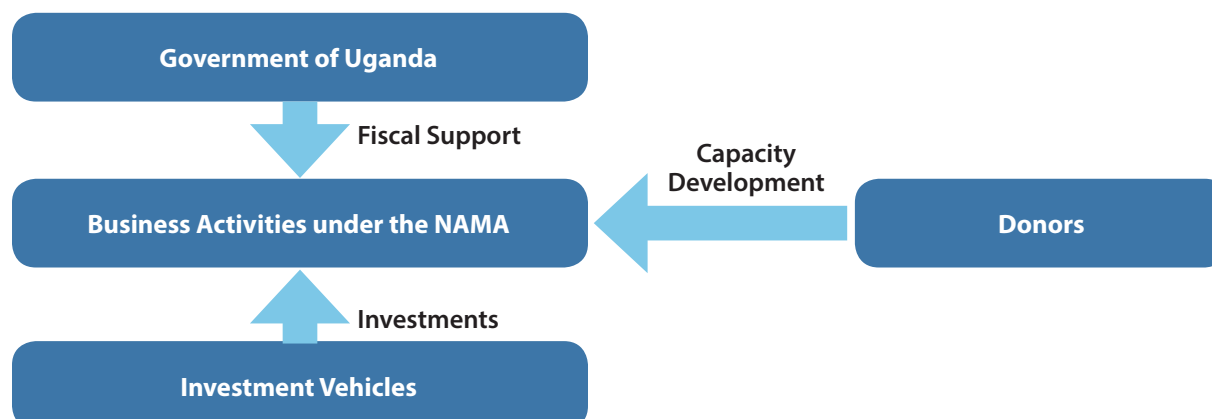
The NAMA Implementer will develop a manual that farmers will use as reference in implementing activities that reduce methane emissions from enteric fermentation such as appropriate feeding strategies, feed supplements and additives, and diet manipulation. For activities that reduce methane emissions from improved treatment of animal manure waste, the NAMA Implementer will serve as an information centre for farmers that seek information about available technologies. The NAMA Implementer will ensure that the sources of technologies are reputable and reliable, as well as ensure that proper transfer of know-how in operation and maintenance of such technologies is provided. The overall structure of the technical assistance flow is shown in the figure below.

Figure 7: NAMA Technical Assistance

6.2. NAMA Financial Assistance Flow

Financial support is needed if transformational reform of Uganda's agricultural sector is to be achieved. For this NAMA, the financial support for implementation will be carried through several existing funds and financial entities, thus not requiring any additional direct financial support for project implementations.

At the same time, this NAMA will require initial donor support for providing tax breaks/tax discounts and technical assistance for trainings and awareness-raising for the activities that are carried out under the NAMA. The support will be provided on an annual basis, once the government of Uganda confirms which activities have been implemented under the NAMA and the tax discount provided to them.

Figure 8: NAMA Financial Assistance

Examples of the activities to be supported by the NAMA have been provided in Section 4.5.

6.2.1. Existing Financial Vehicles

Yield Uganda Investment Fund



Yield Uganda Investment Fund (Yield) is a €12 million Fund to invest in Small and Growing Agribusinesses positioned in agricultural supply chains in Uganda. The Yield is being formed with the support of the European Union Delegation to Uganda and the International Fund for Agricultural Development, which have provided initial funding of €10 million, providing first loss protection to equity investors. The National Social Security Fund (NSSF) Uganda is providing funding of €2 million to the Fund. Due diligence is ongoing with prospective investors, looking to achieve a second closing by November 2017 with a total Fund size of €25 million in capital. The Fund is registered, domiciled, and managed in Uganda.

Broad investee criteria include:

- turnover < US\$ 5,000,000
- employees < 150
- asset base < US\$3,000,000
- actual or strong potential for high market share within the relevant industry segment
- entrepreneurs/management teams able to demonstrate expert market knowledge, a previous track record, leadership skills and a good reputation

Investment Strategy

- To deliver competitive financial returns to its investors while having a high social and developmental impact on smallholder farmers, thereby encouraging greater investment in the Ugandan agriculture sector as a whole
- Over the next 5 years, the Fund will invest in a minimum of 20 sustainable agriculture-related businesses in Uganda, with a total value of up to €22,500,000.

Investment Parameters

- Mix of equity, quasi-equity, and debt designed to generate Euro returns of 16% (equity) and 11% (debt)
- Active coinvestment strategy designed to offer Yield investors access to larger deal-sizes and to share investment management responsibilities
- Investment range from €250,000 to €2 million
- Avoidance of deal concentration in any one sub-sector or value chain location
- Clear social and developmental targets for each investment defined in advance

The investment process is presented below:

Origination	Deals sourced from management team or sourced externally via networks and strategic partners
Fund Manager	Undertakes all managerial activities for the Fund
Due Diligence	Companies that pass initial investment criteria enter due diligence phase Extensive due diligence checklist to be satisfied including full business development support needs assessment Use of external financial due diligence, including tax healthcheck, in partnership with Deloitte Uganda
Investment Committee	Investment Committee meets with all potential investee companies prior to approving investment
Final Investment Committee approval	
Documentation and disbursement	

The Fund is managed by Pearl Capital Partners (PCP) Uganda, which has been operating since 2005, and has unparalleled experience of investing in Ugandan agriculture-related businesses. This includes investments in more than 30 East African businesses to date, including nine in Uganda. PCP invests in the agribusiness value chain by focusing on the supply of farming inputs and services, and increasing market access to rural farmers instead of large scale agricultural production initiatives.

By backing early stage companies with solid business plans, strong entrepreneurial owners and growth strategies, Yield helps build agribusinesses that typically lack access to finance (due to lack of track record and/or collateral) but that, with investment and business development support, can:

- Grow into profitable, scalable businesses
- Graduate into larger financing rounds, engage other financial players and create economic growth

Potential project types currently in the pipeline:

- Staple crops—post-harvest handling, processing and distribution
 - A substantial rice-milling operation in Eastern Uganda
 - Investment in equity and debt: requirement US\$1–US\$1.5 million
- Aquaculture—production
 - A well-established Tilapia operation on Lake Victoria serving the regional market
 - Investment in mezzanine debt: requirement US\$1–US\$1.5 million
- Fruits—processing for domestic consumption and export
 - A high potential business buying from smallholder farmers in central

As of May 2017, the Yield Uganda Investment Fund is open for new proposals and is considered to be one of the financial vehicles to highest potential finance the activities under the NAMA.

Agdevco⁵

Africa Agricultural Development Company (AgDevCo) is a social impact investor and project developer operating exclusively in the agriculture sector in Africa. Their mission, to reduce poverty and improve food security, is underpinned by the belief that the best route out of poverty for the majority of Africa's rural poor is the development of profitable agriculture with strong links to markets. They invest in socially-responsible businesses, operating across the supply chain, which have the potential to make a major positive social impact in their communities.



AgDevCo's range of activities ensures that agribusinesses are supported with all their investment needs and supports businesses through:

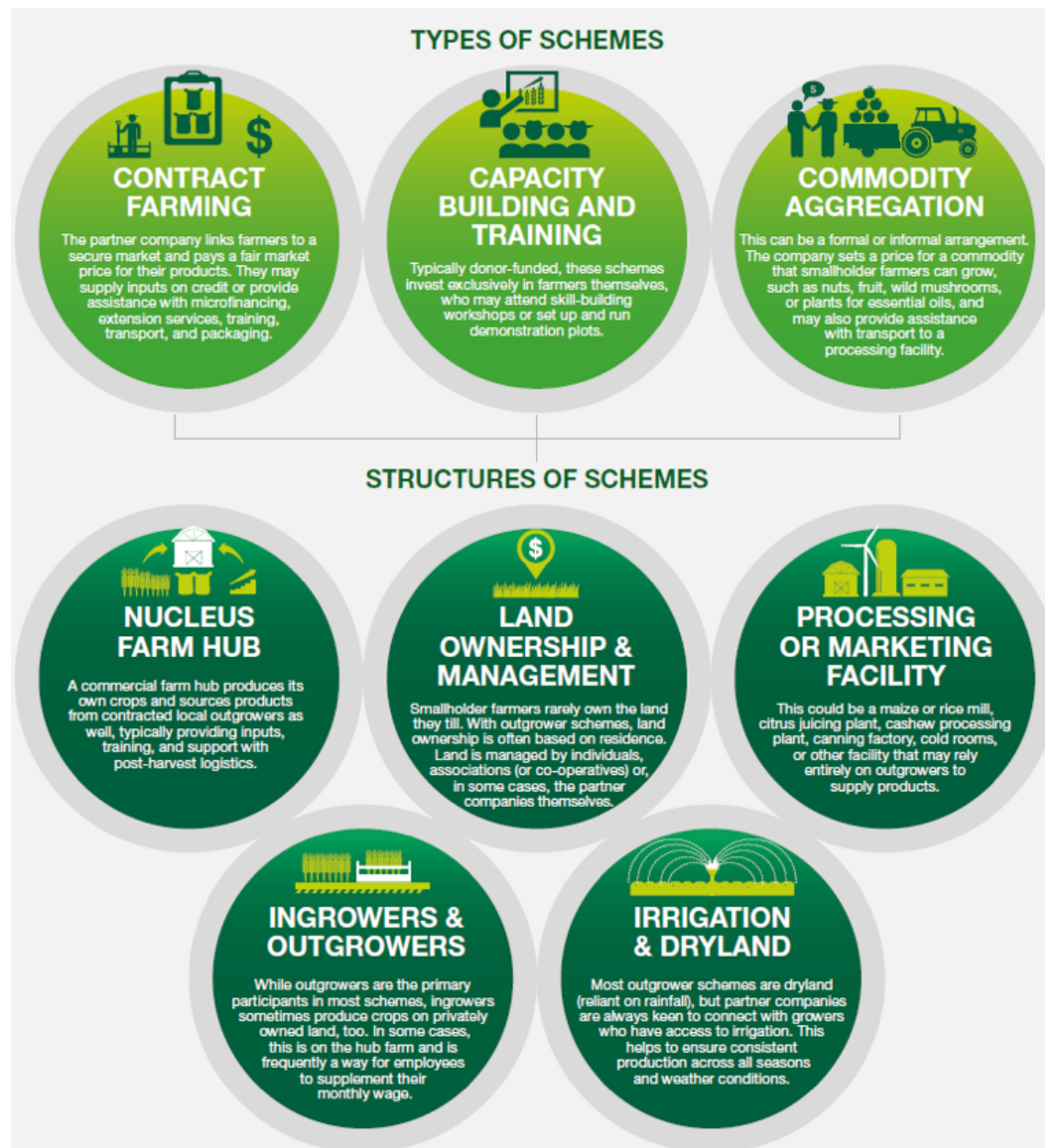
- Long-term, concessional finance for early stage agribusinesses
- Working capital, which is provided through LAFCo, the sister company
- Technical support and grant funding for smallholder schemes, through its Smallholder Development Unit

AgDevCo supports agriculture businesses that have linkages to small-scale and emergent farmers. Eligible businesses must be located in northern Uganda, or have strong links to farmers and/or customers in the north. By providing technical assistance in addition to capital, investees are helped to establish profitable operations that are capable of attracting third-party investing, thereby kick-starting a virtuous cycle of investment and economic growth in this neglected region.

5 <http://www.agdevco.com/our-investments/by-country/Uganda>.

A potential support scheme by AgDevCo is presented in the figure below.

Figure 9: AgDevCo Support Scheme



7

NAMA MONITORING, REPORTING, AND VERIFICATION

For the effective assessment of this NAMA's impact on GHG emissions and sustainable development benefits, a credible and transparent MRV framework is essential. A strong MRV framework would help the country receive due recognition for its contributions to GHG emission reduction and transformation to low-emission sustainable agriculture, while also increasing the likelihood of accessing international financial support.

7.1. GHG Emissions

The MRV system for assessing this NAMA's contribution to reducing GHG emissions is based on the 2006 IPCC Guidelines using the Tier 1 method. The calculation of baseline emissions from enteric fermentation and animal manure management makes use of default methane emission factors for simplified calculations.

Baseline emissions from enteric fermentation and animal manure management are calculated on an annual basis using the formulas and corresponding methane emission factors illustrated in Chapter 5, GHG Baseline. This allows for the baseline emissions to be estimated based only from the livestock population data within the NAMA boundary.

Project emissions are calculated using the same approach as the calculation of baseline emissions, using the formula:

$$PE_y = PE_{Enteric,y} + PE_{Manure,y}$$

Where:

PE_y	Project emissions in the year y (tCO ₂ e)
$PE_{Enteric,y}$	Project emissions from enteric fermentation in the year y (tCO ₂ e)
$PE_{Manure,y}$	Project emissions from manure management in the year y (tCO ₂ e)

Project emissions from enteric fermentation of livestock are calculated using the formula:

$$PE_{Enteric,y} = \sum_T (N_{T,y} \times EF_{PEEnteric,T} \times 10^{-3} \times GWP_{CH_4})$$

Where:

$PE_{Enteric,y}$	Project emissions from enteric fermentation in the year y (tCO ₂ e)
$N_{T,y}$	Number of head of livestock species / category T (head)
$EF_{PEEnteric,T}$	Enteric fermentation methane emission factor for the defined livestock population T in the project scenario (kgCH ₄ /head/yr)
GWP_{CH_4}	Global warming potential of CH ₄ (tCO ₂ e/tCH ₄ , use value of 25)
T	Species / category of livestock

The methane emission factor for enteric fermentation in the project scenario needs to be determined based on the dairy cattle's gross energy intake and percent of gross energy in the feed that is converted to methane that resulted from the proposed interventions.

An FAO report on reducing enteric methane for improving food security and livelihoods⁶ suggest that the mitigation potential of improving feed quality in dairy production in East Africa reaches 19 percent of baseline emissions. On a conservative estimate that the NAMA results in a 10 percent improvement in digestibility of feeds, and hence, decrease in enteric methane production, the NAMA is estimated to result in emission reduction of about 402,500 tCO₂e annually from its enteric fermentation component.

Project emissions from animal manure management are calculated using the formula:

$$PE_{Manure,y} = \sum_T (N_{T,y} \times EF_{PEManure,T} \times 10^{-3} \times GWP_{CH_4})$$

Where:

$PE_{Manure,y}$	Project emissions from manure management in the year y (tCO ₂ e)
$N_{T,y}$	Number of head of livestock species / category T (head)
$EF_{PEManure,T}$	Manure management methane emission factor for the defined livestock population T in the project scenario (kgCH ₄ /head/yr)
GWP_{CH_4}	Global warming potential of CH ₄ (tCO ₂ e/tCH ₄ , use value of 25)
T	Species / category of livestock

However, for the NAMA case, the methane emissions resulting from the use of biodigesters to treat animal manure, or biogas, will be collected and used to produce additional energy in the form of electricity or heat. It could be assumed that associated emissions from the operation of the biodigesters such as power used in operating the facility are negligible. Furthermore, the emission reductions resulting from the use of biogas displacing fossil fuel use (e.g., grid and off-grid electricity, cooking, etc.) will not be accounted for, as a conservative approach. Therefore, project emissions from the treatment of animal manure are zero. Emission reductions arising from the treatment of animal manure amounts to 87,500 tCO₂e annually.

Based on the approach described, the required monitoring parameters for the calculation of actual GHG emission reductions are significantly reduced, and only data for the total number of head of dairy livestock and resulting improvement in emission factor are needed.

The resulting total emission reduction from the NAMA is estimated to be around 490,000 tCO₂e annually. Uganda's NDC identifies 'Livestock breeding research and manure management practices' as one of the policies and measures for its additional mitigation ambition. In this context, the NAMA contributes to the country achieving its target for this sector. Uganda's national emissions in 2000, including Land Use Land Use Change and Forestry, were estimated at 36.5 MtCO₂e/yr, and emissions are projected to rise to approximately 77.3 MtCO₂e/yr in 2030. With a mitigation target of 22 percent emission reduction compared to business-as-usual levels in 2030, the NAMA contributes about 3 percent to achieving this target.

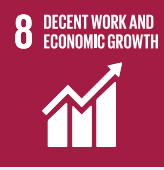
7.2. Sustainable Development Benefits

The NAMA will also cover sustainable development benefits and the impact and contribution of the NAMA to the country's sustainable development is assessed using the Climate Action Impact Tool.⁷ It is an online tool developed by UNDP to help in the assessment of climate action contributions to the SDGs. The tool is a bottom-up tool that can be applied to track 'significant, direct impacts' of actions.

Using the tool, all the necessary information about the NAMA was provided through its online interface. Results of the analysis show that the NAMA have significant positive impacts on the following SDGs.

7 http://impacti.solutions/undp_sdg/index.html#!/.

Table 6: NAMA Impacts on SDGs

SDGs	Impacts
 2 ZERO HUNGER	The NAMA contributes to ending levels of hunger and malnourishment in the community/country by increasing the milk and milk products supply. Aside from adding to the quantity of outputs, the NAMA also results in improved quality of the milk and milk products leading to better nourishment of consumers. The NAMA also contributes to promoting equal rights and incomes to poor farmers as they will have better access to markets.
 3 GOOD HEALTH AND WELL-BEING	The NAMA leads to reduction in air pollution beyond emission reduction by improving animal manure management through the use of biodigesters. Emissions causing bad odor and air pollution emanating from the decomposition of animal manure without proper treatment would be avoided.
 4 QUALITY EDUCATION	The NAMA promotes access to education for people with vulnerable background including indigenous people and people with low income. Its proposed measures and interventions include capacity building and training activities which would benefit farmers.
 6 CLEAN WATER AND SANITATION	The NAMA contributes toward waste and waste water management system including treatment, recycling, and reuse etc., through its activities involving improved treatment of animal manure waste.
 7 AFFORDABLE AND CLEAN ENERGY	The NAMA promotes access to affordable, reliable and modern clean technology/ services as it involves the utilization of biogas, the by-product of animal manure waste treatment using biodigesters, as a source of fuel that could be used for heat and electricity generation.
 8 DECENT WORK AND ECONOMIC GROWTH	The NAMA contributes to creating new employment opportunities for all including for women, youth and members of poor and vulnerable sections of the society; promotes economic growth in higher levels of economic productivity; and promotes innovation, entrepreneurship and growth of SMEs and micro enterprises, as a result of transforming the growth of the dairy value chain to a greener path.
 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	The NAMA promote the growth of small and medium sized enterprises (SMEs) and provide them appropriate support; enable industries to pursue resource efficient business practice and greater adoption of clean technologies; substantially reduce waste generation through prevention, reduction, recycling, and reuse; and promote a culture for innovation through enhanced scientific research and development and investments in new thinking, models and ways of doing business and value addition.
 12 RESPONSIBLE CONSUMPTION AND PRODUCTION	The NAMA is part of a long term national framework programme/ policy to promote sustainable consumption and production. It also promotes environmentally sound management of waste as per international best practices that reduce impacts on air, water and land.

SDGs	Impacts
	The NAMA results in the reduced emissions from enteric fermentation and animal manure management from livestock as well as improved resilience of the dairy sector. This contributes to the overall climate action targets of Uganda and the international community.
	The NAMA leads to reductions in water pollution (including reduction in marine pollution in seas and oceans) through the improvement in animal manure waste treatment. The effluents would be discharged to bodies of water and eventually makes its way to larger bodies of water.
	The NAMA will be implemented with the support from international partners, achieving both national and international goals.

Figure 10 shows a visual representation of the NAMA's contribution and impacts on the SDGs. The goals highlighted in the diagram indicate the SDGs that this NAMA has a particularly strong positive impact on.

Figure 10: NAMA SDG Impacts



In the project scenario, a quantitative analysis on the corresponding SDG impacts can be performed once the related quantifiable parameters are available.

7.3. Monitoring and Reporting Structure

The collection of monitoring data starts from the individual farmers that practice climate smart agriculture through the use of feeding strategies and feed supplements that result in the reduced production of methane from enteric fermentation, and/or through the use of biodigesters in treating animal manure waste and using its by-product, i.e., biogas and sludge, as additional fuel source and fertilizer, respectively.

Participating farmers records the necessary data for the NAMA in order to calculate the GHG emission reductions and SDG impacts, as well as information to demonstrate their compliance with the NAMA requirements. Necessary data to be monitored and recorded by the farmers for the calculation of GHG emission reductions include:

- Total livestock population in every year (or production cycle) segregated per species.

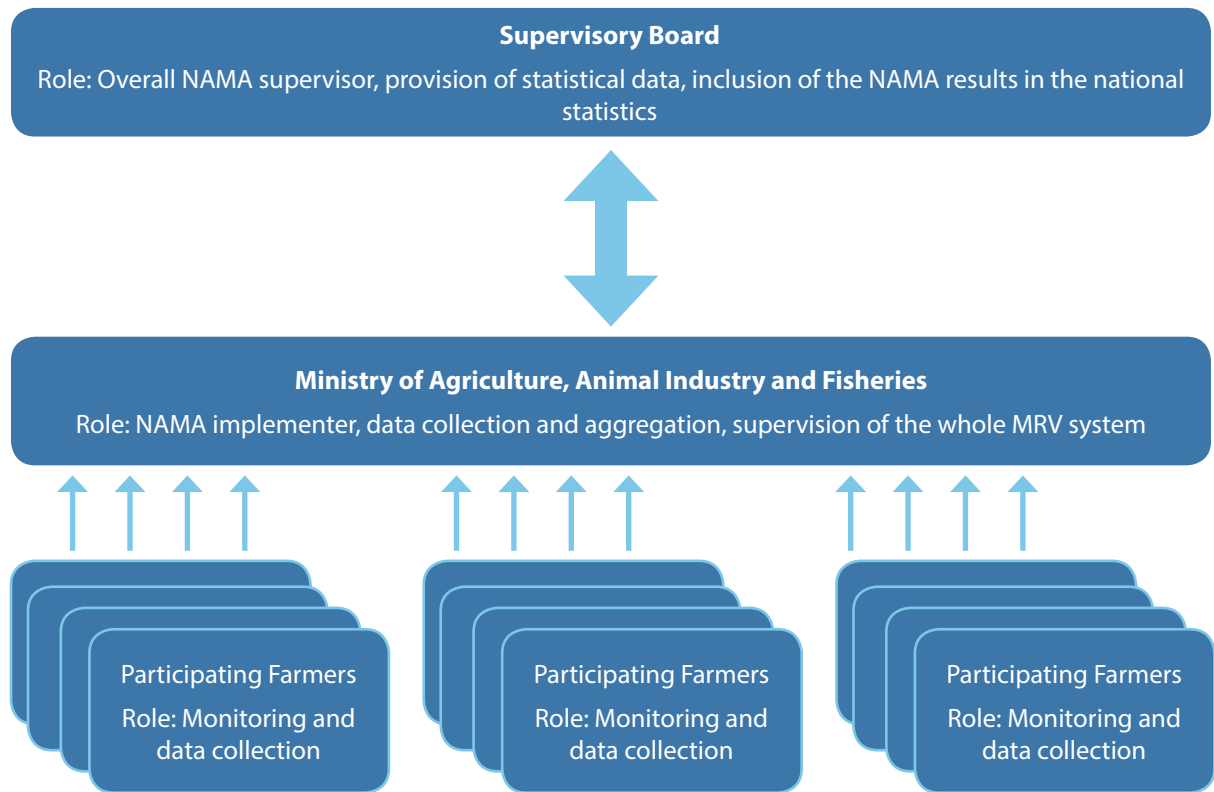
For the monitoring of SDG impacts:

- Amount of biogas produced, if any and measurable.
- Amount of electricity generated from biogas, if any.
- Amount of biogas used as fuel for other uses aside from electricity generation, if any and measurable.
- Amount of sludge collected and used or sold as fertilizer.
- Productivity (product yield per unit of livestock)

For the monitoring of compliance with NAMA requirements:

- Sources of feeds (from certified producers or not)
- Amount of feeds from each source (to be cross-checked with the feed intake requirements of the livestock population)

Participating farmers fill up information on a farmer monitoring sheet, recording all the required information. During the end of every production cycle, or annually, the completed farmer monitoring sheets will be collected by their corresponding farmers' cooperatives, associations, or groups. The farmers' cooperatives, associations, or groups collate the individual data collected from their member farmers and reports it on their cooperative/association/group monitoring sheet. This information is then forwarded to the NAMA Implementer for data processing, aggregation, and archiving. Figure 11 shows the overall flow of the monitoring and reporting structure of the NAMA.

Figure 11: Monitoring and Reporting Structure

8

TIMELINES

The NAMA will be implemented over a period of five years.

Figure 12: NAMA Timeline

Interventions	Year 1	Year 2	Year 3	Year 4	Year 5
Introduction of Feed Standards and Certification System					
Introduction of a Labelling System					
Production of Improved Animal Feed					
Production and Supply of Hay					
Establishment of Milk Collection and Storage Points					
Livestock Manure Management and Biogas Production					
Capacity-Building and Public Awareness					

During the first year, the feed certification system and the labelling system will be introduced. This will be the precondition for the successful implementation of the remaining activities. The capacity building and public awareness campaign will also start from the first year and continue throughout the duration of the NAMA.

From the second year, improved animal feed and hay production are expected to start and be operated under the established certification and labelling standards. The adoption of the new feeds, supported by the ongoing awareness campaign is expected to take approximately one year. Therefore, from the third year, it is proposed to start the establishment of the milk collection and storage points, where proper control on milk quality can be executed. The establishment of the milk collection points and the further promotion of improved feed and hay production will also coincide with the active promotion of animal manure management measures from the third year.

The number of projects under the NAMA are expected to start growing from Year 2 and reach their peak around the end of Year 4. At the end of the five year period of the NAMA a new low-carbon dairy supply chain will be established and will be fully functional in Uganda in line with the targets of this NAMA.

ANNEX: MEASURES TO REDUCE ENTERIC FERMENTATION

1. Interventions to improve productivity of livestock and reduce GHG emissions

a. Introducing high yielding planted forages into existing systems

Describe how this is achieved	■ Screening, establishment, management and use of planted fodder grasses and legumes.
Describe impacts of intervention	■ Improved high yielding forage will lead to increased dry matter (DM) and total digestible nutrients intake leading to increased milk production in milking cows and improved growth rates in growing cattle.
Identify to what production system this intervention is applied	■ Mainly suitable for small and medium scale intensive and semi intensive production systems.
Identify to what category of animals the intervention is applied	■ Mainly suited to ruminant bovine animals. Improved animals record higher impacts (returns on investment). Bovine dominate the commercial dairy herd.
Quantified impacts are based on studies or field experience. Reference/source are provided	■ Feeding Napier grass or improved pasture enhances DM intake by 6.7 to 9.2 kg/day compared to animal on natural pastures and increases milk production by about 1.6 litres per day (Ongadi and others, 2010); Improved planted Napier varieties produce 10–22 t/ha DM, (Lukuyu and others, 2012b). ■ Feeding heifers with a mixture of Desmodium spp. and Napier grass (grown together) can result in an increase in feed intake by 1 kg DM/day, live weight gain by 0.06kg/day and a carrying capacity of 0.7 heifers/ha/year (Kariuki and others, 2001).
GHG impacts	■ Improvement in dairy productivity per unit of CH₄ emitted in terms of early maturity of heifers and high milk production will result in a reduction of methane emission from livestock production. ■ Highly digestibility diets with high energy high protein concentrations produce less CH₄ per unit of livestock product and could reduce CH₄ emissions from beef production by 15–30 percent (Gurian-Sherman, 2011). ■ Tropical forages, in particular Brachiaria spp., have been shown to suppress N₂O emissions (Peters and others, 2013).

b. Integrating leguminous fodder trees and shrubs into existing systems

Describe how this is achieved	■ Screening, establishment and incorporation leguminous fodder trees and shrubs into basal diets of ruminant livestock.
Describe impacts of intervention	■ Leguminous fodder trees and shrubs are high in digestible nutrients, results in increase feed intake and milk production. ■ Fodder trees are more resistant to drought than annual crops, hence they can provide protein during the dry season when high quality feed is otherwise scarce. ■ Fodder trees and shrubs contain secondary metabolites like tannins which serve to reduce enteric production of methane.
Identify to what production system this intervention is applied	Mainly suitable for small and medium scale intensive and semi intensive production systems.
Identify to what category of animals the intervention is applied	Mainly suited to ruminant cattle, sheep and goats.
Quantified impact is based on studies or field experiences. Reference/sources are provided	■ Supplementary feeding with 1 kg of dried <i>Calliandra calothyrsus</i>, which a 24 percent crude protein (CP) and 60 percent digestibility can result in an average increase of 0.75 kg of milk/day (Paterson, Kiruiro, and Arimi (1999) . ■ Supplementing with 1 kg DM of <i>Leucaena leucocephala</i> could result in an extra 0.5kg of milk/day (Reynolds and Jabbar, 1994). ■ One kilogram of dried <i>Calliandra calothyrsus</i> leaf is estimated to contain the same amount of digestible protein as the same weight of the commercial dairy meal (Roothaert, Franzel, and Kiura, 2003). A farmer needs approximately 500 <i>Calliandra calothyrsus</i> trees to provide sufficient feed for one cow throughout the year.
GHG impacts	■ Legumes contain more condensed tannins than does grass, and adding them to the diet can further reduce CH₄ emissions per unit of meat or milk produced. (Wanapat and others, 2013). ■ Methane emissions are also commonly lower with higher proportions of forage legumes in the diet, partly due to lower fibre content, faster rate of passage and, in some cases, the presence of condensed tannins.

c. Enhancing the use of food – feed crop varieties as livestock feeds

1. Roots and tubers
 - i. Sweet potato
 - ii. Cassava
 - iii. Banana
 - iv. Fodder roots and tubers,—turnips, beetroots etc.

Describe how this is achieved	■ Establishment, management and use of common dual purpose crop species and varieties.
Describe impacts of intervention	■ Sweet potato vines have a high CP, OM and digestibility which results in an increase in basal diet intake and performance of the animal. ■ There is potential for better use of sweet potato and other root tuber crops residues as livestock feed particularly in the smallholder pig farming systems in Uganda. ■ Being a major staple food in Uganda (Collinson and others, 2003), cassava is widely distributed in the country. Feeding cassava hay on bovine increases DM, OM and CP digestibility and intakes (Chanjula and others, 2007). Utilization of cassava as livestock feed can result in improved animal protein production and mitigation of its waste and by-products. In addition cassava is important as a drought tolerant crop capable of growing on marginal soils, hence providing a source of dry season feeds. ■ Whereas sweet potato, banana and other root and tuber 'residues', such as vines, leaves and peels are commonly used as livestock feeds in Uganda, at time of harvest there is an excess of feed that goes to waste. If conserved, this fodder can be used during periods of scarcity.
Identify to what production system this intervention is applied	■ Small and medium scale intensive and semi intensive production systems.
Identify to what category of animals the intervention is applied to	■ Suited to all categories of livestock.
Quantified impacts are based on studies or field experiences Reference/sources are provided	■ Feeding sweet potato vines at a rate of 20kg/cow/day has been shown to increase milk production by approximately 4kg/day (Ashiono and others, 2006). Ashiono et al. (2006) reported a 4kg/day increase in milk yield when 20 percent sweetpotato vines were included in diets of dairy cattle fed on a sorghum silage basal diet. ■ Despite recognized nutritional shortcomings due to presence of toxic cyanogenic compounds, processed cassava root/peels can serve as an energy ingredient when combined with appropriate nitrogen sources, substituting for maize at up to ~40 percent of total diets in cattle, 20 to 50 percent in small herbivores (goats, sheep, rabbits), and up to 100 percent in swine diets, 10 to 40 percent in various poultry diets, and 15–30 to > 60 percent in aquaculture diets (Lukuyu and others, 2014).

GHG impacts	■ Improved milk production per cow will result in reduced rumen methane emissions ■ Recent developments, based on enriching protein in cassava chips, have yielded yeast fermented cassava chip protein (YEFECAP) providing up to 47.5 percent crude protein (CP), which can be used to replace soybean meal, and which substantially improves efficiency of rumen fermentation and subsequent ruminant productivity as well as mitigating rumen methane (Wanapat, Kang and Polyorach, 2013). ■ Banana peels found rotting in many corners of Kampala and other urban centres can be dried and used as animal food, which has proven to be a way to reduce city waste while producing inexpensive animal feed. This banana bran is highly nutritious, containing protein, phosphorus, and calcium.
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2. Interventions that improve feed efficiency through processing and diet manipulation

a. Better utilization of local feed resources.

Describe how this is achieved	■ Formulate rations using local feed resources such as cereal by products, oil seed cakes, mineral leaks, vegetable waste, fruits and tree leaves, bone meals, fish meals etc.
Describe impacts of intervention	■ There is availability of a wide variations of local feeds that allows formulation of difference rations hence giving farmers options to choose from. ■ Rations formulated based on local feed resources have a huge potential to improve milk production on smallholder farms.
Identify to what production system this intervention is applied	■ Applicable to all production systems.
Identify to what category of animals the intervention is applied to	■ All categories of livestock.
Quantified impacts are based on studies or field experiences. Reference/sources are provided.	■ Intake of DM and apparent digestibility of DM and crude protein were increased when water spinach replaced up to 15 percent of the DM of the basal diet of rice bran. There is a positive responses in growth rate of gilts when rice distillers by-product was added at the 10 percent level to the basal diet of rice bran and water spinach (Taysayavong and Preston 2010).

GHG impacts	■ Increased feed digestibility will result in reduced CH₄ emissions per unit of meat or milk produced. ■ The use of plant extracts or plants containing secondary compounds (e.g., condensed tannins and saponins), plants rich in minerals and plant essential oils (e.g., garlic, eucalyptus leaf powder) increases animal productivity, reduces CH₄ production while contributing to environmental sustainability (Wanapat, Kang and Polyorach, 2013).
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b. Enhancing quality and utilization of concentrate feeds on the market

Describe how this is achieved	■ Introduce strategies to improve quality of commercial feed concentrate on the market. ■ Optimize the use of concentrate feeds amongst farmers.
Describe impacts of intervention	■ Supplementing dairy cattle with high quality concentrate feeds has the potential to double milk production, improve reproductive performance and improve health performance of cattle, sheep and goats.
Identify to what production system this intervention is applied	■ All production systems.
Identify to what category of animals the intervention is applied	■ Suited to all categories of livestock.
Quantified impact are based on studies or field experiences Reference/sources are provided	■ When Napier grass is supplemented with 0.5 kg dairy meal per day in early and 1 kg in late lactation resulted in an increase in one calf in the lifetime of a cow, and an increased milk production from 1000 to 1400kg in a lactation (Rufino and others, 2009). ■ Increasing the level of concentrates from 2 kg/day in the whole lactation to 4 kg/day for the first half of lactation; or 8kg/day for the first quarter of lactation, reduces the number of open days from 106 to 99, and 90 days respectively and services per conception from 2.2 to 2.0 and 1.5 times respectively and increases milk production between the first 75 and 150 days of lactation from 611 to 629 and 766 kg respectively (Kaitho and others, 2001).
GHG impacts	■ Increased milk production per cow will result in reduced rumen methane emissions per unit of milk produced.

c. Enhancing the utilization of cereals and legumes crop residues

- i. Maize stover
- ii. Rice straw
- iii. Wheat straw
- iv. Bean, cow pears, groundnut haulms etc.
- v. Others

Describe how this is achieved	■ Introduce strategies to improve harvesting and storage of crop residues. ■ Introduce strategies to treat and process crop residues. ■ Introduce strategies to formulate crop residue based diets. ■ Improving farmers' access to knowledge and technologies on production of quality crop residues. ■ Improving farmers' knowledge and skills in feeding livestock on treated and conserved crop residues and agro-industrial by products, hence improved dry season feeding and sustained all year livestock productivity.
Describe impacts of intervention	■ Maize stovers are major crop residues that could be utilized in livestock farms to provide maintenance diets particularly in periods of feed scarcity. ■ Forage chopping enables farmers to effectively mix crop residue based rations.
Identify to what production system this intervention is applied	■ All livestock production systems.
Identify to what category of animals the intervention is applied	■ Suited to all categories of livestock.
Quantified impacts are based on studies or field experiences Reference/sources are provided	■ Unpublished data from work done in Tanzania show that mixing crop residue rations in the right proportions gives high quality feed ration (CP of 10-12 percent; OMD of 49-55 percent) (Lukuyu 2016). ■ Crop residue based ration increased milk production by between 1.5-2.5 litres per day in just 4 weeks of the trial.
GHG impacts	■ Agricultural residues (for example, cotton residues, rice straw) are sometimes burned in the field after harvest, releasing CH₄ and other GHGs. In Uganda, about 32 percent of the total crop residue is burned. This residue could be utilized as livestock feed, reducing GHG from agricultural burning while at the same time improving livestock productivity to reduce GHG produced per unit of livestock product.

d. Utilization of industrial by products in rations for livestock

- i. Brewers' waste
- ii. Biofuel waste

Describe how this is achieved	■ Incorporate industrial waste in on-farm ration formulation
Describe impacts of intervention	■ Wet brewers' waste (WBW) is high in energy and protein. It is very suitable for dairy cows and has a reputation for stimulating milk production. ■ WBW could improve the nutritional status of dairy cattle particularly in stall feeding systems where crop wastes and agro-industrial by-products form a major proportion of the diet.
Identify to what production system this intervention is applied	■ Small and medium scale intensive particularly zero-grazing production systems that dominate the urban and peri-urban centres. Feasible in areas close to breweries.
Identify to what category of animals the intervention is applied	■ Suited to all categories of livestock.
Quantified impacts are based on studies or field experiences Reference/sources are provided	■ Brewers' grain may incorporated into rations fed to dairy cattle at 25 percent, sheep at 10 percent and beef cattle at 20 percent of total dry matter. ■ Incorporation of brewers' dried grains (BDG) in poultry ration at 20 percent DM can result in increase in egg weight, feed intake per bird per day in breeder birds (Mafeni and Fombad, 2001). ■ Incorporation of brewery waste at 25 percent level in concentrate mixture (DM basis) of early lactating crossbred cows producing about 10 kg milk per day reduced the cost of feed per kg milk produced by 24 percent. Therefore, in areas that are close to a brewery it seems profitable to include brewery waste in dairy rations at the level of 25 percent (DM basis) in concentrate mixture (Senthilkumar and others (2012).
GHG impacts	■ Methane production from fermented cassava roots can be reduced further by supplementation with brewers' grains and rice distillers' by-product. ■ Increased productivity from feeding brewers' grain results in lowered GHG production per unit of livestock product.

e. Supplementation using oilcakes;

- i. Whole cotton seed,
- ii. Cold-pressed canola meal,
- iii. Sunflower meal
- iv. Brewers grain
- v. Groundnut cake

Describe how this is achieved	■ Screening and incorporating different dietary oils— all by-products from other agricultural processes—into livestock rations. ■ Stakeholder engagement, training and certification schemes. ■ Catalysing use of concentrate feeds amongst farmers.
Describe impacts of intervention	■ These by-products add energy to the diet; hence they will also increase milk production.
Identify to what production system this intervention is applied	■ Small and medium scale intensive particularly zero-grazing production systems that dominate the urban and peri-urban centres.
Identify to what category of animals the intervention is applied	■ Suited to all livestock but particularly ruminant livestock.
Quantified impacts are based on studies or field experiences Reference/sources are provided	■ The inclusion of sunflower oil to the diet of cattle resulted in 22 percent decrease of methane emissions. The addition of canola oil at 0 percent, 3.5 percent, or 7 percent to the diets of sheep reduced the number of rumen protozoa by 88-97 percent (Machmüller and others, 1998).
GHG impacts	■ Dietary oils like coconut oil, sunflower oil, mustard oil, and linseed have been found to reduce methane production in rumen (Machmüller and others, 1998). ■ Feeding grape marc to dairy cattle reduced methane by up to 20 percent. ■ For every 1 percent extra oil added to the diet of livestock, enteric methane can be reduced by 3.5 percent. The upper limit for dietary fats and oils in feed is 7 percent

3. Interventions that reduce GHG emissions through targeting the rumen environment

a. The use of Feed additives: plant extracts and rumen modifiers

- i. condensed tannins, saponins, essential oils
- ii. yeast, bacterial direct fed microbials, and enzymes

Describe how this is achieved	■ Screening and incorporating plant extracts and rumen modifiers into livestock rations. ■ Stakeholder engagement, training and certification schemes. ■ Catalysing use of fortified concentrate feeds amongst farmers. ■ Catalyse the use of Direct Fed Microbials (DFM) and enzymes. ■ Commonly used DFM include species of Lactobacillus, Bifidobacterium, Enterococcus, Streptococcus, Bacillus and Propionibacterium, all of which are used for ruminants, monogastric animals and even humans, or as inocula for dairy product processing.
Describe impacts of intervention	■ Supplementation of ruminant diets with Essential Oils results in reduction in methane production. ■ Garlic oil has been reported to reduce the emission of CH₄. ■ Adding exogenous enzymes to ruminant diets has the potential to increase productivity. ■ Enzymes enhance the digestibility of feed as well as decreasing production of GHG from livestock production systems.
Identify to what production system this intervention is applied	■ All livestock production systems.
Identify to what category of animals the intervention is applied	■ Suited to all livestock.
Quantified impacts are based on studies or field experiences Reference/sources are provided	■ Supplementation with rain tree pod (Samanea saman) meal and palm oil to diets of lactating cows decreased methane production and increased milk yield, content of milk protein and milk fat (Antasook and others, 2015).
GHG impacts	■ Five essential oils (EOs), namely, clove oil (CLO), eucalyptus oil (EUO), garlic oil (GAO), organum oil (ORO), and peppermint oil (PEO) have been tested and found to significantly reduce methane production. ■ Tannins, as feed supplements or as tanniferous plants, have a potential for reducing CH₄ emission by up to 20 percent (Kataria, 2015).

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