# Quick Scan of Uganda's Forage Sub-Sector

## Netherlands East African Dairy Partnership (NEADAP)

## Working Paper

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This report describes Uganda's forage sub-sector. It looks at the current situation of available forage species and their quality, seasonality, preservation, forage seeds and planting material, fertilizer use, mechanisation, inputs and services, the forage market, education and training, innovations, environmentally sustainable forage production and policies and regulations affecting the forage sub-sector. The report gives recommendations to enhance availability of quality forages. The report is an output of Theme 2: Forages and nutrition of dairy cows, of the Netherlands East African Dairy Partnership project (NEADAP). NEADAP is an initiative by the Netherlands government for learning and sharing amongst different dairy sectors and projects in East Africa.



NEADAP
NETHERLANDS EAST AFRICAN DAIRY PARTNERSHIP

Milk Quality | Forage & Nutrition | Inclusive Business Models | Networking & Influencing | Innovation

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# Acronyms

| | |
|---|---|
| ATAAS | Agricultural Technology and Agribusiness Advisory Services Project |
| ADL | Acid Detergent Lignin |
| AESIF | Agricultural Education and Skills Improvement Framework |
| AET | Agricultural Education and Training |
| AEZ | Agro-Ecological Zones |
| ATC | Agricultural Training Centre |
| A.I. | Artificial Insemination |
| ASAL | Arid and Semi-Arid Land |
| ASARECA | Association for Strengthening Agricultural Research in Eastern and Central Africa. |
| BMZ | German Federal Ministry for Economic Development Cooperation |
| BRIDGE | Building Rural Income through Inclusive Dairy Business Growth in Ethiopia |
| CA | Conservation Agriculture |
| CBO | Community Based Organisation |
| CIAT | International Centre of Tropical Agriculture |
| CIP | International Potato Centre |
| CP | Crude Protein |
| CSA | Climate Smart Agriculture |
| DairyBiss | Dairy Business Information and Support Project |
| DDA | Dairy Development Authority |
| DM | Dry Matter |
| DUS | Distinctiveness, Uniformity and Stability test |
| EAAPP | Eastern Africa Agricultural Productivity Project |
| ECHO | European Commission's Humanitarian Aid Office. |
| EDGET | Enhancing Dairy Sector Growth in Ethiopia |
| FE | Feed Efficiency |
| FEWS NET | Famine Early Warning Systems Network |
| GHG | Green House Gases |
| GIZ | German Corporation for International Cooperation GmbH |
| GOU | Government of Uganda |
| ICARDA | International Centre for Agricultural Research in Dry Areas |
| ICIPE | International Centre for Insect Physiology and Ecology |
| ICRAF | International Centre for Research in Agro-Forestry |
| ICT | Information and Communication technology. |
| IFT | Improved Forage Technology |
| ILRI | International Livestock Research Institute |
| ISSD | Integrated Seed Sector Development |
| ISTA | International Seed Testing Association |
| KMDP | Kenya Market-Led Dairy Program |
| LSB | Local Seed Business |
| LSF | Large Scale Farm |
| LULUCF | Land Use Land Use Change and Forestry |
| MAAIF | Ministry of Agriculture, Animal Industry and Fisheries |
| MASL | Metres above sea level |
| ME | Metabolic Energy |
| MjME | Mega Joules of Metabolic Energy |
| MNC | Multi-National Companies |
| MSF | Medium Scale Farm |
| NAADS | National Agricultural Advisory Services |

| | |
|---|---|
| NAES | National Agricultural Education Strategy |
| NaFORRI | National Forestry Resources Research Institute |
| NARI | National Agricultural Research Institute |
| NARO | National Agricultural Research Organization |
| NaLirri | National Livestock Resource Research Institute |
| NAMA | Nationally Appropriate Mitigation Action |
| NaRL | National Agricultural Research Laboratories |
| NARO | National Agricultural Research Organization |
| NARS | National Agricultural Research System |
| NDF | Neutral Detergent Fibre |
| NDFd | Neutral Detergent Fibre Digestibility |
| NGO | Non-governmental organisation |
| NIR | Near Infra-Red |
| NIRS | Near Infra-Red Spectrometer |
| NPT | National Performance Trial |
| NSCS | National Seed Certification Service |
| NVPT | National Variety Performance Trials |
| NVRC | National Variety Release Committee |
| NWO-WOTRO | Netherlands Organisation for Scientific Research |
| OECD | Organization for Economic Cooperation and Development |
| PMR | Partial Mix Ration |
| PMS | Partial Milk Substitute |
| PUM | Netherlands Senior Experts Programme |
| SHF | Smallholder Farm |
| SIDA | Swedish International Development Cooperation Agency |
| SNV | SNV - Netherlands Development Organisation |
| SOPs | Standard Operational Procedures |
| TAE | Tertiary Agriculture Education |
| TIDE | The Inclusive Dairy Enterprise |
| TMR | Total Mix Ration |
| UNADA | Uganda National Agro-Input and Dealers' Association |
| UNDP | United Nations Development Program |
| USTA | Ugandan Seed Traders Association |
| VCU | Value for Cultivation and Use |
| WHO | World Health Organisation |
| WUR | Wageningen University & Research |
| ZARDI | Zonal Agricultural and Development Research Institutes |

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# Introduction and Summary

## *This report*

SNV Netherlands Development Organisation (SNV) implements (TIDE) , funded by the Embassy of the Kingdom of the Netherlands in Nairobi. The Dutch Government also funds dairy programmes in Kenya (KMDP) and Ethiopia (EDGET, BRIDGE and DairyBiss) and this involvement in East Africa led in 2018 to a regional project for learning and exchange: Netherlands East African Dairy Partnership (NEADAP). In NEADAP focus is on three themes: Milk Quality, Forage (and dairy cow nutrition) and Inclusive Business Models and sharing of lessons learned for 5 countries: Ethiopia, Kenya, Ruanda, Tanzania and Uganda. Implementing partners of NEADAP are SNV, Agriterra, WUR and Bles Dairies.

In the Forage Theme SNV Kenya/KMDP – with the support of WUR Livestock Research - takes lead and developed a framework for Forage Quick Scans for Kenya, Uganda and Ethiopia. The quick scans focus on the current status of forage crops availability, production and preservation practices, technologies, mechanisation and innovations. This includes forages produced and preserved by the farmer in different farming systems: intensive farming (zero grazing), semi-intensive (semi-zero grazing, fenced grazing on improved pastures) and extensive livestock systems (grazing on natural grassland, ranching, agro-pastoralism). The study also pays attention to the commercial forage producers and agricultural contractors that have emerged in the Ugandan forage sub-sector.

This report of the forage sub-sector in Uganda is a Working Paper prepared under the umbrella of Netherlands East African Dairy Partnership (NEADAP). It serves as a reference document and input for a Strategy Paper and Policy Brief for consideration by relevant Ugandan agencies and stakeholders. NEADAP is financed by the Government of the Kingdom of the Netherlands.

## *The Ugandan dairy and forage sub-sector*

Uganda is located along the equator in East Africa. The landlocked country occupies about 241,550.7 km2, of which 41,027.4 km2 is open water and swamps while 200,523.5 km2 is land (Map 1). Uganda is bordered by Kenya in the East, Tanzania and Rwanda in the south, the Democratic Republic of Congo in the west, and South Sudan in the North. In 2011, agricultural land as a share of land area for Uganda was 71.2%, of which 34.3% is arable land; 11.3% permanent crops; 25.6% permanent pasture; 14.5% forest and 14.3% others (World facts 2011 est.). Uganda has significant natural resources, including ample fertile land, regular rainfall and the agricultural area irrigated was 10.6 thousand hectares in 2013 (World Data Atlas 2018)
The land use/cover utilization types are highly influenced by the amounts of rainfall received.
Uganda's population has also continued to grow rapidly from 9.5 million in 1969 to 44.7 million in 2019 (World population 2019 est.) . However, rapid population growth and environmental degradation pose a growing challenge to the continued productivity of the land resources (UBOS 2016).


Map 1. Map of Uganda

Agriculture is one of the most important sectors of the Ugandan economy. It contributes about 20 percent of GDP, accounts for 48 percent of exports and provides a large proportion of the raw materials for the industry (UBOS, 2006.) The sector employs 73 percent of the population aged 10 years and older. About 4.0 million households in Uganda survive on small-holder farming and a significant proportion, (about 30%), of the population live below the poverty line and suffer food insecurity (UBOS, 2010).

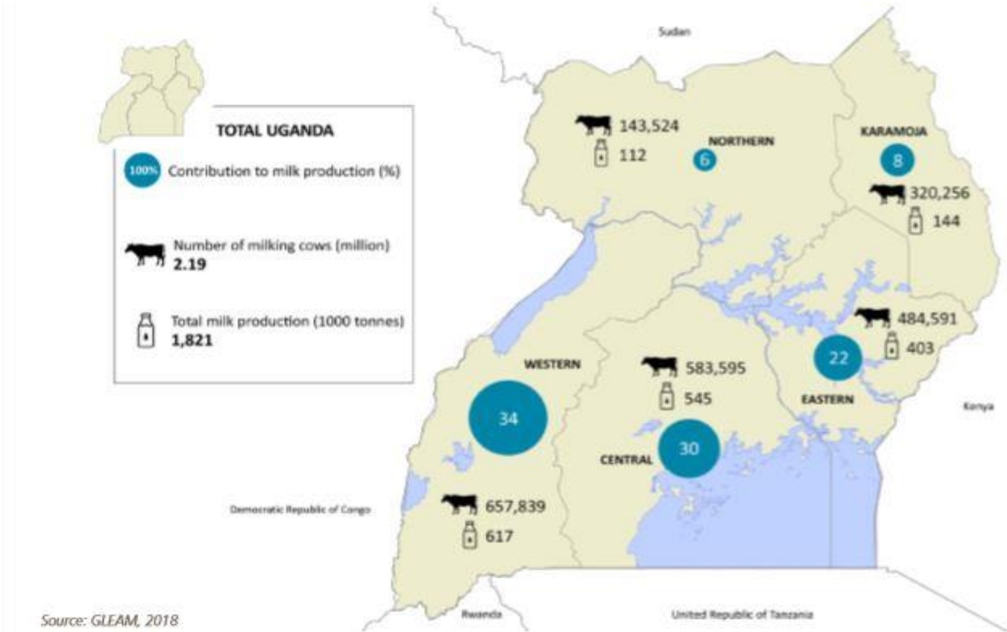
The dairy sector is one of the critical sectors in Uganda, with high potential for improving food security and welfare. Recent analysis provides clear evidence of increasing demand for dairy products (and other foods of animal origin) in Sub Saharan Africa (FAO, 2018).

Uganda Dairy Development Authority (DDA) has indicated that milk production in Uganda has increased from 2.08 billion litres in 2015 to about 2.5 billion litres in 2017/18 about 80% of the total national milk produced is marketed and 20% consumed by the farming households. Only 33% of the marketed milk is processed, 67% is marketed raw. Currently, according to Uganda DDA there are 219 Primary Dairy Farmers' Cooperative Societies and 11 Dairy Farmers Unions across the country (DDA, 2019).

According to the DDA the dairy sector contributes approximately 9% of the national GDP; playing an important role as a source of food, income, and employment. Additionally, DDA estimates that approximately 27% of all milk produced is lost. Of the lost milk, about 6% is wasted at the farm level, while 11% and 10% is either lost to spillage or spoilage during transport and marketing. The value of these losses is calculated at USD 23 million a year.

The DDA divides the country into 5 different so-called milk sheds namely Western, Central, Eastern, Northern and Karamoja contributing to respectively 37%, 24%, 21%, 11%, 7%. While the area of the south-western milk shed covers only 12.8% of all the districts of Uganda, DDA estimates that this milk shed contributes over 25% of the milk produced in the country. More recent figures in a FAO study show a similar contribution with Western and Central contributing respectively 34% and 30%. (FAO&NZAGGRC, 2019)(Map 2).

- Western region: has 22.3 percent of the cattle population and 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/day 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 centres (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, despite 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 (Agriterra, 2012).




Map 2. Milking cows, milk production and contribution to milk production per region (Source FAO/NZAGGRS 2019).

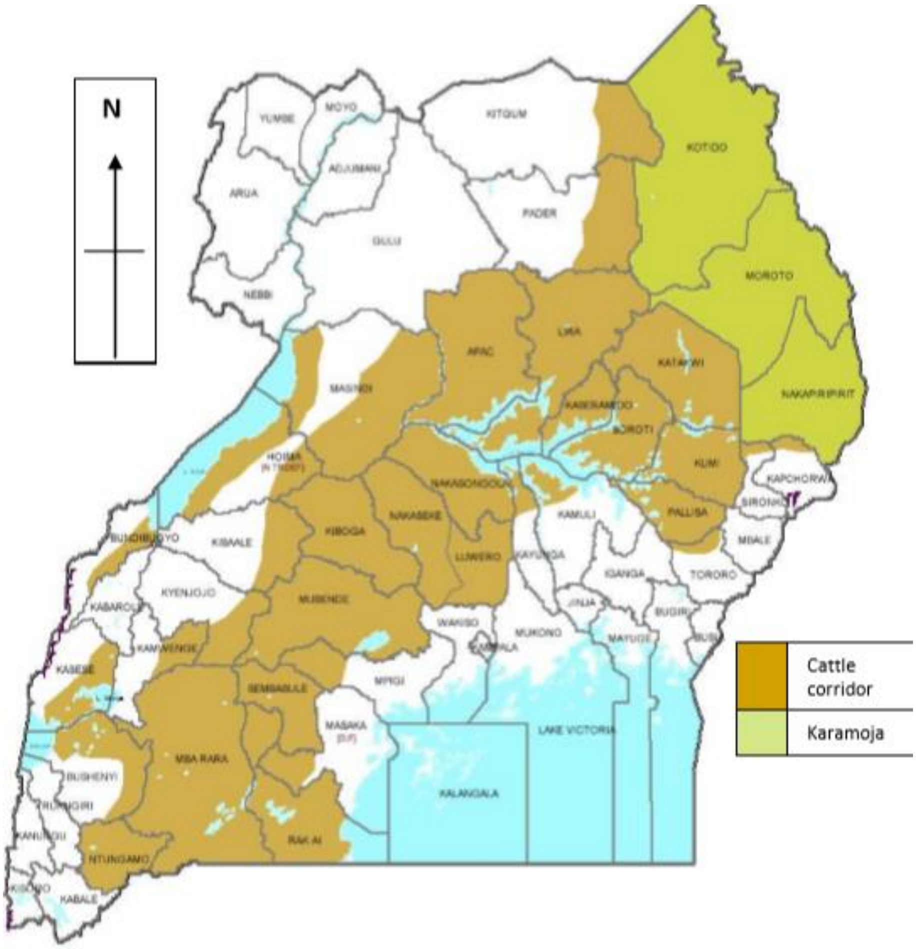
The figures quoted for total milk production differ substantially with DDA quoting 2.500 (1000 tonnes) in 2017/2018, 1.821 (1000 tonnes) in 2018 (FAO/NZAGGRS, 2019) and 1.641 (1000 tonnes) 2017 (UBOS, 2018). Presumably FAO and UBOS do not calculate the 27% milk which is lost from farm to consumer.

According to DDA, milk per capita consumption in Uganda has increased from 25 liters in 1986 to 62 litres in 2017. This however is still below the 90 liters per capita annual consumption recommended by WHO.

## Livestock population

Estimates for 2017 indicated that Uganda had a national cattle population of 14.2 million and an estimated cattle population growth rate of 3% (UBOS, 2018). The indigenous breeds continue to be dominant over the exotic ones.  Out of the 14.2 million cattle in Uganda, 90% (13.3 million) are indigenous. Of the total milk production indigenous breeds contributed 52% and the exotic breeds 48% respectively (UBOS, 2018).

According to an FAO study the cattle population Uganda during the period 2012-2050 will be decreasing from 13.7 to 11.8 million head. Increases in livestock production in Uganda are generally the result of a larger cattle population and/or improved productivity particularly in intensive farming systems. The future expected production increase in milk and beef production is therefore attributed to an increase in productivity this would be an indication of more efficient land use and efficiency in the production system (FAO, 2018).




Map 3. The cattle corridor of Uganda ( Source: adapted from Egeru 2014 / Stark 2011)

## Rainfall

Uganda's climate is considerably modified by elevation above sea level, local water bodies, and local relief. The country experiences both bimodal and unimodal rainfall patterns (Northern region) . Rainfall is evenly distributed throughout the country, except in the northeastern corner. Much of the country receives between 1000–1500mm of rain per annum, increasing with altitude, but this is variable.

The mean annual rainfall varies from 510 mm in parts of Karamoja (North Eastern region) to 2160 mm or more in Sesse Islands. More than 1520 mm fall on Mt. Elgon, Kabale, Bundibugyo, Gulu, and on the island and the north western shore of Lake Victoria. More than 1100 mm fall along a 360-km arc around Lake Victoria from Tororo to Rakai and along a straight belt of similar length striking north-west from Tororo to Gulu. The Northern region receives one rainy season from April to October, and the period from November to March has minimal rain (Kaizzi, 2009)

The country is divided into 3 zones dictated by rainfall distribution. The unimodal which is found above 3° North latitude and the rest of the country south of this latitude experiences bimodal rainfall pattern with transitional zones between latitudes 1° and 3°. The reliability of rainfall generally declines northwards. Amidst the changes being experienced in climate (UBOS 2016).

### Soils

Annex 4 shows the diversity of soils in Uganda supporting different types of farming systems. A considerable proportion of the soils are highly weathered, have low nutrient reserves and therefore limited capacity to supply phosphorus, potassium, calcium, magnesium and sulphur. Some have sufficiently strong soil acidity for soluble Aluminium to be toxic for most crop species. Such include the Ferralsols and Acrisols which form more than 70% of the soils in Uganda on which most of the farming is practised (Bekunda et al, 2002)

The productivity of dairy cows and the cost price per litre of raw milk produced, is mainly based on good feeding practices. Given that the main ingredient in the diet of all ruminants is forage, its quality is key to animal production, fertility, health and welfare, and business profitability. Therefore, high digestibility and nutritive value of forages, reduces feed costs and enables cows to express their genetic potential.

Cows prioritise the use of energy in the following order: (i) maintenance, (ii) milk, (iii) growth, and (iv) fertility. This means that a deficient and/or unbalanced diet can be the main factor of reduced fertility, body condition and production.

For the dairy sector in Uganda to continue its growth, maintain regional competitiveness and expand its domestic milk market, the country needs to accelerate intensified productivity, increase farm profitability and environmentally sustainable agricultural practises. Production growth to boost food security is best achieved by sustainable intensification of dairy farming systems, not by increase in acreage (land-use change) and animals.

Dairy production in Uganda is characterised by low productivity, mainly due to nutritional constraints caused by farmers' unawareness of improved forage production practices, unavailability of technology and rural financial services. Like in other East African countries, there is a risk that a mismatch arises between the genetic potential for milk production and the availability of quality forages that can meet the nutritional requirements of genetically improved breeds, and the skill levels to manage improved breeds and high quality forages and pastures, among the majority of farmers.

The Ugandan dairy sector needs to increase production per animal and productivity per acre to realize this forage production volumes and forage quality need to improve. While at the same time (mechanised) agronomic practices for these improved higher quality forages and (balanced) cow diets, should not increase enteric methane intensity emission per animal.

Generally, the quality of fresh and preserved forages is poor because farmers are unaware and unable to invest in improved agronomic practices and improved forage seeds and planting material. The quantity and quality of forage available show seasonal fluctuation mainly due to lack of farm feed planning. Most areas experience an acute shortage of supply during the dry season and the available forages during this period is of very poor quality.

In the extensive farming systems (incl. the North Eastern region) efforts made by stakeholders on forage production focus on volume (e.g. hay harvested at mature stage) rather than quality, the concern in these farming systems is on maintenance of the animal and availability of roughages during drought, to reduce mortality rates.

| Table 1. Main problems faced by the forage sub-sector in Uganda |
|---|
| • Water availability, storage, efficient use<br>• Insufficient quantity and quality of forages<br>• Land availability<br>• Land use competition<br>• Low digestible forage available and very low digestibility of crop residues.<br>• Inefficient feed utilisation (unbalanced rations)<br>• Seasonality<br>• Feed/Forage testing and standardization not available<br>• Lack of awareness on the links between forage and animal production<br>• Ineffective and obsolete agricultural education, training and extension system<br>• Availability, high cost and/or poor-quality inputs (seed, fertilizers etc)<br>• Persistence of forage legumes in grass/legume mixture<br>• Emergence of new forage diseases and pests<br>• Low level of adoption of (improved) forage technologies (e.g. drought tolerance, disease resistant) that can alleviate seasonal shortages<br>• Access to and cost price of agro-industrial by products<br>• Availability of improved forages to meet nutritive requirements of genetic profile exotic breeds introduced by AI and ET<br>• Genotype– forage (environment) interaction<br>• Shortage of input & service providers to professionalize and commercialize forage production<br>• Lack of forage development plan on farm level, regional or national<br>• Extreme low level of mechanisation<br>• Limited forage crop options and possibilities for crop rotation<br>• Climate change<br>• Little awareness about link between health, food safety and feed safety. |

| Table 2. Recommendations to enhance the forage sub-sector in Uganda |
|---|
| • Accelerate and identify options for dissemination knowledge and knowhow in enhance aware and adoption of improved forage production<br>• Stimulate entrepreneurship to import, distribute and set up service network for appropriate, affordable and scalable farm machinery<br>• Accelerate access to new (better) and more diversified certified forage species/cultivars/varieties through facilitating and stimulating seed companies to import and register suitable seeds, hand in hand with local research<br>• Continue to stimulate the dairy sector with more attention for the domestic milk market<br>• Strengthen public/private partnerships in the forage seed sector in continuation of Integrated Seed Sector Development project<br>• Promote new species, including legumes, such as *Brachiaria* and *Panicum*, and campaign for good management practices during land preparation, planting, growth, harvesting, storage and feeding<br>• Stimulate intensification of livestock systems (e.g. towards of improved zero grazing / semi-zero grazing)<br>• Improve pasture management practices of and commonly used cut and carry forages<br>• Promote and improve preservation practices and methods and facilitate access to new technology<br>• Recognise investors in commercial forages and agricultural forage contractors as entrepreneurs; create enabling environment for investments to expand commercial forage production and mechanisation |

- Support investment in the forage sub-sector, especially by incentivising youth service providers to create businesses specialised in different steps of the forage chain (seed supply, forage contracting services, sales and maintenance of scaled machinery, etc.)
- Building capacity and competence among all stakeholders (incl. education and training institutes) in the forage- subsector in relation to forage production and ruminant nutrition
- Introduce the notion of "quality" among all stakeholder by promoting energy and protein rich forages, feed laboratories for analysis, pricing based on nutritive value, feed standards and good management practices.
- Include and connect forage production and animal nutrition in student education, farmer training and extension programs through public/private partnerships
- Link forage and animal production sectors and create a dynamic cooperation and "growing together approach".
- Campaign for climate smart practices "from seed to feed" focused on productivity, quality and sustainability of agro-ecosystems (Integrated soil fertility management (ISFM) conservation agriculture (CA), reduction of GHG-emissions)
- Rehabilitate and conserve rangelands
- Improve land, soil and water management and use, focused on future generations
- Intervene in the forage market by setting-up strategic feed reserves in areas prone to drought and climate shocks

# Methodology

The approach of the quick scans consists of a combination of desk study, questionnaires, interviews and field visits. This report concerns the forage sub-sector scan for Uganda. Annex 1a presents the list of key resource persons representing relevant organisations who received a questionnaire or were interviewed. With a sample size of N=70, 54% of all organisations responded (Annex 1a); in addition, 33 people (Annex 1b) were interviewed. The questionnaire and the survey diagrams are in the supplement to this report which is provided as a separate document. The respondents were selected based on an existing data base available at the SNV-offices in Kenya. The major limitations of this Ugandan study were: (i) the response (54%), (ii) the lack of entrepreneurs engaged in commercial forage production, and (iii) the lack of collaboration from the private sector involved with the forage chain.

The report itself is structured as follows:

*Section I. Analysis of the Current Situation*, gives a summary of the responses to the questionnaire (and interviews) according to the 13 topics of the survey: 1. General constraints, 2. Forage species, 3. Forage quality, 4. Seasonality, 5. Preservation of forage crops, 6. Seeds, planting material and fertilizer use, 7. Mechanisation 8. Inputs & services, 9. Forage market, 10. Education and training, 11. Environmentally sustainable forage production, 12. Innovations, and 13. Policies.

*Section II. Observations and Recommendations*, includes suggestions for interventions, investments and policies to enhance the forage sub-sector in Uganda. The recommendations are geared to improve the current situation of forage production, preservation, quality and availability with a view to improve dairy rations, margins above feed costs, to increase milk production, to reduce (seasonal) scarcity and to maintain milk production throughout the cow's lactation period. In addition, it draws attention to forage management practices that are in line with most recent developments regarding environmentally sustainable practices, especially those related to soil and water conservation and greenhouse gas (GHG) emissions.

# Section I. Analysis of the Current Situation

*Farming systems*

1. *General constraints*
2. *Forage species and research*
3. *Forage quality*
4. *Seasonality*
5. *Preservation of forage crops*
6. *Seeds, planting material and fertilizer use*
7. *Mechanisation*
8. *Inputs and services*
9. *Forage market*
10. *Education and training*
11. *Environmentally sustainable forage production*
12. *Innovations*
13. *Policies*

# Section I. Analysis of the Current Situation

## Farming systems

Agricultural production in Uganda is primarily based on small scale subsistence farming comprising a system of mixed agriculture with perennial and annual crops as well as grazing throughout most of the districts across 10 agro-ecological zones (AEZ). In Uganda, dairy production takes place under any of the following four categories of farming systems (Table 3):

### Intensive farming system:

Zero grazing (i.e. the cow is fed exclusively on cut and carry forages and concentrates; no grazing). The term refers to the confinement of a few animals in a small enclosure where feeds, fodder and water are brought to the animals. This system is widely practiced in Uganda especially is the Eastern, Western and Southern Western regions. Urban famers feed their livestock on pasture from wetlands and banana peels, but all of these are insufficient in nutritional value.

### Semi Intensive farming system:

Fenced/paddock grazing (i.e. grazing cattle in paddocks or/and feeding them with concentrates) is a common farming practice in areas where the land holdings are small. This type of grazing requires land clearing and improved pasture. It's largely practiced by farmers of exotic and crossbreed cattle and has expanded rapidly. In order to increase production, dairy farmers have planted legumes, Napier/elephant grass, and Lucerne/alfalfa for their cattle in so called fodder gardens.

### Extensive farming system:

Free range grazing (i.e. grazing cattle by moving them all over the farm). In Uganda, small holder farmers own about 90 per cent of all livestock which are under pastoral or agro-pastoral production systems in range lands. It is a common system in the Southern part of Uganda, the farmland is often not paddocked, but the boundaries are fenced with a local plant creating hedges. The daily routine of open grazing is morning milking, grazing, watering evening milking and late evening grazing. This system is being phased out because of the sensitive nature of land encroachment.

Communal grazing (i.e. pastoral grazing on communal land owned by clan). Still practiced in North-Eastern part of Uganda (Karamoja, Kotido, Moroto, Amuria, and Soroti). The government has discouraged this system of cattle grazing, but culture still overrides government initiative.

Table 3. Dairy cattle distribution by region and production system (Source FAO/NZAGGRC 2019)

| Region | Total (million head) | Commercial dairy systems | | | Traditional dairy systems | | | | Share by regions |
|---|---|---|---|---|---|---|---|---|---|
| | | Small-scale intensive | Medium-scale intensive | Large-scale commercial | Small-scale extensive | Medium-scale extensive | Pastoral | Agropastoral | |
| Central | 2,9 | 23,411 | 45,307 | 18,268 | 129,266 | 575,368 | 585,323 | 1,575,047 | 21% |
| Eastern | 3,0 | 16,133 | 22,519 | 4,179 | 56,354 | 380,384 | 161,512 | 2,398,931 | 22% |
| Karamoja | 2,7 | ----- | ----- | 11,229 | 56,814 | 2,362,731 | 340,761 | 340,761 | 20% |
| Northern | 2,0 | 4,251 | 6,961 | 1,227 | 42,669 | 185,856 | 142,313 | 1,627,776 | 15% |
| Western | 3,1 | 18,015 | 55,465 | 5,558 | 204,705 | 791,032 | 536,727 | 1,490,836 | 22% |
| **Totals** | **13,8** | **61,810** | **130,252** | **29,232** | **444,223** | **1,989,453** | **3,788,606** | **7,433,351** | **100%** |
| Share of total | | 0.40% | 0.90% | 0.20% | 3.20% | 14.30% | 27.30% | 53.60% | |

# 1. General constraints

The response of the stakeholders who participated in the survey in relation to the general constraints in the Uganda forage sector was as follows:

> Q2 "Select the five most important constraints that prevent an increase in forage production and preservation in Uganda".
> Awareness, knowledge and skills is the biggest hindrance to improved forage production (15.8%), followed by mechanization (14.6%), availability of forage seeds or plant material (12.7%) absence of a milk market (12.0%) and financial constraints (9.5%) (Survey Diagrams; Figure 1.1).

Major constraints affecting dairy production systems in Uganda include socio-economic, technological, institutional and financial constraints.

The dairy sector is one of the fastest growing agricultural sub-sectors. The following major barriers to the sectoral growth and transformation were identified in the UNDP/MAAIF 2017 study:

1.) Low animal productivity due to poor feeding and animal health;
Inadequate nutrition as a result of low quality and quantity of forages and feeds and use of unimproved practices has been identified as a major constraint in all dairy production systems in Uganda leading to low milk yield, long calving intervals and sometimes death of the animals
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. (Arnaoudov et al, 2017)

The sector is also faced with constraints related to the enabling environment for improving agricultural production and productivity, such as an uncertain policy environment, poor agricultural technology delivery and adoption, lack of capacity for policymaking and planning, lack of capacity for climate change analysis and decision making and low productivity of sector personnel. (CIAT/BFS USAID, 2017)

## 2. Forage species

Q 4. "What are the three most common forage species used by dairy farmers in different farming system?" Fig 1.
Based on the response in the questionnaire in the intensive farming system Napier grass (*Pennisetum purpureum*) Maize (*Zea maize*) and Rhodes grass (*Chloris gayana)* respectively 31.8%, 19.7% and 10.6% are the most commonly used forages. In the system with grazing in fenced paddocks with improved pastures (semi-intensive farming system) Rhodes grass is the most used (26.9%) followed by *Brachiaria ssp.*, Napier grass (Pennisetum purpureum) and Natural grasses and legumes respectively 14.9%, 11.9% and 10.4%. In the Free Range-Natural grassland system (extensive farming systems) Rhodes grass (*Chloris gayana*), Natural grasses and Brachiaria (*Brachiaria ssp.*) 16.4%, 11.5% and 9.8% are the most commented (Survey Diagrams Figure 2.1, 2.2, 2.3)

### Intensive farming system: zero grazing, cut-and-carry, urban and peri-urban

Smallholder producers rely almost entirely on rain-fed natural pastures. Only a small number of households keeping improved dairy cattle make effort to plant improved pastures, such that they practice both zero-grazing and `open' grazing on natural pastures.

For those farmers who have improved grasses in a so called "fodder garden", grass is cut-and-carried to the stalls/feedlot for a short period of time. After having exhausted the resources in the fodder garden(s)animals are taken for grazing o natural grasslands. The reason for this is that farmers establish small plots of improved grasses which do not match with the size of their herd, the main species use for this is Napier (*Pennisetum purpureum)* (Over 53% of the farms surveyed planted Napier (EADD, 2009)), but also grasses such as *Chloris gayana*, Brachiaria spp., Kikuyu grass, and various other grasses and legumes species are cultivated at small scale. Very few farms produce enough fodder to meet the needs of their herds throughout the year. The result is that most animals thrive on sub-optimal energy levels for most of the year.

Studies in the Lake Victoria crescent and Eastern Highlands Agro Ecological Zones (AEZ) of Uganda among smallholder farmers showed that the most prominent forage species used for feeding livestock are *Pennisetum purpureum*, *Calliandra calothyrsus*, *Musa paradisiacal* (peelings and stems), and *Leucaena leucocephala*.

Commonly grown Napier grass varieties include; (a) Bana grass, usually leafy and with few silica hairs, which cause irritation during handling, (b) Clone 13, is resistant to white mould disease and a high yielder but its thin stems make it difficult to establish, (c) French Cameroon, is a high yielder, established easily from canes, (d) Kakamega 1 and 2, both are high yielders though Kakamega 1 has a higher growth rate than Kakamega 2 and (e) Pakistan hybrid, which does well in dry areas (Buyinza J. et al, 2015).

Brachiaria hybrid cv. Mulato, a drought tolerant forage was introduced in Uganda in 2005 as an alternative to Napier, the predominant forage for dairy cattle in zero-grazing systems.

Legumes commonly grown include Glycine (*Neonotonia wightii),* Greenleaf (*Desmodium intortum*), Silverleaf (*Desmodium uncinatum*) and Stylo (*Stylosanthes guianensis*). However, farmers rarely have these forage legumes on their farms. Those who have them have planted them as small plots of pure stands of one or several species.

### Semi-intensive farming system: semi zero-grazing and grazing

A study showed that about 25% of the households practicing extensive farming in south western Uganda plant fodder crops, mainly Napier and various legume species. However, only a small proportion (5%) of the farms, preserved fodder for dry season feeding (Balikowa, 2011). This explains why most farms frequently experience severe shortage of forage during the dry season.

The need for cultivating cattle feed in Uganda has become urgent due to the rapidly declining natural grazing areas. Provision of forage of adequate nutritional quality is fundamental in ensuring increased livestock production in the developing countries (Buyina J. et al, 2015)

Farmers keeping improved dairy cattle are slowly learning to plant improved pastures/ fodder crops. Preferred types include grasses such as *Panicum maximum, Pennisetum clandestinum, Chloris gayana, Bracharia brizantha*; herbaceous legumes such as lab lab (*Dolichos lablab*), centro (*Centrosema pubescens*), Desmodium spp, stylo (*Stylosanthes guianensis)*, siratro (*Macriptilium 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.

## Extensive farming system: free grazing on natural grassland (ranching, pastoralism, agro-pastoralism)

Natural and planted pastures are the major components in the diet of both indigenous and improved dairy cattle in Uganda. Natural grazing represents the major feed resource in the milkshed area. Grazing on natural pastures is commonly practised; as a result, not much effort, is made to establish improved pastures. Farmers consider that pasture establishment is not essential since there is unlimited natural grazing land.

The common naturally occurring pasture species vary from one region to another. In the traditional cattle corridor, common sources of forages include grasses such as *Themeda triandra, Brachiaria decumbens, Digitaria spp., Hyparrhenia filipendula, Panicum maximum, Chloris gayana, Cynodon dactylon, Paspalum dilatatum, and Hyparrhenia rufa.* There is always a severe decline in the quantity and quality of pastures during the dry season which is often accompanied by widespread invasion of unpalatable grasses mainly *Cymbopogon afronardus and Sporobolus pyramidalis* as well as bush encroachment, with subsequent overgrazing of the palatable species, mainly *Brachiaria brizantha and Themeda triandra.*

The Karamoja-region has a high diversity of 65 herbaceous forage species whose abundance is dominated by about 9 species, these include: *Hyparrhenia rufa, Sporobolus stafianus*, *Chloris pychnothrix, Setaria sphacealata, Pennisetum unisetum, Aristida adscensiones, Hyparrhenia diplandra* and *Panicum maximum.* Occurrence varies with the season and within in the region (Egeru A., 2015).
Annex 6 presents a list of forage species found in Uganda.

Field of Lab Lab in South Western Uganda

Field of Sweet potato vines in Central Uganda

**Q5. "Which forage species, in order of importance, do you think give the best return for the dairy farmer in the different farming systems?"**
Based on the responses given to the questionnaire (Survey Diagrams; Figure 2.4) Napier grass gives the best returns according to 25% of the respondence. Maize (*Zea mays*) is gaining in popularity (15.8%) as a forage crop in intensive farming systems. In Uganda the maize varieties used are the same as those used for human consumption due to the absence of forage maize varieties in the local market. In semi-intensive farming systems, responses to the questionnaire indicate that Rhodes grass (23.7%) gives the best returns for the farmers, followed by Brachiaria (15.3%), Napier grass (13.6%) and Desmodium (10.2%). (Survey Diagrams; Figure 2.5). In the extensive farming system Rhodes grass (30.6%) gives the best return for farmers followed by Brachiaria (16.3%) and Natural grass and legumes (12.2%). The Brachiaria species referred to are those occurring naturally in the pasture's contrary to Kenya where Brachiaria is only referred t as hybrids or cultivars. (Survey Diagrams; Figure 2.4, 2.5, 2.6, 2.7)

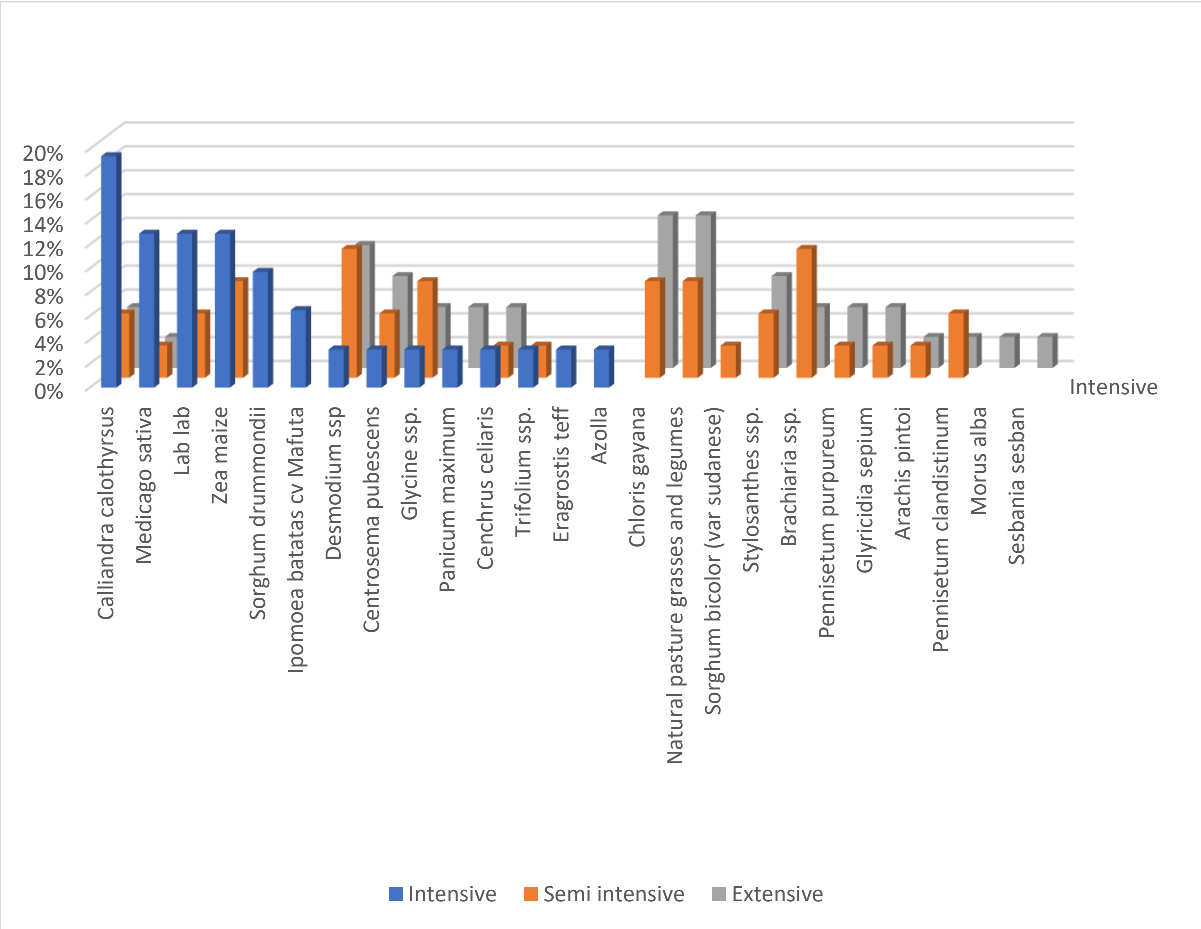



Figure 1. The most common forage species used by dairy farmers in Ugandan farming systems

Q6. “What are the main constraints for forage production in the dairy farming systems and for commercial forage producers?”
In the intensive farming system, land availability (17.1%) and high cost of production/financial constraints (17.1%) are major constraint for forage production in Uganda. Mechanization is also perceived as a constraint (11.4%) (Survey Diagrams; Fig.2.8). In semi-intensive farming systems, knowledge and skills, mechanization and availability, accessibility and affordability of forage seeds are equally (17.1%) seen as a major constraint. Followed by land availability (11.4%) In extensive farming systems, high cost of production/financial constraints (19.4%), mechanization (16.7%), knowledge and skills (16.7%), and availability, accessibility and affordability of forage seeds (16.7%) are all considered to be constraints (Survey Diagrams; Figure 2.9, Figure 2.10). For commercial forage producers, according to the results of the questionnaire, the major constraint for forage production is seen as the market being inadequate, not ready, for commercially produced forages as well as the low level of mechanization in the sector (respectively 24.3% and 24.3%) followed by availability, accessibility and affordability of forage seeds (13.5%) (Survey Diagrams; Figure 2.8, 2.9,2.10,2.11).

Q7.” **What new forage species (energy/protein rich) do you think can be introduced in the dairy farming systems?”**
Figure 2.15 (Survey Diagrams) provides an overview of the three farming systems (intensive, semi-intensive and extensive) and the species considered as promising by the respondents. The Figure shows that in intensive farming systems Calliandra (19.4%) and Lucerne, Maize and Lab lab all at (12.9%) are promising forage crops. Lucerne is seen as a crop with potential in intensive farming systems as well despite often discouraging results in practical situations. In the semi-intensive and extensive farming systems Desmodium (10.3% & 10.8%) Brachiaria (10.8 & 5.1%) , Rhodes (12.8% & 8.1%) and Natural grass and legumes (12.8% & 10.8%) are the most promising forage crop in these 2 systems (Survey Diagrams; Figure 2.12, 2.13, 2.14, 2.15)

## Forage related research

The introduction of exotic cows from Europe after 1960 resulted in extensive grassland improvement. Introduced and local forage species have, over the years been screened for: response to fertilizer regimes; persistence to drought; dry matter yield and nutritive value; compatibility of grass or cereal crops with forage legumes; tolerance to Napier stunt disease; seed production and animal productivity (Kabirizi J., 2016).

Forage research in Uganda has a history of nearly 60 years and is currently carried out by national and international institutes. The main organizations involved in forage development are:

Makarere University is well known for academic program and research in agriculture and a lot off information is available, research focuses on livestock and forage crops.

NARO The National Agricultural Research Organization is a leading producer of pasture seeds in the country. It undertakes initiatives to develop pasture varieties suitable for certain Agro – ecological zones in the country. It also carries out pasture seed multiplication for distribution to farmers and seed producers. NARO is also piloting commercialization of fodder production and conservation. It also carries out training of farmers and extension workers in selected areas of the country on fodder production and conservation.

NaLiRRI The National Livestock Resources Research Institute is one of 16 semi-autonomous national or public agricultural research institutes and 9 Zonal Agricultural and Development Research Institutes (ZARDI). All NaLIRRI’s research efforts focus on bridging the nutrient deficiency gap, conserving year-round farm feeds and improving the efficiency of utilisation of local feed resources.

**NaFORRI** The National Forestry Resources Research Institute is a National Agricultural Research Institute (NARI) mandate to undertake research in all aspects of forestry. The overall objective of the agroforestry research Programme is to develop and disseminate appropriate technologies that integrate trees and shrubs on-farm to mitigate deforestation, rural poverty, food security and environmental instability.

**ICRAF** (International Council for Research in Agro Forestry) also known as World Agro Forestry Centre, encourages the use of forage trees that are highly nutritious for livestock, a variety of up to 9 leguminous forage trees, including *Calliandra calothyrsus*, *Sesbania sesban, Leucaena leucocephala and Morus alba*.

**ILRI** (International Livestock Research Institute) is an international institute working on forages Uganda in different capacities. It has a forage laboratory for tropical forages in Addis Abeba.

**CIAT** (International Centre of Tropical Agriculture), promotes grasses such as *Brachiaria* and *Panicum maximum* as potential alternatives to Napier grass. These two species, originally from Africa, have been improved in South America and new hybrid varieties and cultivars are now being introduced in Uganda in consultation with NARO. The results obtained so far with these two species are very promising, especially on all what relates to quality, but future evolution will especially depend on management and farm practices

### Forage species screening and evaluation

Forage legumes and grass germplasm comprising of local and introduced accessions from CIAT, South America and the International Livestock Research Institute (ILRI) in Ethiopia gene banks were selected for their potential suitability to tropical environments and were evaluated in other agroecological zones of Uganda. Some of the species that showed high persistence at both semi-humid and semi-arid sites were: *Macroptilium atropurpureum*, *Clitoria ternatea*, *Centrosema pubescens*, *Neonotonia wightii*, *Brachiaria hybrid cv mulato*, *Brachiaria brizantha*, *Brachiaria brizantha cv toledo green*, *Lablab purpurens*, *Desmodium uncinatum cv silver*, *Canavalia brasiliensis*, *Stylosanthes guianensis* (*Cook)*, *S. guianensis, S.* hamata (Verano), S. scabra, (Kabirizi J., 2016).

| Table 4. Summary of forage species/cultivars/varieties access gaps |
|---|
| Reliance on few dominant fodder species carries the risk of fast spreading of new forage diseases and pests when emerging |
| Poor persistence of forage legumes in grass/legume mixture |
| Unclear system to import/register/authorise new and improved species/cultivars/varieties |
| Thriving informal market for on-farm seed multiplication |
| Germination rate of seed multiplication in informal system is low |
| Uncertain market, farmers are not familiar with, do not value improved grasses and legumes as yet |
| Not very attractive market, especially for perennials and plant reproduction species |
| Lack of knowledge of good agricultural practices by the farmers and dairy extension workers during planting and growing |
| Lack of awareness of the impact of forage quality on animal production and reduction of feed costs |
| High seed cost for improved/imported varieties |
| Limited capacity and competence with local research on improved local species/test and comparisons with imported improved species/cultivars/varieties |
| Limited knowledge among farm advisors/extensionists on production, conservation and efficient utilization of quality forages |

# 3. Forage quality

Low forage quality and quantity is one of the biggest constraints (Mubiru S. et al, 2011) to higher milk production in Ugandan dairy farms. High NDF and lignin content, low energy and low crude protein, together with the low digestibility of the crude protein and of carbohydrates, are the common characteristics of most of the forages present in the farms (i.e. Napier grass, Rhodes and local natural grasses). This (high NDF content) also is the reason for reduced animal feed intake, low production and high feed cost.

Besides, these tropical grasses have very thick stems that contain high levels of intracellular water. This fills up the rumen with a lot of water and fibre, reducing the animal's dry matter intake and production of milk and meat. It also makes it difficult to wilt the grass unless the stems are chopped into smaller pieces to facilitate wilting (the evaporation of water).

Forage quality and forage nutritive value are often used interchangeably. However, forage nutritive value typically refers to concentration of available energy and concentration of crude protein. By contrast, forage quality is a broader term that not only includes nutritive value, but also forage intake (Adegbola T.A., et al 2017).

In practice, grazing animal performance reflects forage quality and grass management. Where forages are the main component of livestock diet, forage quality of a pasture or crop is determined by animal product (e.g., milk production, body weight gain). If the animal has the genetic potential, animal production on a forage-based diet depends on the nutritive value of forage consumed—the crude protein concentration, available energy, and minerals that are in the forage tissue. (Adegbola T.A., et all 2017).

Q32." What improvements and changes need to be made by commercial forage producers to improve forage production in terms of yield and quality?"

Q 32 and 33 which are presented at the end of the questionnaire, are presented here under the heading forage quality.

According to the survey, the most effective improvements to increase forage yield are related with better management practices (29%), use of improved forage varieties (25%) and adopting new technologies to prepare silage and hay (21%) (Survey Diagrams; Figure 9.5). Forage quality is seen by the respondents as an important point to be addressed. This can be achieved through introduction of new forage species and varieties, but if not well managed it will not be effective. Equally better management of current forages in the market will be effective as well. The respondents to the questionnaire indicated that to improve forage quality, commercial forage producers need to implement better forage crop management practices (38%), followed better soil testing and feed standard facilities (25%) and feed by the use of improved/new varieties (21%). When a new species is introduced, this may require an extra investment if different machinery is required for planting and/or harvesting of particular forage crop (Survey Diagrams; Figure 9.5,9.6).

Next to the forage crops discussed in the previous chapter the major food crops grown in Uganda and their potential by-products are given in table 5. These residues are a potential feed resource especially during the dry season. However, most of these residues are low in digestibility because of high fibre content and are deficient in nitrogen, minerals and vitamins. The cell walls of low-quality roughages are generally high in indigestible fractions of lignin. Digestibility is affected by plant species, maturity, and storage method. Efforts to improve performance of animals fed on low quality roughages include physical, chemical and supplementary treatments to increase the nutritive value and digestibility of these roughages in other words these crop residues need to be optimized for effective dry season feeding.

Table 5. Major crops, field residues and by-products in Uganda

| Major crops, field residues and by-products in Uganda | | |
|---|---|---|
| **Crop** | **Field residue** | **By-Product** |
| Banana | Pseudostem, Leaves | Reject fruit, peels |
| Cassava Leaves | Leaves | peels |
| Sweet potato vines | vines | peels |
| Coffee | | husks/pulp |
| Cotton stalks | stalks | oilseed cake |
| Groundnut haulms | haulms | oilseed cake/shells |
| Beans & other legumes | haulms | |
| Cereals | stover | bran, cobs |
| Pineapple | leaves | pulp |
| Sugarcane tops | tops | molasses, bagasse |

A lactating cow needs ca. 11% of its body weight in energy for maintenance and 5.2 MjME (Mega joule of Metabolic Energy) per litre of milk produced. For example, a 500-kg cow producing 10 litres needs 55 MjME for maintenance + 52 MjME for milk produced, which totals 107 MjME/day. In addition, it needs 15% CP (Crude Protein), minerals and vitamins (Morgan J., 2005). This cow would require 12 kg DM of well managed Napier grass (50- 60 kg fresh Napier grass, fertilized and with a 6 weeks cutting interval). Currently, the main forages used in Uganda are (i) Napier grass – which under the prevailing management practices can offer circa 6 MjME/kg DM (Dry Matter) and 6% CP –, and (ii) hay, with an average ME of 5-6 MJ/kg DM and 4% CP. These type of quality forages will not be able to cover the nutrient requirements of the dairy cow, as these fibrous and low-density forages are limiting the dry mater intake of dairy cows before they cover their nutrients requirement levels.

Ration in which fodder is used with poor nutrient composition supplementation becomes essential to achieve high milk production. Unfortunately, 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 et al, 2005, Lukuyu et al, 2012).

The use of Napier is proving most productive for those farmers who are able to utilise it properly; however, many farmers are wasting this resource by subjecting it to overgrazing or letting it overgrow (Table 6).

Table 6. Example of forage quality and milk production relationship

*(550 kg body weight (BW) stall-fed dairy cow, 150 days in milk, 70 days pregnant, DMI based on 1.3 % NDF, milk 3.7 % fat and 3.1 % protein. Milk price: KES 35/ltr, Napier grass price: KES 2.0, 1.6, 1.0 per kg (from poor to high quality)*

| Forage crop & cutting stage | NDF* g/kg DM | ME MJ* g/ kg DM | CP* g/kg DM | DMI* kg/day | Milk l/day | ME* % | MP* % | CH4* g/l | MAFC* UGX/day |
|---|---|---|---|---|---|---|---|---|---|
| Napier > 120 cm | 681 | 7.4 | 4.2 | 10.5 | 1.3 | 100 | 50 | 261 | 0 |
| Napier = 120 cm | 695 | 8.1 | 8.8 | 10.3 | 2.7 | 100 | 111 | 129 | 142 |
| Napier < 60 cm low CP | 630 | 9.0 | 12.5 | 11.3 | 6.4 | 100 | 132 | 51 | 4080 |

*NDF: Neutral-Detergent Fibre, ME MJ: Metabolisable energy in Megajoules, CP: Crude protein, DMI: Dry matter intake, MP: Metabolisable protein, ME%: ME supply as a percentage of total requirement, MP%: MP supply as a percentage of total requirement, CH4: methane, MAFC: Margin Above Feed Cost.

Another study showed that farmers using improved forage technologies (IFT) had lower total production costs per cow per season, and higher average milk production per cow per season compared to the farmers using traditional technology. As such, they had significantly higher revenue and gross margin, five times higher than that of farmers using traditional technologies (Turinawe, 2012).

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.

In order to target quality, nutrient parameters need to be measured, fast, reliable and affordable. This requires NIR equipment with regression lines for tropical forages, which are currently not available in Uganda. The absence in Uganda of accredited laboratories with the correct NIR regression lines to reliably analyse nutrient content of feeds and forages, makes that reliable data are difficult to obtain.

The lack of feed analyses also makes it difficult to balance the animal ration to improve feed efficiency and margins above feed cost. For tropical grasses, predictions of animal responses are highly dependent on accurate values for NDF, lignin (ADL), CP and soluble protein, and rates of digestion for carbohydrates and protein.

Q 33.” What affects production levels and cost price of raw milk mostly: the quality of forages or of compounded feeds (please explain)?” Give three examples of good quality forage crops

Fifty six percent of the respondents indicated that forages in the ration of dairy cows affect production level and cost of production the most. The influence on production level and costs of production of climate change and compounded feeds (each 13%) was considerable smaller. As examples the respondents gave maize (24%), Rhodes grass (21%) Fodder Sorghum and Napier grass (each 10%) (Survey Diagrams; Figure 9.7a 9.7b).

The concept of quality forage and the relation to nutrition (intake), production, farm economics (optimum production, margin above feed costs) and profitability, needs to be strongly developed within the farmer community and other stakeholders. This needs to be explained in such a way that farmers start to realise the importance of forage quality for the profitability of their enterprise. This will also be the way to change the current forage market that is based on volume and largely benefits commercial forage producers at the expense of farmers. In addition to knowledge of the nutritive value to be able to understand the market value (vis-a-vis other available feeds in the market), farmers need to become more knowledgeable of the cost of on-farm forage production (Figure 2).


Figure 2. Quality concept dynamic change

Based on these basic data, it is evident that for the Ugandan dairy farming sector to increase production per animal, productivity per acre and to reduce feeding cost per animal, both forage production volumes and forage quality need to improve. While at the same time management practices for these improved higher quality forages and (balanced) rations, should not increase enteric methane emissions per animal product (methane intensity).

> Q34.1. "What is your opinion on the opportunity of on farm forage production in agro-forestry systems?" 88% of the respondents see opportunities (65% good and 23% some) for forage production on farm in combination with agro-forestry systems. (Survey Diagram; Fig 9.8)

> Q34.2. "What is your opinion on the opportunity of commercial forage crop production in agro-forestry systems? 69% of the respondents believe that forage production in agro-forestry systems can be commercialized. 38% responded that this is well possible while 31% responded it will somehow be possible. (Survey Diagram; Fig 9.9)

## Mycotoxins

Another point to consider are the mycotoxin levels in feeds and forages, causing food safety issues through the milk. Aflatoxins, the most widely known mycotoxin, occur in many animal feed concentrates including cereal grains, soybean products, oil cakes (from groundnuts, cottonseed, sunflower, palm, and copra), and fishmeal. Brewers grains (a by-product from the production of cereal based alcoholic beverages) can have high levels too (Grace, 2013).

In general, livestock in intensive systems are at higher risk of dietary exposure than animals in extensive systems. Worldwide, a high and increasing proportion of dairy cattle are kept in intensive systems; aflatoxins are thus likely to be an increasing problem.

The occurrence of mycotoxins is influenced by weather and poor storage, given that high moisture and temperature provide the ideal environment for moulds that produce mycotoxins. But also by drought causing stress during germination and growth of the plant (CAC, 1997). Maize stover for example is frequently contaminated with Aflatoxins, which are a group of closely related, biological active mycotoxins that are highly toxic (Kabirizi 2016).

Mycotoxins can also be soil born, where moulds naturally are present in the soil and survive on crop residues particularly seed heads of aflatoxin susceptible crops. Good agronomic practices to avoid or limit occurrence of mycotoxins include soil testing, applying recommended nutrition levels for crops, protection against pests and weeds, avoiding over-population and encouraging crop rotation to avoid crops stress especially during germination and growth. Further, mechanisation, improved forage preservation systems and better storage, are required to reduce mycotoxin content in feeds and forages (CAC, 1997).

| Table 7. Summary of forage quality gaps |
|---|
| Quality concepts of pastures and forages among farmers and other stakeholders are lacking |
| Lack of knowledge as regards to forage quality/animal performance relationship |
| Variable and unpredictable forage quality due to seasonality and gaps in forage management |
| No existing forage quality standards or pricing system |
| Lack of knowledge about available agro-industrial by products to supplement or compensate other natural resources |
| Poor use of genetically improved seed/plant material (cost high-availability low) |
| Lack of knowledge about forage production |
| Absence of accredited laboratory for nutritional analysis based on NIR regression lines for tropical forages |
| Lack of adequate farm machinery and skills for operation and maintenance |
| Limited harvesting and preservation capacity which affects production per unit, nutritional content and market value |
| Poor monitoring and management of soil fertility (soil sampling/management/rotation) |
| In adequate use of fertilizers |
| Exotic animal breeds and their crosses need high(er) quality forage to express genetic potential (and avoid negative energy balance) |

Natural pasture in South Western Uganda

Field (garden) of Napier grass in South Western Uganda

# 4. Seasonality

Uganda experiences a bimodal rainfall pattern and the distribution of livestock feed closely follows this pattern resulting in periods of feed shortage between the rainy seasons and at times within period of the rainy season. Therefore, there is a need to conserve the excess feed produced during the rainy season to stabilize feed supply throughout the year.

How was mention before, natural pasture growth is seasonal, following the rain pattern, characterise by low productivity and poor nutritive value, factors aggravated due to the absence of pasture legumes, lack of good agronomic practices, and overstocking. Traditional communal land tenure systems further hamper efforts to improve the grasslands; and the inability to adjust livestock carry capacity.

Improved pastures can increase milk production in the region. However, farmers lack the skills in managing these pastures once established. Weeds are left to grow together with the pastures; and the pastures are not fertilized. In most cases the farmer is blamed for these failures, but the dairy extension workers should take the leading role in skills transfer and guidance of good agronomic practices for improved pastures to farmers.

This leads to large fluctuations in the forage market and milk supply. The rainfall patterns Uganda vary considerably from the (semi-) arid area in the North Eastern to the high rainfall area's like on Mt. Elgon, Kabale, Bundibugyo, Gulu, on the island and the north western shore of Lake Victoria.

Uganda has 10 different AEZ (Annex 8.) they include: the North-eastern dry lands with an average annual rainfall of 745 mm (where beans, field peas, groundnuts, passion fruits, simsim and sorghum are grown); the North-eastern savannah grasslands receiving 1197 mm (cocoa, millet, tobacco, bee keeping); the North-western Savannah grasslands receiving a range of 1340 mm – 1371mm (coffee, Irish potatoes, rice); the Para-savannahs receiving 1259 mm (cassava fishing, sorghum, peas, tobacco, livestock); the Kyoga plains receiving 1215 mm - 1328 mm of rainfall (sweet potatoes, dairy); the Western savannah grasslands (banana, maize, goats); and the Lake Victoria Crescent, South-western farmlands, Highland ranges, and Pastoral rangelands with rainfall below 1000 mm and characterized by short grassland with nomadic extensive pastoralism (CIAT/BFS USAID, 2017)

### Climate stressors and climate risks due to climate change

In the case of livestock climate change may affect production through: (i) impacts on the quantity and quality of feed, (ii) increasing heat stress, (iii) changes to and spread of livestock diseases and (iv) changes in water availability

Recent reports from the Famine Early Warning Systems Network (FEW NET) indicate that there has been an increase in seasonal mean temperature in many areas of Uganda over the last 50 years. The decline in rainfall (close to –8 percent) is sufficient to increase the frequency of poor harvests that would be expected. The increasingly frequent droughts could be offset by adaptation efforts aimed at improving water and agricultural management practices and raising yields in wetter areas may be a more viable option, for the medium and longer-run, than extending agriculture into more marginal areas. This transition to an even warmer climate is likely to amplify the impact of decreasing rainfall and periodic droughts and will likely reduce crop harvests and pasture availability. (FEWSNET, 2012) The drying trend, is potentially large enough to affect agro-pastoralists, and pastoralists across northern Uganda.

Water, also for forage crops and grassland production remains the most critical factor in Uganda. These systems are largely rainfed. The availability of water for crops and livestock, especially, in the semi-arid cattle corridor is being affected by climate change and variability, and this is expected to continue in the coming years with severe consequences on rural livelihoods (FAO, 2018).

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).

**Q12. "Which forage crops and preservation technologies are best suited to reduce the problem of seasonality?"**
In intensive farming systems, Napier, maize and Brachiaria are the preferred forage crops (29%, 26%, 13%). Silage making is the preferred preservation method (67%) and hay coming second (28%). Hay is the preferred option for Rhodes grass and other natural pasture grasses incl. legumes. In semi-intensive grazing systems, Napier, Rhodes, legumes and maize (23%, 17%, 14%, 14%) are the preferred forage crops. Silage making is also here the preferred way of preservation 52% and hay (43%). In extensive systems Rhodes grass, Brachiaria and mixed pastures (23%, 14%, 14%are the preferred forage crops. Haymaking (29%), Rotational grazing (24%) and standing hay (23%) ways to manage seasonality. (Survey Diagrams; Fig. 5.11, 5.12, 5.13).

**Q13." Where do you think commercial forage production will be developed in the future?"**
The respondents indicated that forage production is likely to develop in South-Western and Mid-Western parts of Uganda (15.7%) and Central (8.7%). The Northern and Eastern regions were less favored for forage crops (7.0%). In the urban and peri urban areas, commercial forage production is not expected to develop in the future due to the land pressure in these areas (Survey Diagrams; Figure 5.14).

**Q14. "Where do you think commercial milk production will be developed in the future?"**
The respondents indicated that in 3 areas, South Western and Mid-Western, Central and Peri-Urban Kampala (16.5%, 13.0% and 9.6%), commercial milk production will continue to grow or develop in the future (Survey Diagrams; Figure 5.15).

**Q15. "Which measures need to be taken to improve the quality of forages?"**
The respondents indicated that measures need to be taken at policy level (31%), knowledge and technology transfer (29%), agronomic practices (21%) and forage seed 19 (%) (Survey Diagrams; Figure 5.16)

| Table 8. Summary of seasonality gaps |
|---|
| No forage production and/or storage plan |
| Lack of water efficient forage species, seeds, and planting material |
| Low level of adoption of preservation practices and poor silage quality |
| Poor storage facility and low forage storage capacity |
| Water management (storage, irrigation) needs continuous improvement |
| Poor herd management and planning (stocking rate, calving/mating season) |
| Absence of regional or national forage bank(s) or strategic reserve to cope with prolonged and more frequent droughts |

# 5. Preservation of forage crops

To increase productivity there is need to improve all year-round fodder availability matched to strategic supplementation (legumes and concentrates). Most dairy farmers have not yet perceived the value of growing and preserving forage with a presumption that they will always be at their disposal. A severe decline in the quantity and quality of pasture occurs during the dry season and consequently affect milk production (Buyinza, 2015).

> Q8. "What are the three most common forage preservation methods used in the dairy farming systems and by commercial forage producers?"
> The response to the question shows that, overall, hay making is the most common way of forage preservation while ensiling is increasingly important). Standing hay is used in grazing systems as an intervention to overcome periods of scarcity. (Survey Diagrams, Figure 5.1, 5.2, 5.3, 5.4).

In recent years the use of crop by-products/residues for cattle feed has increased. NARO developed a number of interventions to encourage farmers to utilize crop residues before or after conservation like supplementation with single source concentrates, intercropping with legumes to increase nutritive content, and production of feed blocks (Kabirizi, 2016).

## Straw and stover

Several food crops are commonly grown in the country: maize stover, rice, beans and to a lesser extend wheat and barley whose straws can be used as forage. If weather conditions are favorable, the straw can be stored immediately after harvest. Yet, in order to minimize the danger of heating in the bale and moulding, straw is often left drying in the field before harvest. Straw is generally preserved in loose form or bales. Stover is commonly referred to as the stem and leaves of grain maize after the cob has been removed. Stover is left in the field and cows can feed on the stover, in some cases stover is collected, stored near the farm compound, grinded and mixed in the cow's ration. Nutritive value and digestibility of straw and stover is very low (Table 9 ).

Table 9. Straw, stover nutritional value.

| Crop residue | DM % | CP % | MjME | NDF % |
|---|---|---|---|---|
| Rice Straw | 88 | 4.6 | 5.5 | 69 |
| Maize Stover | 89 | 5.2 | 7.5 | 74.5 |
| Sorghum Stover | 90 | 8.3 | 8 | 70 |

## Hay

During the rainy season, relatively abundant forage is available, but no use of preservation techniques leads to inefficient use, resulting in compromised hay quality and preservation.

Conservation of forages in form of hay, haylage or silage allows for intensive dairy farming to bridge the gap between wet and dry season. As a result, more productive cows can be kept than would otherwise be possible. The most common method of forage preservation used in Uganda is hay but even hay production has not been adequately addressed even though it can be an easy to achieve solution for supplying quality feed to animals and securing fodder during the dry season. Among small holder farmers the hay box is promoted to bale hay and only in large scale productions systems mechanical, tractor operated bailers are used.

The predominant crop used for hay in Uganda is natural grassland, followed by Rhodes grass.
Pastures used for hay making are often not fertilised, or with very little fertiliser, and cut at flowering stage, which is too mature for good quality forage. For example, the nutritive value of Rhodes Hay

decreases with aging, typical values of Rhodes hay at 90% flowering CP 50 g/kg DM, ME 6.4 Mj/kg DM, NDF 750 gr/kg DM vs hay at 20% flowering CP 90g/ kg DM, ME 8Mj/kg DM, NDF 680 gr/kg DM.

Despite the low nutritive value of tropical grasses and the often late stage of maturity at harvesting for pastoralists in Karamoja and other semi-arid regions of Uganda harvest grass to make hay, which they store and feed to their animals in the dry season can be a strategy to cope with severe and recurrent drought.

It should be noted that weather conditions in many regions in Uganda are not ideal for hay making. The grass grows during the rainy season, which complicates the wilting process and makes it difficult to bale at the right moisture content to avoid heat in the bale. High moisture content in the grass when baled causes the growth of mould and increases the risk of mycotoxins.

### Silage

In areas where hay making is difficult due to wet weather or low temperatures, and for certain crops e.g. maize, silage making is the preferred means of conservation but farmers making silage will need additional skills because a number of factors influence fermentation quality. Fermentation quality is important because poorly fermented silage is unpalatable and, even if high in energy and protein will only support low intakes.

Success in production of quality silage depends the nature of material used for silage making which determines the microbial population, buffer capacity, dry matter content, water soluble sugar, and chemical composition and mechanisms or strategy of pre-treatment (e.g. wilting, chopping, additives etc) which need to be cost effective.

Constraints to the uptake of small-scale silage making technologies include the cost of ensiling materials, high labour demand, absence of forage choppers and unsuitable storage facilities. Inappropriate storage of the ensiled materials resulting to damage by water and pests such as rodents, also discourage farmers from silage production (Owen et al., 2012).

Tropical grasses and legumes have for example a relatively high concentration of cell wall components and the low level of fermentable carbohydrates compared to temperate forage crops. Furthermore, on average storage temperatures in tropical climates are higher than in temperate climates, which might give bacilli a competitive advantage over lactic acid bacteria. In addition, it has to be taken into account that some silo sealing materials cannot withstand intense sunlight, and thus might impair the aerobic stability of the silage.

The International Potato Centre (CIP) in collaboration with NaLiRRI developed a technology to conserve sweet potato residues as silage this has the potential to bridge seasonal feed shortages and seasonal fluctuations in feed prices fluctuations (Kabarizi, 2016).

NARO also did several studies how to improve silages of crop residues, both in terms of fermentation and nutrition, using intercropping or mixing at ensiling, and with the use of additives. There is also potential for the ensiling of many agro-industrial by-products alone or in combination with forages and legumes during periods of abundance when demand and prices for these products are low to lower feed cost for livestock.

Q9. "List at least three most common causes for post-harvest losses in the forage production and preservation chain?"
According to the respondents poor storage of hay (dry place) and silage bunkers (21%), lack of good agricultural practices during crop production causes major post-harvest losses (20%) and fermentation (16%) (Anaerobic conditions for silage) are the other important causes of losses (Survey Diagrams; Fig. 5.5).

Q10. "What farming practices can dairy farmers adopt to prevent or reduce harvest and post harvesting losses?"
The respondents rated right harvesting stage (26%), applying good practices during crop management (24%) and better storage (21%) as the key factors to reduce post-harvest losses (Survey Diagrams; Figure 5.6).

Q11. "Which other conservation methods or technologies do you think could be introduced in the current dairy farming systems?"
Silage making is particularly seen as a potential method to improve intensive farming systems (44.0%). For more extensive farming systems, grass management is an important option (55.0) % for extensive farming systems and (18.0%) for semi-intensive farming systems. For commercial forage producers, silage making (50.0%) and hay (30.0%) are the preferred options (Survey Diagrams; Fig. 5.7-5.10).

| Table 10. Summary of preservation methods gaps |
|---|
| Difficult to introduce new technology |
| Knowledge on preservation technology is lacking |
| Limited access to preservation technology for small holders |
| Limited preservation methods (hay and silage) |
| Lack of scaled machinery, inappropriate machinery, lack of spare parts, poor maintenance |
| Lack of skills to operate and maintain modern machinery |
| Difficult to import machinery |

Irrigation of newly planted fodder garden in Central Uganda

Maize silage bunker in South Western Uganda

# 6. Seed, planting material and fertilizer use

## Seed and planting material

The demand for high quality forage seed for the development of livestock feed resources is increasing rapidly in Uganda. This demand is fuelled by the expanding dairy production occasioned by the increased demand from a rising population, and improved income particularly in the urban centres (Kabirizi, 2016).

**Q16. "In your opinion, what is the availability of the listed seeds/plant material in the market? "**
The respondents of the questionnaire have a general low opinion about the availability of forage seeds varieties. The planting material/seeds most easily accessible are Napier grass (planting material), maize, Brachiaria, and Desmodium varieties. With Rhodes grass and Calliandra seeds being perceived as fairly (medium) available (Survey Diagrams; Figure 6.1). Availability of forage crops seeds is low (64%), with less than 10% of the respondents mentioning forage crop seeds/planting material being easily available and accessible (Survey Diagrams; Fig 6.1)

Availability and application of (improved) forage seeds/planting materials at the farm level is low and is one of the reasons why development and adoption of improved forage production and technology in Uganda remained a low level. Forage seed production and availability include formal registered and certified seed distribution, but so far the majority is informal on-farm reproduction and channels for sharing of seeds or planting material. Unlike Maize and Sorghum used for forage production.

Uganda faces the challenge of seed companies reluctant to take up research products for production and multiplication and onward sale to farmers on the one hand. On the other, farmers hold on to traditional grazing practices and are seemingly unwilling to use part of their lands to grow forage.
The Ugandan government is responsible for developing research capacity, while the private sector carries out seed production, seed processing and marketing. The government should focus on putting policies and regulations in place and creating an enabling environment.

The Ministry of Agriculture, Animal Industry and Fisheries, through the Directorate of Crop Production, is the national authority with the mandate to regulate the seed industry, with the National Seed Certification Services (NSCS) responsible for seed certification (MAAIF, 2019)

Formal procedures for forage seeds need to follow the regulations for variety evaluation, release and registration through NSCS. Before a variety can be recognized and entered in the National List of varieties, it must be tested both for agronomic value and for Distinctness, Uniformity and Stability (DUS). The testing for agronomic value is carried out by the breeders while the DUS testing is the responsibility of the NSCS. (Ssebuliba, 2010).

NSCS ensures that only those varieties which undergo National Variety Performance Trials (NVPT) for two seasons are released for commercial production. Where a variety is already released in another country, such variety undergoes national variety performance trials for at least one main growing season before release provided that the breeder of such variety provides data used for release in similar agro-ecological zones (Ssebuliba, 2010).

**Q17." What are reasons for low availability of seeds in the market (incl. new varieties or species not yet registered in Uganda)?"**
The reasons the respondents of the questionnaire gave for the low availability of seeds are (i) lack of knowledge and awareness of the farmer about the benefit of forage crops (31%), (ii) absence of seed production and multiplication companies in Uganda (25%), and (iii) high cost of improved forage seeds (13%) (Survey Diagrams; Figure 6.2).

Q18." How would you increase the availability of seed/plant material?"
Based on the survey, the most needed action is (i) changing the government policies and regulations on forage seeds and planting material, e.g. simplify the importation, testing and registration processes (39%), (ii) encouragement of international seed producers to enter the Ugandan market with forage seeds (31%) and (iii) increase awareness and knowledge among farmers about the value of forage seeds and planting material (19%) (Survey Diagrams; Figure 6.3).

Q19. "How would you engage dairy farmers to use improved forage seeds/plant material for planting?"
To encourage farmers to use the improved forage seeds in the future, respondents agreed that training of farmers in all farming systems (respectively 92%, 61%, 52%) will be necessary to reap the benefits of improved seeds/plant material (Survey Diagrams; Figure 6.4).

## Seed suppliers

To our knowledge there are about 23 companies in Uganda that supply certified forage seeds, including commercial maize seed that is used as a fresh maize or silage maize to feed to cows. Not all of them stock forage seeds, such as maize, sorghum, lucerne, Desmodium, oats, Boma & Elmba Rhodes grass, Sudan grass (sorghum × drummondii), sunflower, Columbus grass (sorghum x Almum parodi), and beans. None of the private companies have forage seed multiplication sites. Public organisations (like NARO) dispersed over Uganda reproduce forage seeds on government and private farms (see Map 4 below).


Map 4. Areas where pasture seed was produced and forage technologies disseminated (Source Kabirizi, 2016)

## Seed production

The large-scale forage seed multiplication (certified and non-certified) is limited to NARO, the government farms, and private farms. Most seed multiplication sites in Uganda are dedicated to the seed multiplication of grains, and vegetable seeds for human food, which have a higher and repetitive market demand in East Africa (South Sudan, Rwanda, Burundi, Tanzania).

ISSD- project is implementing Integrated Seed Sector Development (ISSD) in partnership with NARO. Their out puts include; establishment of functional local seeds businesses in order to fill the gap in quality seed production. Although the project started with food security crops, they have now included businesses involved in the production of pasture seeds for sale

Seed and planting materials for various forage species including Napier grass varieties that are tolerant to Napier stunt disease, lablab, Rhodes grass, Brachiaria grass, Siratro, Style, Alfalfa, Centro, Desmodium, and *Clitoria ternatea* among others, have been bulked and distributed to stakeholders. Over 500 tons of high quality pasture seed was produced and marketed during the period of 2010 to 2016. The seed was produced both on private and government farms (Kabirizi, 2016).

## Seed quality control

Low quality seed in Uganda is largely attributed to (i) insufficient field supervision and inspection services in seed production, (ii) processing and testing, (iii) low investment in seed research & innovation, and (iv) limited skills. This partly explains the low uptake and use of certified forage seeds and consequently low agricultural production and productivity which continues to stifle the potential of the dairy sector's contribution.

The Ugandan government through the Plant Act is now committed to change this situation but so far priority is on food and vegetable seed. the Seeds and Plant Act 2006 is generally a good law which if effectively implemented, can go a long way in ensuring the sustainable availability of affordable quality seed. The biggest challenge is that to-date the Seeds and Plants Act is not fully operational.

Seed companies would need to collaborate with NSCS in the certification of all commercial forage seeds. The introduction of new forage crops into Uganda from within or outside would require confirmatory tests for Value for Cultivation and Use (VCU) and Distinctness, Uniformity and Stability (DUS). In addition to the long period of variety development, all new varieties undergo two seasons of testing before they can be registered and released as new varieties.

Seed companies from outside Uganda find this process to be cumbersome, more so for forage crops and pasture grasses and legumes as the demand for these improved forage varieties will need to be developed. The cost and time to register new varieties are especially significant for new seed companies, which limits the flow of new varieties into the market.

Local seed companies have basic and certified seed production activities on-farm or with seed growers. Major seed selling outlets are facilitated by the government, agro-dealer distribution networks and non-governmental organizations operating in the region.

Informal channels trade seeds (farmer to farmer) that do not necessarily pass through the regulations (are not certified). The current problems as regards availability and access to reliable and quality forage seed and planting material is likely to be exacerbated by the increased forage demand resulting from increased demand and consumption of milk (-products) and beef.

### Soil fertilisation

A considerable proportion of the soils are highly weathered, have low nutrient reserves and therefore limited capacity to supply phosphorus, potassium, calcium, magnesium and sulphur. Some have sufficiently strong soil acidity for soluble aluminium to be toxic for most crop species. Such include the Ferralsols and Acrisols which form more than 70% of the soils in Uganda on which most of the farming is practised. These soils have been intensively farmed by small holders. The decline in crop and pasture yields, soil physical and chemical properties, vegetation cover and biological diversity has been affected significantly over time (Bekunda et al., 2002).

Nutrient mining in East Africa is among the highest in Sub-Saharan Africa, with an estimated annual nutrient depletion rate of 41 kg nitrogen (N), 4 kg phosphorus (P) and 31 kg potassium (K) per hectare (Bekunda et al., 2002).

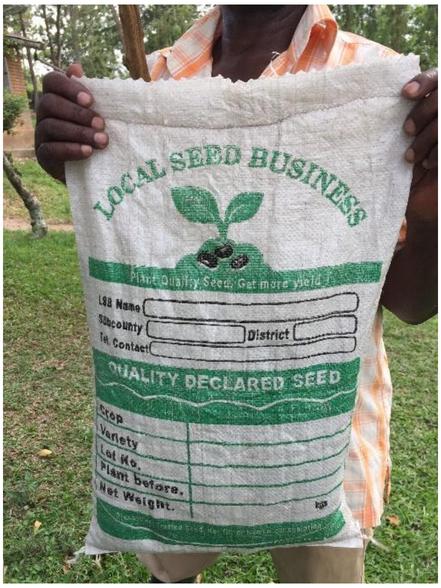
ISFM are practices such as use of manure, compost, use of a crop specifically to incorporate it in the soil (green manure), mulching crop residues, rotation with grain legumes, grass-legume intercropping and cereal-legume multicropping systems, conservation agriculture (CA) in combination with quality (certified) seeds and synthetic fertilizer to replenish the natural soil fertility (Hijbeek, 2019).

Integrated Soil Fertility Management (ISFM) is one of the climate smart practices that can help improve soil fertility to realize acceptable yields and returns under these soil conditions. Though soil fertility in most areas of Uganda is low, farmers have not been able to this technology effectively to redress the downward spiral of soil fertility.

Despite soil fertility being a key ingredient for improved forage production, the national fertilizer application rate is extremely low at an average of 1 kg /ha/year, compared to 5kg/ha in Tanzania and 30 kg/ha in Kenya (Annex 7), and far less than the world average of 100kg/ha. (CIAT; BFS/USAID 2017, FAO, 2018c, World Bank, 2017).

It is estimated that of the total fertilizer use in Uganda, 95% is applied to cash crops (tobacco, tea, flowers, and sugarcane) grown on large estates or by out growers. (Bekunda et al, 2002).

| Table 11. Summary of seed, planting material, fertilizer use gaps |
|---|
| Distribution network of forage seed/plant material driven by public institutions |
| Reliable forage seed production supported by ISSD/WUR |
| Forage seed sector less interesting for private seed production and multiplication |
| Little awareness relationship between forage quality and dairy cow production potential |
| Little Involvement of private forage seed producers (farmers, private companies) |
| High cost of inputs for forage crop production creates association of forage crop with maximum yield not quality |
| Poorly developed seed marketing systems |
| Lack of financial incentives for seed prices |
| Need for soil testing and analyses |
| Availability of synthetic fertilizer |
| Informal production and trade (farmer to farmer) |
| Ineffective dissemination of information, knowledge and research results |
| Land degradation (soil erosion, deforestation, soil fertility, yield decline) |
| Inadequate knowledge on proper soil/land use practices |
| Poor land management practices leading to unsustainable use |
| Population pressure leading to continuous cultivation |
| Inability of smallholder farmers to invest in sustainable land management practices (incl. manure and fertilizer) |




Official packaging of quality declared seed in Uganda


095

ISSD Uganda

INTEGRATED SEED SECTOR DEVELOPMENT (ISSD), UGANDA

Local Seed Business
Certificate of Registration

LOCAL SEED BUSINESS NAME: DREAM FARM KYAKABUNGA GROUP (DFK)

CODE: AKH 6083

LOCATION OF THE LSB

Sub county: NYAKASHASHA

District: KIRUHURA Region: ANKOLE

Postal Address: Lyantonde

Telephone/Mobile No: 0752 637373 (KANUUNU JACKSON)

Validity period: 1st JAN To 31st DEC 2019

WAGENINGEN UR UGANDA LTD.
P. O. BOX 20106
KAMPALA, UGANDA

Signature
The Deputy Chief of Party
Integrated Seed Sector Development, Uganda

Date 31/12/2018

Registration Certificate

Certificate of Registration of a Local Seed Business

Uganda seed test result certificate

Field of Chloris gayana for seed production in South Western

# 7. Mechanisation

Agricultural production is mainly dominated by smallholder farmers engaged in food and cash crops, horticulture, fishing and livestock farming (National Development Plan II). Most farmers in Uganda use rudimentary tools in farming. For instance, out of the 3.6 million respondents from a study conducted by the Uganda Bureau of Standards (UBOS), 95.8% used hoes (UBOS, 2010).

**Q21. What is the mechanisation level for forage production and preservation for the intensive farming systems?**
Respondents indicated that the mechanization level with the small holder farmers is low irrespective of the forage crop the farmers are growing. (Survey Diagrams; Fig. 7.1)

**Q22. What is the mechanisation level for forage production and preservation for the medium and large scale dairy farmers?**
The mechanisation level on medium and large-scale farms is considered very low irrespective of the crops grown as the overall picture. (Survey Diagrams; Fig. 7.2)

This low level of mechanisation at every stage of the farming processes is a contributing factor to low farm output. To change this, the Ugandan government came up with agriculture mechanisation as a strategy of restructuring the sector. The equipment accessed by the farmers through this subsidised program were mainly used for opening up land for bumper production, clearing thickets to allow green pasture growth, opening up new roads to access the markets, di-silting/excavating valley dams/tanks for water harvesting irrigation and preparation for dry spell, spraying, drying, value addition and planting.

Agricultural mechanisation has many benefits. It contributes to improving productivity of cultivated land and facilitates expansion of cropping areas, improving overall forage and fodder security. Mechanisation also eases labour constraints including seasonal shortages, and reduces the requirement for physical hard labour, leading to both improved production and farmers welfare.

According to Lukuyu et al., 2013, labour constitutes the highest cost of production for all forages, with the cost of planting materials, especially forage seeds, coming second. This may be due to high cost of seed, inaccessibility of seed, and governmental rules and regulations restrictions in the forage seed delivery system. This situation, especially the forecasted increase in labour costs, could be a future driver of mechanisation in the forage/animal production sector.

Financial constraints are the main causes of this situation, along with the unpredictable market that drives investors to be very cautious at investing in machinery and technology. Lack of qualified operators and mechanics further contributes to this.

The provision of inputs alone without transferring knowledge can create unintended consequences like depletion of soil health and poor incentives for the private sector which reduces the competitiveness of agribusinesses (Worldbank, 2012).

In order to raise agricultural land and labour productivity, to generate rural employment and make it more attractive and to achieve future growth and poverty reduction agendas, governments must embrace the technological, policy, and institutional innovation opportunities afforded by mechanisation. Successful mechanisation along the value chain will have to be a priority in any future development and growth agendas for African smallholder agriculture. Its success depends on organisational innovations such as reliable services and cooperation arrangements for and with farmers (NEPAD, 2019).

Slow adaptation in Africa can be attributed to low technology adoption, and enhanced farmer education would speed up technology dissemination and climate change adaptation (Barnard, 2015). The importance of extension services in technology dissemination, are hampered by farmers' inadequate funds, technical skills and capacities. Any technology seen to disrupt the existing livelihood systems will not be accepted and assimilated easily. For example, introduction of irrigated agriculture in pastoral communities has always been resisted. However, there are success stories that have been attributed to the way the technology was introduced to the community. Capacity building through demonstration, exchange visits, and incorporation of socio-cultural aspects is key to any technology transfer package (Barnard, 2015).

The ability of farmers to apply new technologies and innovations is an important determinant of Climate Smart Agriculture (CSA) adoption. Farmers need to be sensitized on existing technologies and innovations to appreciate and adopt them. Sensitisation and awareness creation on existing new technologies and innovations is key to promoting adoption and strengthening adaptive capacity.

**Q23. "What do you think is the main mechanisation problem that is currently hindering the production, quality and utilization of forages on dairy farms?"**
According to the survey, lack of appropriate machinery in terms of type and scale is seen by the respondents as the largest constraint for intensive mechanisation (from planting to harvesting to feeding out) (more then 42%). Cost of mechanisation is rated second for all farming systems (> 10.0%). (Survey Diagrams; Figure 7.4).

**Q24." Would you prefer to promote on-farm mechanisation or use of skilled contractors with appropriate machinery in different dairy systems?"**
While there is a demand for skilled contractors, on-farm mechanisation is also seen as a future solution to reduce the burden of an often-heavy workload on the farms and shortage of labour. (Survey Diagrams; Figure 7.5).

**Q25." What solutions do you suggest for enhanced mechanisation of forage production and preservation in small holder, medium and large-scale dairy farms?"**
The respondents rated the option of scaled the machinery as another solution to enhanced forage production in Uganda (21% for SHF and 15% for M&LHF). Training and skills development is nearly the same 15% for SH and 13% for M&LHF. The importance and need of skilled contractors in small holder systems lower (4%) than in medium and large farms (13%) (Survey Diagrams; Figure 7.6).

| Table 12. Summary of machinery gaps |
| --- |
| Availability and accessibility of scaled machinery |
| Distribution network of scaled machinery and spare parts |
| Not easy to import |
| Lack of skills to repair and maintain the machines |
| Scarcity of spare parts |
| Lack of skilled operators |
| Lack of investors (big investment needed for an unstable market) |


Cutting grass for hay in South Western Uganda

Baler on a farm in Uganda

# 8. Inputs and services

Input service providers are suppliers of: Seed, animal feed and animal health products, equipment, artificial insemination, veterinary, advisory services, financial services and business development services for Ugandan farmers (Arnaoudov, 2017). But also, not to forget 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 (Agriterra, 2012; Makoni et al, 2013).

**Q26."" What is your perception of the quality of the input suppliers and service providers in relation to forages, on a scale of 1 - 5 (1 = poor, 5 = excellent)?"**
The perception of the quality of the input suppliers and service providers ranges from poor to below average. Services like supply of mechanization, agricultural contractors and feed laboratories are perceived as either low or not existing. Supply of seeds, training and inputs for silage making is perceived as below average to average. (Survey Diagrams; Figure 8.1).

**Q27 "Which services, according to you, are missing in the Ugandan forage market?"**
Inadequate education/training and extention service was mentioned by (31%) of te respondents as missing in the Uganda forage market followed by lack of a quality feed lab and of feed standards ( 22%), Mechanisation services (19%), quality inputs and quality service providers (13%), regulations by government (6%) (Survey Diagrams; Figure 8.2).

**Q28 "What improvements (maximum three) are required at the level of input suppliers and service providers to achieve improved availability and quality of forages?"**
* To improve seed and plant material supply 50% of the respondents believe a seed certification system for forage seeds need to be put in place. Better accessibility and handling/ storage followed with 14% of the respondents giving these as required improvements.
* To improve training and advisory 58% of the respondents answered extension service to the farmers needs improvement so there will be continuity in training. Better linkages followed with 21% and farmers organisations with 16% of the respondents giving these as required improvements.
* To improve mechanisation services 24% answered contract services need to be available. Affordability (24%) and condition of machinery and Building local expertise followed with 19% of the respondents giving these as required improvements.
* To improve input supply 35% answered availability of farm inputs needs to be better. Inputs need to be standardized mentioned (22%) and 18% answered that the inputs need to be affordable. Followed by mechanisation 13%.
* To improve contracting services 34% answered technical skills are required. While (22%) mentioned the contracting services need to be available and 22% mentioned registration of contracting services, recognising the services as an official business.

There are about 966 input retailers in the country. According to the agro-input dealer's census conducted in 2004, the districts with the largest number of fertilizer retailers included Sironko, Masaka, Mukono, Mbale, Iganga, and Kapchorwa. Census results show that only 20 of the retailers selling fertilizer sold more than 1MT per year, and only 8 sold more than 2 MT. The total rural retail sales to smallholders were less than 150 MT. The Census of 2009 revealed a total of 2,064 input dealers indicating an increase of about 114 percent between 2004 and 2009.

In Uganda, the fertilizer industry is private sector led and liberalised. Uganda currently does not produce inorganic fertilizers, although in the past there was production of phosphate fertilizers. There is, however, an advanced plan to set up a phosphate fertilizer production facility by Guangzhou Dongsong

Energy Group in Tororo district by 2016. Currently all of the synthetic fertilizer used in the country is imported (Godfrey, 2015).

Table 13 shows the percentage of farmers per region making use of farm inputs. The use of improved seeds stands at 6.3% of farmers, while agro-chemicals are at a meagre 3.4 (Hundsbaek R, 2012). The slightly higher figures in the Eastern region maybe caused by cross-border influence and trade with Kenya.

**Table 13. Percentage of farmers using agricultural inputs in 2006 (%)**

| Region | Improved seeds | Manure | Chemical fertilizer | Agro-chemicals |
|---|---|---|---|---|
| Central | 5.5 | 8.7 | 1.3 | 4.8 |
| Eastern | 11.9 | 4.1 | 1.1 | 4.7 |
| Northern | 7.6 | 0.5 | 0.7 | 2.7 |
| Western | 2.2 | 9.6 | 0.6 | 1.5 |
| **National** | **6.3** | **6.8** | **1** | **3.4** |

Hay making as a service delivery is also an opportunity for investments by unemployed rural youth who loathe agriculture as a direct employment option. The youth need technical and entrepreneurial skills in the service provision. The youth can use available land to produce conserved pastures (Kabirizi J, 2016).

Private sector investment would enable access to financing to a sector that has little access to finance. Rural residents are twice as less likely to access finance from formal financial institutions than their urban residents and end up relying on informal and non-bank formal institutions.

Financial institutions are reluctant to extend credit to agriculture because of lack of usable collateral, high transaction costs due to the remoteness of clients, dispersed demand for financial services, small size of farms and of individual transactions, underdeveloped communication and transportation infrastructure and high covariant risks due to variable rainfall, price risks and recurrent incidences of pests and diseases. Combined with poorly developed agri-food value chains and added transaction costs associated with the absence of physical banking facilities in rural areas, most institutions are unwilling to lend (Worldbank, 2012).

Warehouse receipt systems and credit guarantees for example can work as an alternative solution to address lack of collateral and poor credit. Farmer groups and small enterprises can establish good repayment reputation and benefit from lower transaction costs and access to more finance.

Access to credit facility for farmers to improve pasture and fodder production is recommended as one way of expanding and improving forage production. However, this is unlikely to be successful if farmers do not have the needed management skills. Training in pasture management and fodder production is important to increase the availability of feeds for dairy cows (Kabirizi, 2016).

On the smallholder side, this appears to be linked to difficulties in securing finance and uncertainties about whether land invested in can be retained. As was seen above, less than 20% of land can be said to have secure tenure of the type required as collateral for formal loans.

| Table 14. Summary of input & service provider gaps |
|---|
| Market size and uncertainty of demand (low buying power farmers) |
| Business ethics and tendency to push products into the market (irrespective of quality and benefits for the farmer) |
| Lack of business-oriented entrepreneurs |
| Limited financial services |
| Limited knowledge and ability to give the right advise with the product or service |
| Low skills level of technical staff and sales representatives |
| Available knowledge and information do not reach the farmer |
| High prices for certified and improved forage seeds, synthetic fertilizers and agro chemicals |
| Capacity of public and private extension advisory services |

# 9. Forage market

Commercial forage production in Uganda in not common though in the urban and peri urban areas around big towns like Kampala, Mbale, Jinja and Gulu there is a demand for forages.

> Q29." What kind of forages can you find nowadays being offered for sale in the market (e.g. fresh/green forages, imported forages, grass hay, wheat straw, silage, etc.)?"
> According to the respondents of the questionnaire, hay (46%) is the main product in the market, followed by silage (26%) and fresh cut forages (14%).

There is a large demand for hay, silage and haylage by progressive smallholders and medium scale dairy farmers (10-30 cows). These farmers are engaged in commercial dairy production but are usually unable to grow and preserve enough quantities on farm, due to lack of land size, skills and/or capital for mechanization. In general, commercial fodder production is growing – and it has potential to grow further with enhanced management skills and proper mechanization.

The forage market in Uganda is informal and opportunistic and trade increases or slows down depending on the season. No standards are in place, demand and perception of the quality are the drivers in the market. Forage quality is measured by visual inspection, smell, and experience. Weight is estimated based on fresh weight basis or volume (a bundle one can carry).

> Q30." How would you define the actual forage market (e.g. seasonal, opportunistic, formal/informal, quality control, standards, etc.)?"
> Forage trading is carried out through mainly informal channels. The informal channel includes farmers and small traders who directly buy from small producers – even the localized trading of fresh forage (e.g. Napier grass and grass cut along the roadside) between one farmer and another – and it is the dominant channel of forage trade. The formal channel comprises traders, and agro vets that purchase forage from medium- and large-scale producers and directly deliver the forage to dairy farmers. The respondents in the questionnaire defined the Ugandan forage market mainly as seasonal (57%) and informal (24%) (Survey Diagrams; Figure 9.2).

| Table 15. Summary of forage market gaps |
| --- |
| Forage production is not recognised as an economic activity |
| Unpredictable market (seasonal in extensive system) |
| Informal market |
| Lack of pricing mechanism based on quality, lack of standards |
| Volume based and not quality-oriented |
| Lack of reliable feed testing |
| Lack of knowledge and skills about forage production and conservation |
| Poor marketing |
| Buying forage associated with emergency situations |
| Level of mechanisation in forage production very low |
| No economies of scale because of land tenure system |


Storing hay in Eastern Uganda


Hay bale of natural grassland

# 10. Education and training

Various studies (GOU, 2004, USAID, 2014; ASIF, 2019) on education and training in the Ugandan dairy sector have highlighted the lack of practical training and skills development (i.e. good agricultural practice at farm level).

A survey conducted by the task force of the National Agricultural Education Strategy (NAES) in 2004 identified the following major challenges facing formal and non-formal agricultural training and education: (i) lack of a coherent policy for agricultural education and training, (ii) insufficient funding for agricultural education and training, (iii) ineffective institutional framework for the delivery of agricultural education and training, (iv) inappropriate curricula and teaching and learning methodologies in agricultural education and training, (v) negative attitudes towards agriculture in general and agricultural education and training in particular.

The Inter Academy Council (2004) noted that the graduates produced were lacking in a holistic system and critical thinking problem solving skills and were also ill-prepared to assist farmers in the real world. This requires government commitment to provide an environment conducive to promote agricultural education and training.

There is a need to transform Agricultural Education and Training (AET) which is characterised by: outdated traditional training systems that are not based on current employer skills demands; a lack of synergy between Tertiary Agriculture Education (TAE) and research centres; lack of coordination and strategic alignment to the national development priorities; and lack of management information systems. Mismatch between AET and Skills requirement in industry and public institutions (outdated curricula that are not adapted to changing skills demands). AET systems lack practical training and do not use modern training tools. Decrease of AET financing as there is a lack of incentive from private sector and stakeholders towards funding AET (NEPAD 2019).

There is however great potential value in developing youth participation in agriculture value chains; achieving the potential will require however both expansion of agricultural modernization and investment in skill building with young people (USAID 2014). A growing skills base is needed, and enhanced understanding of how to better include large numbers of smallholders in increasingly more demanding high-value agricultural markets (Worldbank group, 2019).

Q35." What is the availability and quality of education and training on forage production, preservation and inclusion of dairy cow ration formulation in the country?"
Among the respondents of the questionnaire, (i) 42% answered that availability of training is limited, (ii) 42% described the availability as very low to low (iii) Only 16% described the availability of the training as good. (Survey Diagrams; Figure 10.1).

Q35." What knowledge and skills are lacking in regard to forage production and preservation?"
Agricultural skills and best farming practices (from seed to feed incl. mechanization) is considered by 44% of the respondents as the key missing skill causing the gap in forage production and preservation in Uganda; 20% indicated that there is lack of knowledge and skills about preservation technology and methods. (Survey Diagrams; Figure 10.2).

Q37." Who should provide this training?"
According to the survey, this training should be provided by either (i) government extension workers (41%), (ii) Non-governmental organizations (20%), or (iii) private sector players (9%), (Survey Diagrams; Figure 10.3).

In Uganda, the NAADS oversees agricultural extension services. According to the National Agricultural Extension Strategy, in 2014 the ratio of agricultural extension staff to farmers was estimated at over 1:5,000 (MAAIF, 2014).

Q38." Who should be trained?"
According to the survey, all the stakeholders involved in forage production need to be trained. These were rated as follows: (i)) training and extension staff (18.7%), (ii) farmers (16.8%), (iii) agricultural contractors, commercial forage producers and farm workers (15.9%), (iv) dairy nutritionists (14.0%). (Survey Diagrams; Figure 10.4).

Mubiru et al. 2011 mentions that the poor performance in the dairy sector indicates a gap in the knowledge disseminated to farmers regarding cattle feeding. One major knowledge gap in Uganda was that farmers did not know the quantities of feeds that would adequately meet the nutritional requirements of their animals.

The relationship between research and local farmers In Uganda over the years has not been strong over the years. Recently researchers started an initiative disseminating information about agricultural technologies themselves because dairy extension workers were not doing it effectively. Dairy extension workers are perceived to be absent and there is no forum for bringing them together. The linkage between academic research and extension is weak while the problem is worsened by inadequate funding for the public dairy extension workers sector.

Extension services need knowledge and focus on quality forage production for dairy cows with a higher genetic potential for milk production; the lack of knowledge in this field makes them ineffective. This gap has been partly filled by extension services of dairy cooperatives, processors, and by development partners and projects who are capacity building training and extension staff of dairy cooperatives and lead farmers, and – also – private dairy advisory services which are emerging Ericksen, P et. al. 2018 mentions that despite years of investment in developing and disseminating improved forages for on farm use, uptake in Kenya (and Ethiopia) remains low. In Uganda the scientist come to similar conclusions.

The major reasons cited by Bernard J. et al. 2015 for low adoption of proven technologies include limited technical knowhow among smallholder dairy farmers augmented by limited extension services and technological costs.

The conclusion is that all the recommendations on forage production proposed in this report need to be supported by a strong education/training plan like proposed in the Agricultural Education and Skills Improvement Framework (AESIF). This framework represents a common agenda for addressing key challenges in education and skills improvement for the whole agriculture knowledge system regionally and nationally. This the needs to be addressed and taken up by all stakeholders in the chain, otherwise the effort could be ineffective.

| Table 16. Summary of knowledge, education, training, awareness gaps |
|---|
| Reduced government extension service, gap not filled by the private sector |
| Lack of practical knowledge and skills on forage crop production, preservation |
| Hence lack of training facilities that focus on practical skills training in forage production and ruminant nutrition |
| Lack on farm research and demonstrations |
| Public -private partnerships in education and extension |
| Lack of awareness / knowledge of the relationship between forage and animal nutrition |
| Lack of curriculum for practical knowledge and training on forage production and dairy nutrition at all levels |
| Lack of market-led research, training and education |
| Formation of dairy farmers' cooperative associations |

Light mechanisation make farming more attractive and  give viable solutions for entrepreneurial youth

## 11. Environmentally sustainable forage production

Forages are essential for the successful operation of animal production systems. This is more relevant to ruminants which are heavily dependent on forages for their health and production in a cost-effective and sustainable manner. While forages are an economical source of nutrients for animal production, they also help conserve the soil integrity, water supply and air quality (Chaudry, 2008).

To maintain sustainability, it is crucial that forage based animal production systems remain profitable and environmentally friendly, while producing nutritious foods of high economical value. Thus, it is pertinent to improve the nutritive value of grasses and other forage plants in order to enhance animal production to obtain quality food. It is also vital to develop new forages which are efficiently utilised and wasted less by involving efficient animals. A combination of forage legumes, fresh or conserved grasses, crop residues and other feeds could help develop an animal production system which is economically efficient, beneficial and viable. Also, it is crucial to use efficient animals, improved forage conservation methods, better manure handling, and minimum fertilisers to maximise animal production without damaging the environment (Chaudhry, 2008)

However, sustaining an ever-growing population of ruminants consuming forages poses a dilemma: while exploiting their ecological niche, forage-fed ruminants produce large amount of enteric methane, a potent greenhouse gas. Resolving this quandary would allow ruminants an expanded role in meeting growing global demands for livestock products (Guyader. et al, 2016).

Uganda has one of the lowest GHG emissions per capita in the world, estimated at 1.39 tons carbon dioxide equivalent, far below the global average of approximately 7.99 tons of carbon dioxide equivalent; yet the country is most vulnerable to global warming and climate change impacts. The total national GHG emissions including land-use change and forestry is about 48.38 Mt CO2e, which is 58.7% of the 82.4 Mt CO2e regional GHG emissions .

The agricultural sector has the highest emissions, contributing about 46.25% (22.38 Mt CO2e) to the country's total GHG emissions. The four main sources of GHG emissions from the agricultural sector include enteric fermentation at 42.8%, manure left on the pasture 31.1%, burning savanna 12.9% and cultivation of organic soils at 4.8% (FAOSTAT 2019). Similarly, from pastoralism, methane emissions can be reduced by improving pastoral livestock keeping practices, such as the use of improved breeds and feeding regimes.

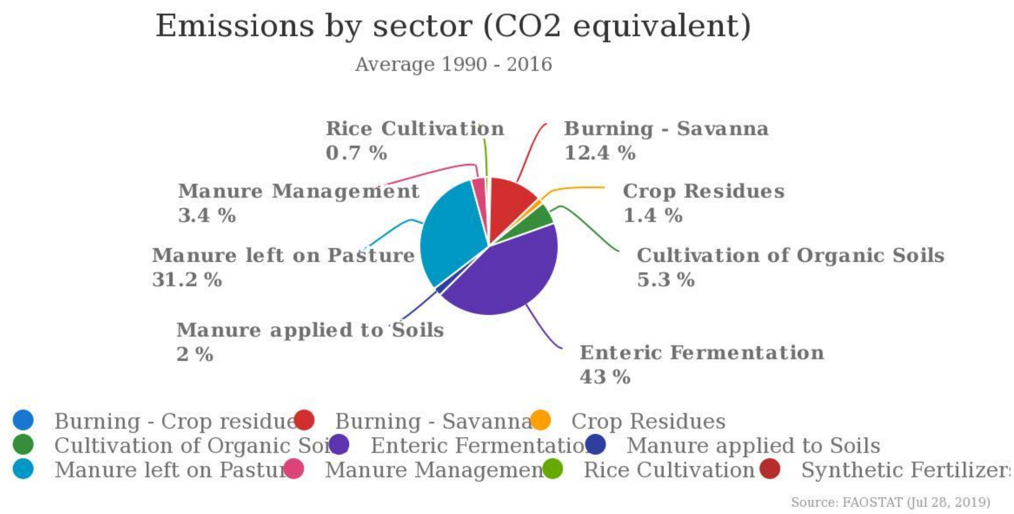



Figure 3. Dairy production, major source of GHG emissions (FAOSTAT, 2019)

For enteric methane emission reduction, the best approach is to increase ruminants' feed efficiency through a balanced diet based on high quality forages, and the production of high quality (preserved) forages following good agricultural practices from "seed to feed". High quality forage production is directly linked to feed efficiency and feed efficiency is closely related with environmentally friendly production systems (Figure 4).


**Figure 4. Relationship between forage quality, produced under climate smart agriculture practices, and methane emission reduction**

Increased feed efficiency is one way around the dilemma. Another way is by raising ruminants in systems using forages, some of the methane emissions can be offset by preserving or enhancing soil carbon reserves, thereby withholding carbon dioxide from the air. Similarly, well-managed systems based on forages may reduce synthetic fertilizer use by more effective use of manure and nitrogen-fixing plants, thereby curtailing nitrous oxide emissions. The potential environmental benefits of forage-based systems may be expanded even further by considering their other ecological benefits, such as conserving biodiversity, improving soil health, enhancing water quality, and providing wildlife habitat (Guyader et al, 2016).

**Q39" How do you rate the effect on the environment of current agricultural practices as regards forage production and preservation?**
Respondents consider that the effect of current practices of forage production and preservation on the environment is either neutral (35%), negative (35%) and positive (30%) (Survey Diagrams; Figure 11.1).

**Q40." What is in your opinion the contribution of current forage production and preservation towards an environmentally sustainable dairy industry?"**
According to the respondents 35% the contribution of current forage production practices as neutral, whereas 55% consider that current practices contribute positively towards a sustainable dairy industry (Survey Diagrams; Figure 11.2).

**Q41 Which good practices, interventions would you recommend as regards the forage sub-sector to reduce the (negative) impact on the environment?**
The use of high quality forages was the option chosen by 28% of the responders, followed by improved manure management and grazing management (16%) %) (Survey Diagrams; Figure 11.3).

**Q42.”What other recommendation do you have – beyond forage production and preservation - for reduced environmental footprint for the Ugandan dairy industry?”**
The three main recommendations the respondents gave to reduce the environmental footprint of the dairy industry in Uganda were (i) Encourage tree planting and afforestation (21.7%), (ii) installing and producing biogas at the farm level (21.7%), and (iii) recycle waste more effectively (8.7%) (Survey Diagrams; Figure 11.4).

**Q43.”Are there any regulations/policy requirements in place that you are aware of to reduce the environmental impact of livestock production systems (national or regional level)?”**
Most of the respondents (53%) mention that there are regulations/policy requirements in place to reduce the environmental impact of livestock production systems on either regional or at national level (Survey Diagrams; Figure 11.5).

**Q44.” In your opinion, how likely do you think farmers/commercial forage producers will adopt practices that will contribute to a better environment, but may require an investment? What will trigger them?”**
For farmers to adopt and implement practices that will contribute to a better environment the respondents believe that farmers would do so if they are being sensitized about the subject (26%). Other considerations included (i) increasing awareness by training and educating farmers (17.4%), good milk prices (17.4%) and economic incentives (13%) (Survey Diagrams; Figure 11.6).

Soils in Uganda are very old and deeply weathered with very low nutrient holding capacity and deficiencies or toxicities of trace elements. Nutrients in these soils have been mined for a long time without replenishment. It is estimated that annual nutrient depletion stands at an average of 87kgs NPK per hectare per year (38kgs of N; 17kg of P and 32kgs of K). Around 200kgs per hectare of mineral/inorganic fertilizer or 3-5 Mt of composite manure per hectare need to be applied annually to replenish the soil nutrients and boost agricultural productivity (Godfrey, 2015).

Widespread degradation of land resources is another challenge in Uganda. In 1991, studies estimated that soil erosion accounted for over 80% of the annual cost of environmental degradation, equivalent to USD 300 million per year. In 2003, the annual cost of soil nutrient loss due primarily to erosion was estimated at about USD 625 million per year. In some places, productivity losses per year for maize from soil erosion have been estimated in some places as high as 190 kg/ha (CIAT, 2017)

In regions with low fertilizer use and low crop yield, increasing fertilizer use can increase soil organic carbon, improve soil fertility, enhance crop yields and in some areas, save carbon stored in forests by avoiding deforestation; however, net greenhouse gas emissions (as $CO_2$-eq) from agricultural soil will likely increase due to increased $N_2O$ emissions associated with N fertilizer use, although this can be minimized through integrated soil fertility management.
Water conservation contributes to sustainable intensification by allowing water to be used efficiently, which results in larger agricultural production throughout the year and improved resilience to drought. This improves farmers’ livelihoods and food security. It involves gathering water from a ‘catchment area’ and channeling it to the area in need. Some techniques for water conservation can also work at a smaller scale within the cropped area, such as minimizing of run-off and storing rain water where possible

Climate-smart agriculture in the dairy sector combines three objectives, namely, (i) to sustainably increase agricultural milk productivity and incomes; (ii) adapt and build resilience to climate change along the milk production value chain; and (iii) reduce greenhouse gas emissions. Mitigation measures that are considered under climate-smart resilient agriculture are those that reduce emissions from enteric fermentation and animal manure management.

The expected reductions in $CH_4$ emissions should not be superseded by increases in $N_2O$ or $CO_2$ emissions (as CO2-eq) resulting from fertilizer application or transport associated with introduction of a new or a combination of species, for example. In order to make sure strategies that a reduction in the emissions from one part of the system does not lead to an increase in the emissions from another part, monitoring and verification tools are needed. Some of the models (CLEANED, FEEDPRINT, GLEAM) can be used for this purpose.

| Table 17. Summary of sustainable forage production gaps |
|---|
| High zone variability and productive systems not well adapted to zones' characteristics |
| High soil/grasslands degradation |
| Poor agricultural practices in soil management, forage crop production and preservation |
| Lack of knowledge on relationship quality of forages, feed conversion and GHG emissions |
| Lack of (holistic) research and little connection to promoting good agricultural practice |
| Lack of feed testing facilities, in particular for tropical forages |
| Lack of governmental policies and strategies |
| Poor manure management practices |

Crop residues mixed with road side grass

Silage bunker of napier grass

# 12. Innovations

The questionnaire included a section on innovations related to the forage sub-sector and dairy nutrition. Innovations were defined broadly and include amongst others good agronomic practices, new forage species or varieties, best practices in silage making and baling of silages, better/new and machinery and technologies, new approaches to practical training, new business models such as specialised service providers and agricultural contractors for forage production and preservation, software for balanced dairy ration calculation.

**Q45. "During the past 5 years, you may have observed some of the innovations that are listed below. Please confirm by rating their impact (high, low, or not observed)".**

A total of 16 different innovative activities were listed in the questionnaire and the respondents were asked to rate the impact of each innovation. Those considered as having a high impact were the following: (i) introduction of baled/packed silage (> 60%), (ii) improved silage practices (>60%) and (iii) new fodder maize/sorghum varieties (>60%), (iv) use of conservation agriculture (50%) hay production (50%), (v) improved hay production (50%). (Survey Diagrams; Figure 12.1).

**Q46. "Which other innovations would you like to add Please indicate their impact (high/low)."**

The respondents consider that the production and use of compounded feeds with maize grain or the agro-industrial by-products of maize processing would have a high impact on the dairy sector. Others mentioned increase the use of agroforestry trees and training farmers in permaculture and sustainable agricultural practices would have a high impact. (Survey Diagrams; Figure 12.2).

**Q48." What aspects need to be considered before a new intervention is introduced or put into action? Please rate from 1 - 5 and explain (1 = low importance, 5 = high importance)**

According to the survey, all proposed aspects (policy, market, technology, knowledge and skills, finance, social/cultural behavior) need to be considered, especially with attention to finance, knowledge and markets (Survey Diagrams; Fig 12.3).

## Innovations observed by this study

In the past 10 years research institutions, government, farmers and dairy cooperatives, private sector and development organisations have made efforts to enhance the forage sector.

Several sector studies on the animal feed and forage sub-sectors were carried out or facilitated by donor funded programmes a few recent projects are listed below:

- Eastern Africa Agricultural Productivity Project (EAAPP) improving household income and food and feed security through forage seed production (WORLDBANK)
- Feed and forage seed business models to support further professionalization of the dairy sector in Kenya and Uganda (NWO-WOTRO)
- Improved forages to enhancing farm productivity, climate change resilience, and environmental sustainability in Eastern and Southern Africa (CIAT)
- Community-managed disaster risk reduction, project on harvesting, storing and utilizing hay European Commission Directorate-General for Humanitarian Aid and Civil Protection (ECHO),
- Napier grass smut and stunt resistance in East and Central Africa (NARO/ASARECA)
- Programme for climate-smart livestock systems (ILRI/GIZ/BMZ)
- Climate-smart Brachiaria grasses for improving livestock production in East Africa (ILRI/SIDA)

Dr. J. Kabirizi senior researcher with NARO lists 24 forage related research topics since 1994 on her website with publications, articles and farmers handbooks.

These and other studies contain a wealth of information on the Ugandan feed and forage sub-sectors, including recommendations for innovations and enhanced policy framework. In addition, handbooks, training material and Standard Operation Procedures (SOP) have been developed to enhance agricultural practices.

ISSD developed forage seed business models to support further professionalization of the dairy sector in Uganda. The aim of this project is to develop viable business models for forage seed production and marketing that assure economically sustainable access to high quality forage seed to diverse clients in Uganda.

Mobile phones are the main conduit for accessing Information and Communication Technology (ICT) services in rural areas. Diffusion of technology is however hindered by poor telecommunications infrastructure, unstable power supply, lack of ICT skills, high costs of acquiring and maintaining equipment, lack of property rights and difficulties in making information available in local languages.

### Forage species, seeds and planting material

NARO is active in research on pasture and legume seeds at their research stations and does maintain a mother bank of forage seeds and planting material used to distribute for seed multiplication at government farms and farmers farms.

NARO, at its research stations does intensive research on forage innovation and solutions for the small holder dairy farmer in Uganda. The following topics have been reported on: Sowing forage legumes, including *Centrosema molle* (formerly *C. pubescens*) and *Clitoria ternatea*, with Napier grass or Brachiaria hybrid cv. Mulato improved both yield of forage and protein concentration and is a promising strategy for year-round feed supply to smallholder dairy cattle in low rainfall areas next to this Kabirizi J. and Byula J. report on research done on supplementary feed rations like Homemade concentrate, Feed ration based on Wild Mexican Sunflower (*Tithonia diversifolia*), Nutrient feed blocks, Maize stover-bentonite feed block, Sweetpotato vine-based partial milk substitute (PMS), Dairy cow pellets by youth groups, Sweet potato silage as a supplement to lactating dairy cows, Maize stover-molasses Total Mixed Ration (TMR).

NARO and CIAT (hybrids) actively promote Brachiaria ssp. and Panicum ssp. and will enhance promotion and marketing of these pasture species in the near future through demonstration plots and in intensified distributor network.

East Africa Seed Company on behalf of Advanta Seeds introduced a forage sorghum under the name Sugargraze and a pearl millet under the name Nutrifeed. Silage making of maize or sorghum is done by progressive farmers and research institutions. So far no specific forage maize or sorghum varieties are known to be registered in Uganda.

### Forage quality, seasonality and preservation

The programme for climate-smart livestock systems and various parties like SNV-TIDE and 2Scale have supported introduction and adoption of climate smart practices including good agricultural practices for land preparation and crop management such as minimum/zero tillage, conservation agriculture, integrated soil fertility management like use of farmyard manure and increased fertilizer applications, forage crop management and preservation. For example, for hay and silage making to enhance production, nutritive value and to cope with seasonality. Some of these good agricultural practices can be directly related to indigenous traditional knowledge and practices to cope with climate risks. These include mulching, intercropping, use of manure some of which have been in existence for a long time. Other local innovations for coping with climate-related risks included establishment of fodder gardens, rainwater harvesting for domestic and agricultural use, and use of organic pesticides. Often, farmers use a combination of these technologies and strategies to cope with climate change and variability and to enhance agricultural productivity.

In all these activities it is abundantly clear that management of the forage crops and the process of hay and silage making is key, as is scaled machinery with the right capacity that assures speed of work to assure quality of the (preserved) forages. Introducing new species or new seed varieties will only then yield higher nutritive value, if managed well and (also) if fed in a well-balanced ration.
For the GOU scaled mechanisation has been a key intervention area to increase farmers' access to agricultural equipment such as tractors, bulldozers, graders, combine harvesters, forklifts, agro-processing machinery, farm tools, straw choppers, excavators, bowsers, transformers, among other equipment (BMEA 2017).

### Forage markets (commercialisation of forage supply)

Makerere University started with an initiative called Consortium for enhancing University Responsiveness to Growing fodder is good business Development (CURAD) to encourage farmers to take up hay production as a business.
While in the Tanga region in Tanzania for example Leucaena leaf meal is a valued ingredient because of its high protein content in rations for dairy cows.
NARO has been testing densified feed blocks and pellets innovative solutions that can further enhance trading in forages and thus make better utilisation of locally available feed resources.

### Knowledge, education, skills

To further enhance transfer and exchange knowledge for adoption of good agricultural practices and development of practical skills in forage production, preservation, feeding and forage-based ration calculation and integrated holistic approach is needed involving all relevant stakeholders involved in transfer of knowledge, knowledge products, quality services and inputs. The establishment of forage demos (including new seed species/varieties), field days, farmer study groups, local, regional and international exchange visits (seeing is believing) will further increase awareness, adoption and adaptation of good practices. Country wide distribution among farmers and agricultural students of existing and additional guidelines and SOPs, training modules and Practical Dairy Training Centres, involvement and coaching by international experts (e.g. PUM Netherlands Senior Expert programme), to co-financing and technical advice of investors through innovation or incubator projects.

An interesting initiative is started by SNV-TIDE through the introduction and contextualisation of Rumen8 to the East African conditions and needs. Rumen8 has shown among some farmers in the South Western region to be a very useful diagnostics, advisory and education tool, provided it is used by persons with good understanding of ruminant nutrition and quality of forage crops and forages used in the farm.

A Worldbank, 2012 report formulated the above as follows "The Fodder Innovation and Adoption projects have demonstrated, technical changes and institutional and organizational changes reinforce each other, hopefully leading to livestock system upgrades that will result in livelihood impacts". And "functional institutional arrangements that enhance in a sustainable way knowledge product, knowledge transfer, services and input access will enhance the rate and extent of uptake of feed-based innovations".

### Environmentally sustainable forage production

Innovations in good agricultural practices (from seed to feed), mechanisation and other quality inputs and services that contribute to intensification of forage production through enhanced soil and manure management, improved forage quality and digestibility with the same or increased yields/ha, are

needed, they have generally a positive impact on (reduced) enteric methane production of the dairy herd in Uganda/East Africa.
Though there is need to further assess or determine the net effect that these improved species/varieties, practises and innovations have on total GHG emissions, and also to differentiate between intensity of emissions (per litre of milk or kg of meat) and total emissions at animal or farm level (FAO, 2018).

The three pictures below show foliage of *Leucaena leucocephala, Calliandra calothyrus and Sesbania sesban*. These leguminous fodder shrubs assist to minimize deficiencies in the basal ration of dairy cows quantitative and qualitative. Lower enteric methane production of legumes is attributed to lower fibre content (NDF) and faster rate of passage of the feed through the rumen. It needs to be mentioned that at one-point leguminous forage trees in intensive farming systems, need fertilizer application of Phosphate and Potassium. The introduction and use of Rumen8 software in addition enables calculation and prediction of the effect of improved (lower fibre content), balanced (higher in protein) dairy rations in terms of optimum milk production and the effect on enteric methane production at cow level and per litre of milk.

Integrating manure management with (well managed) biogas generation and use, also contributes to more environmentally sustainable farming systems.

# 13. Policies

The desk study looked at various policies and regulations related to the animal feed and forage sub-sector, without the objective of being exhaustive but rather to highlight a number of key issues and the most relevant policy documents and responsible government agencies.

The Government of Uganda (GoU) has demonstrated interest in the promotion of forage development and improvement of livestock nutrition through enacting a number of polices and guidelines in the sector.

1. National Agricultural Policy
2. Agricultural Sector Strategic Plan (2015/16 – 2019/2020)
3. National Seed Policy, Draft (2014)– addresses the challenge of the shortage of quality seed by recognizing the informal seed sector as a source of seeds that requires to be regulated. The policy provides for promoting and building capacities of farmers, local seed businesses to produce and market-controlled seeds (quality declared seeds)
4. National Animal Feeds Policy – promotes, support and guide the manufacturing and marketing of animal feeds
5. National Fertilizer Policy (2016)
6. National Agricultural Extension Policy (2016) in combination with the National Agricultural Extension Strategy (2016/17-2020/21)
7. National Dairy Strategy (2011 – 2015) – The strategy recognizes poor nutrition in dairy animals owing to seasonal fluctuations in rainfall causing shortage of fodder during the dry season. One of its focus area's is promoting the adoption of improved feeds and feeding technologies.
8. Dairy Framework Investment Plan (2015/18) – Component 3 of the dairy FIP focuses on strengthening dairy production and productivity attributed partly to the inadequate provision of good quality feeds. One of the focus areas is to build local capacity in feed production and marketing, pasture and rangeland improvement and enhancing of private sector to supply compounded feeds. (Kimbugwa P, 2019)
9. Uganda National Climate Change Policy

The National Seed Policy is only policy that influences and relates directly to forage production as is describes the regulation of the seed sector incl. the pasture and forage seed sector. In the other policies if forage or fodder is mentioned the GOU is supporting the production of quality forages for ruminants.

The existing agricultural policies do not address sufficiently the issues related to the quality of animal feeds incl. forages, 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. The lack of standards prevents informed decision on the side of farmers for concentrates forages and for milk. The Nationally Appropriate Mitigation Action (NAMA) has the intension to introduce standards, labelling, and regulations for animal feeds and milk production.

## Formal seed sector

Uganda's formal seed sector started in 1986 as a seed multiplication scheme under the Ministry of Agriculture. It later became the Uganda Seed Project and then Uganda Seed Ltd. in 1999. Uganda eventually embraced a liberalization policy of its economy that emphasized private sector-led growth. This policy saw the number of seed companies rise from one government-owned Uganda Seed Ltd. to the current 24 privately-owned seed companies (Ssebuliba, 2010).

None of the private seed companies has a breeding program or distributes forage seeds produced in Uganda. On the National Crop Variety List (NCVL) no forage crops, pasture grasses or legumes are listed. From the 20 species on the National Crop Variety List 2015. *Zea Mays, Sorghum, Heliantus Annus, Cajanus cajan, Vigna Unguiculata, Ipomea batatas and Musa spp.* are used as forage for dairy cows either fresh or the crop residues. For maize for example there are 6 breeders active (4 public and 2 private). Only 12 maize varieties have been released in the period between 2011 and 2013. All other forage crops, pasture grasses and legumes are released by NARO but not registered on the NCVL or traded from farmer to farmer. (Mabaya et al. 2018)

The seed industry in Uganda, is now purely private sector driven and governed by the Seeds and Plant Act, 2006. The formal seed sector focuses on breeding, producing and selling seed that is certified by the National Variety Release Committee (NVRS). NVRS conduct official seed certification on behalf of the Ministry of Agriculture. Uganda's formal seed sector is comprised of many different institutions including the government; (e.g., NARO, NARS, NVRC, NAADS, ATAAS, and NSCS); the private sector (e.g., Bayer, Corteva, Syngenta, Seedco, East Africa Seeds Ltd., FICA Seeds, etc.); member associations (e.g., UNADA and USTA); as well as NGOs, development agencies and farmer cooperatives.

Table 18. Key players in the Uganda seed sector

| Role | Key Players |
|---|---|
| Research and breeding | NARO; NARS; MNCs |
| Variety registration & regulation | NVRC; NSCS |
| Breeders and foundation seed production | NARS; NARO; MNCs; Local seed companies |
| Seed production | Local seed companies; MNCs |
| Processing and packaging | Local seed companies; MNCs; agro-dealers |
| Education, training, extension | NGOs; NAADS; local government; ATAAS; rural agro-dealers |
| Distribution and sales | Seed companies; rural agro-dealers; farmer cooperatives; NGOs |

Of the varieties released in the Ugandan Seed market 57.3% were developed through Uganda's public research system. Only two private Ugandan seed companies have their own varieties, contributing a meagre 0.08 percent to the total. Other local seed companies merely multiply and market seeds that are owned by the public sector or by foreign players.
Private sector players released 18 maize varieties were released since 2002 in the Ugandan Seed Market.

### Informal seed sector

The informal seed sector broadly refers to the system where farmers produce, obtain, maintain, develop and distribute seed resources, from one growing season to the next. Because of limited exposure, inability to purchase seeds, limited access to agro-dealers, or other reasons, some smallholder farmers in Uganda still rely on informal seed systems. The steps in the informal seed system are not monitored or controlled by government policies and regulations; rather they are guided by indigenous knowledge and standards. Under Uganda's informal sector, much of the seed is saved and/or exchanged by farmers

### Integrated Seed Sector Development Programme

The Integrated Seed Sector Development programme (ISSD) aims to support the development of a vibrant, pluralistic and market-oriented seed sector, providing smallholder farmers access to affordable quality seed of superior varieties. The program started with a focus on vegetable crops but adopted pastures grasses in phase II of the program. An integrated seed sector development (ISSD) programme builds upon the strengths of both the formal (public and private) and informal (farmers and community-based) seed systems and seeks to consolidate them. The programme guides specific interventions in identified seed systems; linking fodder and seed security to private sector development and aligning and harmonising seed policies, laws, regulations, interventions, programmes and practices. https://www.issduganda.org/

Local seed businesses (LSBs) fill a gap in quality seed production for crops in which the commercial seed companies are not interested e.g. pasture seeds and forage crops. LSBs may start from the informal sector as farmer groups or entrepreneurial farmers who see business opportunities in the production and marketing of quality seed. At the end of the programme these farmer groups produce and sell quality seed of locally preferred crops and varieties to local markets and operate as local businesses.

The ISSD Uganda programme started in 2012 and operates in three geographical areas based on agro ecological zones; namely West Nile, Northern Uganda and Western Uganda. There is close collaboration with the National Agricultural Research Organisation (NARO), a seed expert, an agribusiness expert and a driver based at the zonal research stations of Abi ZARDI, Mbarara ZARDI, and Ngetta ZARDI. Each team works with 10 LSBs. In the second phase of the programme, this number will increase to approximately 100, which will be supported by partner organisations.

At the end of the ISSD Uganda programme, and with the support of Public sector organisations, a process shall be created that will introduce new methods of enhancing effectiveness and efficiency; define complementary roles and create a sustainable mode of operation in supporting other stakeholders in their efforts to produce and market quality seed of superior variety.

It is expected that MAAIF, NARO, NSCS, NAADS, Universities, and others shall increase their collaboration with and work in partnership with commercial seed companies, local seed businesses, farmer organisations and civil society organisations. This collaboration and partnership will specifically be in relation to seed quality control, access to foundation seed, inclusive policy development and the uptake of quality seed by farmers.

Through innovative approaches, a number of bottlenecks in the seed sector, such as seed quality control, access to foundation seed and variety release will have to be resolved at an institutional level. In these three issues, the above mentioned and other public sector organisations have a clear role to play. https://www.issduganda.org/

# Section II. Observations and Recommendations

## 1. Observations

From the desk study, the field visits, interviews and the responses to the questionnaire, the consultants identified a number of constraints that have been listed at the end of each of the chapters of the previous Section I: Survey Results. These can be summarized as follows:

- Water availability, storage, efficient use
- Insufficient quantity and quality of forages
- Land availability
- Land use competition
- Low digestible forage available and very low digestibility of crop residues
- Inefficient feed utilisation (unbalanced rations)
- Seasonality
- Feed/Forage testing and standardization not available
- Lack of awareness on the links between forage and animal production
- Ineffective and obsolete agricultural education, training and extension system
- Availability, high cost and/or poor-quality inputs (seed, fertilizers etc)
- Persistence of forage legumes in grass/legume mixture
- Emergence of new forage diseases and pests
- Low level of adoption of (improved) forage technologies (e.g. drought tolerance, disease resistant) that can alleviate seasonal shortages
- Access to and cost price of agro-industrial by products
- Availability of improved forages to meet nutritive requirements of genetic profile exotic breeds introduced by AI and ET
- Genotype– forage (environment) interaction
- Shortage of input & service providers to professionalize and commercialize forage production
- Lack of forage development plan on farm level, regional or national
- Extreme low level of mechanisation
- Limited forage crop options and possibilities for crop rotation.
- Climate change
- Little awareness about link between health, food safety and feed safety

| Table 19. Main drivers of transformation of the forage sub-sector |
|---|
| Identify innovative ways to disseminate (improved) forage technology to enhance adoption and adaptation |
| Create enabling environment for a strong public/private partnership in the forage seed sector |
| Technology-driven yield increases (improved seeds, quantity and quality of fertilizer, mechanisation) |
| Reform and education and skills training system to enhance awareness |
| Capacity and competence building among stakeholders relating to plant science and animal science |
| Improve agronomic practices (crop rotation, intercropping, multi cropping, crop diversification) |
| Awareness creation among young entrepreneurial farmers through knowledge and skills transfer |
| Continue to stimulate the dairy sector with focus on developing and expanding the domestic milk market |

The majority of Uganda`s dairy cattle farms are South Western and Central regions with a “cool/warm climate within the cattle corridor (Table 2). The zones have a big potential to be self-sufficient in production of forages like pastures and legumes and other forage crops, as needed to maintain a productive dairy system. The extensive pasture grazing system is predominant, semi-intensive grazing systems, with Napier grass as the supplementing forage. These regions have the greatest potential for dairy development. Urban and peri urban dairy farming is found around the towns of Kampala and Jinja here there is big potential market for dairy products, but dairy farming is characterized by intensive farming systems mostly relying on inadequate and poor quality forage. Arid and semiarid areas in the north and north east on the other hand are low population density areas, characterised by high temperatures, fragile soils and poor vegetation covers.

During the dry season the available forage is of very poor quality. This leads to poor nutrition, which results in low production and reproductive performance, slow growth rate, loss of body condition, and increased susceptibility to diseases and parasites. So far, efforts by scientist to improve forage production and utilization of crop residues and preservation technology do have low adoption and adaptation rates. This is attributed to the low level of knowhow on forage production and animal nutrition among the farmers and dairy extension workers while the number of dairy extension workers per 1000 farmers is very low. In the arid and semi-arid regions the main concern is on fodder, like hay making, intervention to overcome dry periods that occur more frequently and are increasingly more severe. production.

If the target is animal productivity and requisite breeds, forage quality should get more priority and be linked to animal nutrition. For this, many aspects of the forage production process need to be considered, including the use of improved forage varieties, forage management and agricultural practices, forage planning and preservation (seasonality, climate change), mechanisation, feed testing and education/training. All these aspects need to be addressed together instead of individually, meaning to connect plant science (agronomy) and animal science (ruminant nutrition). This plant-animal relationship is depicted in Figure 5 below. The relationship between forages/fodder and the animal, is by evaluating and steering on the quality of forages (in the black circle), not just on volume

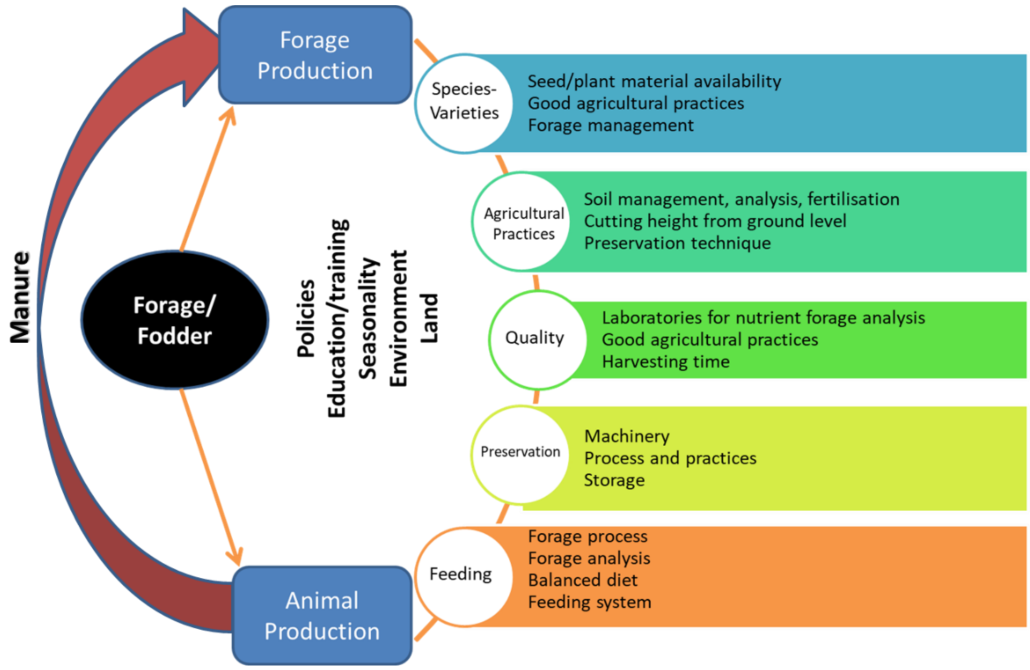



Figure 5. Key aspects that need to be considered to improve the forage sector

## Interventions on a short term

In the short-term, the required steps to alleviate nutritional problems of dairy animals are (i) accelerate and encourage farmers to intensify farming systems through improved zero grazing units and expansion of high yielding cut and carry and/or mechanisation of forages crops, (ii) effective utilisation and better management practices of the available forage resources (i.e. natural pastures, shrubs and forage trees, crop residues, forage crops, agro-industrial by-products), and (iii) appropriate supplementation with concentrates rich in energy and protein of low quality natural pasture and crop residue-based diets, to achieve higher feed efficiency.

Different practices and supplementation strategies could be applied depending on the type, accessibility, and cost of forages and supplementary feeds in a given area. Forage preservation practices, particularly hay and silage making, can be improved and encouraged to be produced commercially (e.g. as business opportunities for youth in rural areas) in order to enable a steady supply of quality forages throughout the year out of currently available sources and land under cultivation which is underutilized. Assessment of the (actual) nutritive value of natural grasses and forage trees and shrubs (which are commonly used as feed source during the dry season) forages, concentrates could be important to maximize utilisation.

## Interventions on medium to long term

In the medium to long-term, important points to consider are: enhanced access to new or improved forage species/varieties suitable to the different Agro Ecological Zones (AEZ) which allow for increased Dry Matter (DM) intake and higher nutritive value for the dairy cows, introduction and use of appropriate technology and machinery for forage production and preservation, inputs (i.e. seeds and planting material, fertiliser, concentrated dairy feed, veterinary drugs, etc.) extension services, education and practical training on forage production, preservation and dairy nutrition and feed and forage testing facilities.

Forage research should directly be linked to animal nutrition and farm economics (e.g cost analysis of improved forage-based production systems), in order to develop commercial and environmentally sustainable solutions.

Local research should (i) work with the private sector and other extension services providers through the public sector to assure that research and innovations find a route to market, (ii) work on climate smart forage production systems (soil fertility management, mitigation of enteric methane emission), (iii) forage and livestock research together with the authority responsible for phytosanitary forage seed regulation and certification should accelerate, abridge and encourage national and international private seed companies to register and market suitable forage seed varieties for the climatic condition in Uganda.

Based on the experiences with food/feed crops, local research can seek partnerships with international players for optimal ways to accelerate access to affordable improved forage seeds and planting material for farmers and suitable to the different AEZ, be it through importing, registration and dissemination of forage seeds and planting materials, or through local breeding and propagation. This should go hand in hand with the development of a national rangeland, improved pasture and forage curriculum, with a focus on meeting the nutrient requirements of the modern dairy cow.

Encouraging seed producers and seed distributers for example to register forage maize and forage sorghum varieties can be an enormous benefit for dairy farmers who make maize or sorghum silage for their herds and can be in interesting alternative for low maize prices in Uganda

However maize silage in Uganda, like in Kenya, is often characterized by high NDF content, low NDF digestibility and low starch content of the silage, because the maize varieties used are grain producing varieties and bred to stay green long without logging and ripen thereafter quickly within a short period while equipment to harvest the maize at a later (dough ripe stage) is only feasible if offered as a service by commercial contractors

# 2. Recommendations

Dissemination of knowhow and skills needs to be accelerated to enhance the adaptation intensified sustainable forage production in combination with adoption of improved zero grazing systems. The potential impact of improved forages to create positive impact in the dairy production areas depends entirely on agronomic practices applied. A more innovate approach can be used to address:

a) Different aspects of the chain, planting, growing, harvesting, storage, feeding
b) Intensified production and maximum profitability of dairy farming
c) Involve all stakeholders including youth and women
d) Competitiveness of all Ugandan stakeholders in the region
e) Link plant science (agronomy) and animal science (ruminant nutrition)
f) Environmental sustainability
g) Strengthen education and training component together with extension services and monitoring of the new innovations to ensure their success.

In addressing the forage value chain, focus should be on "forage species", including seed and plant material availability, "forage quality including feed safety", "management of seasonality" together with new preservation techniques and mechanisation, "Climate-smart agricultural practices", and "rangelands restoration and management" with the aim to intensify environmentally sustainable forage production.

### Forage species/varieties

Improved or new forages (species/varieties) need to be either developed (slow) or imported (fast), and locally tested. Good quality seed and plant material (certified) should be easily accessible and affordable for farmers. Demonstration plots need to widespread, within proximity and easily accessible for farmers while training/extension process should be carried out with main emphasis on best management and good agronomic practices (like integrated soil fertility management) for the new species/varieties introduced.

In the short-term, forage species currently used, such as Napier grass, Rhodes grass, Brachiaria ssp., maize, sorghum, natural grassland, and others need to become available or improved with focus on quality (nutritive value and digestibility). This includes agronomic practices like intercropping in food and feed crops (e.g. maize/Lablab, cassava/cowpeas etc), fertilisation, crop rotation to improve DM yield, nutrient yield followed by optimal animal performance but also harvest and post-harvest practices (e.g. cutting interval, stage at harvesting).
Training in good agricultural vocational skill for farmers to put them into practice is key.

Table 20. Innovations to improve performance of forage species currently used

| Forage | Innovation practices | Potential improvement |
|---|---|---|
| Napier grass | Cut at 5-10 cm from ground level<br>Cut before stem elongation (8-9 leaf state)<br>N Fertilisation<br>Manure application<br>Silage<br>Intercrop with legume (*Desmodium*, pigeon pea, calliandra, stylo, centrosema etc.)<br>Use of new varieties | Increase plant life span<br>Forage quality<br>Soil improvement (N-fixation, break up of hardpan)<br>Feed planning/reserve<br>Seasonality<br>Disease resistant |
| Rhodes Grass | Cut at 5 cm from ground level | Increase plant life span |

| | | |
|---|---|---|
| | Cut before stem elongation (5-6 leaf state)<br>N Fertilisation<br>Manure application<br>Silage<br>Legume mix<br>Use new (imported) varieties | Forage quality<br>Soil improvement (N-fixation)<br>Feed planning reduce seasonality<br>Higher yielding and more nutritive |
| Brachiaria spp/ Panicum maximum | Legume Mixes: Ex. (*Clitoria ternatea*, *Macroptilium atropurpureum*, *Stylosanthes guianensis* and *Stylosanthes seabranna*) cut 10 cm about soil level<br>*Brachiaria brizantha*, *Clitoria ternatea*, *Leucaena spp.*, (28:52:20)<br>Brachiaria/*Panicum maximum* intercropping with annual crops like maize (Brachiaria need to be seeding 25-35 days after the maize) | Opportunity to feed fresh, hay, silage (depending on availability of leguminous crop seeds)<br>Silvopastoral systems<br>Fast turnover |
| Kikuyu grass | Cut at 5cm from ground level<br>Cut before stem elongation (4-5 leaf state)<br>N Fertilisation<br>Manure application<br>Legume mix<br>Use new varieties | Increase plant life span<br>Forage quality<br>Soil improvement (N-fixation)<br>Seasonality<br>Increase plant life span |
| Natural grassland | Cut at 5 cm from ground level<br>Cut before stem elongation of predominant grass specie(s) and season<br>N fertilisation<br>Manure application<br>Varieties identification<br>Reseeding, grass/legume (direct drilling) | Increase plant life span<br>Increase soil covert<br>Increase plant population<br>Better soil conservation<br>Forage quality<br>Soil improvement (N-fixation)<br>Seasonality<br>Increase plant life span |
| Maize silage | High chopped corn silage (40 -50 cm from ground level)<br>Maize/Sesbania (70:30) intercropping<br>Maize/Lablab intercropping | Energy source<br>Planting at the same time / Harvesting time – ensiling |
| White Sorghum | Headlage (Silage from the head of plant only) | Energy source |
| Forage Sorghum | Silage | Energy source |
| Desmodium | Intercropping with different grasses. Seedling growth of Desmodium is especially slow; therefore, existing grass should be closely grazed throughout the establishment period to enhance legume establishment. Recommended seeding rates are 3 to 5 kg/ha on a clean-tilled seedbed and 5 to 10 kg/ha on established grass sod. Inoculum is recommended when sowing on virgin land. | Protein source<br>Forage quality<br>Soil improvement, permanent soil cover<br>Availability of inoculants |
| Lablab | 5 to 8 t DM/ha<br>Fresh: ME 10- 11, CP% 20-30, NDF% 35-40<br>Silage: ME 9- 10, CP% 20, NDF% 50 | Protein source<br>Cutting stage |
| Agro – Forestry tres (Calliandra, Gliricidium, Leucaena) | Hedges or alley cropping with forage crops<br>Fixes nitrogen for adjacent drops<br>Source of fuelwood<br>Natural fencing | Increases feed availability during dry season<br>Protein source<br>Cutting frequency |
| Sesbania sesban | Increase seeding density<br>Cut at 10 cm from ground level<br>Cut every 45 days | Increase yield<br>Seeding rate/ha<br>Protein source<br>How often will Ss re-grow |
| Lucerne | Cut 10% flowering<br>Soil testing<br>Irrigation | Protein source<br>Forage quality<br>Increase plant life span |

The identification of better dual-purpose varieties of food/feed crops already in the market is required, especially for cereal, pulses and oil crops. The introduction of varieties where the crop residues or their by-products have better nutritive value and digestibility (e.g. maize or sorghum stover 5-10% more digestible) then so far and – hence – a higher impact on livestock performance. Particularly in the intensive farming systems and during the dry seasons there is a protein shortage which requires increased acreages of high yielding protein crops. Dual purpose or forage varieties for maize, sorghum and others cereal crops are required in the market, to boost production and productivity of exotic and crossbred dairy cows. To make maximum use of these forage crops and forage production to stay competitive with food production specific management skills and knowledge is required.

Also, extensive farming systems should be improved by improving or introducing community-controlled rangeland management (controlled stocking rate and rotational grazing) and regeneration of grassland (e.g. over sowing and introduction of legumes) Other interventions like silvopastoral management and other forms of agroforestry require detailed knowledge and skills in order to work within the complexity of these systems. Lastly technology can be used to predict available biomass using satellite images.

Table 21. Potential innovations for cereal crops

| | **Corn Silage:** **High chopped corn silage is a practice that is used in many countries with the idea of harvesting a more nutrient-concentrated and digestible forage. (Barber D., 2018)** | | **White sorghum silage:** **Silage using only the head of the plant. To preserve high energy concentrate product and increase starch digestibility. The rest of the plant can be fed fresh after being chopped. (Barber D., 2018)** | | **Forage sorghum silage:** **is a very interesting alternative for surplus forage. Also when the forage for any circumstances has passed the ideal stage to be grazed. Cutting height and cutting stage. (Barber D., 2018)** | |
|---|---|---|---|---|---|---|
| | **Normal (10cm)** | **High Cut (40 cm)** | **Silage WP** | Headlage | **Grazing** | **Silage** |
| **t DM/ha** | 18.50 | 17.00 | 12-18 | 5-7 | 9-18 | 8-16 |
| DM (%) | 40.4 | 41.4 | | | | |
| ME (MJ ME/kg DM) | 10.8 | 11.3 | 9.46 | 11.3 | 9.1 | 7.8 |
| CP (%DM) | 8.9 | 8.9 | 12.2 | 13.2 | 11 | 7.5 |
| Starch (%DM) | 38.7 | 41.7 | 20.5 | 47.5 | 0 | 12.3 |
| NDF (%DM) | 37.2 | 32.2 | 48.5 | 25.0 | 52.7 | 56.2 |

In the medium- to long-term, to date all pasture and forage seeds available in the Ugandan market are produced and multiplied by public institutions in collaboration with farmers farms. In the future a effective and dynamic system of seed/plant material certification and commercialisation needs to be developed and synchronised as a smooth continuation of the ISDD programme with the new advances in genetically improved materials. The introduction of high-quality seeds of energy or protein rich forage crops, already available in other countries with similar climate conditions, will make it more attractive for commercial forage seed suppliers.

Collaboration between regional, national and international institutions working on forage and pasture grass development is needed, but this should be linked to animal scientists specialized in ruminant nutrition. New species/varieties with high potential nutrient content, especially energy and protein need to be introduced and tested on their suitability for different AEZs, feasible animal production target (milk/growth/weight gain) and farm profitability. New (forage) maize and sorghum silage varieties, specifically those with the best performance in energy production should be introduced, and high protein species like *Desmodium,* lablab, lupins*, Agro forestry trees incl. Sesbania sesban, and sweet potato's (vines)* should be selected and disseminated.

The added advantage of these species is that, depending on AEZ and soil conditions, they could fit very well in a crop rotation plan. To facilitate increased access by farmers to seeds, plant material, forage shrubs and trees, the following activities could be carried out: on-farm micro nurseries, forage seed production, plant parts for propagation, and nurseries of multi-purpose shrubs/trees (fruit, wood, fuel, and forage trees).

Improve utilization of crop residues and agro-industrial by-products through re-orientation and innovative re-introduction of existing technology e.g. chopping, compaction, urea addition/treatment and TMR were available using crop residues of improved dual-purpose food/feed crops.

### Feed safety

A variety of products and strategies are available to mitigate the prevalence and the effects of aflatoxin in dairy cattle. With increased emphasis being placed on prevention, practices to curb mycotoxins incl. aflatoxin intake by animals begin with choices made in the field, including the selection of seed (e.g. drought tolerant hybrids), effective tillage (crop residues), crop rotation, harvest practices and storage.

Farmers should be aware of the weather conditions during the growing season that favour the growth and development (e.g. periods of heat stress during growth) of moulds and thus the production of mycotoxins. Storage and processing of grain- and finished feed but also of hay and dried forages should be carried out in a clean, dry space where there is adequate ventilation as well as protection from rainfall and contamination. Silage on the other hand needs to be excluded from oxygen within 12 hours to stimulate the anaerobic fermentation process while feed out needs to cover 1.5 – 2 meters per week to avoid heating and mould growth in the silage bunker.

**Table 22. Strategies to reduce mycotoxin levels in forages**

| Practices to reduce mycotoxin risk in forages |
|---|
| Crop rotation |
| Soil testing and fertilisation to nutritional level of crop (healthy crop less susceptible) |
| Varieties selection |
| Field crop residue management (land preparation) |
| Harvesting time according to weather conditions |
| Mechanisation, to improve preservation process (faster, more efficient) |
| Preservation process adjusted to the conditions (weather conditions, field conditions, crop conditions) |
| Preserve crop only if fermentation process can be successful. (e.g. do not remove seed heads, keep distance short) |
| Use of right inoculant (Inoculant to reduce fungal growth) |
| Storage and storage management (monitoring moisture, temperature, damage) |
| Awareness creation on prevention |
| Standards (laboratory facilities) |

### Management of seasonality

An increase in the availability of quality forages throughout the year is needed, to reduce the fluctuations in milk supply and associated problems like underutilisation of processing capacity. Innovations in this regard can vary from basic reoriented practices to new high technology that could involve investments (see Table 23).

Table 23. Tools for seasonality control

| Target | Innovation | Bottleneck |
|---|---|---|
| Improved species/varieties | Drought resistant<br>More yield/quality | Access, Availability<br>Affordability |
| Improved forage preservation | Technical support<br>Improve actual preservation techniques: silage, hay, baling<br>- Training<br>- Machinery<br>New preservation process/techniques :<br>- Haylage<br>- Compaction<br>- Dehydration<br>- Pelletisation<br>Specialise machinery:<br>- Multi balage<br>- High-compaction systems<br>- Precision chopper / kernel crushers<br>- Conditioners | Skills<br>Knowledge<br>Access to new technology<br>Access to new machinery<br>Investment/ Access to finance |
| Promote commercial forage production | Legal/financial recognition as an economic activity<br>Financial support:<br>- Credit/loan access<br>- Taxes<br>Professional support (business and technical):<br>- Business plan<br>- Training/technical advice<br>- Encourage youth farmers/entrepreneurs | Lack of business approach<br>Financial<br>Investment<br>Market |
| Promote agribusiness clusters | Farmers – Farmers organisations - forage producers-retailers-Government | Collective action<br>Policies<br>Infrastructure |
| Promote agricultural contracting services | Professional assistant (business and technical):<br>-Business plan<br>-Training/technical advice<br>Financial facilities:<br>- Credit/loan<br>- Leasing<br>Encourage young entrepreneurs | Lack of business approach<br>Finance<br>Investment<br>Market<br>Infrastructure |
| Feed budgeting | Storage<br>Pre-contracting acquisition/sale | Knowledge<br>Lack of business approach |
| Improve water management | Government policies<br>- Land/water access<br>- Increase potential irrigation areas<br>Financial support: credit/loan<br>Technical assistant<br>Encourage rainwater harvesting<br>Increase water storage | Collective action<br>Policies<br>Infrastructure<br>Finance<br>Knowledge |
| Grassland management | Government assistant:<br>- Satellite follow-up of grassland evolution<br>- Development of communication system<br>Herd management:<br>- Stocking rate adjustment<br>- Calving/mating season<br>- Rotational grassing<br>- Grassland inventory (pasture library)<br>- Feed budgeting<br>- Storage | Collective action<br>Policies<br>Infrastructure<br>Finance<br>Knowledge |
| Feed bank (assisting poor areas to cope with adverse conditions) | Government/International organisations collaboration<br>National Feed Inventory (FAO/MAAIF)<br>Implementation of new techniques<br>Increase storage facilities<br>Follow forage evolution through satellite scanning | |

Commercial production of forages should be further promoted to increase the forage offer in the market, not only in terms of volumes but also as regards quality of forages and pastures. Ideally forages are grown on-farm, but urban and peri urban farmers have insufficient land, labour and/or capital to produce and preserve their own forages.

With and increasing demand for milk (and meat) the demand for forages in the near future will also further increase in the cattle corridor. Private sector involvement and creating a conducive enabling environment (land, infrastructure and public services, availability at scale of appropriate certified forage seeds for new forage species/varieties, fiscal incentives, amongst others) seem indispensable.

The involvement of agricultural machinery suppliers and forage contractors or service providers should be promoted in all farming systems (intensive-extensive) and farm scales (small-large), to facilitate access to the latest and best (scaled) machinery, technology, increased capacity and preservation methods. As weather pattern are unpredictable and changing this requires that current forage preservation (hay, silage) practices need to be improved. The farm-level techniques used currently require training/education, demonstration as well as access to better and new machinery. Grass (pasture) silage can be promoted and alternative preservation methods such as haylage, dehydration, pelletization, compaction, treatment of crop residues and other technologies need to be considered. This should involve encouraging the private sector with the installation of static plants for dehydration and/or compaction or pelleting, to reduce volume could also be considered.

It is important to optimise the forage supply chains through good agronomic production and preservation practices, appropriate farm machinery and logistics with high capacity, and use of high yielding forage seeds varieties. This increases production per acre and nutritive value in the dry matter. Investments in innovation, knowledge and skills for forage production are crucial and should consider ease of handling and transport.

In the rangelands were water management, irrigation and forage preservation are more difficult to implement improved (proven) breeds, herd management, herd record keeping systems, carrying capacity and controlled calving/mating season should be considered.

These area's will also benefit if a national feed and forage inventory is made in line with the National Feed Inventory and Feed Balance Assessment that was carried out in Ethiopia and Kenya by FAO and MALFI. The outcome can be coupled to institutionalise a strategic forage reserve, possibly in partnership with commercial forage producers.

### Seasonality at farm level

In the process of upscaling and increasing interest for silage making, it needs to be understood by dairy farmers that fresh chopped wilted Napier, whole plant maize and sorghum or sweet potato vines need to be ensiled close to the field where the crop is harvested. The silage pit should be compacted and closed and sealed as fast as possible, to avoid respiration losses. Maize stover will not make a good quality maize silage, due to loss of sugar and starch with the removal of the cob, thus poor fermentation; on feed-out it will easily heat up and is susceptible to moulds.

To manage seasonality on farm level, it is most advisable to make feeding plans (with the requisite budget) that covers the whole year with some allowance for unpredictable rainfall and prolonged droughts. This will enhance drought resilience at this level. Such feeding plans will depend on the AEZ. Storage capacity and preservation methods need to be improved and implemented for forage crops but also for agro-industrial by products to reduce viable nutrient losses in the process.

Seasonality management can be enhanced through the use of more drought resistant forage crop varieties and/or dual-purpose food/feed crops varieties provided that the crop residues of the latter are well stored. Also improved water management can contribute to increased availability of forages (e.g. through investments in rainwater and runoff water harvesting including water ponds, earth dams, plastic-lined water ponds, water pans in rangelands, and used for drip irrigation with the use of solar/wind water pumps contribute).

Access to quality forage seeds, the use of pre-treated seed, drought resistant or water efficient species/varieties, and the selection of species to be grown according to local conditions (AEZ and soil conditions), all contribute to more climate resilient farming systems. All these measures can help stabilise the market throughout the year and improve the capacity to feed the animals and maintain their productivity (milk and growth) all year around.

### Smart agricultural practices

Land productivity is far from its biological production potential. Increasing the productivity of the land already in use and a more efficient animal performance per acre is crucial in the near future to face the challenge of land scarcity. Numerous interventions, technologies and modalities can be used to improve the forage production and utilization in Uganda. Some require new technology and investments. Climate smart agricultural practices related to forage, start with the selection of the right forage species/varieties that are well-adjusted to the farming system and local conditions (soil, water, climate), and need to be reflected in animal production.

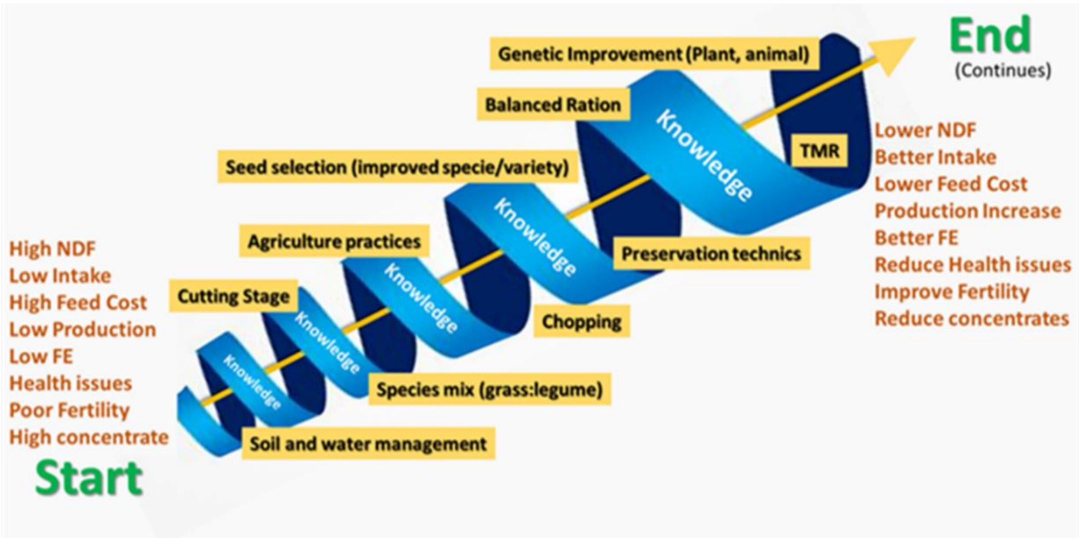



Figure 6. Upscaling recommendation to improve forage sub-sector

After droughts, nitrogen (N) availability in the soil is the main growth-limiting factor in pastures in the tropics. Therefore, the association of grasses with legumes constitutes the first low cost tool at hand to increase N availability in the soil. Many of these practices are based on reinventing and reorienting current practices, rather than heavy investments, and are shown in Table 24 below. However, in the future it is also possible to make use of the latest technology like precision farming when affordable and appropriate.

Table 24. Summary of smart agricultural practices to improve forage supply and quality

| Innovation field | Innovation practice | Expected Forage Improvement |
|---|---|---|
| Soil | Soil tests (every 4 years) | Yield-quality (assess soil nutrient availability) |
| | Nutrient replenishment | Yield-quality |
| | Intercropping / Multi cropping /Inter seeding | Quality-Yield |
| | Provide farmers/advisors with decision tools | Yield-quality<br>Maximise profits |
| | Inputs (manure and composts, crop residues, fertilizers) | Yield-quality (increase soil organic matter and improve soil structure) |
| | Crop rotation | Yield-quality (soil conservation)<br>Crop health/soil nutrient management<br>Decrease mycotoxin contamination |
| | Zero / minimum tillage | Yield (soil conservation) |
| Seed/Plant material | Coated (with water absorbent materials like super absorbent polymers (SAP)) | Yield-quality (improve germination in dry areas) |
| | Pre-treated | Yield-quality (improve germination) |
| | Use of improved seed/plant material | Yield-quality |
| | New species:<br>- Moringa: For forage production<br>- Grasses: Festuca, triticale…<br>- Legumes: *Progardes Desmanthus* | Yield-quality |
| Plant | Grass/legume mix: grassland/pasture/rangeland | Quality, yield, persistency |
| | Harvest time (physiological stage) | Plant life span<br>Plant survival |
| | Silvo-pastoralism/agroforestry system (ASALs)<br>- Native pastures over sown with legumes | Yield-quality<br>Seasonality<br>Feed security |
| | Increase cutting height from ground level | Quality<br>Increase plant life span (perennial species) |
| Preservation | Haylage (40-45% moisture) | Forage quality, seasonality<br>Market |
| | Silage (70-65% moisture) | Forage quality<br>Seasonality |
| | Pelletization | Seasonality, storage, market<br>Emergencies |
| | Dehydration | Seasonality, storage, market<br>Emergencies |
| | Bales compaction | Seasonality, storage, market<br>Emergencies |
| | Densified Feed Block | Seasonality, storage<br>Emergencies |
| | Use of right Inoculant | Quality<br>Decrease mycotoxin risk |
| Feeding | Stem crusher | Increase Intake<br>Increase rumen soluble sugar Availability<br>Improve digestibility |
| | Chopping | Increase Intake<br>Reduce selection<br>Increase digestibility |
| | Urea treatment (ammonisation): 5% urea/water solution, spray on the forage (1:1) and storage under cover 2-3 weeks. | Quality<br>Improve digestibility 10%<br>Improve intake 50 %<br>Decrease mycotoxin risk |
| | Mixing:<br>- On farm (scale mixers)<br>- Commercial (TMR/PMR) | Increase Intake<br>Decrease selection |

| | | |
|---|---|---|
| | Protein supplementation | Increase digestibility |
| | Forage analysis | Feed efficiency<br>Maximise profits |
| | Forage based ration balancing | Feed efficiency<br>Maximise profits |
| Machinery | Direct drillers | Yield-quality (grasslands) |
| | Conditioners | Quality |
| | Precision choppers | Quality |
| | Multibalers | Quality |
| | Mixers | Increase Intake<br>Decrease selection<br>Feed efficiency |
| Market | Offer new products:<br>- Haylage<br>-TMR/PMR<br>- High compacted bales<br>- Dehydrated forage<br>- Forage pellets<br>- Feed/forage blocks | Seasonality<br>Storage<br>Market stabilisation<br>Emergencies |

## Rangeland restoration and management

For grassland measures need to be implemented to prevent or recover land degradation, control bush expansion in Ugandan rangelands (e.g. *Acacia (Vachellia) hockii* De Wild and *Lantana camara* L., and non-palatable grass species such as *Cymbopogon afronardus* Stapfs), improve quality of the browse thus increasing productivity

**1.) Over-sowing or re-seeding** natural grasslands/rangelands with grasses, legumes, shrubs and trees to restore degraded areas, to improve soil cover, increase plant density, and increase the quality and the quantity of grassland forage supply, is very important for the future of land conservation, water conservation and forage production in those areas. The techniques need to be implemented in close collaboration with the communities so the can see the improvement and are encouraged to expand the area over time as custodians on these rangeland ecosystems. These techniques need to be developed for each agro-ecological (zone) or landscape. Some techniques that can be used are air seeding (plane), bomb seeding, pellet seeding, coated seed (hydrogel, antibirds and insecticides). To increase the efficiency of these techniques, high instant stocking rates after seeding is recommended to increase seed-soil contact. Some less effective practices could involve seeding through the animals grazing pasture when the grasses are in the seeding period, and moving animals from these pastures to other areas for reseeding through their droppings. The animal's movement to reseeding areas needs to be made on a daily basis.

**2.) Animal access and stocking rates** can be adjusted through management techniques such as "temporal closure", "permanent closure", "weed and bush clearing through chemical, or mechanical processes", "rotational grazing", and "forage banks (protein banks)", should be considered according to local conditions and opportunities. The temporal exclusion of grazing animals applied at the beginning of the wet season, allows an increase of rhizomes biomass production in natural pastures with a long history of overgrazing. This response occurs due to the predominance of tropical grasses with creeping growth habit, which also have a high above-ground/below-ground biomass ratio. In this sense, at the beginning of the wet season, deferment could be recommended as a sustainable practice

to restore overgrazed grasslands. A right balance between feed supply (carrying-capacity) and animal demand (requirement for livestock and wildlife) needs to be considered in the rangelands, which cover 44% of the country and sustaining 90% of the national livestock herd and 90% of the cattle (MAAIF 2014). Natural occurring (native) species in these areas need to be prioritised for soil restoration, but improved species adapted to the conditions should also be considered.
New technologies in grassland management and utilisation of technology such as GPS, satellite images, electronic pastoral control, remote sensing, and electric fences ("solar wires") are available worldwide, but special training and personal capacitation is required.

**3.) Agroforestry/silvo-pastoral systems** is recognized as an important component of climate-smart agriculture. It can be promoted with the introduction of dual-purpose (food/feed) crops, legumes, horticulture, dates, fruit trees and nuts within and between fodder products to enhance income from cash crops. Likewise, integration has begun with the physiology of the grass as a driving factor. The system basically works with a combination of annual crops (beans, maize, wheat, barley, sorghum and others) and trees associated with forage species (annual or perennial). There are several possibilities of combining agricultural, livestock and forestry components, considering space and time available, resulting in different integrated systems. This technological solution has a big potential but needs to be adjusted to conditions (agro-ecological, social, logistics, etc) (Dawson et al., 2014)

Productive grade dairy farms can be developed but under special design and with high investment. Pasture resources can be developed in several ways including (i) an improved distribution of water points and a reduction of overgrazing; (ii) increased primary production through land use intensification, (iii) reseeding of denuded rangeland, (iv) grassland conservation; and (v) by balancing stocking based on carrying capacity of the natural grassland.

The improvement of rangelands and communal pastures is complex and requires political, social, economic and cultural agreements and acceptance, next to significant financial and management resources. This is further complicated when there is different land- and water-use and interaction e.g. between pastoralists and wildlife conservancies or national parks, wildlife migration routes, and/or expanding (semi-) intensive farming communities or large-scale commercial farming. Hence, strategies to for sustainable rangeland management and rehabilitation need to take a multi-disciplinary and landscape approach.

### Private sector development into the forage sub-sector

Boosting of the forage private sector needs to be prioritized for future expansion and creation of business development services. Encouraging the private sector to become a strong player in the forage sub-sector (including commercialization of the forage seed sector, commercial forage production, mechanization and advisory and service provision). Production of leaf meal of leaf hay for example, of agro-forestry trees can be and interesting business idea for young people to engage in.

Fodder is in short supply in the densely populated urban areas of Central Uganda feed needs to be transported from the rural areas. Hay baling thus becomes attractive due to the reduction in weight of the fodder and the densification of the otherwise voluminous hay. As hay producers or service providers (offering baling services) the youth can become part of the private sector, while farmers benefit from the goods and services they supplied (Duiker et al 2011).

Farmers and large arable government farms could also produce hay, silage or haylage as a cash crop, while not keeping livestock themselves. Hay making as a service delivery is also an opportunity for investments by unemployed rural youth who loathe agriculture as a direct employment option. The youth need training in technical and entrepreneurial skills in the service provision.

Remove bureaucratic hurdles and the perception that they compete with public service providers (e.g. seed production/ multiplication and advisory services). The public sector needs to find mechanisms and strategies to encourage the involvement of the private sector and provide them with an enabling environment and equal opportunity. The emergence of an effective pluralistic service-delivery system can ensure access of smallholder dairy producers to appropriate and affordable technologies and support services from the private sector, whilst allowing the public sector to gradually withdraw from service delivery and focus on regulatory function and quality assurance. However, private sector capacity needs (in entrepreneurship, leadership and partnerships), market linkage, business development service, and access to knowledge, resources and infrastructure all have to be addressed. The capacity of the public sector for taking on regulatory and quality assurance functions effectively needs to be strengthened alongside private sector development.

### Knowledge and skills, management capacity

Dissemination of knowledge and knowhow is the most urgent to ensure that information available at the national and international research institutes can be understood and utilized by all stakeholders in the forage sub-sector. Through education, skills training, practical demonstrations and field visits awareness can be raised among individual farmers, trainers, dairy extension workers and other stakeholders in the chain about available (new) forage production technologies. The involvement of all stakeholder is important to ensure that the individual farmer does not receive contradicting messages when making important (farming) business decisions. Collaboration with ongoing dairy development partners like SNV-TIDE can be very effective and efficient to develop advisory business services. Existing simplified curriculum can be used train farmers and dairy extension workers how to make a feed plan, estimating forage quality, optimize and balance diets, categorise animals according to requirements. It is crucial that farmers understand the relationship between "feed:animal production" and how to make use of peak growth in relation to quality of forage crops during the growing season. The development of a feeding budget per farm that covers the whole year with allowances for dry seasons can be an easy starting point to manage seasonality. Such feeding plans will depend on the agro-ecological zone. To be competent, smallholder dairy producers need an appropriate, affordable and easily accessible full package of production technology.

Greater emphasis must be placed on the development of knowledge and skills needed to successfully introduce and manage good practices and innovations. A very strategic and well-designed educational/ training system needs (e.g annex …) to be developed for all forage related topics and for various agro-ecological environments. The curriculum should focus on youth and women and have a strong skills-based component and address all levels of the forage chain including pasture management, forage production, forage preservation and mechanisation, in an integrated approach with ruminant nutrition. Future farm coaching and advisory businesses need qualified and competent staff aware of latest technologies, cost benefit analysis for different farming systems and successful application. The relation between forage production and the animal's nutritional requirements is missing in Uganda's agricultural education and training programmes and among dairy extension workers.

### Feed testing

For farmers and dairy extension workers to get an understanding of the variability in quality of animal feeds and forages nutrient parameters need to be measured and for this, laboratories for forage/feed analysis are needed. They should offer precise and fast analysis and should be easily accessible

Meanwhile steps can be made in this respect, even in the absence of accredited laboratories for adequate forage analysis with the required regression lines for tropical forages. For example, the quality of Napier grass can be assessed by cutting interval, cutting height and fertilisation but also ensiled Napier grass can be assessed on chopping length, compaction, presence of moulds, odour, temperature of silages. The same applies to hay where the grass is not fertilized and harvested when it is overgrown, long after flowering (CP reduces and NDF increases). Maize silage for example can be assessed rather accurate through observation of e.g. physiological state, size of chopped maize, presence of whole kernels, moulds, smell, temperature of silages) and practices used such as plant population, fertilisation, stage of harvesting, stem/leave ratio, stubble height, use of a kernel crusher, speed of work, compaction and coverage

It is better however to facilitate the sector with accredited and professional feed testing facilities (stationary wet chemical analysis or future handheld NIRS) that have access to NIR regression lines for tropical forages. Application of feeding standards by dairy advisors and farmers, requires information on the nutritive value of available feed ingredients, the amount of feed intake, and the requirements of the animals.

Ration balancing and optimizing through combining available forages and other locally available single source feed ingredients will further improve productivity and more efficient use of available feed resources. NARO researchers with assistance of CTA developed ENDIISA ([www.sowandgrowgroup.org](www.sowandgrowgroup.org)) an online tool to assist farmers with ration optimization. The use of total ration formulation software (like Rumen8, [https://.cowsoko.com/rumen8](https://.cowsoko.com/rumen8)), when based on accurate and reliable feed analyses, will assist qualified dairy extension workers and advisors to justify the cost of different ration ingredients - be it locally grown, bought locally or imported against their actual nutritive value (DM, ME, CP, NDF) when used in ration formulation for ruminants.

NIR results linked to "total ration balancing software" will enhance cow rations, increase feed efficiency, optimize milk yield and reduce feed costs, whilst also reducing enteric methane emissions per litre of milk or kilogram meat produced (e.g. Rumen8 total diet ration balancing software piloted in by SNV-Kenya and recently introduced by SNV-TIDE in Uganda).

Table 25. Potential innovation for feed and forage analysis laboratory

| Innovation | Impact |
|---|---|
| Development of professional forage laboratory analysis system | High: possibility to balance diets, increase FE, reduce enteric methane emissions, improve farm profitability |
| Local lab NIRS calibration needs to be contrasted with local wet chemistry analysis | High: increased accuracy, calibration,<br>Dry/homogenised sample for better reading, time needed, and logistic support. |
| University/Research institutes collaboration | Medium: Credibility and trickledown effect |
| On-farm use of handheld NIRS based on local Lab NIRS regression lines/calibrations | High: Results are rapid, can be incorporated into management decisions very fast. Multiple reading from the same forage, to assess variability in your feed. Less accuracy than lab analysis (availability, affordability and calibrations available). |
| Affordable and easy access to forage analysis | Medium: Would create a big data base for future development and forage innovation |

### Reduction of environmental impact from livestock through improved forage technology

An increase in feed efficiency based on high quality forage production and adapted/improved breeds could be an effective tool to decrease enteric methane emissions. The use of high-quality forage in combination with balanced diets increases the ability of cows to turn feed nutrients into milk. When there is an increase in cows' feed efficiency, a smaller amount of nutrients is excreted in the manure and urine. At the same time, an increase in animal productivity associated with an increase in feed efficiency can allow a reduction in the stocking rate. Implementation of any strategy to mitigate enteric methane must consider the impact of these on other GHG emissions (e.g., $N_2O$) from (i) the dairy production unit, and (ii) associated agricultural practices. Adoption of mitigation strategies by dairy producers will depend on these considerations as well as on the feasibility of implementation, economic impact, and regulatory policy (Knapp et al., 2014).

Manure utilization can be improved through training and education resulting in the adaptation of integrated soil fertility management (ISFM) in conjunction with scaled machinery to facilitate its management and use. Manure can also be used for biogas production, yet this can compete with its use as soil amendment. With the increment of forage conservation, plastic residues will increase, thus recycling systems need to be put in place via woreda offices, input/service providers, and farmers.

# 3. Epilogue

From the desk study, interviews and survey it is concluded most identify dissemination of knowledge and knowhow to enhance awareness in forage production and the relation between producing good quality forage and animal performance as the main factors to enhance growth and competitiveness of dairy (and beef) sector. Followed by the nearly absence of farm equipment or mechanisation and scarcity of good quality forage. Over the past years, many farmers and other stakeholders (e.g. agricultural contractors, dairy cooperatives, dairy advisors, government officials and researchers) have successfully increased the level of milk production in Uganda resulting in Uganda becoming a country that exports milk, this increased awareness among farmers regarding importance of continuous (daily and year round) supply of forages in the ruminants ration, either fresh or preserved (dried/ensiled).

Also NARO the national research station has over the past decades done a lot of research in improved forage technology and needs to be able to dismiss their results a strengthened relationship with public and private partners who have the capacity, competence and expertise to transfer knowledge and skills effectively to farmers and other stakeholders in the Ugandan dairy sector. To take advantage of this growing awareness and understanding of the need for year-round availability of quality forages. These can be summarized in the following steps and direction and recommended to all Ugandan stakeholders.

- Accelerate and identify options for dissemination knowledge and knowhow in enhance aware and adoption of improved forage production.
- Stimulate entrepreneurship to import, distribute and set up service network for appropriate, affordable and scalable farm machinery
- Accelerate access to new (better) and more diversified certified forage species/cultivars/varieties through facilitating and stimulating seed companies to import and register suitable seeds, hand in hand with local research.
- Continue to stimulate the dairy sector with more attention for the domestic milk market.
- Strengthen public/private partnerships in the forage seed sector in continuation of Integrated Seed Sector Development project
- Promote new species, including legumes, such as *Brachiaria* and *Panicum*, and campaign for good management practices during land preparation, planting, growth, harvesting, storage and feeding.
- Stimulate intensification of livestock systems (e.g. towards of improved zero grazing / semi-zero grazing)
- Improve pasture management practices of and commonly used cut and carry forages
- Promote and improve preservation practices and methods and facilitate access to new technology.
- Recognise investors in commercial forages and agricultural forage contractors as entrepreneurs; create enabling environment for investments to expand commercial forage production and mechanisation.
- Support investment in the forage sub-sector, especially by incentivising youth service providers to create businesses specialised in different steps of the forage chain (seed supply, forage contracting services, sales and maintenance of scaled machinery, etc.).
- Building capacity and competence among all stakeholders (incl. education and training institutes) in the forage- subsector in relation to forage production and ruminant nutrition
- Introduce the notion of "quality" among all stakeholder by promoting energy and protein rich forages, feed laboratories for analysis, pricing based on nutritive value, feed standards and good management practices.
- Include and connect forage production and animal nutrition in student education, farmer training and extension programs through public/private partnerships

- Link forage and animal production sectors and create a dynamic cooperation and "growing together approach".
- Campaign for climate smart practices "from seed to feed" focused on productivity, quality and sustainability of agro-ecosystems (Integrated soil fertility management (ISFM) conservation agriculture (CA), reduction of GHG-emissions).
- Rehabilitate and conserve rangelands.
- Improve land, soil and water management and use, focused on future generations.
- Intervene in the forage market by setting-up strategic feed reserves in areas prone to drought and climate shocks.

The slow transition to a sustainable development of dairy production is attributed to a mixture of continued high-risk issues: lack of awareness amongst farmers and ineffective knowledge transfer systems, inadequate provisioning of improved technologies (incl. seed, fertilisers and machinery), large swings in prices of raw milk, and continued weakness in input and output marketing (e.g domestic market). The weakness in (domestic) markets is associated with both the lack of roads and an underdeveloped private marketing and transportation network

Poor performance of the dairy sector at farm level remains an ongoing concern caused by unbalanced diets and unawareness of basic knowledge and skills in ruminant nutrition and at times unavailability of (quality) forages. This is a serious issue in all farming systems during periods of the year and is increasingly so with the use of exotic breeds to upgrade the dairy herds. Also, for those farmers that have enough land to grow their own forages often do not have the farm equipment with right capacity, do not have a fodder plan in place and the concept of timing to harvest good quality forage is missing.

As expected, the magnitude of this problem varies from farmer to farmer, but it is clearly a main constraint in order to reduce cost of production and utilize the available genetic potential. If the target is to intensify productivity of dairy cows, forage quantity and quality should get more priority and be linked to ruminant nutrition.

For this, many aspects of the forage production process need to be considered, including forage management and agronomic practices, education/training, scaled mechanisation, the use of improved forage species and varieties, forage planning and preservation (seasonality, climate change) and feed testing. All these aspects need to be addressed together instead of individually in such a way that the farmer will be more aware, capable and empowered (Figure 7).

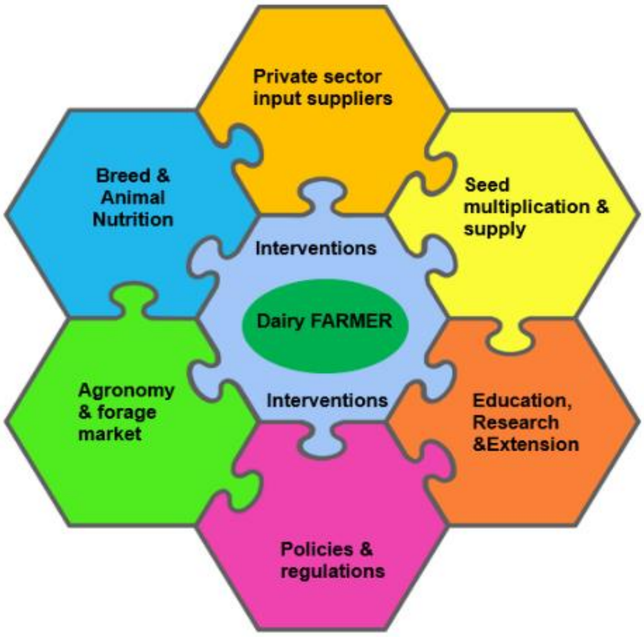



Figure 7. Diagram of interventions in the forage value chain

These steps address different aspects of the forage chain. If the target if improved animal productivity forage production needs to be turned around in Uganda and consequently dairy farming can be a successful business, this however requires strong dedication of and coordination between stakeholders, for the proper execution of various innovations, training and follow up. To improve and accelerate adoption, implementation and adaptation, these recommendations and related initiatives to enhance the forage sub-sector, Uganda Government must provide a conducive enabling environment.

Table 26. Policies and strategies to enhance the forage sub-sector

| Topic | Strategy |
|---|---|
| Seed and plant material | Developing appropriate legislation to forage seed variety release and certifications<br>Maintaining a commitment to develop, register and release new high yielding varieties<br>Ensuring that the technical procedures are flexible and appropriate to forage varieties<br>Ensuring that the seed quality standard is realistic in terms of species characteristics<br>Facilities for processing and storage<br>Supporting forage seed production activities<br>Stimulating involvement of the private sectors<br>Encourage public-private partnerships<br>Identification of distribution channels<br>Providing credit facilities to seed producers/traders<br>Suitable institutional arrangement<br>Maintaining seed security stocks<br>Involvement of various national stakeholders<br>Linkage of forage seed production, supply and market systems<br>Networking as joint effort to strengthen national forage seed programs |
| Feed/Forage | Recognize (commercial) forage producers like feed processors<br>Possibility to apply VAT system for forage producers |

| | |
|---|---|
| | Develop and legislate Animal Feed Resource Strategy<br>Encourage and assist establishment of forage/feed processing plants<br>Encouraging and supporting business development services<br>Develop feed & fodder quality control system (standards)<br>Encourage and provide incentive for feed processers in the livestock development potential areas |
| Land | Revising of the land policy to incorporate the forage production/grazing areas<br>Integrated land, water, soil resources development strategy<br>Silvo-pastoralism/Agro-forestry expansion,<br>Encourage forage bank establishment in potential feed deficit areas<br>Improve pasture use through appropriate grazing land management system,<br>Natural resources governance |
| Livestock | Animal breeding strategy (match genetics and feed)<br>Impose livestock tax and assign quota for stock control<br>Stratification of livestock production system, |
| Knowledge | Restructure Agricultural Education and Training<br>Restructuring and Strengthen extension services<br>Rural training and skills centers<br>Stimulate practical demonstration sites.<br>Intermediate degree for specially topics related with forage/animal production<br>Facilitate access to social media and mobile apps used as teaching tool in rural areas<br>Knowledge systems and institutes target awareness creation of youth and women |
| Research | Encouraging research on imported and indigenous plant materials<br>Conducting research, training and extension improved forage technology<br>Contribution of balanced diets to mitigation of enteric methane emission<br>Exchange of germplasm materials and beyond<br>Reinforcing the extension efforts and accessibility of new forage varieties<br>Streamlining and coordinating research, training and extension<br>Unified forage and animal production research |
| Finance | Promote rural financial institutions<br>Provide and facilitate finance opportunities for youth and women to start Business Delivery Services<br>Attractive financing for scaled mechanization of farming activities<br>Adjust taxes system to forage/seed producers and service providers<br>Promote rural insurance system |
| Infrastructure | Improve roads<br>Access to wireless telephone → information<br>Rural electrification and /or solar power<br>Support established of cooperatives and farms associations |

# Annexes

# Annex 1a. List of key resource persons

| List of Key resource persons | | |
|---|---|---|
| | Name | Organisation |
| 1. | Denis Mpirwe | Makerere University (Dept. Of Agricultural Production) |
| 2. | William Matovu | Heifer (EADD) |
| 3. | Susan Atyang | Heifer (EADD) |
| 4. | Phomolo Maphosa | SNV |
| 5. | Aikiriza Stephen | SNV |
| 6. | Herbert Kirunda | Technoserve |
| 7. | Rose Ademun | Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) |
| 8. | Juliet Sentumbwe, | Ministry Of Agriculture, Animal Industry And Fisheries (MAAIF) |
| 9. | Sean Graville -Ross | Mercy Corps |
| 10. | Churchill Nokrach | BRAC |
| 11. | Onyinge Jackson | BRAC Seed Uganda Limited |
| 12. | Kayondo Siraj Ismail | NARO |
| 13. | Stephen Justin Ecaat | Farm Radio International / Radios Rurales Internationale |
| 14. | Henry Mutabaazi | ABI Trust |
| 15. | Lawrence Mayega | DPO -Masaka |
| 16. | Gideon Nadiope | Iowa State University |
| 17. | Jean Jacques Mbonigaba Muhindi | ASARECA |
| 18. | Emma Naluyima | FODDA Foundation Solutions Uganda Ltd |
| 19. | Jolly Kabirizi | NaLiRRI |
| 20. | Bamwine Elly | KAZO B.H.A |
| 21. | Dr. Sekimpi Patrick | DAFAN |
| 22. | Dr. Tingiira | Kiboga |
| 23. | Asiimwe John Baptist | Kiruhura Dlg |
| 24. | Erison Tumusiime | Kazo Dryland Hus Agro Pastrolists |
| 25. | Kanuunu Jackson | Dream Farm Kyakabunga Group |
| 26. | Rtd. Col Dick Bugingo | Agro Dairy Farm |
| 27. | Matsiiko Polly | NDAFCU |
| 28. | Pius Lutakome | ICRAF-EADD |
| 29. | Nanguku Moses | Mbulamuti Dairy Investment Farm-Kamuli |
| 30. | Segawa Shakim | NASARI |
| 31. | Nkusi Charles | Nampante Dairy |
| 32. | Batanda Dan | Caritas Kasanaeris Nakaseke. |
| 33. | Lule Samuel | Nampante Cooperative |
| 34. | Erongu, Moses Edward | MAAIF/NSCS |
| 35. | Dr. David Kiryabwire | Mukono DLG |
| 36. | Dr. Eswagu Sam | Nakasongola District Local Government |
| 37. | Churchila Nokrach | BRAC, Seed |
| 38. | Chris.T. Muwanika | NARO Holdings Ltd. |
| 39. | Bamdow Alexander | NARO |
| 40. | Dr. Mugerwa Swidiq | NARO |

| | | |
|---|---|---|
| 41. | Noeline Labu | Victoria Seeds Ltd |
| 42 | Josephine Okot | Victoria Seeds Ltd |
| 43. | Lagu Godfrey | Engineering Solutions (Eng Sol) |
| 44. | Edna Nuwasasira | Link Maash Agro Ltd |
| 45. | Hilda Nduhura | 4DIZ |
| 46. | Tom Katsyamira | Kirabo Uganda Ltd |
| 47. | Dick Bugingo | AGDI Practical Dairy Training Farm |
| 48. | Kantongole Bells | Dairy Cooperatives: Sanga, Nyamistindo, Abeesigana, NDFCU |
| 49. | Dr. Halid Kirunda | NARO - Mbarara ZARDI |
| 51. | Dr. Ronald Twongyirwe | Mbarara University Of Science And Technology (MUST) |
| 52. | Juliet Sentumbwe | Ministry Of Agriculture, Animal Industry And Fisheries (MAAIF) |
| 53. | Dr. Andrew Sekitoleko | Dairy Development Authority (DDA) |
| 54. | Dr. Charles Lagu | NAGRIC |
| 55. | Dr. Grace Asiime | Local Governments – Kiruhura |
| 56. | Dr. William Mwebembezi | Local Governments – Mbarara |
| 57. | Dr. Yake Basulira | Local Governments – Ntungamo |
| 58. | Dr. Ronald Bameka | Local Governments – Lyatonde |
| 59. | Emmanualle | Grow More, Seeds and Chemicals |
| 60. | Dr. Pathmanathan K | Pearl Dairies Ltd |
| 61. | Dr. S.S. Verma | Brookside Ltd |
| 62. | Emmanuel Tayebwa | Farmer |
| 63. | Phelomena Nshangano | Farmer |
| 64. | Loyda Twino | Farmer |
| 65. | Robert Tusingwire | Farmer |
| 66. | Agaba Godfrey | Farmer |
| 67. | Kharm Kamuntu | Farmer |
| 68. | Jane Nyenda | Farmer |
| 69. | Eleanor Turyakira | Farmer |

# Annex 1b. List of persons interviewed

| List of people interviewed | | | |
|---|---|---|---|
| | Title | Name | Organization |
| 1. | Prof. | Samwin Kigwana | Farmer |
| 2. | Dr. | Alfa Kebanakanga | Vet |
| 3. | Mr. | Peter A. Kisambira | Uganda National Farmers Federation |
| 4. | Mr. | Sam Kabanda | Eng. Irrigation |
| 5. | Mr. | Ikanga Zutairi | Farmer |
| 6. | Mr. | Waisedha Faridha | Farmer |
| 7. | Mr. | Rinus van Klinken | SNV-Tide |
| 8. | Dr. | Halid Kirunda | National Agricultural Reasearch Organization (NARO-ZARDI) |
| 9. | Dr. | Pathmanathan Kannathasan | Pearl Dairies Ltd. |
| 10. | Mrs. | Edna Nuwasasira | LinkMaash Agro Ltd. |
| 11. | Mr. | Lagu Godfrey | Engineering Solutions |
| 12. | Dr. | Moses Ahimbisibwe | Fodder production officer |
| 13. | Mr. | Alfred Wagama | Fodder production officer |
| 14. | Mr. | Dick Bugingo | AGDI Dairy Farm Ltd. |
| 15. | Mr. | Jackson Kanuunu | Dream Farm Kyakabunga Group |
| 16. | Mr. | Erison Tumusiime | Kazo Dry Land Husbandry Agro Pastoralists Association |
| 17. | Mr. | Anthony Nambafu | Bukaka Dairy Cooperative Society |
| 18. | Mr. | Enock Rukidi | Murumba Farm |
| 19. | Mr. | Erick Musiime | Ngabo Farm |
| 20. | Mr. | Robert Twinamatsiko | DVO Kiruhura district |
| 21. | Mr. | Charles Nateekateeka | DAO Kiruhura District |
| 22. | Mrs. | Clementine Namazzi | National Agricultural Research Organization (NARO) |
| 23. | Mr. | Muhammad Kiggundu | National Agricultural Research Organization (NARO) |
| 24. | Dr. | Charles Lagu | National Animal Genetic Resources Centre and Data Bank (NAGRC) |
| 25. | Dr. | Juliet Sentumbwe | Min. of Agriculture Animal Industry and Fisheries (MAAIF) |
| 26. | Mr. | Dennis Maholo Mulongo | Min. of Agriculture Animal Industry and Fisheries (MAAIF) |
| 27. | Mrs. | Phomolo Maphosa | SNV-Uganda |
| 28. | Mrs. | Sylvia N. Kyeyune | Simlaw Seeds Company Ltd. |
| 29. | Mrs. | Josephine Okot | Victoria Seed Company Ltd. |
| 30. | Mr. | Monday Lwanga | Mascor Uganda - John Deere dealer |
| 31. | Dr. | Patrick Okori | DVO Sironko District |
| 32. | Mr. | Ronald Akol Omaswa | DVO Bulambuli District |
| 33. | Dr. | Lawrence Owere | National Agricultural Reasearch Organization (NARO) - BugiZARDI |

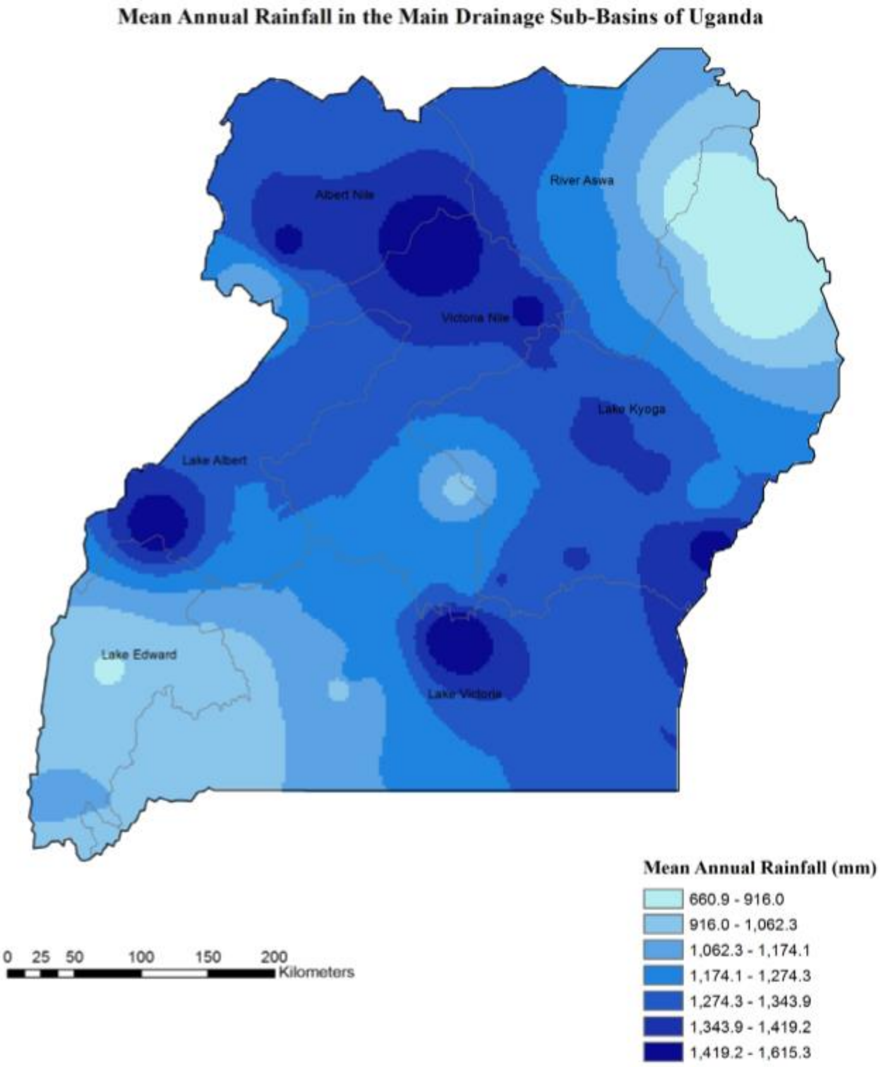
## Annex 1c. List of participants validation workshop and program

| | Title | Name | Institute | Location |
|---|---|---|---|---|
| 1 | Dr. | Jolly Kabirizi | NaLiRRI | Kampala |
| 2 | Mr. | Tom Kirabo | Kirabo Uganda Ltd | Mbarara |
| 3 | Mr. | Aikiriza Stephen | SNV – TIDE | Mbarara |
| 4 | Mr. | Anton Jansen | SNV – TIDE | Mbarara |
| 5 | Dr. | Ronald Bameka | Local Government – DVO | Lyatonde |
| 6 | Dr. | Andrew Sekitoleko | Dairy Development Authority (DDA) | Mbarara |
| 7 | Mr. | Robert Tusingwire | Farmer | Isingiro |
| 8 | Mr. | Jos Creemers | Pro Dairy | Nairobi |
| 9 | Mr. | Amon Twahirwa | Kanyanya DFCS | Kiruhura |
| 10 | Mrs. | Joan Atukunda | Nyamambo DFCS | Kazo |
| 11 | Mr. | Kanuunu Jackson | Dream Farm Kyakabunga Group | Kiruhura |
| 12 | Mr. | Erison Tumusiime | Kazo Dryland Hus Agro Pastoralists | Kazo |
| 13 | Mr. | Dick Bugingo | Farmer / PDTF | Kiruhura |
| 14 | Mr. | Kharm Kamuntu | UCCCU / farmer | Mbarara |
| 15 | Mr. | Ian Walker | Engineering solutions | Kampala |
| 16 | Mr. | Loyda Twino | Farmer | |
| 17 | Mrs. | Phelomena Nshangano | Farmer / PDTF | Mbarara |
| 18 | Mr. | Dennis Maholo Mulongo | Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) | Entebbe |
| 17 | Dr. | Irene Mbatidde | NARO-ZARDI Mbarara | Mbarara |
| 18 | Mrs. | Okot Josephine | Victoria seeds | Masindi |
| 19 | Mr. | Charles Palms Ezati | National Animal Genetic Resources Centre and Data Bank (NAGRC) | Entebbe |
| 20 | Mr. | Ashabaruhunga Mathius | Linkmaash | Mbarara |
| 21 | Mr. | Mugyeni Arthur | NDAFCU | Ntungamo |
| 22 | Dr. | Sakwa | Local Government – DVO | Bulambuli |
| 23 | Dr. | Ronald Twongyirwe | Mbarara University Of Science And Technology (MUST) | Mbarara |
| 24 | Mr. | Peter A. Kisambira | Uganda National Farmers Federation | Kampala |
| 25 | Mrs. | Walugembe Fatiwa | NaLiRRi | Wakiso |
| 26 | Mr. | Ariho Kiiza Junior | NARO Holdings ltd | Wakiso |
| 27 | Dr. | Yake Basulira | Local Government – DVO | Ntungamo |
| 28 | Mr. | Emmanuel Tayebwa | PDTF/farmer | Kiruhura |
| 29 | Mr. | Mark Woltheas | Bles /pearl dairy | Mbarara |
| 30 | Dr. | Franklin Nshimye | Local government | Kiruhura |
| 31 | Mr. | Kataambira Napoleon | NARO-NARI | Mukono |
| 32 | Mr. | Daniel kizza Alitudde | St. Jude farm project | Masaka |
| 33 | Mr. | Richard Wanyama | Heifer international | Mbarara |

| Time | Activity | Responsible |
|---|---|---|
| 8:30 am | Arrival at Royal City hotel Bugolobi and registration | |
| 9:00 am | Introductions and opening remarks | Anton Jansen, Paul Kimbugwe |
| 9:30 am | Keynote address on Forage subsector in Uganda | Anton Jansen |
| 10:00 am | Coffee/tea break | |
| 10:30 am | Summary of the forage quick scan report | Jos Creemers |
| 11:00 am | Overview of the outcome of the questionnaire | Jos Creemers |
| 11:45 am | Summary of the forage quick scan observations and recommendations | Jos Creemers |
| 12:30 pm | Lunch break | |
| 1:30 pm | group discussions on selected chapters and recommendations | All participants |
| 2:30 pm | Feedback /presentations per group | All participants |
| 3:30 pm | Plenary discussion, summary and way forward | Paul Kimbugwe/Anton Jansen |
| 4:30 pm | Workshop closure | TIDE |

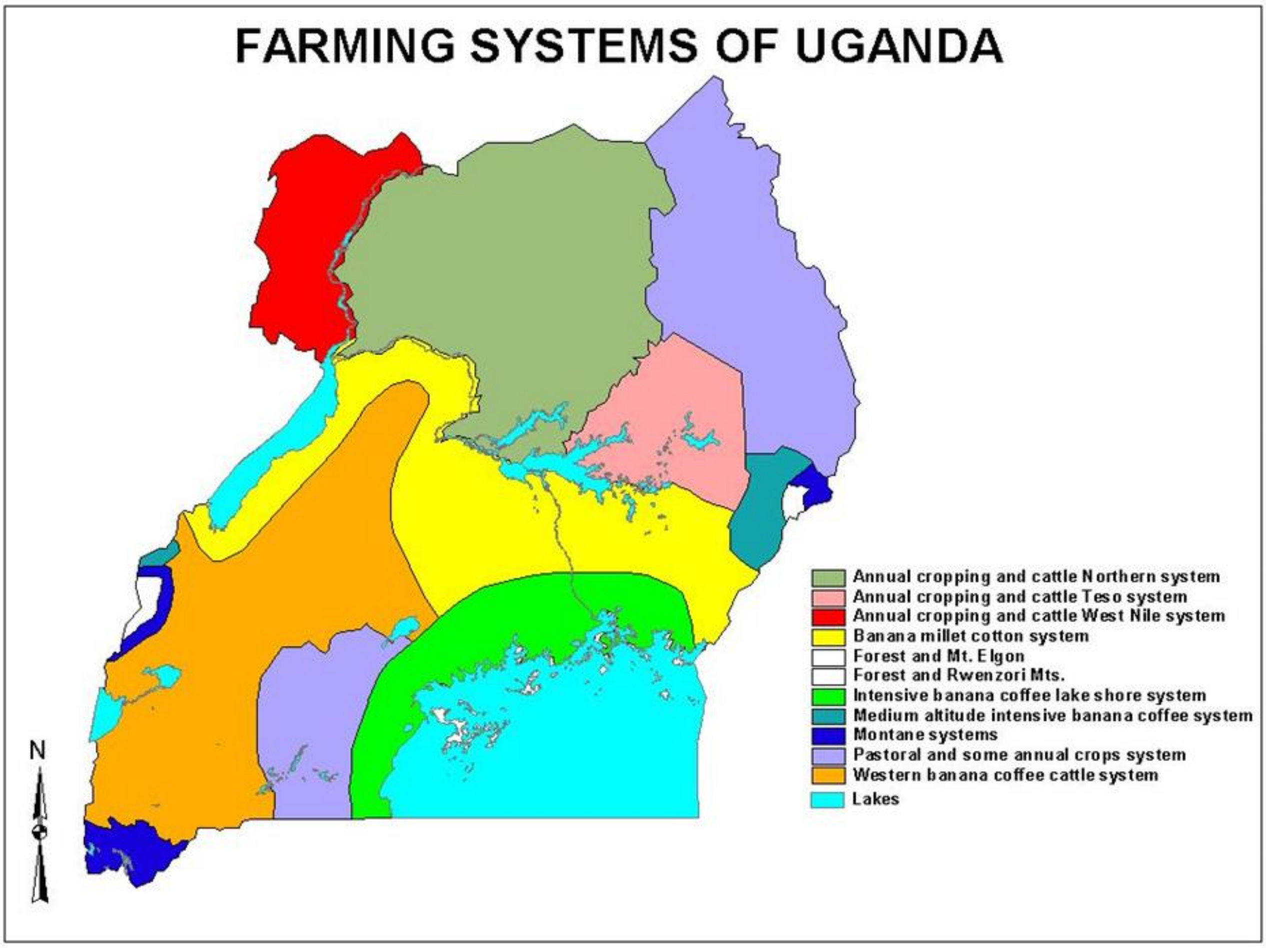
# Annex 2. Map of average rainfall in Uganda

(Source: Nsubuga N.S.W., Namutebi E.N., Nsubuga-Ssenfuma M. Water Resources of Uganda: An Assessment and Review Journal of Water Resource and Protection, 2014, 6, 1297-1315 Published Online October 2014 in SciRes. http://www.scirp.org/journal/jwarp http://dx.doi.org/10.4236/jwarp.2014.614120)



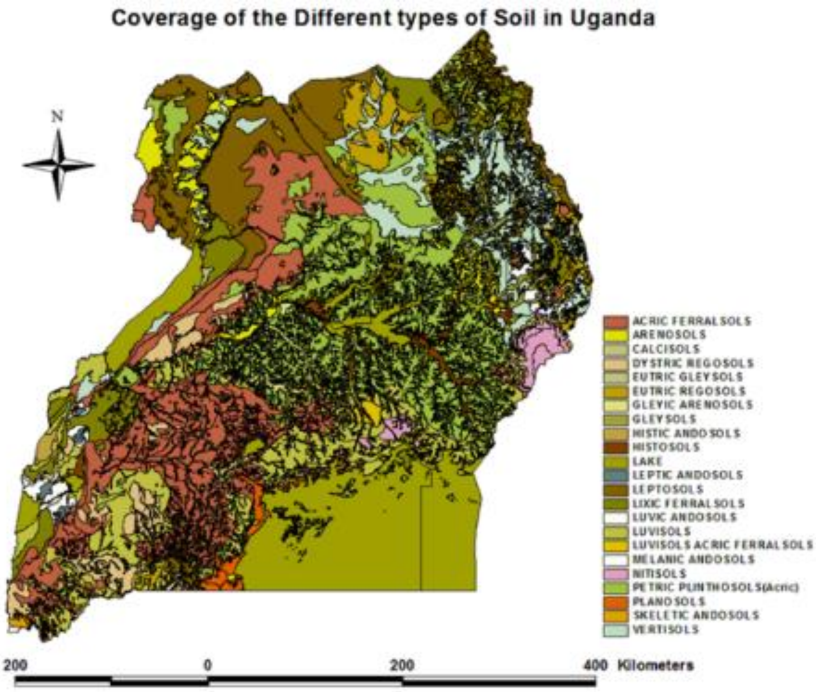
## Annex 3. Map of mixed crop-livestock farming systems of Uganda

(Source: Kaizzi K., Description of cropping systems, climate, and soils in Uganda http://www.yieldgap.org/uganda)



# Annex 4. Map of coverage of different types of soil in Uganda

(Source: Kaizzi K., Description of cropping systems, climate, and soils in Uganda http://www.yieldgap.org/uganda)




The general distribution of Uganda's soil with the most and least productivity potential based on the Reconnaissance Soil Survey of Uganda in which each soil unit is given an approximate potential productivity rating is presented in the following section

1. Soils with productivity greater than average

(a) (i) Soils formed from parent material containing volcanic ash occurring on the lower slopes of Mt. Elgon in the eastern Uganda, on the triangle from Lake George and north of Lake Edward in western Uganda, around Fort Portal in Kabalore district, and (ii) around Kisoro in south-west Uganda.

(b) Clays formed from parent material partly or wholly from basic amphibolite rocks which occur around Jinja and central Uganda and in small patches on the southern-most corner of Busia district, around Sunga in Kabale district; and in the south-west corner of Nebbi district.

(c) Deep, red or brown, loam or clay loam, pediment soils occurring in what was dubbed the "fertile crescent", 40 – 48 km wide around Lake Victoria from Jinja to south Masaka, in the rectangular block about 48 km wide, extending north-east from Fort Portal volcanic ash soils into north Mubende, as patches of dark-red clay loams, mainly lying between Hoima and Masind, in south-east Kabale district including Kabale, and around Ibanda Hill in Mbararar district

(d) Deep sedimentary soils occurring Around Bundibugyo in Bwamba County, Bundibugyo district, and in the neighborhood of Lira and around Dokolo in the south-east of Lira district.

2. Soils with low or nil productivity

(a) Shallow or very sandy or gravelly soils which occur over most of the huge block country stretching from West Nile scarp across the whole of Gulu and Kitgum districts and much of Moroto and Kotido district, much of Katakwi, Kumi and Soroti districts, along the margins of Lake Kyoga and its branches and the north of central Uganda, along the margins of Lake Victoria in central Uganda, in the north and west of Masaka district up to Lake Wamala, and on the Singo hills north of Lake Wamala in central Uganda.

(b) Montane soils occurring on the upper slopes of Mt. Elgon and Rwenzori and patches of soils in western Uganda (Kaizzi, 2009).

# Annex 5. List of forage species found in Uganda

(Source: desk top study, survey and personal interview for quick scan of Uganda's Forage sub-sector 2019)

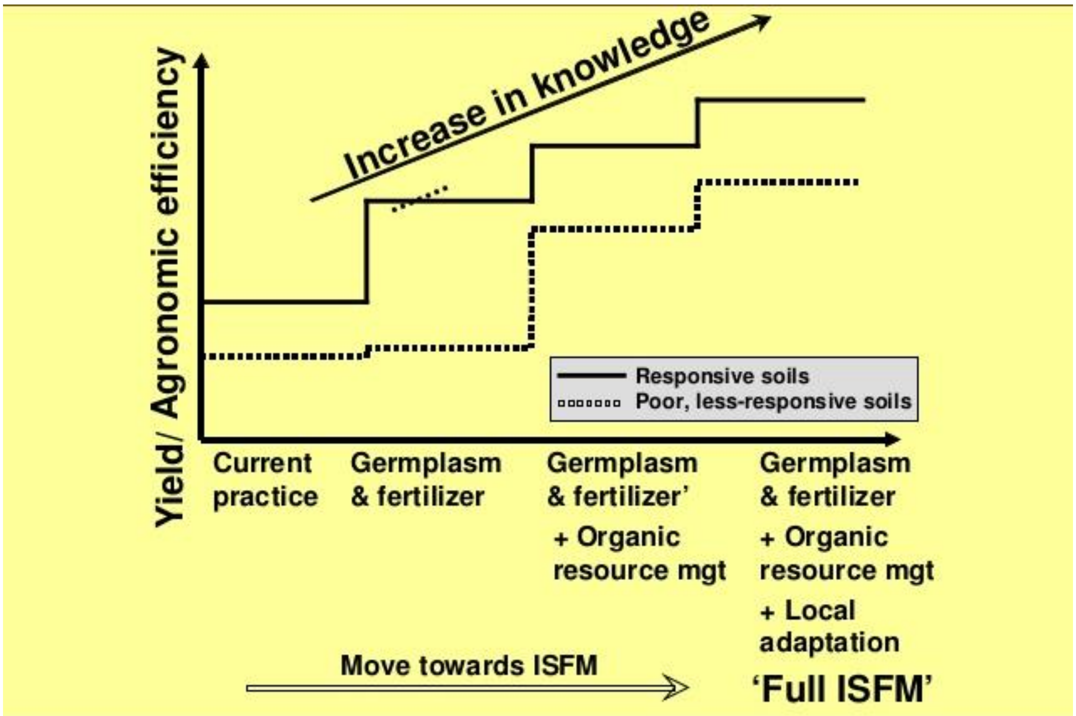
| Common Name | Scientific Names |
|---|---|
| Acacia | *Acacia spp* |
| Blue stem Grass/Gamma grass | Andropogon gayanus |
| Amba grass, Tambuki grass | *Andropogon spp* |
| Forage peanut | Arachis pintoi |
| Common Needle grass | *Aristida adscensionis* |
| Jack Fruit | Artocarpus heterophyllus Lam |
| Oats | *Avena sativa* |
| Axiliaris | Axiliaris |
| Duckweed Fern | *Azolla* |
| Fodder beet | Beta vulgaris |
| | *Brachiaria brizantha* |
| | *Brachiaria decumbens* |
| Congo Signal / Ruzi grass | *Brachiaria ruziziensis* |
| Brachiaria varieties | *Brachiaria ssp* |
| Kale | *Brassica oleracea* |
| Turnips | *Brassica rapa var. rapa* |
| Pigeon pea | *Cajanus cajan* |
| Calliandra | *Calliandra calothyrsus* |
| African Foxtail / Buffel grass | *Cenchrus celiaris* |
| Common centro / Butterfly pea | *Centrosema mole* |
| Centro | *Centrosema pubescens* |
| Roundleaf sensitive pea, | *Chamaecrista rotundifolia* |
| Rhodes grass (Katambora, Boma, Mbarara) | *Chloris gayana* |
| Rhodes grass (ex Tosi) | *Chloris gayana cv ex Tosi* |
| Tsawko | *Chloris pycnothrix* |
| Horsetail grass | *Chloris roxborghunia* |
| Chicory | *Cichorium intybus* |
| Butterfly/Blue pea | *Clitoria ternatea* |
| Hemp varieties | *Crotolaria spp* |
| Blue Citronella grass | *Cymbopogon (afro)nardus* |
| Star grass (Naivasha, Bermuda) | *Cynodon dactylon* |
| Giant / African Star grass | *Cynodon plectostachyus* |
| Star grass varieties | *Cynodon spp* |
| Cock's foot | *Dactylis glomerate* |
| Bundleflowers | *Desmanthus virgatus* |
| Silver leaf desmodium | *Desmodium incanum* |
| Green leaf desmodium | *Desmodium intortum* |
| Desmodium varieties | *Desmodium ssp* |
| African Couch grass | *Digitaria abyssinica* |
| Jarra Digit grass | *Digitaria milanjiana* |
| Barnyard grass | *Echinochloa ssp* |

| | |
|---|---|
| Finger Millet | *Eleusine spp* |
| Bush Rye | *Enteropogon macrostachyus* |
| Bungoma grass | *Entolasia ssp* |
| Stink grass | *Eragrostis cilianensis* |
| Love grass | *Eragrostis superba* |
| Natal fig | *Ficus natalensis Hochst* |
| Perennial Soybean | *Glycine javanica* |
| Soybean | *Glycine max* |
| Perennial Soybean | *Glycine neonotonia wightii* |
| | *Glycine ssp* |
| Glyricidia | *Glyricidia sepium* |
| Black spear grass | *Heteropogon contortus* |
| Barley | *Hordeum vulgare* |
| | *Hyparrhenia diplandra* |
| | *Hyparrhenia filipendula* |
| Giant Thatching grass | *Hyparrhenia rufa* |
| Sweet potato vines | *Ipomoea batatas cv Mafuta* |
| Dolichos/ Hyacinth bean / Njahi | *Lablab purpureus* |
| Sprangletop | *Leptochloa obtusifolia* |
| Leucaena | *Leucaena diversifolia* |
| Leucaena | *Leucaena leucocephala* |
| Leucaena | *Leucaena trichandra* |
| Italian rye grass | *Lolium multiflorum* |
| Rye grass | *Lolium perenne* |
| Lotononis | *Lotononis ssp* |
| Lupins | *Lupinus albus graecus* |
| Sweet lupins | *Lupinus angustifolius L.* |
| Siratro | *Macroptilium atropurpureum* |
| Siratro | *Macroptilium atropurpureum cv. Siratro* |
| Perrenial Horsegram | *Macrotyloma axillare* |
| Horse gram | *Macrotyloma axillare* |
| Lucerne varieties | *Medicago sativa* |
| Moringa | *Moringa oleifera* |
| Mulberry | *Morus alba* |
| Banana | *Musa paradisiaca L* |
| Coloured Guinea | *Panicum coloratum* |
| Guinea grass | *Panicum maximum* |
| Guinea grass | *Panicum maximum cv likoni* |
| Guinea grass | *Panicum maximum cv makueni* |
| Panicum varieties | *Panicum ssp* |
| Bahia grass | *Paspalum dilatatum* |
| Kikuyu grass varieties | *Pennisetum clandestinum* |
| Pearl millet | *Pennisetum glaucum* |
| Napier grass | *Pennisetum purpureum* |
| Napier grass | *Pennisetum purpureum* |

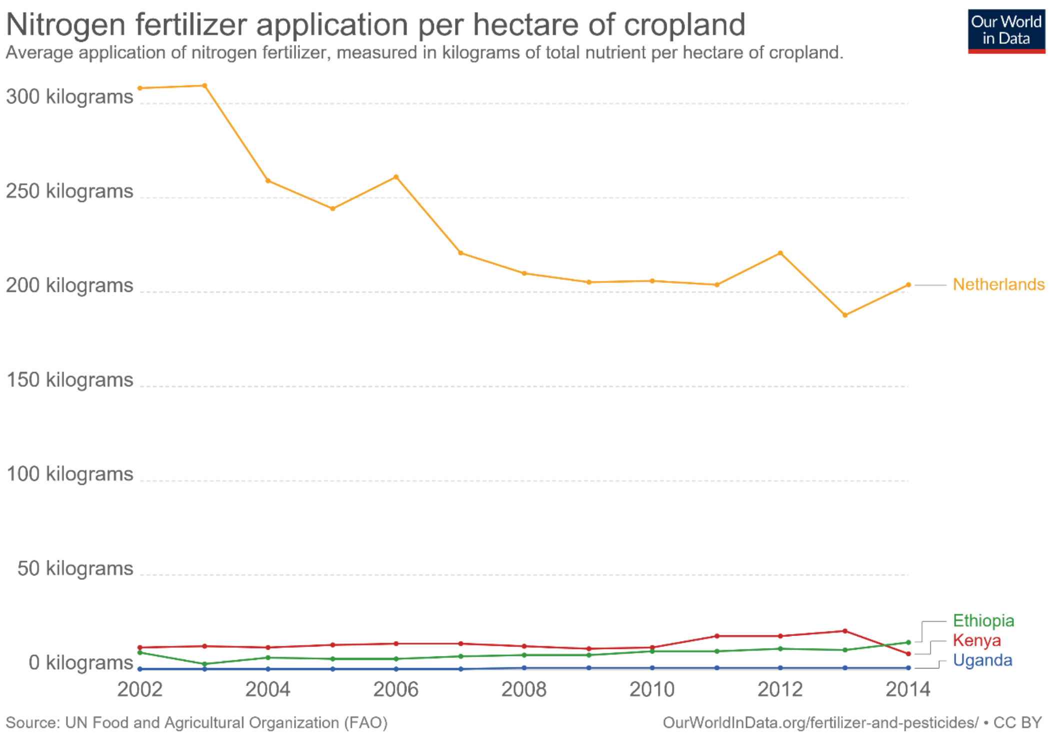
| | |
|---|---|
| Natal grass | *Pennisetum unisetum* |
| Avocado leaves | *Persea americana Mill.* |
| Reed canary gras | *Phalaris arundinacea* |
| Plantain | *Plantago lanceolate* |
| Tropical kudzu | *Pueraria phaseoloides* |
| Sesbania | *Sesbania sesban* |
| Foxtail Millet | *Setaria italica* |
| Nandi Setaria Grass (Golden Bristle) | *Setaria sphacelata cv Nandi* |
| Nasiwa Setaria Grass | *Setaria sphacelata cv Nasiwa* |
| Giant Setaria | *Setaria splendida* |
| Columbus grass | *Sorghum almum* |
| Sudan grass | *Sorghum bicolor (var. sudanese)* |
| Forage sorghum | *Sorghum drummondii* |
| Sorghum | *Sorghum vulgare* |
| Dropseed grass | *Sporobolus fimbriatus* |
| | *Sporobolus pyramidalis* |
| | *Sporobolus stafianus* |
| Velvet /Mucuna beans | *Stizolobium spp* |
| Stylo | *Stylosanthes guianensis* |
| Stylo | *Stylosanthes guianensis* |
| Stylo | *Stylosanthes guianensis* |
| Stylo | *Stylosanthes humilis* |
| Stylo | *Stylosanthes mucronate* |
| Stylo (pencilflower) | *Stylosanthes scabra* |
| Red oat grass | *Themeda triandra* |
| Wild Mexican Sunflower | *Tithonia diversifolia* |
| Madre de agua | *Trichanthera gigantea* |
| Kenyan White clover | *Triflorum semipilosum* |
| Kenya Purple clover | *Trifolium burchellianum* |
| Guatemala grass | *Tripsacum laxum* |
| Bitter leaf | *Vernonia amygdalina Delile* |
| (Purple) Vetch | *Vicia sativa (benghalensis)* |
| Cowpea | *Vigna unguiculate* |
| Maize | *Zea Mays* |

## Annex 6. Graphic representation of Integrated Soil Fertility Management

(Source: Adapted from Vanlauwe, 2013) Integrated soil fertility management: definition and impact on productivity and soil C)

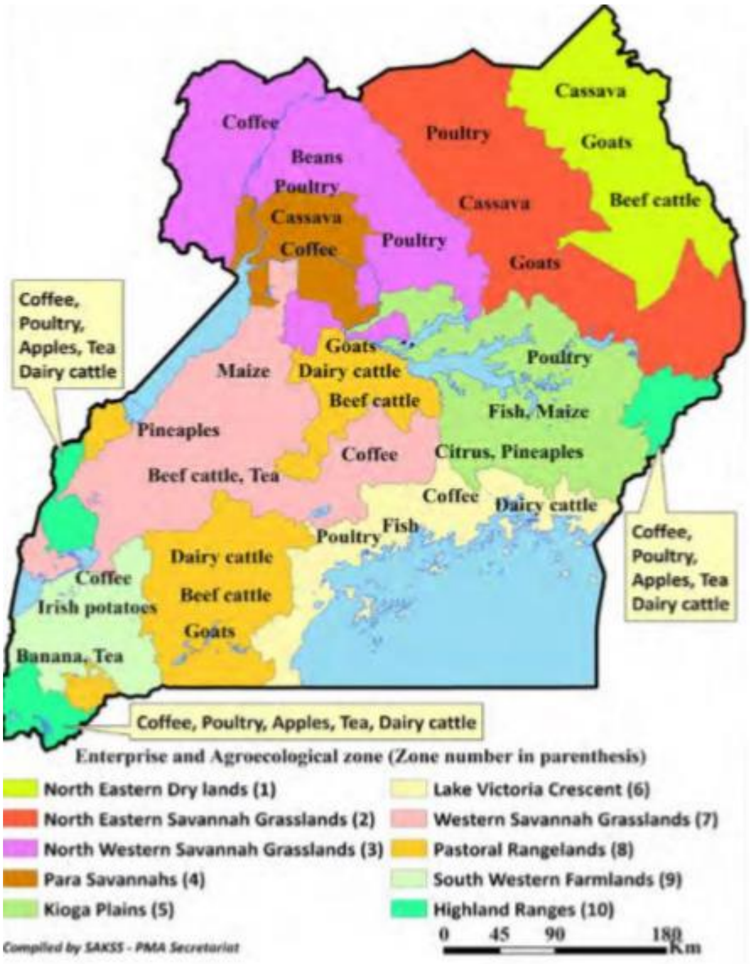


## Annex 7. Nitrogen fertilizer application per hectare of cropland in Uganda, Kenya and Ethiopia.



## Annex 8. Agro-Ecological Zones in Uganda

(Source: Dale N., Markandya A., Bashaasha B., Beucher O., Economic Assessment of the Impacts of Climate Change in Uganda, 2015)



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