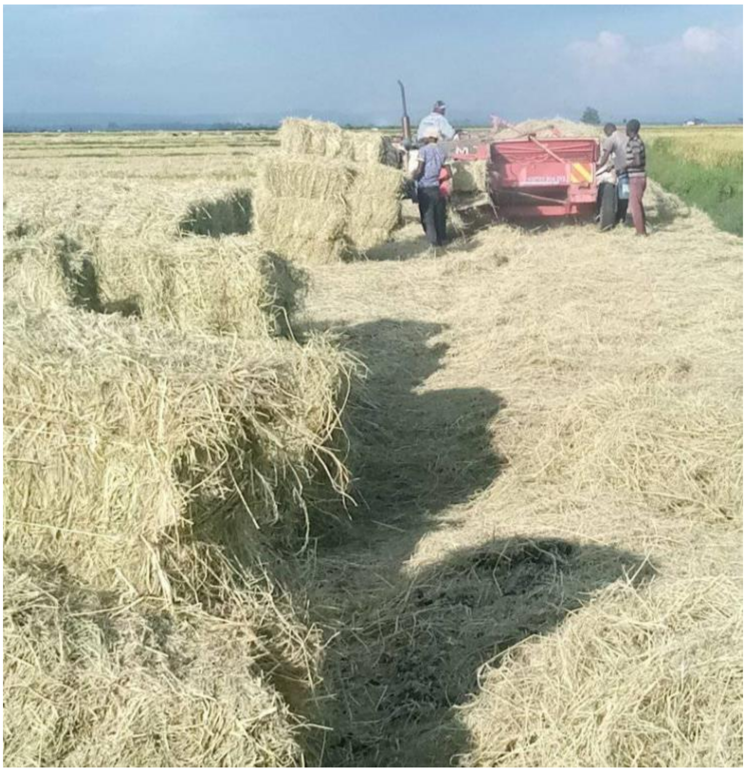


Scarcity of Feed and Fodder:

A Barrier to Sustainable Livestock Development

Challenges, Implications and Solutions

HEIFER INTERNATIONAL
KENYA

Kenya Livestock Marketing & Resilience Project (KLMP)

Presented by
J. Creemers
F.A. Opinya

ProDairy
For Professional Dairy Farmers

ProDairy East Africa
P.O. Box 1009 Karen Nairobi, Kenya
info@prodairy.co.ke

Table of Contents

Executive summary

The livestock sector in Kenya plays a critical role in its economy, contributing to income, jobs and food security; and accounting for an estimated 12% of GDP (Mwendia *et al.,* 2020). In the Arid and Semi-Arid Land (ASAL) areas for example, livestock rearing, mainly ruminants – cattle for beef, sheep and goats as well as camels – is the most predominant economic activity and source of livelihoods among households (Kidake *et al.,* 2016). Presently, the ruminant livestock sector in the ASAL counties primarily depends on natural range pasture. Similarly, the production systems in the ASAL regions of Kenya, mainly through pastoralism is an integral part of agriculture in Kenya and contributes to national food production, income and employment. However, the growth of the livestock sector in ASAL areas is significantly hampered by a myriad of challenges, erratic climatic conditions, rangeland degradation and high cost of production of milk and meat. These are largely related to severe vegetation deficits, low-quality fodder and feed, and unavailability of quality forages year-round. Furthermore, the Kenya Livestock Marketing and Resilience Project (KLMP) identified (i) increasing climate challenges from drought and degraded rangelands, (ii) inadequate nutritious supplemental feed, (iii) poor access to inputs to grow, process and/or store feeds, and (v) knowledge gaps in both maximizing production of forage and in formulating balanced rations as additional challenges.

To address these challenges, providing accessible, cost-effective and nutritious feed to ruminant livestock is critical to ensure livestock health and performance, which are essential for creating sustainable livelihoods and food security in the targeted communities. An in-depth assessment of these challenges would objectively inform specific interventions or solutions for the project.

This study focused on Nakuru County and pastoralist communities in the ASAL counties of Kajiado and Isiolo, as these are some of the counties where KLMP is implemented. They are perceived to have significantly active red meat-producing households. Kajiado and Isiolo counties are classified as ASALs, while Nakuru County varies between semi-arid to sub-humid conditions. The beef value chain, especially in the ASALs areas, is thought to hold significant growth potential; and by extension, these counties demonstrate high interest in developing the forage value chain. The study was designed in three scenarios; (i) Scenario A: Conservancy-managed livestock; (ii) Scenario B: Youth and women's livestock market groups; and (iii) Scenario C: Village-level, women-managed milking herds and small ruminant flocks.

Discussions between ProDairy EA and Heifer International Kenya (HPIK) purposively informed the selection and identification of key informants/respondents as summarized in Annex 4. This selection of respondents was based on indications of their potential to engage and influence the forage value chain as well as based on categories/scenarios listed above.

Various approaches and methodologies were used to collect information presented in this report. Two sets of semi-structured questionnaire and checklists were used for data collection: from (i) forage producers for supplementation and (ii) forage seed producers, both formal and informal. For the former, data was collected on socio-demographics, forages cultivated, cost of production, packaging and distribution, pricing and market descriptions (Annex 7). For the latter group, data collection covered socio-demographics, portfolio of forage seeds, seed demand versus supply, sales/distribution networks, knowledge and training as well as collaborations and roles played by external actors (Annex 8). We also triangulated these data with insights from key informant interviews, conducted with fodder group leaders, extension officers in the respective County Departments of Agriculture and Livestock, private service providers, and individuals drawn from development partners working within the counties. Participatory farmer and focus group discussions, each comprising members drawn from different fodder groups, were also conducted. The data was then analysed using both qualitative and quantitative methods. Literature was also useful in obtaining data and information for this work.

Currently the ruminant livestock sector in Isiolo and Kajiado (rangelands) primarily depends on natural pasture, while Nakuru and parts of Kajiado, forage is cultivated on smallholder -mixed crop-livestock farms and found on roadside, uncultivated public and private lands. Very few farmers grow quality pasture and fodder or re-seed rangeland for the purpose of feeding their livestock. The limited availability of quality pasture and fodder, combined with a shortage of pasture seed and lands for grass and forage crop cultivation, is one of major bottlenecks in livestock production in the three counties. Responses needed to protect lives, livelihoods and ecosystems, important for livestock production and wildlife, include range pasture, grassland and fodder technologies (such as rangeland reseeding, grass seed production, processing and storage) as well as improved fodder/pasture utilization, conservation and storage. However, most farmers do not have access to information on good agricultural practices (GAP) to enhance production of pasture and fodder, pointing to a significant capacity development gap.

Based on literature analysis and field findings, this report presents recommendations to mitigate these challenges and tap into opportunities within the forage value chain and cattle enterprises. The report is therefore a product of mixed methodologies, including a comprehensive literature review, consultative meetings, key informant interviews, and field observations. With respect to optimizing forage production in Commercial Ranches and Community Conservancies linked to Ecosystem Resilience (Scenario A), it is important to recognize their shared goal: when properly managed, livestock can be a force for ecological good. This requires a) prioritizing on-site forage optimization through managed grazing and ecological restoration to build a resilient feed base; b) diversifying their feed portfolio to mitigate market risks; c) adopting modern (digital) technologies; and finally, d) establishing partnerships with like-minded organizations.

Similarly, improving feed and supplemental feed access to youth near livestock markets (Scenario B) and women-owned village herds (Scenario C) requires a multi-faceted approach involving deep inclusion (visibility) and capacity building. Quite often, women, despite their central role in daily animal care and their extensive traditional knowledge, face systemic barriers to accessing productive assets, credit, information and decision-making authority, disproportionately affecting women-managed livestock systems. Opportunities to address these constraints lie in cultivating drought-tolerant forages, utilizing alternative feed resources, such as crop residues, and the implementing decentralized water management solutions. `

For interventions to be effective, they must integrate ecosystem /environmental health, animal nutrition, and socio-economic factors. Innovations in fodder supplementation have greater impact when integrated combined with sustainable rangeland management practices and advanced water management systems.

Glossary

Browse: Leaves, shoots and sprouts, including tender twigs and stems of woody plants, found in rangelands or cropped to a varying extent and eaten by domestic and wild animals. The term may also include fruits, pods and seeds that provide valuable feed, especially when trees shed leaves seasonally .

Climate-Smart Agriculture (CSA): As defined by the FAO, an approach for developing agricultural strategies to secure sustainable food security under climate change.

Concentrates: Feeds that contain a high density of nutrients, usually low in crude fibre content (fibre less than 18% of dry matter (DM)) and high in total digestible nutrients (TDN).

Fattening: Aims to increase the animal's weight, fat deposition (marbling in beef cattle), and muscle mass, within the shortest possible period resulting in a higher quality and marketable product. Fattening involves providing a balanced, high-energy diet, along with adequate water.

Feeding: Process of consuming feed by animals. Feeding results in the ingestion of food to provide nutritional needs, particularly energy, protein and fibre. Animals must eat (be fed) in order to survive, nutrients are needed for body maintenance, milk production, growth, and activity.

Finishing: Final phase where animals are fed a specific diet to maximize weight gain and fat deposition, preparing them for slaughter. Finishing aims to bring animals to optimal market weight and quality, ensuring they meet the standards for slaughter and produce high-quality meat. Finishing diets are often high in concentrates, which provide a readily available energy source for rapid weight gain.

Fodder: Wide range of crop and pasture species that are grown, harvested and lightly processed (dried, ensiled) to facilitate both on-farm use and domestic trade. A number of factors affect the production and supply of fodder in a region. Land use and cropping pattern of the region, number and density of livestock in the region, livestock feeding pattern, storage of fodder, and intra- and inter regional fodder trade are some of the critical factors, which have significant bearing on availability of fodder.

Forages: Plants or parts of plants eaten by livestock. It may be grazed, browsed or fed as cut and carry.

Grassland: Grassland occurs naturally and the vegetation in the area is dominated by grasses (*Poaceae*) and often used for grazing. However, sedge (*Cyperaceae*) and rush (*Juncaceae*) can also be found along with variable proportions of legumes, and other herbs.

Herbage: Non-woody vegetation such as grasses, herbs, or small shrubs, typically used for grazing or pasture. It may also refer to the whole plant, including stems, leaves, flowers, seeds and sometimes roots which can be consumed by animals.

Pasture: Land covered with cultivated grass and other low plants suitable for grazing animals, especially cattle or sheep.

Roughages: Feeds with a low density of nutrients, with a crude fibre content over 18% of DM, including most fresh and dried forages and fodders.

Pastoralism: Refers to both an economic activity and a cultural identity. As an economic activity, pastoralism is an animal production system which takes advantage of the characteristic instability of rangeland environments through strategic mobility, where key resources such as pastures, nutrients and water for livestock becomes available in short-lived and largely unpredictable concentrations. Crucial aspects of pastoralism specializations are the interaction of people animals and the environment, particularly mobility of livestock while grazing/browsing and watering at intervals; and the development of flexible resource management systems, particularly communal land management and non-exclusive entitle.

Ranching: A livestock production enterprise where a group jointly owns freehold title to land and herd their livestock collectively though they own them individually. Selection of members to ranches in Kenya was based on kinship and traditional land rights. Ranching is a concept in the Rangelands that is slowly gaining popularity due to its sustainable approach and the immense benefits it offers its members.

Rangelands: Vast undisturbed natural resources and landscapes in the form of grasslands, bushland, woodlands, wetlands and deserts. They grow primarily indigenous vegetation, rather than plants established by humans.

Range management: The science and art of ensuring the sustainable use of range resources. It relies on ecological principles in dealing with the use of rangelands and range resources for a variety of purposes. These purposes include use as grazing for livestock, as wildlife habitat, watersheds, recreation and other associated uses. Rangelands are managed principally with extensive practices such as managed livestock grazing and nomadic pastoralism rather than more intensive agricultural practices of seeding, irrigation, and the use of fertilizers.

Sedentary: Not migratory, livestock keepers state that, sometimes because of the harsh climate condition, it is better to stay in the same place all year round, generally near a well. In parallel to the traditional, migratory, grazing practices, the development of the semi-urban form has taken place, which is closely linked with towns and cities.

Spate irrigation: A type of water management that makes use of water from “spates”, short duration floods. Spates – lasting from a few hours to a few days – are diverted from normally dry riverbeds and spread gently over agricultural land. After the land is inundated (forage) crops are sometimes sown immediately. Often the moisture is stored in the soil profile and used later. Besides providing irrigation, spates recharge shallow groundwater (especially in river bed), they fill (cattle) ponds, and they are used to spread water for pasture or rangelands in some places.

Transhumance: The action or practice of moving livestock from one grazing ground to another, depending on fodder availability, in a seasonal cycle without considering regional boundaries or country borders.

Tropical Livestock Units (TLU): Livestock numbers converted to a common unit. It is based on a weight of 250 kgs. Conversion factors are cattle = 0.7, sheep = 0.1, goats = 0.1, pigs = 0.2, chicken = 0.01.

Xerophytes: Species of plant that has adaptations to survive in an environment with little liquid water. Xerophytes, such as cacti, can withstand extended periods of dry conditions as they have deep-spreading roots and capacity to store water. Their waxy, thorny leaves prevent loss of moisture.

List of Boxes

List of Figures

List of Graphs

List of Maps

List of Pictures

List of Tables

List of Acronyms & Abbreviations

ADC	Agricultural Development Corporation
AEZ	Agro-Ecological zone
AI	Artificial insemination
ASAL	Arid and Semi-Arid Land
ASDSP	Agricultural Sector Development Support Program
ASGTS	Agriculture Sector Growth and Transformation Strategy
BETA	Bottom-Up Economic Transformation Agenda
CAGR	Compound Annual Growth Rate
CBO	Community Based Organization
CCAFS	Climate Change Agriculture and Food Security program of the CGIAR
CFP	Commercial Forage Producer
CGIAR	Consortium of International Agricultural Research Centers
CIAT	International Centre for Tropical Agriculture
CIDP	County Integrated Development Plan
CIG	Common Interest Group
CLO	County Livestock Officer
COMESA	Common Market for Eastern and Southern Africa
CP	Crude Protein
CSA	Climate Smart Agriculture
DM	Dry Matter
DTMRB	Densified Total Mixed Ration Blocks
DUS	Distinctiveness, Uniformity and Stability
ECOWAS	Economic Community of West African States
ENNDA	Ewaso Ng'iro North Development Authority
EU	European Union
EWS	Early Warning Systems
FAO	Food and Agriculture Organization of the United Nations
FPCM	Fat and Protein Corrected Milk
FWG	Forage Working Group
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GoK	Government of Kenya
GRA	Global Research Alliance
HPIK	Heifer Project International Kenya (aka Heifer International Kenya)
ICSIAPL	Integrated & Climate Smart Innovations for Agro-Pastoralist Economies and Landscapes Kenya's ASAL
IGAD	Intergovernmental Authority on Development
ILO	International Labour Organization
ILRI	International Livestock Research Institute
ISTA	International Seed Testing Association
ITC	International Trade Centre
JKUAT	Jomo Kenyatta University of Advanced Technology
KALIMA	Kajiado Livestock Marketing Association
KALRO	Kenya Agriculture and Livestock Research Organization
KCSAP	Kenya Climate-Smart Agriculture Project
KEBS	Kenya Bureau of Standards
KFFA	Kenya Fodder and Feed Association
KII	Key Informant Interview
KMDP	Kenya Market-Led Dairy Program
KMT	Kenya Markets Trust
KNBS	Kenya National Bureau of Statistics
KWS	Kenya Wildlife Service
MASL	Meters Above Sea Level
ME	Metabolizable Energy
MOALD	Ministry of Agriculture and Livestock Development
MoALF	Ministry of Agriculture, Livestock and Fisheries
NARIGP	National Agricultural and Rural Inclusive Growth Project
NCVL	National Crop Variety List
NDC	Nationally Determined Contribution
NDMA	National Drought Management Authority
NGOs	Non-Governmental Organizations
NIA	Neighbours Initiative Alliance
NIRS	Near Infrared Spectroscopy
NPT	National Performance Trial
NRT	Northern Rangeland Trust
PMR	Partially Mixed Ration
PPP	Public-Private Partnership
PRISE	Pathways for Resilience in Semi-Arid Economies
RAE	Rehabilitation of Arid Environments
RFQ	Relative Forage Quality
RFV	Relative Feed Value
SADC	Southern African Development Community
SEAZ	Small East African Zebu
SPEN	Service providers Enterprise Network
TDN	Total Digestible Nutrients
TLU	Tropical Livestock Unit
UPOV	International Union for the protection of New Varieties of Plants
VCU	Value for Cultivation and Use
VSLA	Village Savings and Loaning Association
WSC	Water Soluble Carbohydrates
WWF	World Wildlife Fund / World Wide Fund for Nature

List of Symbols & Units

CH_4	Methane
CO_2	Carbon dioxide
CO_2-eq.	Carbon dioxide equivalent
Ha	Hectare
KES	Kenya shillings
kg	Kilogram
km^2	Square kilometre
m^3	Cubic metre
MJ	Megajoule
MT	Metric tonnes
N	Nitrogen
N_2O	Nitrous oxide
USD	United States Dollars

CHAPTER ONE: INTRODUCTION

1.1 Background of KLMP

The Kenya Livestock Marketing & Resilience Project (KLMP) is part of the Practice for Change, a Signature Program by the Heifer Project International Kenya (HPIK). The project is being implemented in nine (9) Counties across Kenya, namely Kajiado, Isiolo, Busia, Kakamega, Nandi, Uasin Gishu, Trans-Nzoia, Nakuru and Bungoma. The overall goal of KLMP is to strengthen the production and marketing systems for improved livelihoods and resilience. These targets improving the livelihoods of 38,000 poultry and red meat-producing households by uplifting their economic standards (annual income) by 2026. The project further seeks to expand into the beef value chain in the Arid and semi-Arid lands (ASALs) and deepen Heifer Kenya's interventions in the Lake Basin Economic Block (LBEB), targeting value chains with the highest impact among the smallholder farmers, youth and women.

1.2 About the Study

1.2.1 Problem and Justification

Livestock production systems in the ASAL regions of Kenya, mainly through pastoralism are an integral part of agriculture in Kenya and contributes to national food production, income and employment. Furthermore, it contributes largely to economic and social-cultural functions to over 14 million pastoralists inhabiting vast drylands of Kenya (Saada *et al.,* 2019). Pastoralism, however, faces numerous challenges, key being inadequate nutritious livestock feed supplies to optimize production. This is accelerated by adverse effects of climate change that lead to feed scarcity and poor-quality feed. The KLMP project identified challenges in these counties that include among others; (i) increasing climate challenges from drought and degraded rangelands, (ii) inadequate nutritious supplemental feed which is cost-effective for livestock farmers, (iii) poor access to inputs to grow, process and/or store feeds and (v) knowledge gaps in both maximizing production of forage and in formulating balanced rations to optimize livestock production, and maximize livestock health and farmer income.

To address these challenges, providing accessible, cost effective and nutritious feed to ruminant livestock is critical to ensure livestock health and performance, which are essential for creating sustainable livelihoods and food security in the targeted communities. Nonetheless, an in-depth assessment of the challenges would objectively inform specific interventions or solutions for the project, as pathways of necessary change along with the required enabling environment, to sustainably support uptake of the proposed solutions. This study focuses on Nakuru County and pastoralist communities in the ASAL counties of Kajiado and Isiolo.

1.2.2 Study Objectives and hypotheses

The broad objective of this study was to conduct a situation analysis of the potential for fodder supplementation and forage seed availability in Isiolo, Kajiado and Nakuru counties, identifying the challenges and opportunities. These will help develop recommendations for scalable solutions, viable business models, and capacity-building needs for livestock nutrition and feed production i.e. to improve livestock production.

As a precursor to guide this study, the following hypotheses were formulated.

1. **H_1:** Identifying and sourcing of available, accessible and affordable forage seed is necessary for impactful design of interventions for improvement.
2. **H_2:** Improved climate-resilient forage varieties and better agronomic and land restoration practices are needed for increased forage production in rangelands.
3. **H_3:** Forages produced on farm and those available in the market (rangeland grazing, cultivated forages, crop residues, and agro-industrial by-products) need to be cost-effective for livestock producers.
4. **H_4:** Functional, transparent feed markets linking prices to feed quantity and feed quality to livestock production justify investments in improving nutritional value of crop residues, fodder preservation and storage.
5. **H_5:** Knowledge, tools and technologies suitable for youth and women to adopt with an impact on livestock productivity.

Within the broader objective and formulated hypotheses, the study seeks to propose interventions for the project to achieve the following outcomes:

- Increased forage (including reseeding and recovery periods) and fodder productivity and livestock nutrition.
- Enhanced drought resistance and ecosystem stability in the areas of project implementation.
- Economic opportunities for herders and community groups through sustainable production methods.
- Sustainable restoration of rangelands and prevention of further degradation, especially in Isiolo and Kajiado counties.

1.2.3 Scope of the study

The scope of this study specifically focused on three production systems or scenarios within the counties.

Scenario A

Conservancy or ranch managed livestock. Identify pathways to support improved access to feed for livestock (i.e., cattle and small ruminants) that is (a) economical for the producers, and (b) leads to sustainable and regenerative grazing of conservancy lands. Specific areas of interest.

- A needs assessment and developing a production model that identifies the value-added potential of supplemental fodder in reducing drought impact, reduced degradation of rangelands, and improving livestock profitability.
- Identifying successful examples/models of supplemental fodder production in both northern and southern ASAL Kenya, with a focus on scalability.
- Identifying opportunities for dedicated fodder and seed production zones.
- Identifying opportunities for integrating capacity building and extension service provision on livestock nutrition and diet into existing herding systems.
- Identifying opportunities and viability for soil rehabilitation initiatives, with the use of organic soil amendments like compost or manure from livestock to enhance soil structure, fertility, and microbial health.
- Identifying where communal (group-based) grazing, including their norms/dynamics might be beneficial to long term sustainability of conservancies.

Scenario B

Youth and women's livestock market groups near livestock markets. Identify pathways to support improved access to feed for livestock – to consider goats and sheep that are a) economical for the producers, b) leads to positive growth of youth and/or women's producer groups and uses regenerative agricultural principles. Specific areas of interest included.

- A needs and opportunities assessment targeting each youth and women involved in livestock enterprises.
- Exploring current models of supplemental feed usage and identifying scalable solutions.
- Developing a production model, identifying sources of fodder and opportunities to upgrade or establish new systems.
- Assessing the need for upskilling on livestock nutrition and its integration into herding practices at this level.
- Identifying opportunities to promote agroforestry systems combining fodder trees and shrubs with grass species.
- Opportunities in capacity building and extension provision in soil conservation techniques, targeted for youth and women's groups with focus on soil conservation practices such as terracing, water harvesting, and mulching, etc. to prevent land degradation and enhance productivity. This would include management of application of animal health drugs that negatively impact soil biological health.
- Opportunities to include integrated livestock and crop systems where crop residues are used for livestock feed, and livestock manure is applied to fields, closing nutrient loops and improving soil fertility.

Scenario C

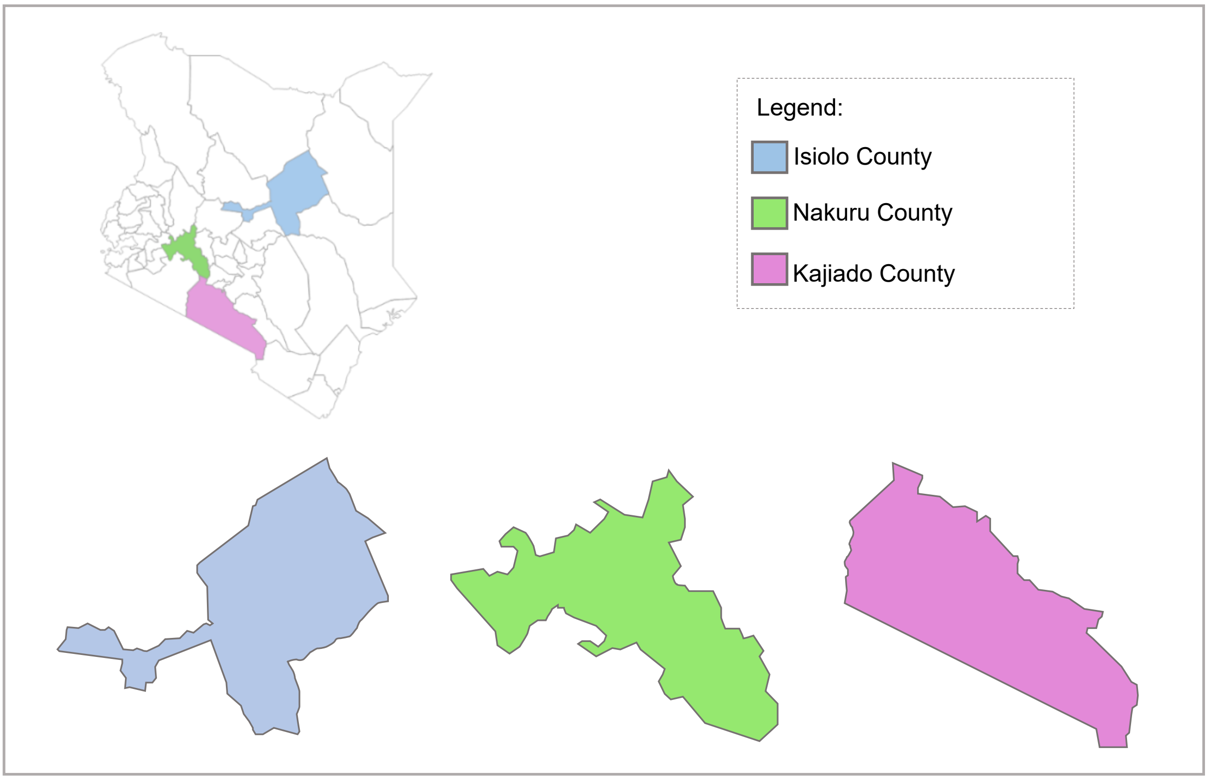
Village-level, women-managed milking herds and small ruminant flocks. Conduct a needs assessment for improving supplemental feed access for small ruminants and cows in villages. To include assessment of benefits of livestock to community, including nutritional benefits to families and children in villages. Specific areas of interest included.

- Conducting a needs assessment for improving supplemental feed access for small ruminants and cows in villages. This would further entail assessment of the benefits of livestock to community, including nutritional benefits to families in villages.
- Identifying existing models and potential upgrades to forage/fodder production systems.
- Recommending capacity building and extension service provision needs and strategies for integrating livestock nutrition into community-level practices.
- Identifying opportunities where localized soil improvement and/or composting initiatives might work, where women and village members are supported in developing composting systems using animal waste and plant residues.
- Helping to identify fodder cultivation with resilient species: where KLMP can introduce drought-tolerant and nitrogen-fixing fodder species that enrich soil while providing high-nutrition feed.
- Opportunities for small-scale water management systems where the project can promote technologies that enhance irrigation for fodder crops and protect soil from drying out.

1.2.4 Study Approach and Methodology

Study areas

The study purposively selected three Counties namely Isiolo, Kajiado and Nakuru (Map 1) because they are among the beneficiaries of the KLMP intervention. Kajiado and Isiolo counties are (ASALs while Nakuru county varies between semi-arid to sub humid. The rainfall pattern in all the counties is bimodal with long rains in March-April-May (MAM) and short rains in October-November- December (OND). Isiolo County is located in northern Kenya where most of the land, about 95%, is very arid, receiving an annual average rainfall of 580 mm. Kajiado County receives mean annual rainfall ranges between 300mm and 800mm around the Amboseli basin and increases to 1,250mm per annum in Ngong' hills and Mt. Kilimanjaro slopes. (GoK, 2023c). Nakuru County is one of the counties in the Great Rift Valley and occupies an area of 7,505km^2. The mean annual rainfall is highest on the Mau Forest receiving over 1,600mm and decreases to between 1,200-1,600 mm in Kuresoi region. The central parts of the County receive between 800-1,200mm. The areas around Lake Elementaita southwards receive moderate rainfall of between 600 and 800 mm. The drier parts of the County receive as low rainfall as 400-600 mm annually. The county is located between longitudes 35°28' and 35° east and Latitude 0°13' and 10°10' South at an altitude of about 1,912 meters above sea level (GoK, 2023d). The Maps below show the various counties of study.



Map 1. Geographical locations of counties of study

Sampling and data collection

Literature review was conducted at the inception phase to determine the project indicators, inform research design, and provide an understanding of the contextual issues.

The sampling design used for primary data collection employed a stratified random sampling approach, where the strata defined according to the three production systems/scenarios: (i) conservancies, (ii) youth and women's livestock market groups, and (iii) village-level, women-managed milking herds and small ruminant flocks. Based on this framework, a list of relevant groups, conservancies and other stakeholders was developed from the ProDairy EA database, supplemented by those working with HPIK in implementation of KLMP. This combined list served as the sampling frame, from which respondents were selected across the counties.

Interviews were held with a sample size of more than 33 respondents, guided by semi-structured questionnaires tailored to forage seed producers and forage suppliers. Key Informants, including extension staff from county governments, were also interviewed using the same tools. Additionally, unstructured interviews were held with input service providers and individual farmers to capture their opinion on forage seed access and supplementation practices.

For forage producers (Annex 7), data collected included socio-demographic characteristics, types of forages cultivated, cost of production, packaging and distribution channels, pricing structures and market descriptions . For forage seed producers (Annex 8), data focused on seed portfolio, seed demand versus supply dynamics, sales and distribution networks, knowledge and training capacity, and collaborations and roles played by external actors .

Subsequently, the data were analysed using both qualitative and quantitative methods.

Data analysis

Information from the field questionnaires and unstructured interviews were interpreted and data on feed samples collected from the field, further analysed using the ruminant nutrition software Rumen8.

Ruminant model: The Rumen8 tool

The Rumen8 was used as a model to simulate milk production, growth and methane (CH_4) emissions from enteric fermentation. The model predicts feed intake and supply of nutrients to the animal from knowledge of the fermentation process in the Rumen and passage of feed constituents (carbohydrate and protein) through the gastrointestinal tract. A static component of the model determines the animal's response to nutrients in terms of growth and milk production. Rumen8 uses published nutrition models we have found accurate enough over many years using it on farms and Research Centres. Rumen8 includes feeding standards for both dairy and beef cattle and allows to assess the predicted diet from both a nutritional and economic perspective. It is based on Metabolisable energy (ME), Metabolisable protein (MP) and neutral detergent fibre (NDF), but also reports a range of other diet parameters. The model was developed in Australia and validation of the model in East Africa has been carried out in pilots in Kenya and Uganda on more than 60 farms for a minimum of nine months and the results suggest that the model has the required accuracy for decision support at the farm level.

Rumen8 is a comprehensive ruminant nutrition tool with an emphasis on ease-of-use that sets it apart from others. This makes it ideal for creating and checking cattle diets on-farm. It is used in pasture-based and stall-fed systems all over the world. Although, it does not apply to semi-arid extensive beef production systems it can be used in stall fed systems (feedlot).

Limitation of the study

This study had two major limitations. The field data collection component relied on perceptions and opinions of key stakeholders/respondents in the sector, although selectively subjected to further triangulation with KIIs and secondary data or literature. In addition, a limited number of stakeholders/respondents were interviewed.

1.2.5 Structure of the report

This report typically introduces the study in Chapter One, providing background information of KLMP and the study. It states the purpose, hypotheses and scope of the study as well as the approach used. Chapter Two details a holistic situation analysis of the forage value chain; providing an overview at global, national and county levels within the areas of interest. It further defines the roles and influence of the value chain stakeholders and actors and how they impact the chain. A summary of key issues and cross-cutting constraints, their probable root causes and how to address them are also discussed. Chapter Three delves into forage crop seeds and vegetative planting materials; defining the formal and informal channels, availability of planting materials and how government policies affect forage seeds, as well as constraints faced. Additionally, Chapter Four investigates the forage crops, production systems and commercialization. Price determination, supply versus demand and utilization define market aspects. This chapter further discusses sustainable production together with climate change and associated technical knowledge gaps. In the last Chapter, we make conclusion, opportunities identified and recommendations for the Project. Here, our analysis of findings informs recommendations for KLMP intervention and discusses scalable innovations and business opportunities for youth, women and conservancies to strengthen fodder environment within scope of activities in the Project.

Throughout this report, we have within our best, incorporated the following cross-cutting issues.

- Alignment with government strategies such as Livestock Feed Strategy in Kajiado County and County Integrated Development Plans (CIDPs) in all the counties.
- Conducted a solutions analysis for each scenario, identifying: (i) potential locations with quick wins for investment, (ii) target beneficiaries and their needs, (iii) viable business models and their potentials to address challenges such as drought alleviation and nutrition; and (iv) key enabling environments that promote sustainability of interventions.
- From a sustainability perspective, opportunities for promoting regenerative agricultural techniques including rangeland restoration, water harvesting and capacity building.

CHAPTER TWO: SITUATION ANALYSIS OF FORAGE VALUE CHAIN AND STAKEHOLDERS

2.1 Overview

The livestock sector in Kenya plays a critical role in its economy, contributing to income, jobs and food security; and an estimated GDP of 12% (Mwendia *et al.,* 2020). In the ASAL areas for example, livestock rearing is one of the most predominant economic activities and source of livelihoods among the rural households (Kidake *et al.,* 2016). The sector is poised for growth due to population expansion and rising per capita consumption in Kenya of animal-sourced food (Creemers *et al.,* 2024). The livestock species kept in these areas are mainly ruminants – cattle for beef, sheep and goats – as well as camels. The most essential and basic input for efficient and quality dairy and beef production is good quality forages (Ponnampalam *et al.,* 2025). At present the ruminant livestock sector in the three counties primarily depends on natural range pasture, fodder cultivated by smallholder farmers practicing mixed-crop livestock systems and fodder found along roadsides, or uncultivated public and private lands. Very few farmers cultivate improved pasture varieties and forage crops for the purpose of feeding their animals to improve livestock productivity.

As of 2022, the value of livestock products in Kenya was measured at around 250.1 billion KES (KNBS 2024). Kenya produced approximately 238,000 MT of beef in 2022, worth approximately 129.5 billion KES, production is estimated to grow towards 1,277, 000 MT in 2050. Goats and sheep play a key role in the food security and incomes of pastoral households due to their short-generation intervals, high adaptability, and versatile feeding habits. The country, in 2023 was home to an estimated 35.0 million goats and 23.2 million sheep, which produced in 2022 about 129,213 MT of goat (chevon) and sheep (mutton) meat annually, worth an estimated 88.1 billion KES. Annual meat consumption is expected to increase from 10.3 to 20 kg per capita; with the highest increase in beef also expected. Milk production in Kenya is largely driven by the informal (80%) milk sector. An estimated 1,800,000 small-scale farmers and 350,000 small-scale milk vendors dominate the milk marketing chain. Milk production in 2023 was 5.3 billion kilograms worth 319.1 billion KES and is estimated to grow towards 13.3 billion kilograms in 2050. Annual per capita milk consumption on average is estimated at 115 kg ranging from 19 kg in rural areas to 125 kg in urban areas (KNBS 2024 and Creemers *et al.,* 2024).

The growth of the livestock sector, especially in ASAL areas is significantly hampered by a myriad of challenges; key among them erratic climatic conditions, rangeland degradation and high production costs of milk and meat. These are largely related to low-quality fodder and feed, and unavailability of quality forages year-round (Mwendia *et al.,* 2020). Forages are a primary source of feed for cattle, sheep, goats and camels. According to a study by SNV-NEADAP, most forages that make up animal rations include tropical grasses supplemented by legumes and crop residues (Creemers and Aranguiz 2019), which significantly impact production costs. While local/native forage varieties are preferred by many farmers (e.g. Boma Rhodes grass), there has been an increase in the adoption of improved forages in recent years, particularly by dairy farmers. However, the overall adoption rate is still low, for example, due to underdeveloped forage seed markets (Forage Working Group 2025).

2.1.1 Global Status of the forage value chain

The global forage industry is estimated to be worth USD 901 million by 2025 and is anticipated to reach USD 1,531 million by 2035, reflecting a compound annual growth rate (CAGR) means, measure of 5.4% over the period 2025 to 2035. Kenya's forage sector is characterized by national players and mostly serving the domestic and regional market. In comparison, Kenya's share falls into a very small fraction of the global forage market. Based on rough estimations it is likely to account for well under 1% of the global animal feed market.

Fuglie *et al.* (2021) estimated that in Africa, over 7.8 million hectares are cultivated with forage crops, with an economic value of USD 4.741 billion. The region with the largest cultivated area is Sub-Saharan Africa, accounting for 43% of the total, but the region with the highest economic value of forages is North Africa, representing 37% of the continent's total value.

When feed in the rangelands or on livestock production farms becomes scarce or is no longer available, livestock farmers resort to feed in the domestic forage/feed market. To get an understanding of commercial quality forage production and its trade value, we can look at the global trade value of Lucerne/alfalfa meal and pellets in Africa, as tabulated below.

Table 1. Global market share and trade value of Lucerne meal and pellets in Africa

Alfalfa meal and pellets (Code 121410)	Total over 2020-2023	Global Market Share
	1000 USD	Average %
Global	1,700,594	
South Africa	158,993	9.3%
Egypt	126,426	7.4%

South Sudan	73,821	4.3%
Sudan	53,693	3.2%
Namibia	1,677	0.1%

Source: https://www.trademap.org

Regionally, South Sudan leveraging on its strategic geographical location, favourable climate, and Nile-sourced water resources, stands as East Africa's top producer of Lucerne hay. This has positioned South Sudan as a pivotal player in the Gulf states Lucerne market. The availability of good quality forage has even made several companies involved in Lucerne production to venture into local dairy farming – which is testimony that dairy farming is economically attractive when quality forage is available. The goal of these companies is to export value-added products, such as live calves, meat and processed milk or milk powder, targeting markets in the Gulf states. South Africa has recently taken the lead (9.7% of Global market) in the African Lucerne market, driven by heightened demand amid Africa's severe drought (2021-2023). Known for its supreme quality and grading (KEBS 2019b), South African Lucerne fetched the highest price in the market at 35.6 KES/kg.

Data from the International Trade Centre (ITC) Trade Map revealed that in 2023, Africa's Lucerne hay imports reached 70,274 MT, marking a 22.4% increase from the preceding year. This increase was the result of the increased demand for milk and meat and the nutritional quality which Lucerne offers in the diet of ruminant livestock. The trade value and quantity of Lucerne in Africa is presented in Table 2 below.

Table 2. Trade value and quantity of Lucerne in Africa

Country (2021)	Trade Value (USD)	Quantity (Kg)	Rate USD/KES (110)	Price/kg (KES)
South Africa	48,167,460.00	148,768,100	0.32	35.6
Egypt	18,070,950.00	64,104,500	0.28	31.0
Namibia	146,770.00	914,100	0.16	17.7
Lesotho	8,810.00	29,672	0.30	32.7
Cameroon	4,140.00	57,500	0.07	7.9

Source: https://wits.worldbank.org/

In Kenya the total acreage of Lucerne was reported to be 361,180 acres in 2019. The national government has the ambition to increase the acreage to 709,600 acres in 2030 (GoK 2023b). This is because of the increasing demand for animal sourced protein by the increasing population, higher urban/rural ratio of the population, higher income and the ambition of the Kenya government to increase export of red meat and milk. Entering the export market for animal sourced protein will, eventually, link the so far mostly domestic and regional feed market to the global feed market. This will challenge the current pricing mechanism in place in the forage and feed market. An effective pricing mechanism of feeds used for livestock production systems is crucial to be able to produce milk and meat cost effectively.

The Table 2 shows that the price of Lucerne meal/pellets of large exporters ranges between 31 and 36 KES per kg Lucerne. The price in the domestic market of Lucerne hay ranges between 25 and 33 KES per kg (authors data). Imported Lucerne pellets and domestically produced meal or pellets in Kenya are sold between 67-75 KES per kg. In Kajiado County for example, one of the commercial forage producers (CFPs) interviewed sells Lucerne meal at KES 65 per kilogram. Nutrients are essential in livestock nutrition, as they play an important role in optimizing the growth and performance of livestock. Based on this the market can be further segmented into dry matter, metabolizable energy, protein and neutral detergent fibre (NDF). For example, based on the global market price for Lucerne the price range per kg dry matter is between 39.7 to 42.7 KES/kg DM, for crude protein (CP) in the product the price ranges between 180-200 KES/kg DM and for Metabolisable Energy (ME) 4.0-4.5 KES/MJ per kg DM.

Crop residue (e.g straw of cereals and pulses, bagasse etc.) is a by-product of primary food production, the quantity available from farmers is dependent upon the success of the harvest. For example, with a good maize crop, 20% is harvested as maize kernels while 80% is left in the field as crop residue. A 2008 report by the Biomass Research Development Board in the US estimated that farmers will need to receive between KES 2,540 and KES 3,810 per MT of dry crop residue. Densified, baled, crop residue would be KES 3,810 per MT or higher. Becerra-Pérez *et al.,* (2022) estimated minimum selling prices for maize stover in Mexico: KES 3,361 per MT (for delivery to the biorefinery's), storage was estimated at KES 314 per MT and nutrient replenishment was estimated at KES 2,005 per MT. Based on these international market price estimates for maize stover as an energy source, the price range per kg dry matter ranges between 3.76 and 6.35 KES/kg DM, the latter including storage and nutrient replacement, for crude protein (CP) in the product the price ranges between 72-122 KES/kg DM and for Metabolisable Energy (ME) 0.5-1.0 KES/MJ per kg DM.

This shows that there are big differences between forages in price, dry matter, energy and protein in the global market. With the use of ration formulation tools livestock producers can determine the usefulness and cost effectiveness of the different ration ingredients in their production system. The latter being more important when costs of ration ingredients are high.

2.1.1 National status of the forage value chain

Determining the value of Kenya's forage market in comparison to the global market is challenging because the market is often analysed as part of the broader animal feed or livestock sector. What we do know is that Kenya's forage market—is largely driven by smallholder dairy farms in urban and peri-urban settings and pastoralist livestock systems when faced with drought; the latter has been growing significantly over the past decade and is expected to continue to grow. Small land size of smallholder farms and the cultural attachment to ruminant livestock further exacerbates' the growth of the commercial forage market. The major driving factor for a commercial forage market in Kenya is the rise in demand and need for (high-quality) forage to sustain the increasing ruminant livestock population in Kenya. Based on the forage type, the market is segmented into grass hay, legume hay, silage, fresh traded forages and pellets and TMR/PMR rations, the latter forming very small segments of a developing forage market.

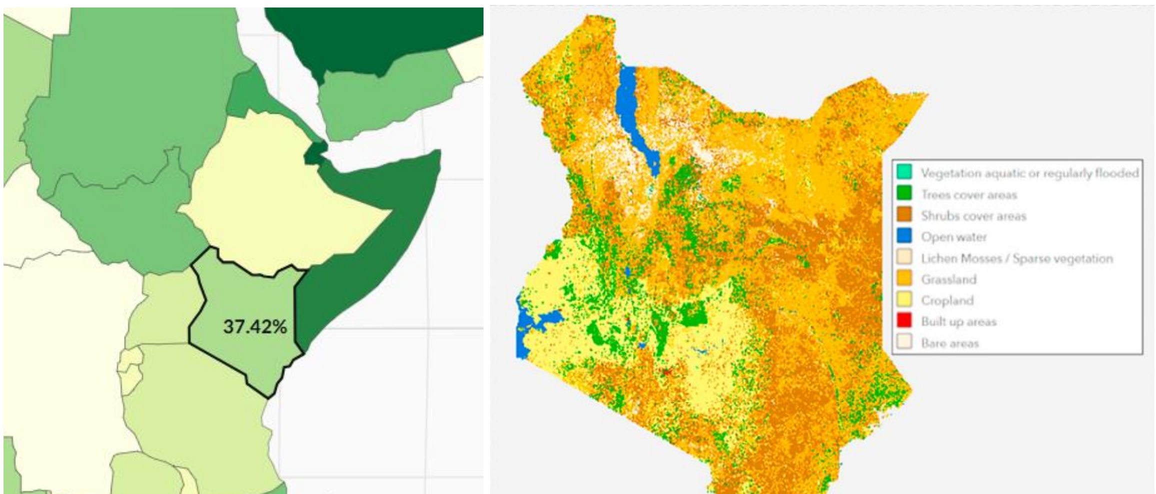
Recently the size of the domestic fodder market was estimated by the Kenya Forage and Feed Association (KFFA) at 500 billion KES (USD 3.87 billion) (Citizen 2025). However, forage trading in Kenya is an informal market, not regulated although the Kenya Bureau of Standards issued quality requirements for grass hay and Lucerne hay (KEBS 2019a; KEBS 2019b) in 2019. The implementation and enforcement of these two standards appear to be difficult without reliable and agreeable laboratory capacity in the country; while on the other hand using standards for fodder leads to the question of what happens with fodder that does not qualify to the standards. The ideal would be a transparent price mechanism that is fair to all market players, vendors and buyers, but this will require a feed validation system linked to the nutritional requirements of ruminant livestock.

Commercial forage producers in Kenya are sometimes registered as a trading company in feed and forages, such as hay (Rhodes grass, Brachiaria grass and Lucerne), and in the last decade baled silage (Maize and Napier grass). The trade is generally based on a volume basis (a bale of hay, a bale of silage – small or big) and not on internationally recognized standards, such as weight (kg), dry matter weight (kg DM), or even more accurate on nutrient content, MJ ME/kg DM or kg protein (Staines et al, 2023) or the Relative Feed Value and Relative Feed Quality index (Undersander, 2004; RuMeth, 2019).

Rhodes grass hay and Lucerne are the most widely traded forages in Kenya. Perfometer (2024, unpublished) noted that in 2023/2024, crop residues (e.g., rice straw, wheat straw and maize stover) showed a growing trend in sales, often marketed as hay. Technically, once a cereal or pulse crop has its seeds shed or harvested, the remaining residue is referred to as straw. In the forage market in Kenya, parts of these crop residues are referred to as "hay" (e.g. straws from rice or grass after seed harvest). This creates confusion, particularly because the KEBS hay standard categorizes straw as the poorest quality category of hay (KEBS, 2019a). Localized trading of fresh fodder between farmers constitutes the informal market segment. Within this segment, Napier grass is the most commonly traded forage, exchanged among farmers in close proximity.

In Kenya, less than 15% of total agricultural acreage is estimated to be allocated to cultivated forage production on smallholder farms (GoK, 2023a). Despite this relatively small share, cultivated forages play a critical role in supporting milk production. Smallholder dairy production, a special feature of the highlands in Kenya (e.g., Nakuru and parts of Kajiado), accounts for 51% of national cattle milk production. Map 2 illustrates that 37.42% of Kenya's land area was classified as permanent grassland and pasture in 2022. The accompanying map further shows the spatial distribution of these grasslands across Kenya, with areas shaded in light orange representing grassland coverage.

Map 2. Left: Share of land used for permanent grassland and pastures in Kenya in 2022 | Right: Kenya land cover map, highlighting key land uses



Source: Left FAO, 2024 | Right Wefle et al., 2022

In Kenya, the cattle segment within ruminant livestock no longer dominates the markets in numbers in 2023, but cattle are the major source of end-use products such as milk, meat and leather. Quality forage helps to improve forage conversion into milk or meat (feed efficiency), affects quality aspects of meat and milk and strengthens the immune system of animals. Therefore, to attain quality livestock products, livestock farmers need to focus on quality forage (Ponnampalam *et al.,* 2025) as a practice to minimize total feed cost.

In 2013 Techno Serve started with an intervention among commercially oriented forage producers. They reported that over the period 2013-2016, the market for commercial hay went from essentially non-existent to over 14,000 acres under production and the hay market was estimated at 33 billion KES, a market which could give business opportunities to 60,000 farmers and reduce the price of a 15 kg hay bale from 250 KES to 90 KES for cattle farmers. In 2017 the first feed and fodder conference took place in Nakuru, followed by a second conference in 2019 in Wote, Makueni County. More recently in 2022 SNV 2SCALE launched the Feed Alliance in Nyeri county. During the SNV KMDP project baling equipment for commercial sale of ensiled forages in sizes of approximately 1 m^3 weighing approx. 350 kg was introduced in 2018 followed by the introduction of baling machines with a capacity of 50-80 kg in 2019. There have been several initiatives to produce and process into ‘protein’ pellets or briquettes crops such as Lucerne, Lucerne/Rhodes grass mix, Tagasaste, Water hyacinth and Duckweed (CSAI 2018) and most recent in 2024 Juanco Napier grass was used to produce a grass pellet.

On the other hand, research, public and private seed companies are strengthening innovation in forage genetics and collaborative efforts are underway to both, improvements through selection of a number of existing local varieties (African Foxtail, Bushrye and Horsetail grass) and at the same time introduce novel varieties from elsewhere Guinea grass, Urochloa hybrids (South America), Pakchong Napier (Thailand) and Juancao Napier (China) that promise greater yield, quality and adaptability. These initiatives are complemented by government and support from development partners, aimed at quickening the adoption of high-quality forage seeds (planting material) and integrated farm management practices.

2.2 Status of the forage value chain in Isiolo, Kajiado and Nakuru Counties

Nakuru county has some areas that are semi-arid (35%) and the counties of Isiolo, Kajiado are classified as arid, semi-arid and are largely populated by communities with a pastoral livelihood. Pastoral destitution in Kenya is primarily driven by feed and water scarcity, since the natural resource base, browse, in the rangelands is shrinking fast. This is due to prolonged and more frequent climate extreme events which are causing a mismatch between the availability of feeds and feed requirements by ruminant livestock. These rangelands, in Isiolo and Kajiado counties are highly degraded due to overgrazing and continuous overstocking, leading to inadequate forage for animals. Furthermore, significant tracts of land are either bare, left bare after cultivating food/horticultural crops (e.g tomatoes) or heavily infested with invasive bush species Ipomea (IUCN 2025; Argemone, Wafula MW, 2019), *Acacia reficiens, Opuntia ssp* Ouko et al., (2020), *Prosopis juliflora*, Choge et al., (2022), hence not desirable for forage species.

Kenya carried out a feed inventory and feed balance assessment and in 2021 the State Department of Livestock Development (SDLD) under the Ministry of Agriculture and Livestock Development (MoALD), compiled a report “National Feed Inventory and Feed Balance Assessment” The report discloses a structural feed deficit for the three counties in terms of Dry Matter (DM), Metabolizable Energy (ME) and Crude Protein (CP). Forage is by far the largest source of animal feeds in the counties. Consolidated findings for the three counties in the national feed inventory and balance assessment are presented in Table 3 below.

Table 3. Feed balance for Isiolo, Kajiado and Nakuru Counties

County	Potential feed availability as DM	Actual feed availability as DM	Livestock (DM) requirement	Feed balance as DM based on potential feed availability	Feed balance as DM based on actual feed availability and use
	(tonnes)	(tonnes)	(tonnes)	(%)	(%)
Isiolo	1,906,028	681,760	934,303	104	-27
Kajiado	1,967,824	905,439	1,381,553	42.4	-35
Nakuru	1,726,427	1,330,929	1,486,901	16.1	-11
County	Potential feed availability as CP	Actual feed availability as CP	Livestock CP requirement	Feed balance as CP based on potential feed availability	Feed balance as CP based on actual feed availability and use
	(kg)	(kg)	(kg)	(%)	(%)
Isiolo	243,009,521	87,300,528	104,926,018	131.6	-17
Kajiado	243,720,171	107,082,372	155,517,447	56.7	-31
Nakuru	138,023,820	103,860,166	163,884,190	-15.8	-37
County	Potential feed availability as ME	Actual feed availability as ME	Livestock ME requirement	Feed balance as ME based on potential feed availability	Feed balance as ME based on actual feed availability and use
	(MJ)	(MJ)	(MJ)	(%)	(%)
Isiolo	14,584,563,291	5,120,002,117	11,765,473,824	24	-57
Kajiado	14,683,710,922	6,773,971,838	17,023,350,939	-13.7	-60
Nakuru	13,904,509,424	10,619,945,369	16,291,380,062	-14.7	-35

2.2.1 Isiolo County

The total land area of Isiolo County is approximately 25,700 square kilometres' and supports an estimated livestock population of 2.93 million. The total annual feed requirements for Isiolo county in terms of DM, ME and CP is 934,303 tonnes, 11,765,473,824 MJ, and 104,926,018 kg respectively (Table 3). Isiolo County has a long history of livestock feed deficit (-27% on dry matter basis) occasioned by prolonged droughts, overstocking and post-harvest losses. Prompt and appropriate responses are, therefore, needed to address these emerging trends to protect lives, livelihoods and ecosystems that are important for livestock production and wildlife. Some of the responses applied are range pasture, grassland and fodder technologies such as rangeland reseeding, grass seed production, processing and storage as well as fodder/pasture utilization, conservation and storage. However, Kidake *et al.,* (2016) and Braintec (2025) reported that most farmers do not have access to information on good agricultural practices (GAP) to enhance production of pasture and fodder. This points to a capacity development gap as regards suitable forage species, (range) pasture and fodder establishment, management and dissemination of (range) pasture and fodder technologies. Pastoral communities are used to the ability of ruminants to selectively graze or browse (Ikanya *et al.,* 2022) in the rangelands thus selecting the most palatable and nutritious parts of the herbaceous biomass available.

2.2.2 Kajiado County

The total land area of Kajiado County, approximately 21,872 square kilometres', supports an estimated livestock population of 3.21 million. The total annual feed requirements for Kajiado in terms of DM, ME and CP is 1,381,553 tonnes, 17,023,350,939 MJ, and 155,517,447 kg respectively (Table 3). The arid to semi-arid grasslands in Kajiado County are characterized by open grass plains, acacia woodlands, rocky thorn bush lands, swamps and marshlands. Soils are at times flooded, volcanic and rocky, which make pastoralism the only feasible land use in most parts of the County (Omollo *et al.,* 2023). Kajiado County like Isiolo also has a long history of livestock feed deficit (-35% on dry matter basis) occasioned by prolonged droughts, overstocking and post-harvest losses.

2.2.3 Nakuru County

The total land area of Nakuru County, approximately 7,505 square kilometres', supports an estimated total of 1.684 million animals. The total annual feed requirements for the county in terms of DM, ME and CP are 1,486,901 tonnes, 16,291,380,062 MJ, and 163,884,190 kg respectively (Table 3). The ILO (2025) reported that there are 2151 fodder farmers in Nakuru County, cultivating 23,380 acres of hay yielding 2,686,324 bales of hay valued at KES 537.3 million. This does not take into consideration the feeding value of the hay bales.

It needs to be noted that in the three counties, Isiolo, Kajiado and Nakuru, the energy (ME) deficit in the diet is the highest standing at respectively -57%, -60% and -35% of the Livestock ME requirement. The deficit in protein (CP) is standing at -17%, -31%, -37%. The grass hay produced in Kenya is generally of low quality and, unless better production practices are adopted, it is unlikely that the grass hay can address livestock productivity other than a reduction of livestock mortality during periods of drought. This was confirmed by respondents in the Braintec (2025) Learning Study for Resilient Arid Lands Partnership for Integrated Development Plus (RAPID+).

County size and human population

The table below presents the population distribution in Nakuru, Kajiado and Isiolo counties in comparison with Kenya.

Table 4. Total human population, number of households and persons/km²

County	Total population	Total number of households	Land area, Km²	Density, Persons Per Km²
Kenya	47,564,296	12,143,913	580,895	82
Nakuru	2,162,202	616,046	7,505	290
Kajiado	1,117,840	316,179	21,871	51
Isiolo	268,002	58,072	25,351	11

According to the Housing and Population Census 2019, Isiolo County total population stood at 268,002 being 0.6% of the Kenyan population. Kajiado County total population stood at 1,117,840 being 2.4% of the Kenyan population and Nakuru represents 4.5% of the Kenyan population. For the counties Isiolo, Kajiado and Nakuru, females represent respectively 49.9%, 50.1% and 49.99%, while males 50.1%, 49.8% and 50.01%, respectively. The livestock sector in Kenya employs 75% of the total population and provides nearly 40% of the country's food requirements. This is likely higher in the pastoral communities of Isiolo and Kajiado and may be lower in Nakuru where, next to the livestock sector also the manufacturing sector plays and increasingly important role.

County climate

The climate, vegetation and land use potential have been used to assess land suitability for different uses. The major elements of climate that affect herbage growth are the intensity and duration of rainfall; the relationship between annual rainfall and potential evapotranspiration; and the year-to-year variation in rainfall. Kenya is divided into seven agro-climatic zones using a moisture index (Sombroek *et al.,* 1982) based on annual rainfall expressed as a percentage of potential evaporation. Areas with an index greater than 50% have high potential for cropping, and are designated zones I, II, and III. These zones account for 12% of Kenya`s land area. The semi-humid to arid regions (zones IV, V, VI, and VII) have indexes of less than 50% and a mean annual rainfall of less than 1,100 mm. These zones are generally referred to as the Kenyan rangelands and account for 88% of the land area. The ASAL receive less than 625 mm of rain per year and are characterized by long dry spells interspersed with low and erratic rainfall – both of which weather conditions are worsened by climate change.

The seven agro-climatic zones are each subdivided according to mean annual temperature the semi-arid and arid zones lie below 1,260 metres above sea level and have mean annual temperatures ranging from 22 °C to 40 °C. There are four inter-connected factors that determine the long-term availability of grazing resources in pastoral production systems: (i) variability in rainfall; (ii) the efficiency with which rainfall is converted into useable forage; (iii) the use of grazing resources by the domestic and wild herbivores; and (iv) the relationship between quantity and quality of the resources.

Kajiado County is predominantly semi-arid at an elevation of 1,582 masl but also has areas of tropical wet, dry and savanna climate. The annual rainfall amount ranges from as low as 300mm in the Amboseli basin to as high as 1,250mm in the Ngong Hills and the slopes of Mt. Kilimanjaro GoK 2023c). Temperature range is between 12°C-28°C. About 92% of Kajiado county land mass is semi-arid lying between agro-ecological zones (AEZ) V and VI.

Isiolo County is a typical arid and semi-arid region with a bi-modal rainfall pattern. The short rains fall between October and December (OND) while the long rains fall between March and May (MAM). The annual average rainfall amount is below 580mm. Temperature range is between 22°C-34°C. About 95% of Isiolo county land mass is arid lying in agro-ecological zones VI.

Nakuru county has wide range of agro-ecological zones ranging from tropical alpine to lower mid lands. There is a wide variation in altitude ranging from 1400 to 2970 masl. Rainfall is bimodal with long rains between March, April, May and June, while short rains occur between October and December with an annual average range of 500-1900mm.

Temperature range is between 9ºC-27ºC. Nakuru, a county with three Agro Ecological zones produce hay in all areas of the county. The Table 5 below presents the moisture indices and land cover for the different AEZs in the three counties.

Table 5. Moisture availability in Agro Ecological Zones in Kenya, Isiolo, Kajiado and Nakuru with rainfall and proportion of land

Zone	Classification	Moisture Index	Average rainfall	Land cover Isiolo	Land cover Kajiado	Land cover Nakuru	Land cover Kenya
		%	(mm)	%	%	%	%
I	Humid	>80	1100-2700				12%
II	Sub Humid	65-80	1000 -1600				
III	Semi humid	50-65	800-1400			28%	
IV	S. humid – S arid	40-50	600-1100		8%	39%	5%
V	Semi-arid	25-40	450-900	5%	56%	33%	15%
VI	Arid	15-25	300-560	95%	36%		22%
VII	Very arid	<15	150-350				46%

Source: Modified from: Sombroek et al., (1982) and County Integrated Development Plans.

The magnitude and severity of droughts have increased in the recent past because of climate change and variability arising from global warming, with the ASALs being the most affected. Effects of the cyclic droughts include negative socio-economic and environmental consequences.

Livestock- production & farming systems

Livestock is the mainstay in Isiolo and Kajiado County's economy contributing 84 and 48 percent of cash income in the pastoral and agro-pastoral zones, respectively. The major livestock species kept are cattle, goats and sheep. Cattle are kept in Kajiado for both dairy and beef purposes; in Isiolo goats and sheep play a more important role while the cattle and camel populations are almost similar. In Nakuru dairy cattle are the dominant type of livestock kept by farmers followed by sheep, beef cattle and goats, as depicted in Table 6 below.

Table 6. Livestock population in Kenya in 2023

	Cattle		Sheep		Goat			
2023	Dairy	Beef	Wool	Hair	Dairy	Chevon	Camel	Donkey
Kenya	5,544,218	16,337,790	1,270,256	21,938,285	603,349	34,385,998	4,284,497	1,724,463
Isiolo	6,764	166,184	-	883,010	1,255	1,090,745	162,516	39,283
Kajiado	137,500	378,400	-	959,654	3,453	1,033,419	2,653	40,102
Nakuru	466,779	251,150	259,503	537,937	47,593	298,170	-	21,490

Source KNBS 2024

In the arid and semi-arid lands of Kenya predominantly indigenous cattle breeds of Small East African Zebu (SEAZ) are kept. In Kajiado these cattle are increasingly crossed with Sahiwal cattle in other cases Boran cattle and their crosses (Figure 1) are used. In high-altitude areas in Nakuru and parts of Kajiado, exotic cattle breeds and cross breeds are kept for dairy production, and cull animals are slaughtered for the domestic market. In the domestic market, the cull animals from dairy farms often fetch higher prices than the indigenous cattle breed due to their larger frame (Wafula *et al.,* 2018).

Table 7. Species composition (million) of ruminant livestock population in Kenya in the past 60 years

	Year 1963	Species composition in livestock population	Year 2023	Species composition in livestock population	Relative increase

	Million	%	million	%	
Cattle	6.8	42%	21.9	26%	322%
Sheep	3.9	24%	35.0	41%	897%
Goats	5.1	32%	23.2	27%	455%
Camels	0.38	2%	4.28	5%	1126%
Total	16.2		84.4		

Source FAOSTAT, 2024

In a study by Kenya Markets Trust (KMT), under the Pathways for Resilience in Semi-Arid Economies (PRISE) Project the sharp decline in cattle population from 42% to 26% was attributed to the fact that cattle can only thrive in an environment with temperatures between 10°C to 30°C, and start developing mild symptoms of heat stress at temperatures above 25°C and > 50% relative air humidity hence the reason for a sharp decrease in percentage of the population in counties whose average temperatures have risen above 30°C, like Isiolo and Kajiado. Camels, (hair) sheep and goats can withstand relatively higher temperatures. The higher feed demand for cattle, due to their size, as compared to sheep and goats is another contributing factor as the most common feed resource in ASALs areas that provide nutrition for their livestock are browse and natural pastures comprising grass and locally available legumes, including trees and shrubs. Although the percentage of cattle in the total herd population has been decreasing, the total livestock population increased from approximately 16.2 million in 1963 to 84.4 million in 2023. This in combination with the increasing human population, that resulted in increasing pressure on the land for grazing livestock, which consequently led to higher stocking rates resulting in rangeland degradation.

The three distinct livestock farming systems (Figure 1) in the three counties are:

- Intensive livestock farming system: This system is characterized by mixed crop-livestock and cut-and carry feeding system at times farmers use total or partial mixed ration formulations, which are provided either in feedlots or stall-fed in zero-grazing units at higher altitudes in the more humid Agro Ecological zones (I, II, III, IV) of the counties.
- Semi-intensive livestock farming system: The system combines grazing on natural pastures with supplementation in feedlots or dairy units. The system is practiced in all the Agro Ecological zones.
- Extensive livestock farming system: The system is characterized by grazing on natural pasture and rangeland, and it is predominant in the agro-pastoral and pastoral areas being agro-ecological zones V, VI and VII of the counties.

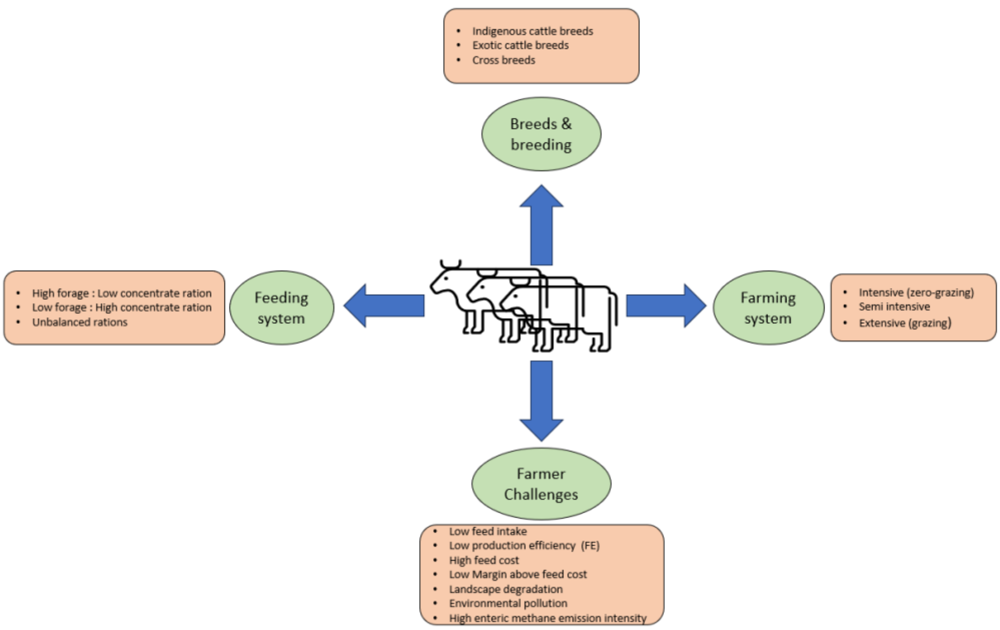


Figure 1. Status of cattle farming in Kenya (Creemers et al, 2024)

The farming systems (pastoralism/agro-pastoralism) in Isiolo and Kajiado counties are extensive and involve seasonal or annual migration (transhumance) of livestock in search of pasture and water. This can be coupled with some semi-intensive (supplementation and grazing) or intensive (feedlot) feeding systems in ranches and in or close to urban centers. Previously, the pastoralists would migrate (transhumance) with the entire herd including lactating livestock. However, there is a trend whereby the risk group (calves, sick animals) and milking herd are left behind (sedentary) with the women to provide milk for food and sale/income to the household as the rest of the herd is migrated to other areas (Creemers J., 2021). In the agro-pastoral systems, there is a greater degree of settlement and more interactions with crop farming. In the ASALs dairy is produced with camels or goats while dairy cattle are predominantly kept in high-altitude areas such as in Nakuru and Kajiado Counties.

Although the highlands in Nakuru and some areas in Kajiado (Ngong, Rongai, Kiserian, Kitengela) areas are also suitable for smallholder exotic dairy cow production, the Small East African Zebu are found and raised for beef and milk. Most if not all zebu milk is consumed in the home, although in Kajiado county there are examples of groups (e.g. Kajiado Maasai Women Dairy Cooperative, Oltili Lewangan Women Dairy, Reto group), who started to collect, sell to processors and/or process milk as a group in the past 10 years.

In the category of small ruminants, the small East African hair-goat is predominant, however, in parts of the northern rangelands, the Galla goat is popular and is becoming increasingly common in other areas. Fat-tailed sheep are predominantly found, especially the red Maasai and black headed Somali. In some areas, the genetic potential of the flock has been improved by the introduction of the Dorper breed. In fact, the breeding system is actively practiced by one of the respondents near Isiolo. Sheep and goats are kept in mixed herds with cattle, and in Isiolo with camels. Goats are the only source of milk for pastoralists who do not own cattle and become more important when milk production from cattle is low. Small ruminants are kept for subsistence meat production and are also sold for cash in the nearby livestock markets.

In Isiolo and Kajiado counties livestock are fed primarily by allowing them to graze on rangeland, fenced grassland or pastures, road sides, arable and non-arable lands and forests to some extent. Animals are also allowed to graze on common lands, and around the homestead. However, stall-feeding is common in Nakuru and becoming important in Kajiado county around (peri)-urban areas as the lands available for animal grazing is becoming less. Supplemental feeding is practiced by livestock farmers who feed fodder or concentrates (Figure 2), rather than fodder naturally browsed by herds on rangelands. Generally, according to the respondents, supplemental feeding in Isiolo and Kajiado counties is very seasonal, occurring mostly during the dry season due to the scarcity of herbage and browse on natural rangelands and a drastic drop in nutritional quality. The practice is more generalised among livestock farmers in high potential livestock farming areas and practiced almost all year round. Similarly, cultivation of forages both for farm use and commercial purposes is most notable in areas with intensive and semi-intensive dairy production systems i.e. Nakuru County, suggesting that forage cultivation align closely with dairy cattle density patterns.

Livestock products market

In 2022, the average annual production of livestock products was estimated at 5,284,136 tonnes of milk, 237,907 tonnes of beef, 51,691 tonnes of mutton and 77,521 tonnes of chevon (KNBS, 2024), The share in livestock products of Isiolo, Kajiado and Nakuru stands at 1.6%, 1.7% an 6.0% for milk production, 0.4%, 2.0% and 1.8% for beef, 2.4%, 4.0% and 1.2% for chevon and 3.8%, 5.6%, 5.2% for mutton. The trade value of milk was KES 319.1 billion and of red meat for Kenya was 205.1 billion KES. For milk Nakuru county contributes the highest share of the total value with 4.8% followed by Kajiado 2.6% and Isiolo 2.0%. Kajiado contributes the highest share in red meat value of 3.2%, Nakuru 1.7% and Isiolo 1.6%, as deduced from Table 8, 9 and 10 below.

Table 8. Milk and beef production, price and value in 2022

2022	Milk Kg	Unit price KES	Total value KES	Beef kg	Unit price KES	Total value kg
Kenya	5,284,136,021	60	319,106,476,474	237,907,405	544	129,518,418,866
Isiolo	85,200,483	77	6,532,037,030	1,058,942	533	564,769,067
Kajiado	91,808,540	90	8,262,768,600	4,730,001	700	3,311,000,700
Nakuru	318,978,431	48	15,223,970,570	4,242,880	517	2,192,797,269

Source KNBS 2024

Table 9. Chevon and mutton production, price and value in 2022

2022	Chevon Kg	Unit price KES	Total value KES	Mutton kg	Unit price KES	Total value kg
Kenya	77,521,430	696	53,927,170,229	51,691,388	661	34,155,690,626

Isiolo	1,834,732	717	1,314,891,267	1,986,773	717	1,423,853,983
Kajiado	3,100,257	800	2,480,205,600	2,878,962	800	2,303,169,600
Nakuru	927,027	582	539,361,164	2,699,731	582	1,570,752,727

Source KNBS 2024

Table 10. Camel meat production, price and value in 2022

2022	Camel (Kg)	Unit price (KES)	Total value (KES)
Kenya	55,204,088	589	32,500,394,031
Isiolo	1,482,146	533	790,477,867
Kajiado	-	-	-
Nakuru	-	-	-

Source KNBS 2024

In both milk and red meat value chains, it is noted that the average unit price for milk and meat is higher than the average unit price in Kenya, that is 150% milk, 129% beef, 115% chevon and 121% mutton.

Forage species

Despite being some of the most important crops globally, there has been limited research on forages, including grasses when compared with cereals, fruits, and vegetables (Capstaff *et al.,* 2018). Also, in Kenya forages did not receive the attention they may have needed to assure enough supply of seeds (vegetative and reproductive) and feeds for the growing ruminant livestock population over the past 60 years.

While in the 1960/70's research was carried out on tropical grasses such as Rhodes, Guinea and Seteria grass, these were gradually replaced with Napier grass in the 1980's to serve the needs of the cash and carry feeding system, promoted in the farming systems of smallholder farmers (FAO 2006).

However, the choice of suitable pasture and forage species for majority of commercial forage producers and livestock farmers varies, depending on suitability to ASALs'; for example, tolerance to drought and grazing, soil conservation and potential benefits such as nutritional value. Pasture resources in rangelands can be developed in several ways including (a) improving the distribution of water points and reducing overgrazing; (b) increasing primary production by intensifying land use, reseeding denuded rangeland and conserving forage; and (c) balancing the livestock population and the available feed resources (FAO 2006). These ambitions as described under (a), (b) and (c) have not been realized. The livestock population increased to 84.4 million in 2023, and permanent grassland reduced to less than 38% of the total land area and pressure on land use for grazing increased at the same time. To date most of the attention is directed to re-seeding denuded rangeland and forage conservation (e.g., grass hay).

Major grass species found in the rangelands, and interesting for re-seeding activities in Kajiado, Isiolo and Nakuru counties are: Red oat grass (*Themeda triandra*), Bush rye / Needle grass (*Enteropogon macrostachyus*), African foxtail grass (*Cenchrus ciliaris*), Maasai love grass (*Eragrostis superba*), Horsetail grass (*Chloris roxburghiana*), Digitaria spp., Guinea grass (*Panicum maximum*), *Sporobolus fimbriatus,* Crowfoot grass (*Dactyloctenium aegyptium*), *Digitaria milanjiana, Digitaria abyssinica, Digitaria macroblephara, Eragrostis cilianensis, Eustachyus paspaloides, Aristida adscensionis, Aristida kenyansis*, Cynodon spp., Sweet pitted grass (*Bothriochloa insculpta*), Black or bunch soear grass (*Heteropogon contortus*), Amakale grass *(Hyparrhenia rufa*). Some of the naturalised legumes include *Stylosanthes scabra*, *macrotyloma axillare* and *Leucaena leucocephala*.

Natural browsing species include Desert thorn, *Acacia tortilis*, *Prosopis juliflora* (*mathenge*), and *Acacia melifera*.

Cultivated forage species are: Rhodes grass (*Chloris gayana*) Napier grass (Cenchrus *purpureum*) Brachiaria Hybrids, Brachiaria spp, Sweet potato vines (*Ipomea*) Forage Maize (*Zea mays*), Forage Sorghum and Forage millet.

Omolo et al., (2023) identified 24 preferred grasses among pastoralist communities. About 80% of the people interviewed mentioned grazing with livestock and 6% hay for sale as the most important function of the grasses; other uses are erosion control and roof thatching. In addition to the species mentioned before, the study by Omolo *et al.,* (2023) identified Pom-pom wire grasss (*Pennisetum mezianum)*, *Chrysopogon plumulosus*, Tall spear grass *(Heteropogon contortus)* and *Sporobolus helvolus*, *Brachiaria leersoides*, *Latipes senegalensis*, *Sorghum purpureo-setaceous,* as important grasses for the pastoralists. In Isiolo county and more so within the peri-urban areas there is minimal use of cultivated forages, crop residues and commercial feed supplements in livestock, for example beef or camel rations. Kinna, Tutkinisa Community-Based Organization (CBO) sub-county being the exemption where hay production is successful, and more people are starting to show interest in this method of conservation. The use of Pencil tree (*Euphorbia tirucalli*) as a dry and drought season feed resource is becoming increasingly important for camel keepers.

2.3 Cross cutting constraints in the livestock sector in Isiolo, Kajiado, Nakuru Counties

Livestock nutrition is one of the most important constraints to increased livestock production, especially during dry season when forage quality and quantity is low. In this period, water is also limiting because most springs are seasonal, dams and reservoirs are dry and water capacity of boreholes reduced. This affects all livestock feeding systems (Figure 2) including intensive (e.g. cut and carry), semi-intensive or free-range grazing systems. The constrain of livestock nutrition is intertwined in other constraints discussed below – as also gathered from field interviews and stakeholders.

A. Land degradation and overstocking of livestock

Due to the cultural attachment to livestock amongst the pastoral communities, there has been resistance and general unwillingness to adhere to sustainable stocking rates that correspond to the grazing capacity of the available grasslands often resulting in resource-based conflicts during drought (IGAD 2024). Most of the pastoralists sell their cattle at the very time of financial need without any prior planning or because of market dynamics, hence the income earned in such cases is not optimal. Overgrazing and selective browsing by small ruminants (goats and sheep) can shift plant species composition, often leading to the dominance of less palatable or invasive woody plant species. Such transformations not only decrease the availability of high-quality forage for cattle but can also contribute to land degradation and biodiversity loss (Slayi *et al.,* 2024).

B. Unstructured livestock markets

Livestock traders operate informally with no objective criteria for determining livestock prices. Although the country passed the Livestock Yard Sale Bill that requires livestock traders to use the designated weighing scales in the sale yards, enforcement has not been successful yet, leaving traders (Annex 3 – Meat Value Chain) to remain very influential when it comes to setting livestock prices. The price mechanism for livestock used is not transparent and livestock farmers express concerns about being given unfair prices. On the other hand, traders, with their extensive networks and means of transport, play an important role when aggregating groups of animals. There is need, however, to enforce the law and ensure strict adherence to the system of sale on a live weight basis, to make the market more transparent and inclusive and give farmers fair prices for their livestock. Currently, livestock farmers often prefer markets where large numbers of livestock are gathered to fetch the best possible price. This argument was mentioned in Oloitoktok, Isiolo town as well as in Kimana by respondents for livestock farmers, this often comes with large walking distances to the market. If objective criteria are used, farmers could fetch good prices on markets closer to their homesteads.

C. Importation of livestock from neighbouring countries

Large numbers of cheaply priced livestock are imported from Tanzania and Somalia. The importation of cheap livestock from neighbouring countries affects local prices of livestock and hinders the control of diseases and parasites in the counties. It also disrupts the local production systems affecting grazing plans, water resources and overall profitability for livestock farming, making it unsustainable.

D. Unstructured forage markets

The price/quality mechanism in the forage market used is not transparent and livestock farmers express concerns about unfair prices in relation to the quality of the feed (e.g low nutritional value, woody and contaminated). On the other hand, also in the forage market traders, with their extensive networks and means of transport, play an important role when aggregating feed for livestock. There is a need, however, to restructure the forage and commercial feed market and ensure farmers are informed of the weight and quality (DM, ME, CP) or quality category of the feeds they buy. Currently the forage market is very informal and there is a need to create transparency to be fair for all actors (vendors and buyers) in the feed market. One of the respondents mentioned that budgetary limits prevent effective measures to enforce KEBS standards.

E. Inadequate livestock extension services

The counties lack sufficient resources to offer farmers quality and timely extension services to meet their needs and coach them to adopt new innovations. There is a need for remodelling of the extension services to incorporate private sector players to improve the reach and impact for the benefit of farmers. The extension officer to farmer ratio was in 2021 in Isiolo 1:500, Kajiado 1: 2030, Nakuru 1:1200 against the FAO recommended ratio of 1:400. In the three counties livestock extension and farmer training is, to some extent, done by NGO's (Braintec 2025), development, wildlife or rangeland organizations (e.g. SNV, HPI, WWF, Grevy's Zebra Trust, Just Diggit, Lans o Lakes, FAO, etc). Continuity of the extension service is in this context a concern because the teams of trainers working for these organizations are often dissolved after the project ends.

E. Livestock diseases

Dense grass in rangelands can impact livestock health and diseases through various mechanisms. Overgrazing, often associated with dense grass, can lead to increased consumption of certain plants that may be toxic or less nutritious. Additionally, dense vegetation can create favourable microclimates for disease vectors and parasites like ticks and flies, increasing the risk of transmission mentioned some of the respondents. Conversely, moderate grazing can improve forage quality and reduce the spread of certain diseases by promoting plant diversity and reducing the accumulation of dead plant material (Sircely *et al.,* 2021). Other diseases which are a constraint are viral diseases, bacterial diseases, endoparasites and wildlife derived diseases, as over 70% of Kenya’s wild game is found in range areas outside the national parks. Pastoralists in the rangeland need to maintain a balanced equilibrium between the density of the vegetation, disease pressure and grazing wildlife.

F. Low adoption of new innovations and fodder technologies

Culturally, the pastoralist communities are herders and not arable farmers. Many of them therefore, according to some respondents, do not easily embrace the practice of harvesting grass seeds, cultivating grass or forage crops also mentioned in the Braintec (2025) study. Sufficient time and resources are required to create this awareness, followed by training and coaching of young herders to adopt best practices and inspire trials of new ideas. Several respondents emphasized that (agro) pastoralists will need to visualize new technologies in a pilot or demonstration sites before they can gradually adopt the new idea of improved forages. They are also used to native grasses which, reported by Omollo *et al.,* 2023, are preferred by livestock. These need to be included in the demo plots if found impactful for rangeland restoration. The success of the program to introduce cultivated native grasses (those developed and multiplied by KALRO and other seed distributors), for seed and forage (hay, grass straw) production will be enhanced through sustained sensitization and adoption by the early adopters.

G. Land change use, urbanization and industrialization

Transhumance is moving, together with livestock from one grazing ground to another, depending on fodder availability, in a seasonal cycle without considering regional boundaries or country borders. Sedentary is not migratory, livestock keepers stated that, sometimes because of the harsh climate condition, it is better to stay in the same place all year round, generally near a well. In parallel to these traditional grazing practices, the development of the semi-urban form of livestock feeding systems has taken place, which is closely linked with (peri) urban areas. In addition, the continued subdivision and fencing of land into smaller pieces for private and public use (commercial/real estate developments) has disrupted the pastoralist traditions and culture, thereby reducing resources e.g. communal land available for grazing (MIDP 2025, unpublished). This will in the long-term affect the livelihood and livestock farming system of pastoralist communities as grasslands diminish over time unless private ranches, community conservancies or individual farmers adopt sustainable grazing practices, forage production, conservation and feed -planning and -budgeting that can sustain more intensified livestock production in the rangelands next to conservation areas for wildlife habitat.

H. Human-wildlife conflicts & agro-pastoral and pastoral resources conflict

Past reseeding efforts, according to several respondents, in rangelands near wildlife corridors were hampered by wildlife and human conflict destroying the developed pastures before they were ready to be grazed. During the dry season, wild animals (elephants, gazelles and zebras) invade recently established fields thus destroying cultivated pastures. This shows that there is a need for concerted efforts and stakeholder involvement across county borders in rolling out rehabilitation of rangeland areas. Respondents often cite Just Diggit's use of half circle or semi-circular bunds to reduce erosion, capture runoff, and re-seeding with rangeland grasses as a successful example of rangeland rehabilitation.

Several respondents pointed out the repeated occurrence of recourse (grazing land, water for livestock) based conflicts. Pastoralist communities need to share their natural resources and pointed out that isolated pilots set aside land for dry season grazing or fenced areas for hay production will often be invaded by other herding communities or wildlife in times of scarcity. Some counties like Baringo, Isiolo and Samburu are working together with Laikipia County on an initiative known as ‘AMAYA Triangle’ which seeks to address such resource-based conflicts as a way of adapting to climate change (2018) in the PRISE project. The initiative sought to modernize pastoralism by establishing feedlots and fodder conservation, while at the same time working together to improve roads, learning institutions among other amenities across the counties. An initiative that likely also applies to cross borders with Tanzania, Somalia and Ethiopia and can resort under IGAD.

I. Inadequate investments in infrastructure, feed industry, disaster preparedness (e.g. climate change), disease prevention, response efforts

In many cases, the inability to provide adequate feed, due to lack of strategic feed reserves in the counties, livestock keepers in the ASALs’ are forced to sell or cull their animals, often after losing substantial live weight and before they are ready for the market. This leads to loss of valuable resources and depletion of valuable live assets. It does not only reduce the future earning potential of pastoral communities but also undermines their capacity to recover from economic shocks. There are livestock traders located closer to the end market (abattoirs) in Kajiado county (Kitengela, Isinya) who particularly source this category of animals to finish them in a feedlot.

J. Invasive weeds competing with grassland and pasture

Undesirable plants are not readily utilized by animals and may cause rangeland degradation. They include invasive species and poisonous species (e.g. *Lantana camara and Solanum incanum*). They may be removed by stumping, ring barking, and application of chemicals, using hot prescribed fires or mechanical means like bulldozers, motorized saws, and brush cutters. One of the biggest challenges facing productivity of rangelands in Kajiado and Isiolo counties - in addition to overstocking and overgrazing - is the invasion by *Prosopis juliflora* also known as “Mathenge” and in Kajiado East and Central *Ipomoea hildebrandtii* has colonized the rangeland and spreads rapidly especially after the rainy season. The plant has infested up to 60-80% of grassland (Kidake *et al.,* 2015) and is mainly flourishing in disturbed or degraded sites. The degree of invasion in crop fields is low (about 10%) because of the comparatively small amount of crop farming in Kajiado and because during cultivation, invasive species are removed. The poor road network in the county has also hampered access to some areas of the county. In Isiolo next to “Mathenge”, *Acacia reficiens* and *Opuntia ssp* are considered invasive species reducing forage spaces for livestock and wildlife (Ouko *et al.,* 2020; Kimiti *et al.,* 2020). Management of *Prosopis juliflora* and *Acacia reficiens* by cutting the trees and turning them into charcoal is not allowed. Some attempts were made but stopped because other trees were also cut to produce charcoal, this if to be successful requires a multi-sectoral approach.

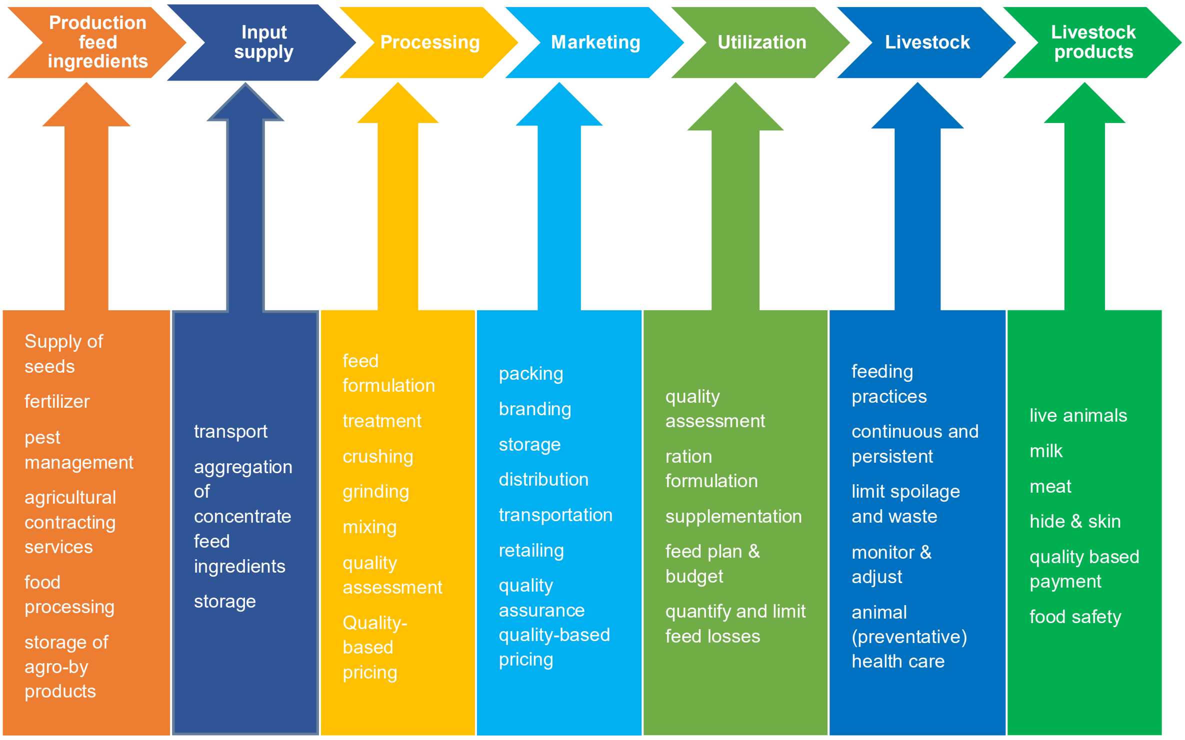
K. Socio-economic limitations

Natural growth of herbage as fodder in arid rangelands has been traditionally considered as the main source of nutrition for livestock. However, the production of this fodder may be influenced by some socio-economic and climatic factors. For example, fodder production varies according to precipitation. As a result, livestock farmers may want to follow supplemental feeding on rangelands as a strategy to face scarce natural fodder resources. On the other hand, livestock farmers find it difficult or cannot access credit to invest in supplemental feeding as they must buy these feeds in the market. Limited adoption and continued application of agricultural technologies is also reported, mostly because of the high input costs. Cultural constraints reported include those related to gender discrimination, especially in the ownership, transfer and usage of land. Women in many societies in Kenya do not inherit land and, as a result, very few of them own land, even though they do most of the operations on the farm. Braintec (2025) reports that decision making and division of labour on fodder producing farms is increasingly done jointly between men and women. The other cultural constraint is the traditional inheritance practice in which a parent gives land to each of his sons. This leads to land fragmentation into small uneconomic units. In other areas of Kajiado and Isiolo counties, communal land is subdivided and privatized resulting in units that are not sustainable for grazing in ASALs’. Poor infrastructure in many areas is another hindrance to livestock development. Poor and scattered market outlets often because of poor management, especially in the marketing of live animals, slaughterhouses and milk processing, still discourage many farmers from making use of formal market channels. Lack of commercial orientation is a constraint because beef cattle are kept by pastoral communities with sociological attachments to their livestock. A recent study in Ethiopia (Bedelian *et al.,* 2025) showed that market trends do not necessarily provide an incentive for pastoralist to sell their cattle but instead the need for cash, for example to pay medical or school bills.

2.4 Forage value chain Actors and Stakeholder analysis

The feed value chain in Kenya, on the one hand, is composed of various actors and stakeholders who undertake different roles, such as input supply including feed raw materials, mixing/processing, bagging, transport, marketing/trading and feeding defined in the feed value chain, as depicted in Figure 2 below.

Figure 2. Feed value chain (nodes) in Kenya



Source: Creemers 2024

On the other hand, the forage value chain consists among other producers, aggregators, processors, marketing and utilization. Figure 3 below presents a schematic presentation of the key nodes and support functions that define the forage value chain.

Figure 3. Forage value chain (nodes) in Kenya

[Blank]

Source: Creemers 2024

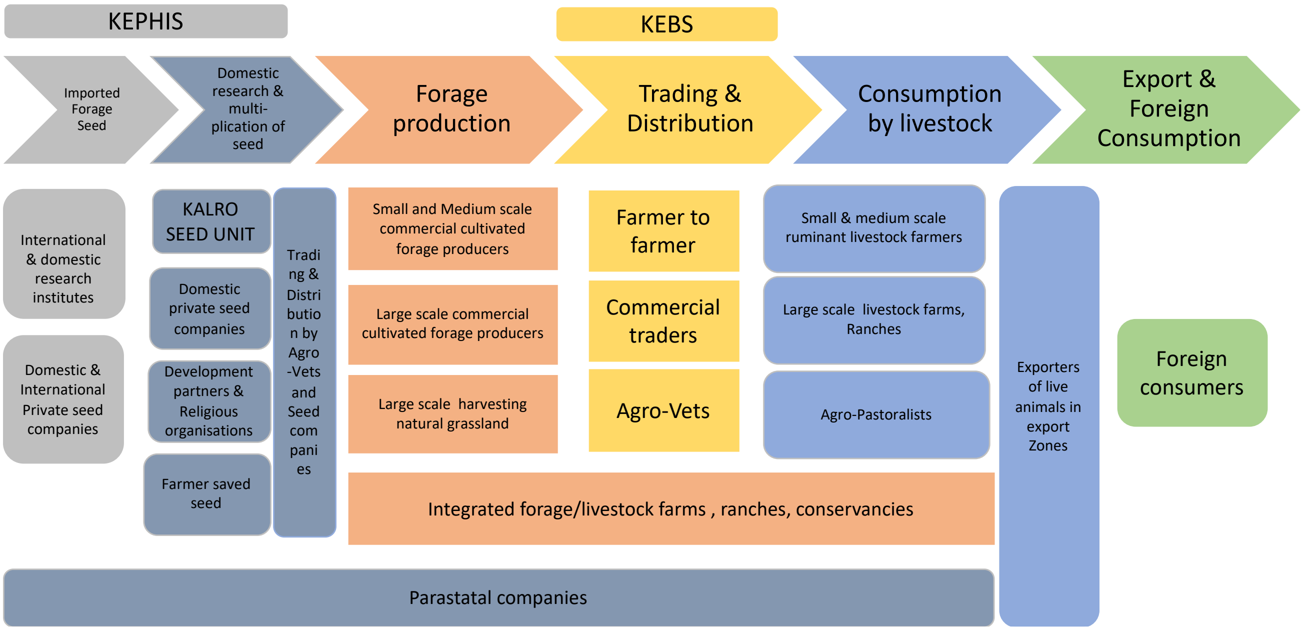
The major enablers and service providers for the proper functioning of the value chains are road networks, research outputs like seed varieties and planting materials, awareness, training, mechanization services and reduced waiting time in license provision. Most of the available service providers are common along the various stages of the value chain and include the government extension system, research institutions, cooperatives and donor-funded organizations. Among the pre-requisites for developing a sustainable fodder value chain (Figure 3) are information on the productivity, nutritional quality and drought and grazing tolerance of grass species, production and post-harvest handling practices; market structure; and challenges and opportunities in the value chain.

Information on feed and forage value chains is crucial in guiding selection and breeding of grass species suitable for the drylands; identification of species that require conservation; identification of the best agronomic and post-harvest technologies; and market decisions (Wasonga *et al.,* 2016).

2.4.1 Stakeholder's roles, influence and impact grid

There are various stakeholders that play different roles in the feed and forage value chain and the larger livestock value chain in Kenya, including in the counties of Isiolo, Kajiado and Nakuru – shown in the Figure 4 below.

Figure 4. Integrated forage and feed value chains in Kenya



Source: Adapted Waziria M.D., Uliwab P., Supply and Commercial Viability of Forage in Tanzania, May 2025

The Kenya Bureau of Standards (KEBS) serves as a standards and regulatory authority ensuring the quality and safety of forage feeds in Kenya's livestock value chain. Through these roles, KEBS helps improve forage feed quality, protect consumer interests, and support the overall growth and transformation of the livestock subsector in Kenya. Some of the responsibilities are:

- **Standard Setting and Codes of Practice:** Establishes standard codes of practice that apply to all feed business operators involved in the forage feeds value chain—this includes farmers and forage producers. By setting these standards, KEBS ensures that forage feeds meet minimum quality criteria, which is vital for animal health and productivity.
- **Quality Monitoring and Enforcement:** Responsible for monitoring the quality of feedstuffs used in the forage value chain. This includes conducting regular spot checks and inspections to detect and control fraudulent or sub-standard feed manufacturers and suppliers in the industry.

The Kenya Plant Health Inspectorate Service (KEPHIS) is the regulator tasked with certification of planting materials, including vegetative propagules. KEPHIS ensures the quality and phytosanitary standards of planting materials under various laws including Plant Protection Act Cap 324 and the Seeds and Plant Varieties Act Cap 326. There are ongoing developments of draft regulations, such as the 2023 draft Vegetatively Propagating Seeds Regulations, which aim to strengthen certification and quality assurance systems for vegetatively propagated planting materials.

Other roles and functions of KEPHIS as well as other players in the value chain are summarized in Table 11 as follows.

Table 11. Stakeholders' supporting functions and roles

Stakeholder	Roles and functions
KEPHIS	Registration of new forage seed species/varieties. Approval for importation of forage seeds. Conduct National Performance Trials (NPT). Ensures seed quality control and monitoring. Campaigning and advocating the benefits and use of registered, certified seeds.
(2a) Seed companies	Provision of germplasm for the production of pastures and fodder. For example, Kenya Seed Company produces pasture and legume seeds such as Rhodes grass and Lucerne. KALRO bulks improved fodder crops like Napier, Brachiaria grasses, fodder sweet potato vines. Forage seed importation and distribution. Breeding, seed multiplication, collection, distribution. Training and creating awareness on production and utilization of forages in ruminant rations (technical team).
(2b) Seed bulking projects	Promoting of multiplication of germplasm for the production of range pastures. For example, religious organisations promote seed multiplication of Rhodes grass seed; Just Diggit promotes pasture seeds, buys, stores and redistributes such as African Foxtail grass and Maasai Love grass.
Commercial forage producers, private agri-preneurs, semi parastatals, ranches	Production of forages for commercial and subsistence purposes at competitive prices for livestock farmers in the country. Conservation of forages. Utilization of farm inputs and services. Mechanization services.
Regulatory agencies i.e. KEBS	Develop and enforce quality standards for forage inputs and products e.g. hay/silage. Monitor input and output markets for quality assurance.
National Government	In charge of policies and regulations on forage trade through MOALD (State Departments), KEBS & KEPHIS and Ministry of Trade. Promotion of technology and innovations on forage production. Introduce and advocate projects related to sustainable forage production. Collection of taxes and licenses (transport licence for hay), transport limitation 6AM-6PM.
County Government	Collection of local taxes (CESS).
Research institutions e.g. KALRO, ILRI	Research on and introduction of new, improved seed varieties. Trials and awareness creation on new forage seed species/varieties. Breeding, seed multiplication, collection, distribution of germplasm. Distribution of forage seeds (direct or working with partners). Training and dissemination of knowledge and skills on best practices for forage crop production and utilization (including grasses and legumes) to extension staff, farmers and agricultural institutes.
Academic institutions (Universities, Agricultural TVETs/Colleges, ATCs)	Potential hubs for research and demonstration. Awareness, knowledge and skills exchange on importance of forage seed, forage crops, range pastures. Training and dissemination of knowledge and skills on forage production, mechanization, and conservation.
Ruminant livestock farmers/keepers	Production of forages for own use and commercial purposes. Utilization of forages as end users. Production of livestock products (e.g. milk, in-calf heifers, meat, skin).

	Livestock keepers are also instrumental in bulking and exchange of various planting materials.
(10a) Dairy cooperatives	Extension, creating awareness on farming topics and business skills. Forage production, awareness and trade. Forage conservation and storage. Training farmers on improved forage production and utilization. Marketing of milk from members.
(10b) Livestock marketing and abattoirs'	Although not very prominent in the forage production value chain, awareness of the role of forage production in the meat value chain is increasing and a precondition for livestock trade. Forage buyer for livestock in holding/ quarantine areas.
CBO/CIG involved in forage seed and fodder production	Community Based /Community Integrated Groups setting up grass seed banks and/or fodder banks.
(12a) NGOs, Wildlife & Conservation organisations, Development organizations and implementing partners	Promotion of improved forage species/varieties and adoption by farmers. Take on the role of or provide through service providers extension services. Awareness programs on best forage conservation practices. Infrastructure for forage conservation e.g. constructing hay storage and provision of farm (harvesting) equipment. Promote, range pasture and landscape rehabilitation. In Kajiado and Isiolo counties, various NGOs help communities bulk natural pasture seeds for sale or use to rehabilitate degraded range areas.
(12b) Carbon Credit	Promotion of landscape rehabilitation through better grazing practices and land use.
Input suppliers & support services	Provision of forage seeds, fertilizers and crop protection. Provision of farming services & equipment. Training on forage agronomy and best practices in feeding.
Traders & transporters	Forage trade price setting and market linkages. Distribution of forages to ruminant livestock farmers.
Financial institutions, SACCOs	Provision of financial credit and lending to livestock farmers/forage producers and other actors.
Agricultural ICT and Tech service providers	Offer digital platforms for input sourcing and market linkages and price trends. Development and maintenance of Weather apps. Early warning systems.
Consumer Marketing Groups (Dairy groups, Hay Growers and Mechanization groups and Steer fattening groups)	Produce and aggregate fodder demand from member farmers Promote investment in improved varieties and mechanized production and conservation. Offer contracted supply roles e.g. mechanization. Market inclusion.
Advocacy	Promotion of civil and cultural rights (extended to the right of save seed and livelihood) -e.g. Seed Savers Network in Nakuru.
Feed traders & feed millers	Aggregate and distribute single source concentrates for livestock farmers. Produce and aggregate commercial compound feed for livestock farmers.

The County Governments are the other key players in the forage value chain. They offer support services as Livestock Department or through joint coordination within various county departments. These include establishment of forage demo plots and training in sustainable forage production, developing forage trade regulations and policies, enforcement and levies collection e.g. cess. Kajiado County for example, developed the Kajiado County Livestock Feed Strategy 2023-2033. The County governments through their Agriculture Mechanization Services Departments also provide subsidized mechanization services such as land preparation, planting, fodder harvesting, silage making and hay baling (tractors, balers, choppers). The County government also co-hosts various government parastatals and co-implement different development projects with the National government and development partners. The table below enlists some of the projects and influencers active as at the period of our field visits.

Table 12. Influencers and projects with scope in forage value chain in Isiolo, Kajiado and Nakuru counties

Organization/project	County	Category	Major role
National Drought Management Authority (NDMA)	Kajiado, Isiolo	Government parastatal	Coordinates all activities related to drought management, Kenya's Vision 2030 and BETA. Despite this existing policy and legislative framework, droughts still result in emergency situations.
National Agricultural Value Chain Development Project (NAVCDP)	Isiolo, Kajiado, Nakuru	Government Project – funded by World Bank and National Government	To increase market participation and value addition for targeted farmers in select value chains in project areas.
DRIVE Programme	Horn of Africa (including Isiolo, Kajiado, Nakuru)	ZEP-RE, Government funded by World Bank	To address challenges and protect the pastoralists, the Horn of Africa De-risking, Inclusion and Value Enhancement (DRIVE), Enhance pastoralists' access to financial services for drought mitigation, include them in value chains, and facilitate livestock trade in the Horn of Africa. To impact more than 1.6 million pastoralists drawn from 2,500 pastoralist groups over a five-year period. DRIVE will enable the region to adapt to the impacts of climate change, commercialize livestock production in pastoralist communities, and ensure the inclusion of marginalized and vulnerable groups, including women in the sector.
African Pastoral Markets Development Platform (AU-IBAR)	Isiolo, Kajiado, Nakuru	Inter African Bureau for Animal Resources	Policy strengthening and implementation; strengthening private sector engagement; strengthening and diffusing functional data ecosystems
Agrovets	Isiolo, Kajiado, Nakuru	Private sector	Provision of farm inputs e.g. Sale of Livestock medicine, feeds, seeds, hay
Kenya Development Corporation	Isiolo, Kajiado, Nakuru	Development Finance Institution (merging the operations of Industrial and Commercial Development Corporation, Tourism Finance Corporation and IDB Capital Limited).	Aligned with the DRIVE project the organisation promotes sustainable socio-economic development by providing development finance, infrastructure finance, business support and advisory services to medium and large-scale industries, infrastructure projects and commercial undertakings in target sectors in Kenya and elsewhere.
ILRI – International Livestock Research Institute	Isiolo, Kajiado, Nakuru	International research	Research on Livestock and environment (Mazingira Centre)
GATSBY Foundation	Isiolo, Kajiado, Nakuru	Development organisation	Development partner targeting the red meat sector and feeding solutions
Center for Research and Development in Drylands (CRDD)	Isiolo	Center for Research and Development in Drylands (CRDD) is a Kenyan based non-profit organization that promotes people-	Promotes transdisciplinary research to address the complex situations in drylands development. It develops and implements programs that contribute to sustainable livelihoods for communities living in drylands of Kenya.

		centered research and development.	
RAPID +	Isiolo, Kajiado	Millennium Water Alliance through primary funding from the Swiss Agency for Development and Cooperation (SDC)	The Resilient Arid Lands Partnership for Integrated Development Plus (RAPID+) program represents a transformative multistakeholder initiative focused on strengthening resilience in Kenya's ASALs.
FAO (CASHA)	Isiolo, Kajiado	FAO and SNV with support from the Mastercard Foundation	The CASHA Project aims to empower over 200,000 youth across 15 ASAL counties over the next five years.
Mercy Corps, Frontier Counties Development Council (FCDC), and the University of Twente (ITC)	Isiolo	The Resilient Approaches in Natural RanGeland Ecosystems (RANGE) program is a five-year initiative funded by the Dutch Ministry of Foreign Affairs	Seeks to strengthen the resilience of the ASAL communities that contribute to sustainable economic and social development in a well-managed landscape by enhancing livestock productivity and driving inclusive local economies.
IGAD	Isiolo, Kajiado, Nakuru	Mainstreaming climate adaptation and mitigation into rangelands management planning; strengthening existing regional rangeland forage monitoring for drought early warning system and contingency planning for early action in cases of drought extremes.	IGAD aims to work on integrating the Horn countries in political, economic, social and cultural respects in line with sustainable development. IGAD developed the cross-border forage prediction model is an important planning and decision support tool aimed at informing the livestock and other relevant sectors on the seasonal outlooks on forage conditions.
University of Nairobi	Isiolo, Kajiado, Nakuru	Knowledge and research institute	The institute provides research and knowledge generally on a project basis
KEMLEIC Meat and Livestock exporters Industry Council of Kenya	Isiolo, Kajiado, Nakuru	Lobby, member organization for meat and livestock exporters	Promotion of meat exports
Northern Rangeland Trust (NRT)	Isiolo	Community-led organization supporting 45 conservancies in Kenya & Uganda which employs 1,033 wildlife rangers	Northern Rangelands Trust monitoring wildlife, combat poaching, prevent illegal activities, and reduce human-wildlife conflict, helping to protect endangered species and ecosystems.

MIDP	Isiolo	Merti Integrated Development Programme (MIDP) is an umbrella CBO that coordinates self-improvement actions by various community-based groups in Merti	Coordinate self-improvement actions by various community-based groups in Merti
WWF	Kajiado	Wildlife conservation organization	Promoting rangeland management and sustainable grazing
Just Diggit	Isiolo, Kajiado	Development organisation	Together with our implementing partners, we bring back sustainable vegetation to the areas by utilising and promoting effective rangeland best-practices. Two essential techniques are the establishment of semi-circular bunds and the creation of grass seed banks.
LISTEN - SNV in partnership with Frontier Counties Development Council (FCDC) and the Alliance for a Green Revolution in Africa (AGRA).	Isiolo	Funded by the Embassy of the Kingdom of the Netherlands in Kenya	Seeks to strengthen institutional capacities for climate change adaptation at county level, and increase smallholder famers' knowledge and adoption of climate-smart irrigation technologies and practices, while applying an Integrated Water Resource Management (IWRM) approach along the Ewaso Nyíro basin.
Grevy's Zebra Trust	Isiolo (Kenya-Ethiopia)	Wildlife conservation organization	Promoting planned grazing and Holistic Land and Livestock Management (HLLM) to enhance rangeland health through regenerative grazing practices.

CHAPTER THREE: FORAGE CROP SEEDS AND VEGETATIVE PLANTING MATERIALS

3.1 Forage seed availability in the counties: Formal and Informal Channels

In Kenya, the Kenya Agricultural and Livestock Research Organization (KALRO) is the institute which is most dominant in the distribution of forage seeds and planting material (Figure 5). KALRO operates in both the formal and the informal segment of forage seed production because not all seed which is distributed to farmers is registered and listed on the National Crop Variety List (NCVL). Together with private seed companies KALRO plays a crucial role in breeding, multiplying and distributing certified forage seeds. With KEPHIS as the National Authority mandated to oversee the formal seed sector, these organizations ensure that seeds meet quality standards and are accessible to farmers across the country.

Kenya imports most of the registered and listed forage seeds, especially grasses and legumes. The Table 13 below shows the trade value of imported forage seed and Lucerne seed in Kenya, in comparison to South Africa, a country with which Kenya likes to benchmark when it comes to milk production.

Table 13. Trade value of imported forage seed and Lucerne seed in Kenya and South Africa

		Value in USD				
Country	Import of Forage Seeds category	2020	2021	2022	2023	2024
Kenya	Seeds of forage plants for sowing (excl. of cereals and of sugar beet, Lucerne, clover…)			261	370	457
South Africa	Seeds of forage plants for sowing (excl. of cereals and of sugar beet, Lucerne, clover…)			4,754	4,870	5,027
Kenya	Lucerne seed for sowing	36	104	126	63	49
South Africa	Lucerne seed for sowing	5,223	5,896	4,712	5,736	4,192

Source: Trademap

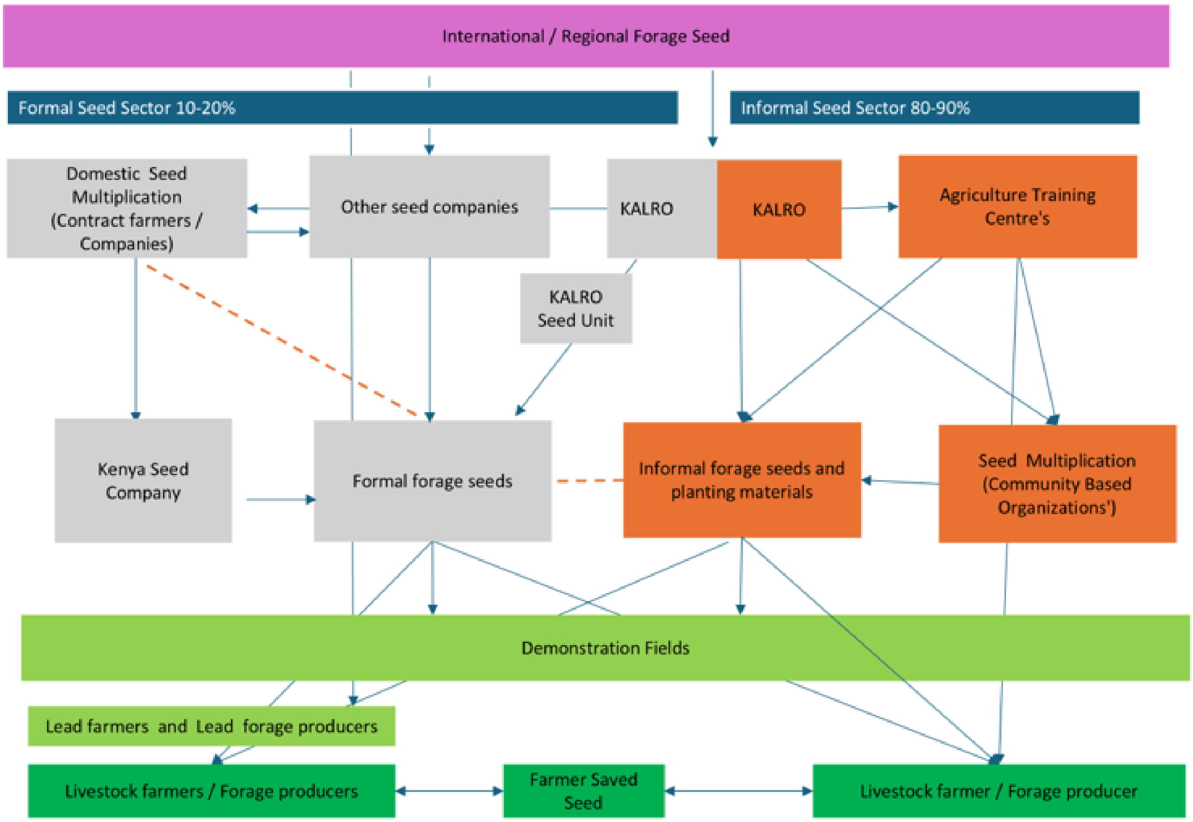
From the table above, the value of the forage seed importation in Kenya is negligible. South Africa imports more than tenfold the value of forage seeds of which at least 50% is spent on seeds for high quality forage such as Lucerne. The production of grass seeds involves several stages, including selection of high-quality parent plants, field production, harvesting, processing, and packaging. Also, in comparison to the horticultural sector where 43% of the vegetable seed demand is imported, importation of forage seed against the total demand, estimated based on total acreage under grassland, pasture, cut and carry and other forage crops is very low. The demand for maize seed stands at over 50 million MT per year (Musyoki 2024) and only a small proportion is designated for forage production (Forage Working Group 2025).

In the informal sector, the main sources of grass seeds are KALRO and farmers' own sources - harvesting from naturally growing grass to obtain startup seeds (Omollo *et al.,* 2018). The production by farmers is only small scale and dependent on use of locally available and cheap resources such as ox-plough during land preparation and own/family labour for other production activities. Seed producers mainly plant grass through seed broadcasting and control weeds by manually uprooting sprouting unwanted plant (Kidake *et al.,* 2016; *Omollo et al.,* 2018). In Kajiado county we identified one commercial producer of Rhodes grass seed who adjusted existing combine harvesters to be able to harvest the grass seed mechanically.

In 2024 following different studies by CIAT and SNV (ICSIAPL and NEADAP) into the forage seed market, a Forage Working Group (FWG) was installed to give recommendations on technical aspects of registration and listing of forages on the NCVL and policy recommendations (Forage Working Group 2024). Currently the FWG is finalizing a situational analysis of Kenya's Forage and Forage Seed sub-Sector. The Forage working group found that pasture seed production in the formal channel in Kenya in the past 5 years was low. Reliance on Rhodes grass in domestically produced forage seed is very high with 82% of the potential acreage covered which could be established with the available seed. Of the total imported forage seeds, Rhodes grass covered 40% of the potential acreage established with imported forage seeds (Forage Working Group 2025).

The need for pasture seed especially in the rangelands including Isiolo and Kajiado counties is generally acknowledged to be high (IGAD, 2024) but the demand for commercial pasture seeds may be low because seed is not available and farmers resort to different options. (e.g. collecting own seed or vegetatively propagated seed material). The value chain for formal and informal forage seed and vegetative planting material is depicted in the following figure.

Figure 5. Formal and informal sources of forage seeds and planting materials in the ASAL areas of Kenya



Source: Authors, Adapted from Mwendia et al., 2016

Research by Biodiversity-CIAT shows slow but sustained growth in the improved forage seed market, with local innovations by KALRO playing a crucial role in improving the availability and adoption of forage crops (ICSIAPL 2025, unpublished). In the ASAL counties of Isiolo and Kajiado, improvement of range pastures and pasture seed production face various challenges key among them, the unavailability of quality seed. Some range pasture seed varieties are available through formal marketing channels Table 15 information on seed in Kenya, but multiplication and commercialization remain a concern. A list of registered and listed forage varieties is presented in Annex 1. Livestock keepers in the ASALs rely on development and research institutions, NGOs, the government through the respective State or County Departments, informal seed sellers and fellow farmers for provision of germplasm.

However, Kenya has a strong history in forage seed research and evaluation that goes back to the 1960's. In fact, East Africa became known internationally as a centre of genetic diversity (or gene centre) of the best known and most important cultivated tropical grasses, not only of Rhodes grass, but of many genera such as African Foxtail (Buffel), Guinea, Signal, Star grass and legumes like Kenya white clover, Glycine and Lablab. Unfortunately, the high-quality fodder and grass research seems to have come to an end since the departure of these scientists in the 1980s and in subsequent years. This can be attributed to lack of policy support, government funding, inadequate skilled human resource and research.

Next to Rhodes grass, the dryland grasses, such as African Foxtail, Needle -Bush rye- grass, Horsetail and Maasai love grass can be locally multiplied and marketed not only in Kenya but also in the entire IGAD region and beyond. In addition to these dryland grasses there is an enormous potential that is untouched because during the Forage Collection and Evaluation (1974–1987) project, a total of 202 grass and 164 legume accessions were collected from various parts of the country. The project also introduced promising forage crops from abroad. A total of 93 grass accessions were introduced/re-introduced, with special emphasis placed on *Cenchrus ciliaris* and *Panicum maximum* for improving rangelands in Kenya (FAO 2006). Unfortunately, between 1976 when the Rhodes grass variety ‘Boma’ was registered and listed on the NCVL and 2021 when the first rangeland grasses were registered and listed in the NCVL (Annex 1)), there was no or little activity in terms of formal seed multiplication, distribution and marketing of pasture grasses including those suitable for rangeland rehabilitation.

Meanwhile the government of Kenya developed the ambitions to achieve a higher level of commercialisation and intensification of its ruminant livestock sector – to improve amongst others farmer income but also to reduce dependency on importation of milk and meat for a growing population. To achieve this the government of Kenya together with the livestock sector must find cost effective solutions to overcome the reduced size of farmer holdings to grow feed and food crops. Also, the need for efforts to enhance availability and use of improved (climate-smart) forage seed and planting material cannot be over-emphasized. In addition, the maintenance – and to an important extent regeneration - of Kenya’s landscapes and rangelands where most of the livestock kept by (agro) pastoralist communities graze, require suitable drought-tolerant range grass varieties in sufficient quantities and choice, to assure healthy, biodiverse and dense plant cover.

Based on feedback from the respondents and earlier studies by Creemers *et al.,* (2023) most of the grass seed used for rangeland rehabilitation is produced and distributed through informal channels. KALRO produces seed of *Cenchrus ciliaris, Chloris roxburghiana* and *Enteropogon macrostachyus* and registered four (4) varieties with KEPHIS on the NCVL but commercial quantities of these rangeland grasses are to date limited. Interplant Agriculture EA in Naivasha has seeds of *Cenchrus ciliaris* (cv Molopo and cv Gayana), Weeping love grass (*Eragrostis curvila*), *Panicum maximum* (cv Gatton), and *Digitaria eriantha* (cv Irene). The biggest supplier of rangeland grass seed in the three counties is, according to the respondents Rehabilitation of Arid Environments (RAE) Limited based in Baringo County. The company supplies most of the NGO’s (Just Diggit, WWF, NRT, Grevys Zebra Trust) and others engaged in re-seeding and rangeland restauration with *Cenchrus ciliaris*, *Eragrostis superba* in large quantities’ and *Cymbopogon pospischilli, Sehima nervosum*, *Enteropogon macrostachyus*, *Lintonia nutons* in smaller quantities. Just Diggit has recently been building a stock of *Cenchrus ciliaris* and *Eragrostis superba* seeds in Kajiado county (Picture 1). Seed from other rangeland grasses mentioned by pastoralist households in Isiolo is not available in sizable quantities in Kenya.

Picture 1. *Cenchrus ciliaris* seeds (left) and grass seeds packed in gunny bags by Just Diggit (Right) in Kajiado County

That said there are some trends in Kenya's forage seed market that reveal an evolving sector with several initiatives. For example, in 2015 KALRO registered 5 Lucerne (*Medicago sativa*) varieties and 40 years after the last registration and listing of Elmba Rhodes grass in the NCVL, Urochloa hybrid grasses were listed, followed by other Urochloa ssp and Guinea grass (*Megathyrsus maximus*) cv Siambaza in the period 2020-2021. KALRO registered the range grasses Horsetail (*Chloris roxburghiana),* Needle grass -Bushrye- (*Enteropogon macrostachyus*) and 2 varieties of African Foxtail grass -Buffel- (*Cenchrus ciliaris*) cv MGD1 and TVT-3 in 2021. The KALRO varieties being the most relevant for range pasture establishment and reseeding of rangelands.

Figures from KEPHIS on forage seed multiplication and importation between 2019-2024 reported by the forage working group (Forage Working Group 2025) show that the government’s targeted increase in forage production in acreage and yields (GoK 2023) cannot be met by far (Rhodes grass seed gap >65%) by the current supply of certified forage seed in the market. If adding grass seed for periodical replacement of existing grasslands and reseeding of degraded landscapes is taken into consideration, the shortage of available certified forage seed becomes even more astounding (range pasture grasses gap >98%). In addition to availability, the choice that farmers have regarding certified, (including climate resilient) forage seed is also limited to only a few species and their varieties.

The FWG considers it crucial to increase and fast-track the availability and diversity of forage options for the various livestock farming systems and agro-ecological zones in the country. Part of the solution lies, according to the FWG, in reviewing the regulatory framework for forage seed variety-release and listing, to enhance availability, access, choice, agro-ecological suitability and affordability of certified forage species and their varieties in Kenya.

Community-based pasture and seed production by CBOs (and CIG's) are other options to increase forage seed availability. This involves, for example, setting up seed multiplication centres supported by the national or county governments, NGOs or contracting farmers to undertake seed production, and bulking. Another system that is picking up momentum are Fodder Seed Banks, in Kenya promoted by several organizations like Just Diggit, Nature Kenya, Pastoralist Community Initiative and Community Development Assistance, Save the Seeds LANASET, Reconcile, Maasai Wilderness Conservation Trust, South Rift Association of Landowners, Mercy Corps, KEFRI together with JICA and Seed Savers Network; illustrated in the picture below.

Picture 2. Inside seed bank by Seed Savers Network in Diatomite, Nakuru county.

Communities in Kajiado and other counties of Baringo and West Pokot benefit from enclosures established ("Fodder (seed) banks") to restore the native vegetation. By doing so they were able to harvest and sell grass seeds, hay or grass straw from these plots and use them for dry season grazing leading to an improvement of their livestock. In the informal seed producing channel quality aspects such as germination rate, purity and contamination do not play an important role even though it does affect the results of the next group or organization buying the seeds. As the market share of informal range pasture seed production increases it is recommended that government authorities (KEPHIS, MOALF) and regional authorities, such as IGAD, find ways to gradually include this production channel in the 'formal' seed production channel.

These initiatives taken in the informal seed producing sector are promising steps to reduce seed and feed scarcity in the rangelands. However, it is still a daunting task because Burkart and Mwendia (2024) found in their study that bridging the forage deficit in East Africa would require the cultivation of 2 million hectares and the involvement of 1.5 million farmers. The forage seed market presents, in their view, an economic opportunity, potentially valued at USD 877 million over a period of 10 years which justifies the involvement of many actors who can contribute to making forage seed available preferable through quality-controlled seed systems.

Based on the Feed strategy of the GoK 2023 dry land grass seed needed for rehabilitation of rangelands can be estimated as follows. If one percent (1%) of the pastoral and ranching area (at respectively a biomass yield of 0.92 and 1.4 tDM/ha) would be reseeded, an estimated 11 thousand MT of dryland grass seed would be required (Table 14 below). It is not possible to make an inventory of availability of range pasture seed production in the informal channel but quantities in stock of most respondents are less than 10 MT which gives an impression of the seed gap in the country.

Table 14. Range Pasture Feed resource

Feed resources	2025
Pastoral (MT Dry Matter)	95,039,122.56
equal hectarage needed (0.92 tDM/ha)	103,303,394
Ranching (MT Dry Matter)	10,144,852.96
equal hectarage needed (1.4 tDM/ha)	7,246,324

Source: Feed Strategy 2023 / Production estimates Creemers J. 2025 -Pastoral and Ranching -FAO 1988)

The production of high-quality (e.g. factors such as germination rate, purity, free from diseases, free from weed seeds and contaminants) forage seeds is essential for establishing and maintaining productive pastures. In Kenya, forage seed production is carried out by both large-scale seed companies (Kenya Seed Company, KALRO Seed Unit, Leldet Seed Company, Kerio Valley Development Authority and RAE). These companies work closely together with KEPHIS on seed that is produced domestically or imported. The availability of certified forage seeds ensures that farmers have access to varieties suitable for their location (ASALs versus High potential areas), high-yielding, palatable and disease-resistant. Currently the multiplication and production of rangeland pasture seed in the informal channel does not meet the requirements for registration and listing on the NCVL but they fulfil a demand among pastoral communities and wildlife conservation organisations. KALRO and University of Nairobi worked with the producers of seed in the ASALs and developed training material for them on harvesting and storage methods of range pasture seeds (IGAD 2025). Next to this research institutions and private seed companies are strengthening innovation in forage genetics. Collaborative efforts are underway to both improve existing local varieties (e.g. work done by KALRO Lanet, Kiboko) and introduce novel materials (CIAT, ILRI and partners) that promise greater yield and adaptability. These initiatives are complemented by government and non-governmental support, aimed at quickening the adoption of high-quality forage seeds and integrated farm management practices.

3.2 Availability of Vegetative planting materials

Napier grass is the main forage crop and widely used across Kenya as feed for dairy and beef cattle. It is more prominent in Nakuru county as compared to Kajiado and Isiolo counties. Its quality is poor under current management conditions resulting in poor animal productivity (RuMeth 2019). Current management among smallholder farmers is focused on achieving high yields and as such, is harvested at ground level with long harvest intervals (e.g grass reaching >200 cm), which reduces quality. Harvesting Napier grass at leaf stage six (60-90cm) appears appropriate for feed nutritive value and cattle growth (Kariuki J.N 1998; Roy *et al.,* 2025). Solutions are required to reduce yield loss associated with cutting interval (35-42 days) which targets leaf stage six (60-90 cm), such as increasing plant density (plant population), and this should be the focus of project interventions in those Agro-Ecological Zones within the three counties where Napier grass performs well and/or under irrigation.

3.2.1 Kakamega I and Kakamega II Napier grass

Napier grass Kagamega I and Kakamega II are smut disease–resistant varieties developed mainly for Kenyan smallholder dairy farmers facing devastating Napier head smut disease, which can reduce yields by 60–80%. Both varieties have become increasingly popular since their introduction in 1996, particularly in zero-grazing systems and in regions where the disease is widespread. Kakamega I is distributed widely through government programs, Kenya Agricultural and Livestock Research Organization (KALRO), agricultural training centres, dairy cooperatives, and local farmer groups (see Figure 5). By 2007, about 13% of Kenyan smallholder farmers in smut-prone areas were using Kakamega I. Farmers continue to share planting material, creating a robust informal distribution network. Kakamega II was released alongside Kakamega I but this variety which shows better performance was targeting humid highland conditions. Like Kakamega I, trustworthy planting materials is available from KALRO, and agriculture training centres. Both varieties are recommended but not registered and listed by the Kenya Plant Health Inspectorate Service (KEPHIS) for their disease resistance. The informal distribution network which KALRO and the farmers created, is getting intense competition from actors who are multiplying and distributing foreign Napier grass varieties, such as Pakchong I and Juncao, in Kenya.

3.2.2 Pakchong 1 / Super Napier grass

In 2017, the National Livestock Resources Research Institute (NaLIRRI) under the National Agricultural Research Organization (NARO) and The Green Elephant received permission from the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), Entebbe to import 90 cuttings of Pakchong 1 / Super Napier grass from Thailand. The Green Elephant wanted to develop high quality silage, briquettes, pellets and feed blocks using high yielding forages such as Napier grass. From Uganda, Pakchong 1 found its way into Kenya and was marketed by Christie's Farm Gate in Juja. Super Napier grass also known as Pakchong 1 is an interspecific hybrid of two species native to South East Asia. A team of Thai researchers developed this special high-yielding grass variety in 1960s by culturing the tissue of pearl millet (*Pennisetum glaucum*), with the African Napier grass (*Pennisetum purpureum*) (Kabirizi *et al.,* 2024).

3.2.3 Giant Juncao grass

Four years ago (July 2021) Crevation International introduced Juncao grass to Kenya. In China, Giant Juncao or *Pennisetum giganteum* (*Pennisetum purpureum* x *Pennisetum typhoideum*) is a commonly used forage crop which exhibits high average productivity as well as bioenergy value added products. In addition, its role has been established in soil erosions and salt stress alleviation (Hayat *et al.,* 2020, Sonwai *et al.,* 2022). The National Agricultural Value Chain Development Project (NAVCDP) is incorporating the cultivation of Juncao grass, to enhance livestock farming and promote climate-smart agricultural practices in Kenya. The Kajiado County for example, launched pilot extension services that will involve 25 one-acre farms, one farm per ward. The sites will function as demonstration, bulking centers and/or propagation nurseries to facilitate wider adoption and future expansion of the Juncao grass. The aim is to improve fodder availability for livestock all year round, establish bulking sites for large-scale Juncao grass propagation and enhance farmer resilience against drought and other climate change challenges. In Nakuru County the Crevation International had bulking centres domiciled in Lenginet and Rongai areas.

Picture 3. Aerial view of Chinese-invented Juncao grass farm - changing fortunes of Kenya's dairy farmers.

Source: Belt and Road portal - https://eng.yidaiyilu.gov.cn/p/0NSD2CKK.html

3.2.4 Red Napier and Dwarf Napier grass

The Moo Fodder Supermarket in Laikipia and Nyeri Counties, promotes, sells and multiplies Napier grass varieties Australian Red Napier and Indonesian Smart (Dwarf) Napier, which both originated from South East Asia. The Indonesian Smart (Dwarf) Napier grass has a lower yield as compared to other Napier grass varieties but is commended for its high leaf stem ratio, high crude protein content and digestibility as compared to Australian Red Napier. The latter is yielding more biomass than Dwarf Napier and showing very constant crude protein content (11%) across stages of maturity in comparative trials in Malaysia (Zailan 2016).

The multiplication and production of vegetatively reproduced planting material for forages have been largely uncontrolled. With the arrival of foreign planting material in Kenya farmers are advised to acquire healthy, certified planting materials—preferably from KALRO, government centres, or recognized training farms—to ensure disease-free stock (Head Smuts, Snow Mold, Leaf Spot) and maximize fodder yields. Imported planting material, if it followed the government procedures, is declared disease free on release but is not tested against common diseases in Kenya. In addition, it is noted that producers of vegetatively reproduced planting materials promote the grasses claiming nutritional qualities or attributes that are not substantiated through research. The law governing vegetatively reproduced planting material in Kenya is embedded primarily in the Crops (Horticultural Crops) Regulations, 2020 (Legal Notice 118 of 2020) which states that nursery operators are legally required to sell only planting materials that have been certified by the Kenya Plant Health Inspectorate Service (KEPHIS).

The popularity of the Napier grass varieties among smallholder farmers is due to their high biomass yield. This is an important decisive factor for smallholder farmers, when choosing which grass to grow in their farms a choice which is closely related to allocation of small portions of land for forage production in relation to the number of ruminant livestock kept on farms. Next to this, labour requirements for maintaining, harvesting and feeding the grass plays a role. High yield per acre is therefore important as it also addresses labour intensity of the forage crop. Although promotors of the Napier grass varieties are claiming their varieties are drought-tolerant, it needs to be noted that it is true that Napier grass is a highly efficient grass in terms of its Water Use Efficiency (WUE) but this does not necessarily mean the grass is productive under dry conditions. For example, all the bulking sites for Giant Juncao Napier grass which were visited had an irrigation system in place to support production of vegetatively propagated seed material (Picture 4), biomass for silage making and fresh grass for farmers in the vicinity of the bulking centres.In the (social) media in Kenya the promotors of the Napier grass varieties claim next to high biomass yield, high crude protein content even if cutting height exceeds 2.5 meters. However, Napier grass can only yield >50 tDM/ha/year with non-limiting N (nitrogen) fertiliser (usually with >500 kg N/ha) and water (>1,100 mm) in many regions of the tropics and subtropics (Islam *et al.,* 2023). MacDonald *et al.,* (2010) advice after each cutting, a side-application of 150 kg N/ha. This should be followed as closely as possible by an application of water (about 25mm).

Picture 4. Irrigation system installed in Napier grass (Juncao) planting materials in Lenginet Farm, Nakuru county.

In the field it is also not well understood that Napier grass varieties differ widely in yield, plant height, leaf to-stem ratio and nutritive value. In Kenya like in other countries in the region there is no information on what characteristics should be considered to obtain both yield and quality and which varieties that are currently available and popular among farmers can overcome seasonal growth limitations, including higher altitudes (e.g. Mount Kilimanjaro region, Ngong Hills and parts of Nakuru) with lower average day temperatures to ensure a year-round supply of quality forages.

When farmers choose a Napier grass variety it is important to be aware that there is a trade-off between yield and quality. For example, Snijders *et al.,* 2011 found that dry matter yield increased with cutting age and Nitrogen rate. The leaf content and leaf/stem ratio and contents of crude protein (CP) and ash decreased with longer cutting interval (CI), while content of dead leaf (senescence) increased. This is in line with test results of MacDonald *et al.,* (2010) reporting crude protein (CP) content ranging from 91-115 g/kg DM at 50 cm (4 week cutting interval) and 58-67 g/kg DM at 200 cm (10-12 week cutting interval) on trials with Giant Juncao in Fiji and KwaZulu Natal. Roy *et al.,* (2025) found that Pakchong 1, with increasing leaf number from six to fourteen leaves, crude protein (CP) content decreased from 184 g/kg DM to 118 g/kg DM and metabolizable energy (ME) content from 10.4 to 7.3 MJ/kg DM.

Snijders *et al.,* (2011) reported that Nitrogen availability in the soil from synthetic fertilizer, manure, or Desmodium (leguminous plant) will contribute to nitrogen yield and can have a positive effect on both Napier yield and digestibility if other growing conditions (e.g. water availability, average day temperature) allow. They further found that if cutting regimes are harvested over the same period, leaf and nitrogen yields tend to peak at a cutting age of about 5-7 weeks, starting to decline subsequently thereafter. In-vitro organic matter digestibility of Napier grass increased with contents of green leaf, leaf/stem ratio and crude protein content (CP), and strongly decreased with age and contents of dead leaf, and fibre content - neutral detergent fibre (NDF), acid detergent fibre (ADF) and lignin (ADL) (Snijders *et al.,* 2011).

In practice this means that the advice is to harvest Napier grass at 6 leaf stage, cutting height between 60-90cm, with residual height not below 10cm and cutting interval between 5-7 weeks to achieve best animal performance. If the quality declines because of longer cutting interval or age. Livestock will need to be fed subsequently more concentrate ingredients in the ration to maintain the same milk production or daily live weight gain. For example, Roy *et al.,* (2025) found that Napier grass cv Pakchong 1 harvested and fed at 6 leaf stage to cattle had a greater growth rate and higher feed conversion ratio (FCR) than the Napier grass if harvested at 14 leaf stage (610 versus 270 g/day LWG and 6.4 versus 16.2 kg feed DM/kg, kg LWG respectively) indicating a trade-off of yield with quality. Snijders *et al.,* (2011) explored the effects of N (nitrogen) on milk yield at a rate of 210 kg N per ha/year (1 kg N ha/per day during the growing season), the increase in milk yield per kg fertiliser N varies from 13.1 kg milk per kg N at the 6-week cutting interval to 10.6 kg at the 16-week cutting regime. While for half the N rate, the effect of N improves substantially, from 15.2 to 3.5 kg milk per kg fertiliser (equivalent) N. There was an optimum for N use around cutting ages of 6 to 8 weeks.

In the field and in the (social) media promotors also claim high sugar content in the newly introduced Napier grass varieties improving palatability and suitability for silage making. Napier grass (*Pennisetum purpureum*) is widely used for silage making, but one of the main challenges for high-quality silage is its relatively low natural sugar content. This low water-soluble carbohydrate (WSC) level often leads to sub-optimal fermentation, making it common to add sugar-rich sources like molasses during ensiling to improve fermentation and silage quality. The baseline sugar content in fresh Napier grass typically has low levels of WSC, reported values for untreated Napier grass silage are around 14–15g/kg dry matter (DM), which is considered below the optimum (>70g/kg DM) for good lactic acid fermentation during ensiling. Adding molasses or other fermentable carbohydrate sources can nearly double the WSC content (up to 28–29g/kg DM or higher), substantially improving silage fermentation and preservation, as shown by improvements in lactic acid content and reductions in pH and ammonia nitrogen (Rambau *et al.,* 2022; Nyambati *et al.,* 2013).

It is recommended that in those areas where Napier grass is used or will be introduced for feeding in intensive farming system or for supplemental feeding farmers are coached to adopt and maintain best practices linking good quality forage production to healthier animals and an increase in animal performance.

3.2.4 Lucerne (Alfalfa)

Lucerne is commercially produced under pivot irrigation and distributed by a number of specialized companies in Naivasha (for example Marula Farm, Morendat Farm and the former Delamere Farm). The market largely consists of medium and large-scale dairy farmers, and some dairy cooperations. The demand for lucerne has surpassed the supply and at least one of these farms is planned for a significant expansion. Production of Lucerne in Kenya is a niche, and the demand is so high that it affects quality of the product (e.g often baled and sold when hay is too wet) and at times results in unethical trading (e.g. traders divide one bale in to two but still sell at the price of one 18kg bale).

3.3 Other alternative dry land forages

3.3.1 Maralalfa and Gama Umami Napier grass

Napier grass is not a dry land forage; however, given the increased attention to exotic Napier grass varieties (Pakchong 1, Juancao, Australian Red Napier, Indonesian Smart (Dwarf) Napier), it is not unthinkable that this material will be introduced to Kenya and promoted in semi-arid lands. Like Giant Juancao grass, Maralfalfa (*Pennisetum purpureum* × *Pennisetum glaucum*) was developed in Colombia and Gama Umami grass (*Pennisetum purpureum* cv. GU) in Indonesia.

3.3.2 Prickly pear cactus

In Kenya, research on prickly pear cactus is done at JKUAT. This is an unconventional solution to solve the forage gap in the ASALs' but the spineless variants of the prickly pear cactus (*Opuntia ficus-indica*), originally from central America could contribute to ruminant ration used by smallholder livestock owners. Researchers have tested a wide range of lines in Jordan and India, where the best adapted are now being grown as feed.

3.3.3 Anameka

Anameka is another unconventional solution, it is a drought-tolerant saltbush variety developed in Australia, primarily for its ability to provide supplementary feed for livestock in arid lands and aid in land regeneration. Anameka is a product of CSIRO research and is part of their Drought Resilience

3.3.4 Mission.Sulla

Picture 5. Sulla (*Hedysarum coronarium*); Source: Feedipedia

In Tunisia, ICARDA has been working with a national program to promote reseeding pastures with indigenous forage legumes. One of these is Sulla (*Hedysarum coronarium L.*) – shown in Picture 5, a deep-rooted and drought-resistant forage species that is also highly palatable to livestock, nutritious and productive. This has helped farmers boost their livestock productivity while reducing soil erosion and enhancing carbon sequestration – a triple win for the farmers and their environment. The main challenge with alternative dryland forages is the availability of seed in Kenya or the investments and technology required to bring them to scale. For example, the work done on rangeland legumes is according to the respondents at research level and no activities are known that multiply or produce rangeland legume for further distribution.

3.4 Regulations and Policies

Kenya is a signatory to the Common Market for Eastern and Southern Africa (COMESA) Seed Trade Harmonisation Regulations, 2014. The COMESA, a regional trading bloc of 21 countries, enacted the Seed Trade Harmonisation Regulations in 2014. The regulations for seed were developed to enhance seed production, seed trade, reliability, and increasing competitiveness of the seed industry in the COMESA region. Through these regulations, a COMESA seed certification, variety release and phytosanitary system is created. The primary objectives of the COMESA regulations are to harmonize phytosanitary measures for seed in the region, ensure the varieties listed in the Variety Catalogue and traded are of high quality, and encourage investment in seed business among others. Four classes of seeds are established: pre-basic seed; basic seed; first generation certified seed and second-generation certified seed. A variety shall only be released upon satisfying the DUS test carried out in accordance with the UPOV guidelines, and the VCU or National Performance Trials (NPTs). The regulations also provide that seed testing methodologies must be based on the ISTA Rules. Equally, existing varieties cannot be entered into the COMESA Catalogue without providing for DUS and VCU data. While the regulations provide for a procedure for registration and release of Genetically Modified Varieties, there is no reference to indigenous varieties. Regarding the range pastures KALRO has registered with KEPHIS, the challenge they are facing is to make the step from basic seed to first generation and second-generation certified seed. This basically is the bulking of seed to commercially viable volumes. It is not the mandate of research organisation KALRO but requires private companies to take up these tasks.

The COMESA regulations are framed in a manner that does not enable trading of varieties not tested, released or registered in the COMESA Catalogue. Indigenous varieties of forage crops, in more particular native grasses) in the COMESA countries are not registered. It is worthy to note that 19 of the 21 COMESA countries have adopted the regulations. While it is possible for a COMESA country to sustain two separate and parallel systems for testing, registration and release of seed to also ensure availability of clean seed of indigenous (forage) varieties (through 'quality declared seed' system like adopted in Uganda) such a system is on the one hand likely to add more costs but on the other hand would allow livestock farmers accessing forage seed which is likely to have impactful income and livelihood implications (Creemers *et al.,* 2022).

The SADC for example provides for opportunities for registration of landraces and indigenous varieties just like the EU does with conservation varieties (e.g. varieties for reseeding rangelands). SADC has been able to achieve this objective by incorporating a quality declared seed (FAO 2006) scheme into its overall scheme. COMESA on the other hand is very strict in this regard, following ISTA standards.

There is public debate about farmer owned seed and farmer to farmer sharing of seed. The debate is targeting food crops; and forage seeds have, so far not been included in the discussion. Seed Savers Network does work with some farmers in Baringo on seed multiplication of African Foxtail grass but on a very small scale. In July 2025 the debate reached a next level when a private member's bill sought to transfer regulation of variety release and seed certification to KEBS for some key food crops. The bill mentioned Sudan grass, Rhodes grass and Lupins as typical forage crops while Lablab and Mung bean can be seen as dual purpose (food/feed) crops. Having two agencies domiciled in different ministries to regulate seed and in our case forage seed is likely to cause confusion but it shows the urgency for the government of Kenya to review the current system and possibly consider a 'quality declared seed' (QDS) system for forage seed which can fast track and include the registration of landraces and indigenous varieties for rangeland pasture seeds.

3.5 Sources of information on forage crop seeds

Sources of information on availability and suitability of forage crop seeds are limited. Since 1980, research and government extension focused on Napier grass and its only in the last decade that other grasses, such as rangeland grasses are receiving the attention they deserve since 37% of Kenya is permanent grassland. The following are some sources of forage seeds and information to farmers.

Government and Research Institutions

The Kenya Agricultural and Livestock Research Organization (KALRO) is the major breeder and distributor of both vegetatively propagated (e.g., Napier grass, sweet potato vines etc.) and seed-based forage crops such as forage Sorghum, Rhodes grass and perennial rangeland grasses (e.g. African Foxtail, Horsetail and Needle -Bush rye- grass) and legumes (e.g. Vetch, Lupin, Lablab bean and Cowpeas). KALRO sells seeds and vegetative planting material through its various centre's (e.g. Lanet, Ol Joro Orok, Embu). The Agricultural Training Centres (ATCs) too across the country distribute a range of forage planting materials and information regarding the same to farmers, for example Wambugu ATC/Kenya School of Government in Nyeri.

Private Forage Seed companies

(presented in Table 15) who distribute and sell seed of grasses, legumes and other forages to farmers directly or through agrovets and other distribution networks.

Table 15. Seed companies stocking forage crops seeds suitable for ASALs

Company name	Description / Forage Focus	Location	Contacts
Rehabilitation of Arid Environments Ltd/Trust	*Cenchrus ciliaris* variety Baringo (Buffel grass/African Foxtail), *Eragrostis superba* (Maasai Love grass), *Enteropogon macrostachyus* (Bush Rye), *Sehima nervosum* (Sehima Needle grass), *Cymbopogon pospischilli* (Narrow-leaved Turpentine grass)	Baringo County Kenya	05351418 / 0721892566 www.raetrust.org
Leldet Seeds	Rhodes grass, Forage sorghum variety E6518	Rajwera Farm, Nakuru Kenya	0723329393 www.leakeygroups.co.ke

Just Diggit	African Foxtail grass & Maasai Love grass		
Seedballs Kenya	Eragrostis superba (Maasai Love grass), Acacia nilotica, Acacia Senegal, Acacia tortilis, Acacia xanthopholea, Acacia kirkii, Sesbania sesban (Sesbania)	Nairobi Kenya	0700380009 www.seedballskenya.com
Interplant Agriculture EA Limited	*Cenchrus ciliaris* variety Molopo, Gayana (Buffel grass/African Foxtail), *Panicum maximum* var. Gatton (White Buffalo grass), *Panicum coloratum* (Coloured Guinea Grass), *Chloris gayana* (Rhodes grass) var. Katambora, var Endura, Brachiaria var. Sabia, Lablab bean var. Highworth, *Digitaria eriantha* variety Irene (Pangola/Smutsfinger grass), *Eragrostis curvula* variety Ermelo (Weeping Love grass), *Antephora pubescens* variety Wollie (Bottle brush grass)	Naivasha, Kenya	0254 729 060 124 www.interplantea.co.ke
Hygrotech East Africa	*Cenchrus ciliaris* variety Gayndah (Buffel grass/African Foxtail), *Digitaria eriantha* variety Irene (Pangola/Smutsfinger grass), *Antephora pubescens* variety Wollie (Bottle brush grass *Chloris gayana* (Rhodes grass) var. Katambora	Tigoni and Naivasha, Kenya	0202053917 www.hygrotech.co.ke
KALRO (HQ/Kiboko/Dairy Research Station)	*Cenchrus ciliaris* var MGD1, TVT3 (Buffel grass/African Foxtail), *Lablab purpureus* variety Rongai (Dolichos bean), *Enteropogon macrostachyus* (Bush Rye), *Chloris roxburghiana* (Horse Tail grass), *Sesbania sesban* (Sesbania), *Chamaecytisus palmensis* (Tree lucerne)	Nairobi/Kiboko/Lanet/Naivasha, Kenya	www.kalro.org
Kerio Valley Development Authority	*Cenchrus ciliaris* variety Baringo (Buffel grass/African Foxtail)	Eldoret, Kenya, KVDA Chemeron Station	0205363361 'www/kvda.go.ke/pasture-seed/
KWS SAAT SE & Co. KGaA/ Agventure	Forage Sorghum	Nakuru, Kenya	https://www.kws.com/corp/en/sustainability/social-responsibility/development-cooperation/#4225709
Crevation International	*Cenchrus purpureum* variety Juncao (Napier grass)	Kitengela, Kenya	0710888886/0710299538 https://www.facebook.com/profile.php?id=61556984909377
Christies Gate farm	*Cenchrus purpureum* variety Pakchong 1 (Napier grass)	Juja, Kenya	0715 342986 https://christiesfarm.com/
Moo Fodder Supermarket	*Cenchrus purpureum* var Juncao, var Pakchong 1, Dwarf Napier grass and Australian Red Napier grass	Rurin'gu along Kiandu road, Marua Junction, Muruguru – Gatitu road	0722 722 189 0726 307 730 https://moofodder.com/
Kenya Seed Company (KSC)	Wide range of certified forage seeds, cover crops like Rhodes, *Panicum coloratum* (Coloured Guinea Grass), Columbus grass, Oats, Desmodium	Kitale, Kenya	0722 205 144 / 0726 144 856 https://kenyaseed.com/

Simlaw Seeds (KSC Subsidiary)	Suppliers certified forage and pasture seeds, Brachiaria grass, Kikuyu grass, Rhodes grass, Oats, Sudan / Colombus grass and legumes such as Desmodium, Lucerne, Lablab bean	Nairobi Kenya	020 2215067 www.simlaw.co.ke
Advanta Seeds Africa	Forage Sorghum and Forage Pearl Millet	Westlands, Nairobi Kenya	0743478081 www.advantaseeds.com
Amiran Kenya Ltd (Distributor for Interplant Agriculture EA)	Range of forage seeds, including Brachiaria cultivars	Old North Airport Road, Embakasi Nairobi Kenya	0800720720 www.amirankenya.com
Advantage Crops Limited	Seeds for high potential areas like Cayman, Cobra, Mulato II, *Crotalaria juncea* (Sunn hemp)	Rodi, Homabay County Kenya	0715519922 www.aclseeds.com
U-Farm	Seeds for high potential areas like Cayman, Cobra, Mulato II, *Crotalaria juncea* (Sunn hemp)	5th floor, West point, Mpaka Road Westlands, Nairobi Kenya	0719227700 www.ufarm.biz
East African Seed Company	Forage Pearl millet (Pennisetum glaucum) Forage Sorghum (Sorghum -drummondii, S. bicolor)	Dakar Road, Nairobi Kenya	0722207747 / 0734333161 www.easeed.com

Source: Adapted from Creemers et al., (2021)

Social media and digital (media) platforms

promote distribution and sales of forage planting materials to farmers. Farmers make orders and pay electronically, and the seeds are delivered, often to the nearest town.

Development organizations, religious groups, Wildlife conservation agencies, CBO's and CIG's active in creating awareness

among farmers of the potential of grass seed to rehabilitate rangelands and as an income generating opportunity. Encouraging and actively supporting farmers and women groups in multiplication of rangeland pasture seeds.

3.6 Constraints in forage planting materials

In general, tropical (C4) grasses have a lower digestibility and crude protein content and higher fibre content in all stages of growth compared to temperate (C3) grasses. The lower digestibility is due to greater lignification of the plant leaves, which is a mechanism tropical grasses have developed to minimise water loss (transpiration), which increases their survival in hot climate conditions and the coarse nature of tropical grasses, containing more stems.

Tropical grasses like Guinea grass (*Megathyrsus maximus* former *Panicum maximum*,) African Foxtail (*Cenchrus ciliaris)*, Maasai Love grass (*Eragrostis superba*) and Rhodes grass (*Chloris gayana*) are important rangeland pasture grasses in ASALs.' In the informal channel there are several actors who encourage local production of range pasture seeds, but the volumes of these range pasture seeds produced do not meet the ambitions of local county governments nor the national government.

Pasture legumes such as Cow pea (*Vigna unguiculata*), Lablab bean (*Lablab purpureus*), and Siratro (*Macroptilium atro-purpureum*); and fodder trees such as *Leucaena leucocephala*, White-ball acacia (*Acacia angustissima*), and *Calliandra calothyrsus* are only produced in the informal channel and availed in small quantities. The Cow pea and Lablab bean need to be cultivated and are dual purpose which means that the use can change during the growing season for feed to food depending on the needs of the household. Although the Feed Strategy (GoK 2023) does not mention the targeted acreage in 2030, it was noticed that when seed demand increases as a result of project activities the seed supply quickly stagnates.

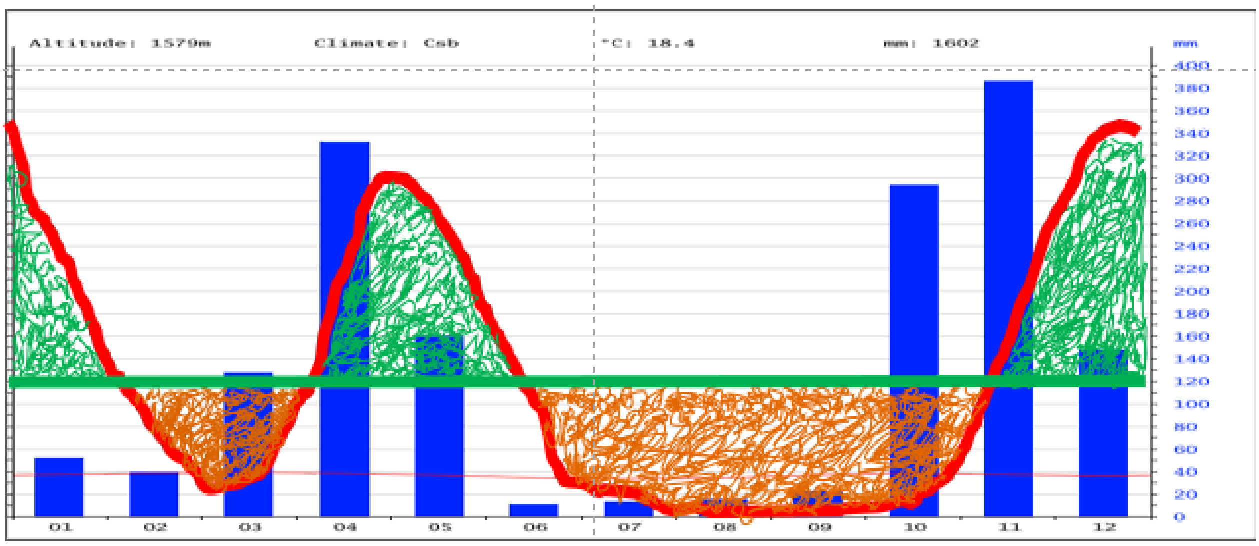
Guinea grass according to many of the respondents, is a type of grass which is highly favoured by livestock but has largely disappeared, while other grasses do not thrive in semi-arid or arid areas such as in Isiolo and parts of Kajiado (e.g. Magadi) county due to high temperatures and low precipitation.

Low adoption of reseeding and cultivated forage crop production is also attributed to lack of awareness and/or extension staff for farmer coaching (1 to >500 farmers), shortage of labour due to overlapping of the farming calendar with the main cash crops in Nakuru, high cost of forage crop production, unavailability of forage seed, and land scarcity.

Because of the increasing land scarcity for forage production and reduction in grazing land, it is therefore important for farmers to maximise production of those (native) species adaptable to their climatic conditions.

It is evident that herbage produced in the rangelands and quality forage produced on-farm is the cheapest ration ingredient. Current practices, grazing management and management of cultivated forages result in high feeding cost and quality forage that does not support livestock performance. However, to support livestock all year-round preservation of excess biomass (during wet season) is a technology that needs wider adoption to ensure fodder availability for supplementation. In Figure 6 below the green lines shows the biomass needed to feed livestock on the farm, the red line shows excess forage production, above the green line and a shortage of forage on the farm, below the green line.

Figure 6. Forage requirements for cattle and seasonal forage production gap



Source Adapted from Perdok, Rumen8, (2019)

Therefore, efforts are needed to increase utilisation of excess biomass and accessibility to prepared fodders, farmers in the three counties are encouraged to start cultivating fodders themselves on a small to medium large scale there were this is feasible and cost effective. A large share of livestock farmers, for example rely on seasonal rain fed (poor-quality) forage. Increasing supply through on-farm or commercial, domestic fodder cultivation would require utilizing more arid and semi-arid land for fodder crops and pasture (re-seeding) production. The productivity of cultivated forage crops of farmers in the three counties is currently deemed relatively low (except for some of the commercial fodder producers in Nakuru), forcing farmers to use a larger share of commercial, fodder alternatives for supplementation in the ration of their livestock. In addition to commercial fodders for supplementation, some farmers are found to add raw material with high protein contents (fish meal, maize germ, cotton and sunflower seed meals) to increase the nutritional value of the rations.

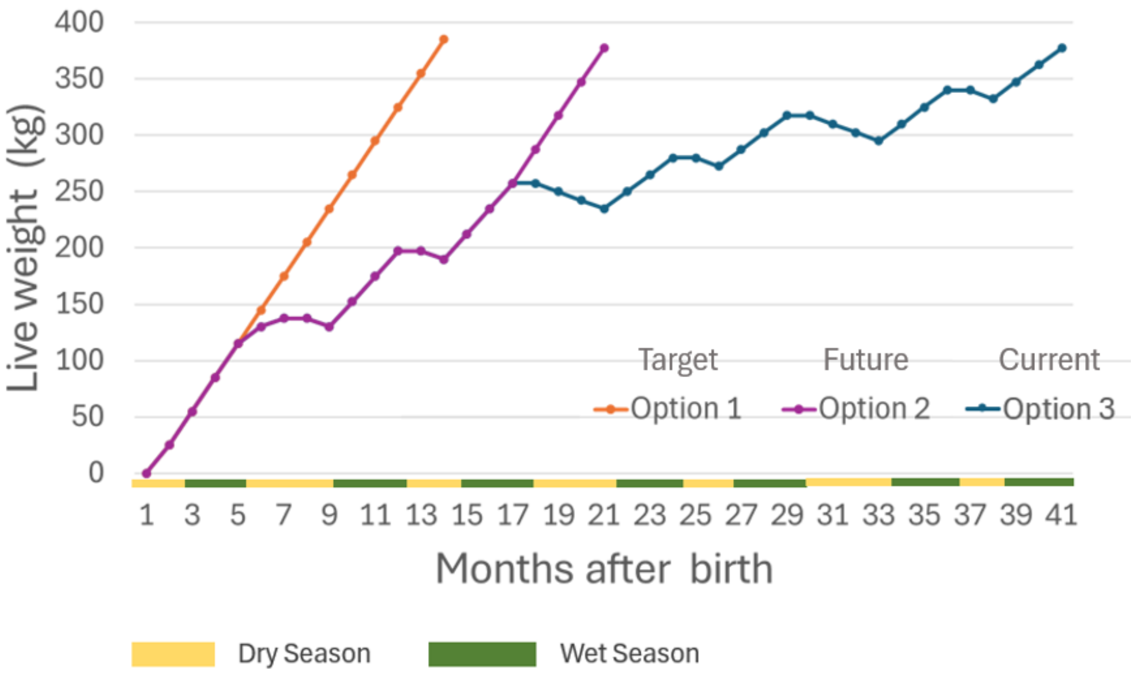
It is important to realize that the main mechanisms through which improved forage condition increases food security is through livestock productivity enhancement. Improved income of livestock farmers from livestock (e.g. live animals, milk, meat, manure, hides and skin) and at the same time reduced prices of basic food commodities (cereals, legumes, and vegetables), and utilization of better coping strategies by households in the ASALs resulted in households being more food secure. This suggests the need for interventions and initiatives aimed at boosting livestock productivity and reducing vulnerability to drought-induced poor forage conditions in the ASALs. Additionally, the need for improved practices around cut and carry grasses, conservation and cultivated forage crops in areas where these crops are suitable, for example when weather conditions are unpredictable farmers prefer not to cut the grass for haymaking because of fear it will spoil, technology and mechanization which allows farmers to act faster such as haylage making could assist to utilize the available excess biomass more efficiently. It is evident that the constraints around forage crop seed and planting material and practices of how to grow and utilize this resource need to be solved.

CHAPTER FOUR: FORAGE CROPS, PRODUCTION SYSTEMS AND COMMERCIALIZATION

4.1 Fodder in relation to livestock production

Ruminant livestock need a minimum quantity of fibrous material (grass, forage, crop residues, hay, silage) in their daily ration for an optimum functioning of the rumen. Fodder contains a high level of fibrous material, while concentrate feeds hardly contain any fibre. Various studies indicate that when ruminant livestock are allowed to graze and browse freely their preference goes to herbage and browse with high crude protein and low neutral detergent fibre concentrations, indicating that forage nutritive value affects the forage preference of cattle, small ruminants and camels. (Kaitho R.J., 1997; Ikanya *et al.,* 2022; Sagala *et al.,* 2022). However, in intensive, semi-intensive (e.g. with supplementation) feeding system, rations of grazed fodder are supplemented with other forages, by products of agro-industry or concentrates. On a dry matter basis, a minimum of 40% of the ration should consist of fodder (or roughage) while 60% could be concentrate feed, low fibre by-products etc. Low amounts of roughage in the day-to-day ration can result in digestive disturbances like poor digestion, rumen acidosis, low growth rate and/or milk production, and health problems. Feeding enough fodder (roughage), which means maximum voluntary feed intake (*ad libitum*), is the most important aspect of feeding ruminant livestock. During seasons with good rainfall animals may find enough herbaceous material to graze or browse on but during the dry season and more so during prolonged periods of drought feed intake is not enough resulting in animals which are no longer productive (see Figure 7 below) and eventually lose weight and mortality among the herds.

Figure 7. Simulation of live weight development in different feeding systems



Source : Creemers J., (2024)

Supplementation is used to compensate scarcity of fodder in the rangelands, nutritional deficiencies, increase animal performance such as growth or milk production or a combination of the these. In Isiolo town for example, one respondent in the KII – a commercial concentrate feed stockist – reckons that Range Cubes concentrate is a fast-selling product used by livestock keepers as a concentrate supplement due to its high protein (and energy) content. Scarcity and instability of fodder resources, coupled with other factors such as manpower, financial resources, socio-cultural characteristics etc, have led, in some places, to a change in feeding systems. To cover the nutritional needs of their livestock or to address market demand of livestock products such as milk and meat, a different livestock feeding system in ASAL counties has emerged – the peri-urban livestock feeding system. Examples include Kajiado Maasai Women Dairy Cooperative, Windy Ridge Youth group, Women of the Queen of Peace Initiative.

Vicious cycle of rangeland degradation and feedlot businesses cashing in on compensatory growth

When forage quality is reduced, it leads to reduced digestibility and nutrient balance for the animals. If the quantity of the forage is limited at the same time (animals must walk long distances). It forces livestock to mobilize their fat and muscle reserves (Option 3 in Figure 7) to meet energy demands for maintenance, visibly impacting their body condition scores and significantly reducing reproduction efficiency (animals go into anoestrous).

This creates a vicious cycle of degradation: environmental stress, because of drought, leads to vulnerable rangelands, which results in low quantity and quality forage available for livestock (feed deprivation), subsequently reducing animal productivity, and in turn, increasing pressure on the remaining land, ultimately driving further degradation. This demonstrates that sustainable rangeland management is not merely an environmental concern but a direct and critical determinant of livestock productivity and the viability of pastoralist livelihoods.

Following a period of feed deprivation and when given the opportunity (after the onset of the rains or in a feedlot), animals grow at a faster rate than unrestricted animals. This is called compensatory growth it works on the principle of having a high number of bulls or any class of cattle being ‘break-even’-fed at only maintenance levels during the dry season and relying on compensatory growth rates in the following wet season. During the compensatory period they appear to utilise feed more efficiently.

The extent of compensatory growth is influenced by the age of the animal, the severity and length of the restriction. However, complete liveweight recovery is frequently not attained before maturity, depending to some extent on the age at which restriction occurred, its severity, and the period of recovery. Generally, the younger the animal and the more severe the restriction, the poorer the compensation. If nutrition is very good following restriction, greater compensatory growth can be expected.

Compensatory growth is common in pastoral beef farming. The incorporation of a period of lower growth in the dry season followed by compensatory growth in the wet season is consistent with a seasonal pattern of range pasture production. Compensatory growth works through a combination of reduced maintenance requirements, increased efficiency of growth, increased protein deposition and increased feed intake.

There are no hard and fast rules to predict compensatory growth. There are quit several feedlot businesses in Kenya, operating on this principle. For example, feedlot that are operational when pastoralist sell animals at low (throw away) prices due to drought and livestock losing body condition and live weight. The feedlot owner, located in (peri) urban areas stocked on relatively cheap feeds during periods with good rainfall. This type of feedlot can bring their animals in a relative short period (60-90 days) to acceptable market conditions achieving liveweight gain above 1.3 kg/day.

However, the sector at large will benefit more if live weight loss is avoided as much as possible (see Figure 7). The table below shows the energy density of the ration and the live weight gain that can be expected (excluding walking distance).

LWG (g/day)	50	350	500	700	900	1100	1300
Ration density (MJ / kg DM)	6.4	8.3-8.6	9.4-9.6	10,1–10,2	10,5–10,7	10,9–11,1	11,5–11,8

In the three counties of study, the quantity and quality of fodder is often too limited (see Table 3) as compared to the requirements of the animals. Nakuru being the exception as a county when ASAL areas face fodder shortage; but where large-scale commercial forage crop producers can be found with substantial storage capacity. Livestock production based on locally grown fodder is in general more economical than livestock production based on cultivated fodder; certainly, when this needs to be transported over long distances, or when high concentrate feed rations (of which some ingredients are imported) are needed for supplementation to meet the nutritional requirements of the animals.

4.2 Some theoretical background

Intake of roughage (fodder) depends on many factors but quality of fodder, expressed in organic matter digestibility (OMD) is a main determinant of intake. Digestibility of the roughage is a major factor while protein content (crude protein) can also be an important factor if no supplementation with concentrates is practiced. A very low protein content in the fodder can be corrected by feeding a supplement with a high protein content (e.g. commercial concentrates or browse leaf meal). Roughage intake capacity is also determined by the cow's weight and rumen size. Heavier cows (e.g. Sahiwal or improved Boran) will eat more but will also need more feed to maintain their body weight. Native cows (e.g. Small East African Zebu) with a lower body weight will have a lower feed intake capacity, partly compensated by their lower need for maintenance. A similar approach applies to small ruminants and camels. The quality of roughage in terms of digestibility has two effects on dry matter intake and potential growth rate and milk production. A higher digestibility of the forage results in a higher dry matter intake because of a faster digestion in the rumen and as a result a higher passage rate. This means that for example the maximum intake of over mature rangeland grass with a very low digestibility is about 25-35% lower (See Table 16 below) than that of the same grass at very early vegetative stage when organic matter digestibility is high. Besides the higher intake, a higher digestibility of a roughage results also in a higher energy content per kg dry matter (higher nutrient density). Both factors: higher intake combined with a higher nutrient density result in a much higher average daily gain and/or milk production per animal per day (See Table 16 below for milk production) for roughage with a high digestibility in comparison with very poor-quality roughage such as rice straw or maize stover. This low-quality forage is in part responsible for the low animal performance (L/d), high intensity of enteric methane emission (CH_4 g/d) and low profitability (MAFC KES/d) (See Table 16 below). The simulation shows a rapid increase in feed intake, milk yield and profit (margin above feed cost), and a dramatic drop in methane intensity with increasing digestibility of the forage and diet.

Table 16. Effect of grass growth stage on milk yield, CH4 & MAFC. Simplified example based on Urochloa decumbens

Simulation: Grass at different growth stages is fed to 450 kg crossbred cow, 140 days in milk (no liveweight change), 57 days pregnant, milk with 4.15% Fat and 3.15% True protein DMI estimated from NDF intake of 1.4% of body weight. Feed cost KES/tonne as fed: (1) 1,000; (2) 1,500; (3) 2,000; (4) 2,500; (7) 2,500. Cost of grass increases if harvested at earlier vegetative stage. Maize bran 32,000; CSM 50,000; Limestone 8,000 and Milk price 45 KES/L.

#	Growth stage	CP, g/kg DM	NDF, g/kg DM	ME, MJ/kg DM	DMD %*	DMI kg/d	L/day	CH_4 g/day	CH_4 g/L	MAFC KES/d
	Flowering/seeding	64	804	6.7	49	7.8	0	320	-	- 18
	Late vegetative	91	742	7.4	53	8.5	0.3	323	1076	- 28
	Vegetative	115	676	8.2	58	9.3	2.9	312	108	61
	Early vegetative	118	608	8.7	61	10.4	5.4	311	58	111
	#4 + 2.8 kg Maize bran	113	565	9.5	65	11.2	8.3	302	36	166
	#4 + 5.5 kg Maize bran & 0.6 kg Cotton seed meal	125	515	10.3	70	12.3	12.1	296	25	236
	Early vegetative 160 CP g/kg DM + 6.8 kg Maize bran	130	503	10.4	70	12.5	13.0	297	23	270

Source: Perdok H., and Creemers J., 2023

4.3 Forage crop production systems in the Counties

Production and supply of fodder in a region is affected by a number of factors. Land use and cropping pattern, number and density of livestock, livestock feeding pattern, storage of fodder, and intra- and inter regional fodder trade are some of the critical factors, which have significant bearing on availability of fodder.

The contribution of grazing biomass, roughages, cultivated fodders and concentrates to actual feed availability and use (GoK/FAO 2021 Feed Inventory) is presented in Table 17 below.

Table 17. Contribution of grazing biomass, roughages, cultivated fodders and concentrates to actual feed availability

County %	Contribution			
	Grazing biomass	Roughages	Cultivated fodders	Concentrates
Isiolo	85%	0.2%	0.0%	0.002%
Kajiado	85%	11%	2.7%	0.75%
Nakuru	<1%	94%	0.0%	2.85%

The (agro) pastoralists in the Isiolo and Kajiado counties rely predominantly on grazing on the rangelands to feed their cattle. In the major towns of Isiolo and Kajiado counties, compound feeds for dairy and beef are available and sold per bag (50 and 70 kg bags), or the bag is opened by the retailer and the compounded feed is weighed and sold per kilogram; as a percentage to actual feed availability is low in all counties but with nearly 3% highest in Nakuru. In Nakuru county grazing is only making a very small contribution to actual feed availability, for the biomass here comes from roughages (e.g straw of cereal and pulses, hay, cut and carry grasses).

There are only a few farms that use crop residues to feed or supplement cattle in Isiolo while in Kajiado this is more common in Kajiado North (Kiserian/Ngong). Supplementation with concentrate feeds is rare in both counties. In Nakuru, availability and access to feeds for supplementation is more widely spread within the county for example grass hay and baled silage of forage maize or sorghum. Several respondents mentioned they were currently selling their hay stock at around 160 KES/15 kg bale. The company Crevation International has two multiplication sites for vegetatively reproduced planting material in Nakuru county (Rongai and Lenginet Farms) and is intending to do so in all 33 counties spread across seven (7) geographical clusters in Kenya implementing the National Agricultural Value Chain Development Project (NAVCDP). There are several feed millers in Nakuru County selling compound feeds and single source concentrate ingredients.

In the Arid and Semi-Arid Lands (ASALs) where natural grasses are used to feed livestock, grassland is divided into grazing blocks and conserved through controlled grazing of these blocks; whereby some areas are dedicated for grazing in the wet season and other blocks reserved for grazing in the dry season or dry periods (sometimes referred to as standing hay). Reseeding programs such as one designed and rolled out by Just Diggit are gaining popularity in Isiolo (e.g. Nakupratt Gotu Community Conservancy and Nasuulu Conservancy) and Kajiado (Kuku Group Ranch) to restore natural grassland; Westgate Community Conservancy (WGCC) in Samburu County being the successful example as referred to by many of the respondents in Isiolo. A good part of the natural grassland in Isiolo and Kajiado counties is, according to the respondents depleted due to prolonged droughts and unsustainable use like overstocking. Rangeland grazing is a type of fodder production in arid areas that has been traditionally considered as the main source of nutrition for livestock. However, the production of fodder in these rangelands may be influenced by some socio-economic and climatic factors. For example, fodder production in rangelands varies according to precipitation. As a result, livestock keepers follow supplemental feeding on rangelands with hay or concentrates (e.g. Range cubes) as a strategy to face scarce natural fodder resources.

4.4 Production costs

Forage production refers to growing of plants specifically as animal feed. They include a variety of pasture grasses like *Panicum maximum*, *Cenchrus ciliaris*, and *Chloris gayana*; pasture legumes such as *Vigna unguiculata*, *Dolichos lablab*, and *Macroptilium atro-purpureum*; and fodder trees such *as Leucaena leucocephala, Acacia angustissima*, and *Calliandra calothyrsus*. However, most of them do not thrive in semi-arid or arid areas such as in Isiolo county due to high temperatures and low precipitation. Low adoption of forage crop production is in addition also attributed to lack of extension for farmer training (1 to >500 farmers), shortage of labour, in Nakuru, due to overlapping of the farming calendar with the main crop, high cost and unavailability of seed, and land scarcity. It is therefore important for farmers if they decide to grow a forage crop to maximise production of the species adaptable to their climatic conditions to keep the cost per kilogram of dry matter (metabolizable energy and crude protein as low as possible).

The gross value of cultivated forages is given by the product of their area, yield and price. The respondents in Nakuru County where hay production was commonly mentioned, a cost price for a standard 15kg bale of Rhodes grass hay is 130

KES. With the cost of mowing, tedding and baling being approximately 46%. In the SNV managed Integrated & Climate Smart Innovation for Agro-Pastoralist Economies and Landscapes (ICSIAPL) project, hay production was monitored and Mgeno Ranch and Olosentu Ranch calculated a cost of 120 KES/bale and 169 KES/bale of 15 kgs respectively[1]. The same range of cost per 15 kg bale was also mentioned by some of the respondents in Nakuru and Kajiado counties. However, utilized yield from grazed land is difficult to measure, and even when harvested it may only be used on the farms where they are grown. When livestock farmers in pastoral communities are asked, they generally do not cost grazing in the rangelands (ILO 2025). One of the responders mentioned the cost for grazing as 20 KES/head/day which results with a financial ration analysis as given in the Table 18 below for two scenarios.

Table 18. Financial (high roughage) ration analysis for two scenarios on local Sahiwal/zebu bulls

Financial ration analyses		
	High Roughage Ration	
Performance Indicator	Local Sahiwal /Zebu bull	Local Sahiwal /Zebu bull
	Scenario 1	Scenario 2
Feed cost (KES/head/day)	20	20
Income (KES/day)	128	128
Margin (KES/head/day)	108	108
Weight at start (kg)	250	290
Live weight change (g/day)	692	487
Finishing Period (days)	195	195
End weight (kg)	385	385
Total income (KES)	70,000	70,000
Total feed cost in feedlot (KES)	3,902	3,902
Total income (KES) - Feed Cost (KES)	66,098	66,098
Cost of bulls at start (KES/head)	45,000	45,000
Margin (KES/head)	21,098	21,098

Source: Creemers, 2025

Based on the purchase and sales prices it is estimated that the animals are bought at a liveweight of 250 or 290 kilograms. The latter being the more realistic scenario because live weight gain during the 195-day period is estimated by the authors to be below 500 gr/head/day. Average dry mater intake is 8.4 kg/head/day assuming that enough grass is available for the animals to eat to satisfaction (*ad libitum*). The feed cost of KES 3,902 for the whole period is the equivalent of 2,200 KES/tDM. The table below presents a comparison between the cost for grazing and grass hay per tonne of dry matter.

Table 19. Cost for grazing per tonne of dry matter versus feeding cost of grass hay

	335 KES /15 kg bale	**145 KES /15 kg bale**	**335 KES /15 kg bale**	**145 KES /15 kg bale**
Feed prices (t/DM)	(KES/tDM)	(KES/tDM)	%	%
Grazed pasture	2,200	2,200	100%	100%
Pasture hay (poor quality)	26,267	11,267	1194%	512%

From Table 19 above, if pastoral herders buy grass hay at 145-335 KES/15 kg bale (dry matter content is 85%) for supplemental fodder and assuming grazing is not entirely without cost (not free) instead feeding costs are low at 2,200 KES/tDM (when grazing cost are indexed at 100%); then the feeding cost increase with 512-1194% depending on the price at which the 15 kg bale of hay was bought. Even though pastoralism has its cultural significance and the communities provide environmental stewardship, such an increase in feeding cost is difficult to overcome if the cost is re-occurring and because of climate change re-occurring more frequently. Based on the current (option 3) beef production scenario in Figure 7, the price of a bale of hay (85% DM) should not go beyond 210 KES to be able to break even if the

[1] For detailed cost calculation we refer to Lessons-Learned-ICSIAPL-Innovation-Fund-07APR2025.pdf page 68, table 8.

animal is ready for slaughter at 41 months. This shows that interventions in pastoral livestock economies need to be carefully considered and that high cost of fodder in commercial markets may not contribute to improving livelihoods.

Market information on quantities of hay or silage traded and prices received is very limited, but hay producers mentioned that movement of the stock in the wet season is slow even though hay prices collected at the producer's storage vary between 160-200 KES/bale. For many hay producers the general assumption is that the sales price in the dry season – ranging from 300-400 KES /bale excluding transport – gives good guidance for a profitable business. As much as the buying price of KES 360-500 may be economically viable to prevent animals from dying during prolonged drought (as a strategy to reduce mortality), for livestock farming systems (including fattening or finishing) to be profitable, the price of hay needs to be as low as possible depending on the quality, preferably below 210 KES /15 kg bale as fed (85% DM and including losses and transport). Reasons given by respondents why hay is not purchased when price is low are; 1.) Financing possibilities to purchase feed stock, 2.) Storage capacity near the homestead 3.) Livestock response (growth/day) to feeding hay as supplement is poor 4.) Cost of grazing is low, and herders try to get by as long as possible on this low-cost option.

Production of high-quality grass or hay (cutting at younger stage) will result in a lower total dry matter production than production of grass cut at an older stage. This lower dry matter production can be compensated by more and better fertilization (more N from manure, fertilizer or legumes) which will result in more cuts per year (Chalie *et al.,* 2025). The most economic strategy (fertilization and cutting of grass at a young stage versus cutting at an older stage) will be evaluated against the production of the animals. This will be determined by economic calculations – see Table 16 in paragraph 4.2 (response in quantity and quality of grass in relation to availability and costs of concentrating feed supplements).

Although costs of grazing (or environmental stewardship) are not considered, it is good to realize that natural vegetation especially the grasses, are low in digestibility and crude protein, and dry matter production is low in the dry period. While the areas of natural pasture in the rangelands in Isiolo and Kajiado counties is large, the low nutritive value of the grasses, is compensated somewhat by the availability of browses of higher protein content. This limit daily intake of digestible organic matter (OM). Consequently, the resultant productivity of cattle and sheep is low. On good quality (young vegetative) rangeland pastures average daily gain of 0.5 kg/day is achievable. As the grass matures the growth rate reduces to 0.25 kg/day and just enough for maintenance during dry period and not enough for maintenance leading to weight loss during prolonged periods of drought. Similar limitations of poor quality (low nutrient density) are seen where large quantities of crop residues are fed to cattle, sheep and goats.

4.5 Forage market

Pasture management during dry spells is a major challenge to livestock farmers/pastoralists especially when it fails to rain and there is lack of pasture and fodder for their livestock. The situation can be quite costly to a farmer who was not prepared for the drought. Supplemental fodder includes products such as hay, silage, crop residues but also further processed forage such as leaf meal, pellets, briquettes and Densified Total Mixed Ration Blocks (DTMRBs) which are used to complement natural grazing. The production and utilization of these fodder types have been instrumental in mitigating the effects of feed shortages during drought periods. The demand for supplemental fodder is driven by fodder scarcity among farmers who keep livestock. The reason of fodder scarcity is because farmers do not have enough land to produce all the fodder, they need for their entire herd (dairy cattle, cattle held for beef production, sheep and/or goats) or due to the dry season or prolonged periods of drought, when there is not enough grass or browse in the rangelands for grazing. Maintaining a healthy herd through a dry spell calls for extra efforts by the farmers. Some of the measures farmers take to cushion their interests against adverse effects of drought are culling and pasture management.

4.5.1 Forage crop conservation and utilization

Supplemental fodder includes products such as hay, silage, and crop residues, which are used to complement natural grazing. The production and utilization of these fodder types have been instrumental in mitigating the effects of feed shortages during drought periods.

Hay

Drying of grass and leguminous forages into hay is the most common technique used by livestock farmers in the three counties to conserve feeds on farm for periods of scarcity. Hay is made from both cultivated pastures as well as from natural grassland. Hay is a common supplemental fodder made from dried grasses and legumes. It is harvested during the rainy season and stored for use during dry spells. The quality of hay depends on the plant species used, the stage of maturity at harvest, and the drying and storage conditions. On a small scale there is experience with hay making from Rhodes sp. and African Foxtail sp. Some larger farms have equipment to mow, wither and bale hay.

Silage

Silage is defined as an acidic, fermented, stored product from an agricultural crop. Silage making is probably more than 4000 years old. The ancient Egyptians and Greeks stored grain and whole forage crops in silos. Silage is a high-moisture fodder made from crops like maize, sorghum, and Napier grass. The ensiling process preserves the nutritional content of the fodder, making it a valuable feed resource during periods of scarcity. Poor silages of overgrown Napier grass will - at best - supply sufficient energy for maintenance (Creemers *et al.,* 2019). The development and adoption of silage making in Kenya has been slow due to less favourable characteristics of tropical grass as compared to temperate grass. Secondly, climatic conditions do not always allow for rapid field-drying of forage crops (e.g. high stem leaf ratio); and third, the availability of materials and mechanized equipment to ensure that the forage crop can be harvested, fast, frequent and contained and fed out under anaerobic conditions for several months. In 1983 Wouters *et al.,* (1989) carried out experiments in Naivasha in the National Dairy Development Project to develop methods and techniques suitable for smallholders for the ensiling of Napier grass, Columbus grass and maize stover to overcome feed shortages during the dry season. In the KMDP project silage making of the maize crop was popularized first in the North Rift region among medium to large scale farmers. In 2019 baled maize silage was introduced in the Kenyan forage market, first in 350 kg bales and later in smaller bales of 50-100 kg. General experience with silage making is not good, because it is not possible to cut and collect large quantities in a short period, and moreover it is not possible to maintain enough feeding speed when feeding out.

Bio-fermentation

Bio-fermentation is the process when freshly harvested, (green) crop residues are chopped (12-30 cm), and well compacted (>650 kg/m^3), ensiled with lactic acid bacteria and low-cost, good substrates for growth of lactic acid bacteria (e.g. molasses/urea mixture) at a moisture content of 60-70% and sealed for 42 days to create an anaerobic environment. Investors interested in this type of commercial forage production will have to budget the input costs, especially the cost for the machines. The use of machines for the bio-fermentation increases amount, decreases cost, and increases quality of the treated crop residue or low-quality rangeland hay. The quality of the treated low-quality hay/straw, its acceptability by animals and shelf-life are better than the untreated low-quality hay/straw; and it forms a good feed for ruminant livestock including lactating animals. Bio-fermentation can be a practical and economic way to improve the feed efficiency of crop residues (e.g. rice straw) or low-quality hay (e.g rangeland grass hay) (Cheng *et al.,* 2025).

Table 20. Example of Bio fermentation of Rice Straw in Nepal (Normal rice straw is 140 KES/15 kg)

Source: Adapted from Abdul Sidiki, ILRI (2025).

Bio-fermentation is a good method to improve digestibility of crop residues; it raises ME from 5.5 to 9.24 MJ/kg DM but also the price per kg dry matter (DM) increases from KES 10.33 to KES 32.55. and the price per MJ of ME increases from KES 1.88 to 3.52. The protein price reduces from 517 to 412. The price increase needs to be offset against faster live weight gain, reducing the number of days of the finishing period which means the animal must be fed fewer days also

Nepal Scenario	Normal straw	Straw-lage	Silage
Selling price (KES/kg) = 'fed as is'	9.30	13.02	11.16
DM %	90	40	35
Price (KES/kg DM)	10.33	32.55	31.89
ME (MJ/kg DM)	5.50	9.24	9.00
Price (KES/MJ of ME)	1.88	3.52	3.54
CP (% kg DM)	2.00	7.90	8.00
Price (KES/kg CP)	517	412	399

reducing the changes of morbidity and mortality.

Crop residues

Crop residues such as maize stover, wheat, rice and grass straw, and rice husks are by-products of crop production. These residues are often used as supplemental feed, although their nutritional value is generally lower than that of cultivated fodder crops (Staines *et al.,* 2023). Proper storage and utilization of crop residues like maize stover and preserving feeds like sweet potato vines, cassava or fodder trees may prove better than feeding overgrown Napier grass (Wouters A.P. *et al.,* 1989). The two tables below, Table 21 and Table 22, show the food crops grown in the three counties that could yield crop residues to feed to livestock. In Isiolo county, the acreage under food crops in very small and there for crops residues will not contribute to the feed requirements of livestock. In Kajiado county Maize stover and Bean straw can contribute to feeds used for supplementing in the dry season while in Nakuru also the by-products of Sorghum, Finger millet, Sunflower and Rapeseed can contribute to the feed basket for supplemental feeding next to maize grain and pulses (beans, green grams, pigeon pea and cow peas).

Table 21. Acreage (ha) and production (Metric tonnes) of Maize, Beans, Green grams, Pigeon pea and Cow peas, which can contribute to crop residue in Isiolo, Kajiado and Nakuru counties

County	**Maize**		**Beans**		**Green grams**		**Pigeon Pea**		**Cow peas**	
	Acreag e	**Productio n**	**Acreag e**	**Productio n**	**Acreag e**	**Productio n**	**Acreag e**	**Productio n**	**Acreag e**	**Productio n**
	ha	**tonnes**	**Ha**	**tonnes**	**ha**	**tonnes**	**Ha**	**tonnes**	**ha**	**tonnes**
Isiolo	256	176	114	42	47	27			27	8
Kajiado	33,241	40,733	47,957	42,525	87	48	100	62	105	47
Nakuru	71,470	215,412	50,835	99,926	100	104	68	63	28	25

Table 22. Acreage (ha) and production (Metric tonnes) of Sorghum, Sweet potato, Finger millet, Sunflower and Canola, which can contribute to crop residue in Isiolo, Kajiado and Nakuru counties

County	**Sorghum**		**Sweet Potato**		**Finger Millet**		**Sunflower**		**Rapeseed (Canola)**	
	Acreage	**Production**	**Acreage**	**Production**	**Acreage**	**Production**	**Acreage**	**Production**	**Acreage**	**Production**
	ha	**tonnes**	**Ha**	**tonnes**	**ha**	**tonnes**	**Ha**	**tonnes**	**ha**	**Tonnes**
Isiolo	0	0	32	253						
Kajiado	2	2	27	88	15	15				
Nakuru	559	856	97	529	590	809	564	890	1192	4314

Source KNBS 2024

Further, a certain amount of crop residue must be left on the ground to ensure soil health. The amount of crop residue that must be left behind is somewhere between 50%-70%, depending on the type of crop, crop yield, topography, climate, soil type, soil management practices and other factors. Some farmers may find that leaving the entire residual amount in the field offers additional soil enrichment benefits as compared to using the crop residue as a feed for their livestock or to bale it and sell in in the commercial forage market. Farmers must also factor in crop rotation (some crop residues yield more biomass than others), delay in cultivating the land, erosion, decreased habitat for wildlife (especially birds), soil nutrient issues and the alternative uses of crop residue. (e.g. cooking fuel).

When using crop residues as feed for livestock, it is important to note that in Kenya, cereal residues, grass hay and dry pasture grasses are low in nutrients especially protein and high in fibre and therefore cannot support high levels of ruminant production. Many browse species are endowed with high levels of protein and hence suitable as supplements (Kaitho R.J., 1997).

Pellets

The growth and utilization of fodder is greatly influenced by seasons. When rains subside, forage turns yellow (senescence) containing less nutrients in the dry season. Yet, during the wet seasons forage grows vigorously, containing more nutrients to the extent that livestock cannot eat all of it during the wet seasons. To make full use of grass and pasture mixes grown in the wet season which cannot be fed fresh to livestock excess can, as mentioned before, be wilted and conserved as silage or dried and fed to livestock as hay or pellets. The processing involved for pellets is as follows; mowing, chopping, drying, solar drying, crushing and pelleting. During the pelleting a sticking agent (e.g. molasses) can be added. Compared to fresh grass or grass silage, grass or Lucerne pellets are convenient for storage and transportation. For example, in Taiwan, Napier grass is used to produce dehydrated grass pellets used as a supplementary livestock stock feed. In Kenya Lucerne pellets are more common, first imported but in recent years a few companies produce Lucerne and Napier grass pellets locally in small volumes.

Browse (leaf) meal

At least 75% of the trees and shrubs of Africa serve as browse plants and many of these are leguminous. Many browse species have been documented as useful animal fodders. Although not all browses are legumes, more than 200 species of leguminous trees are reported to be used for fodder, with most species tropical or sub-tropical in origin. The most used species come from the genera Acacia, Albizia, Calliandra, Desmanthus, Desmodium, Gliricidia, Leucaena, Prosopis and Sesbania (Kaitho R.J., 1997). For example, at the coast in Tanzania where Leucaena is invasive, leaf meal is harvested and traded to livestock farmers. The beneficial effect of feeding browses to the animal includes increased metabolizable energy intake, increased nitrogen intake, better animal performance and feed efficiency, improved palatability, increased availability of minerals and vitamins, improved rumen function and a laxative influence on the digestive system. An important added advantage is a lowered cost of feeding due to a reduced dependence on purchased energy and protein supplements. During the dry season or in times of drought, trees provide green feed (or browse meal which was dried and stored) that is rich in protein, minerals and vitamins while the herbaceous cover provides only poor-quality (grass) straw. However, tannins (phenolic compounds) are widespread, abundant and appear to be the major constraint of browses as forages because of their effect on intake, digestibility and animal metabolism; hence therefore also referred to as antinutritional factor. The tannins have beneficial attributes at moderate levels (e.g., effect on methane producing bacteria – Mwangi *et al.,* (2024)) and detrimental effect at high levels (e.g., interfere with reproduction). The optimum level of browse supplementation is 30 to 45% of the ration dry matter (Kaitho, 1997).

Compressed Feed Blocks

These include Molasses Urea Mineral Blocks (MUMBs), Compressed Complete Feed Blocks or Densified Total Mixed Ration Blocks (DTMRBs) (FAO 2012) based on Napier grass, Mexican sunflower or Browse leaf meal, mixed with locally available high quality agro-industrial by-products, such as cotton seed cake, molasses, Diatomite (feed grade) aflatoxin binder and/or mineral powder.

4.5.2 Methods of Fodder trade and transport

The methods of fodder trade vary with the type of feed. Different practices are adopted to determine the quantity of traded feed; both weighing and measurement by volume are practiced in the forage trade. Usually sale and purchase of rice, wheat, grass straw and grass or Lucerne hay and maize, sorghum and grass silage at the farm level are done on the basis volume (a bale). The quantity of the forage is determined as per the lot size, size and number of (small) bales or extended bag; and truck/ cart load. The method of weighing is also practiced where facilities are available.

All sorts of transport facilities are used to carry fodder of different volumes from one place to another. Various modes of transport used in fodder marketing are presented in the table below. The mode of transport depends on volume, distance and purpose of transportation.

Table 23. Modes of transport used in forage trade

Important modes of fodder transportation
* Carried by one or 2 people
*** Different types of 2 wheelers**
o bicycle
o motor cycle
* Different types of carts
o hand push cart
o donkey cart
o three-wheeler motor cycle

*** Tractor- trailer**
*** Trucks/ lorries**
o pick-up vans
o small trucks (5 Tonnes)
o big trucks (10-20 Tonnes)

Source: Creemers, Joe and Opinya, Felix, 2025

4.5.3 Agro-industrial by-products and conventional supplements

The main by-products suitable as ruminant livestock feed produced in Kenya are wheat bran, maize bran, maize germ, rice-bran, coconut meal and brewers' grain. The ruminants, however, must compete increasingly with the poultry, pig and fish sectors, and industrial activities like distilleries and biofuel. Imported oil seed meals such as sunflower seed meal, cotton seed meal, soya bean meal are also available as concentrate feeds. When sourced from the sugar industry in western Kenya, molasses is still a relatively inexpensive energy dense ration ingredient, but the establishment of distilling industries and use as a raw material for biofuel production is diverting molasses from animal feeding. At far distances from the sugar factories the prices in the field can be double to fivefold or diluted with water. Because of this the use of MUMBs manufacturing or in DTMRB's may in the foreseeable future not be feasible.

The largest feed categories in the market for commercial compound feeds are poultry and dairy of which around 70% is for poultry, while an estimated 20% is for dairy. The remaining animal feeds for fish, pigs, and other livestock categories are a very small proportion of the total (CAK 2025). The feed ingredients used to make commercial, and on-farm produced compound feeds are by-products of agro-processing plants. The most commonly use by-products are from processing of cereals (wheat, maize, rice and barley) as well as pulses and other seeds used for extracting oil (e.g soya bean, rapeseed, sunflower, cotton seed) (CAK 2025; Tegemeo 2022). Other by-products of plants originate from the sugar industry (molasses), and fruit processing (citrus pulp, pineapple peels) and horticulture waste (rejected fresh beans and sugar snaps). Animal by-products include blood, bones, meat and bone offal's, fat, intestine and rumen contents from slaughterhouses, whey from milk processors, tannery by-products, and poultry manure.

Feed manufacturers rely on by-products from the food agro-processing industries from domestic and neighbouring countries in the East Africa Community (EAC) or international markets. Maize, wheat, soya beans, sunflower and their products are the most dominant in the production of commercial compound feeds. Additionally, raw materials of vitamins, mineral premixes and other additives are imported (CAK 2025; Tegemeo 2022).

In high potential livestock farming areas, farmers who make use of dairy oriented intensive feeding systems, supplemental feeding with concentrate ration ingredients (including compound feeds) is further driven by milk production and common almost all year round, which is shown in Table 24 below for Nakuru County.

Table 24. Supplementation of concentrates on farms with dairy cattle in Nakuru county

Nakuru	**Commercial supplements**	**Non-commercial meal**
Feeding system	(tonnes)	(tonnes)
Intensive	43,927	35,940
Semi-intensive	9,250	1,632
Extensive	12	69

Source: Larive International 2020

A similar trend is already noticeable in the red meat sector where livestock (cattle and sheep) are kept in feedlots in (peri-) urban areas. When the feeding system (only grazing, grazing followed by fattening, feedlot) is adjusted and driven by performance level (live weight gain/day) the use of compound feed increases.

The main consumers of commercial, compound concentrates are livestock farmers whose livestock produces milk (dairy cows, goats and camels). The farm sizes vary for smallholders, medium and large-scale farms. Smallholder farmers because of limited financial and/or storage capacity buy commercial feeds on a weekly basis. In some towns ration concentrates, including commercial compound feeds are, repacked and sold by agrovets per kilogram. This practice was confirmed by some respondents in Isiolo county who bought compound concentrates for supplementation during prolonged periods of drought.

Medium and large-scale farmers often have more financial capability and storage facilities and can purchase large quantities of feeds, sometimes on a contract basis from feed millers. They can also buy agro-industrial by-products for on-farm ration formulation when they are abundant in the market at competitive prices and store them on farm.

The prices of different concentrate ration ingredients depend on the prices of raw materials in the domestic and international market. Unlike the forage market, the concentrate market is more organized and competitive, with a narrower quality range in feed ingredients. However unethical trading, diluting, mixing with cheaper feed ingredients, and feeds which are contaminated is a concern and frequently mentioned by respondents.

4.5.4 Feed quality and price formation in the forage market

The forage market can be segmented into forage for cattle, goat, sheep and camels. The demand from the cattle segment dominates the market in Kenya. Although cattle, in 2023 were no longer the largest in numbers (26% versus 41% sheep and 27% goats) they are, still a major source of end-use products such as milk and meat. Cattle require, due to their live weight and rumen capacity a substantial amount of the available forage. Quality forage helps to improve forage conversion and strengthens the immune system of animals. Therefore, to attain quality livestock products, farmers and trading companies need focus on quality forage. Based on this the market should, ideally be segmented into dry matter, metabolizable energy and protein. Nutrients are essential, as they play an important role in optimizing the growth and performance of livestock. Rather than implementing a mandatory analysis of feed quality a sector driven initiative by feed millers and commercial forage traders to measure weight and declare quality of the feed is preferable. The price mechanism currently observed in the forage market appears to be simple. Farmers either accept the prevailing volume-based market price of fodder, irrespective of the quality and weight, in the nearby location or region or negotiate the price assuming the prevailing market price as a reference. Urgency of demand, availability of fodder is considered while prices are determined.

Counties that have a deficit of fodder face critical shortage of livestock feed during periods of severe drought. Under such circumstances, the demand for livestock feed rises fast and many folds and hence price negotiations are driven by scarcity and urgency of demand this results in prices for grass hay and cereal straw and stover on the forage markets which are no longer cost effective in livestock feeding systems. The market situation during such periods may supplement income of commercial forage producers but when these dry fodders of low-quality are used for livestock production do not result in increased livestock production or profit.

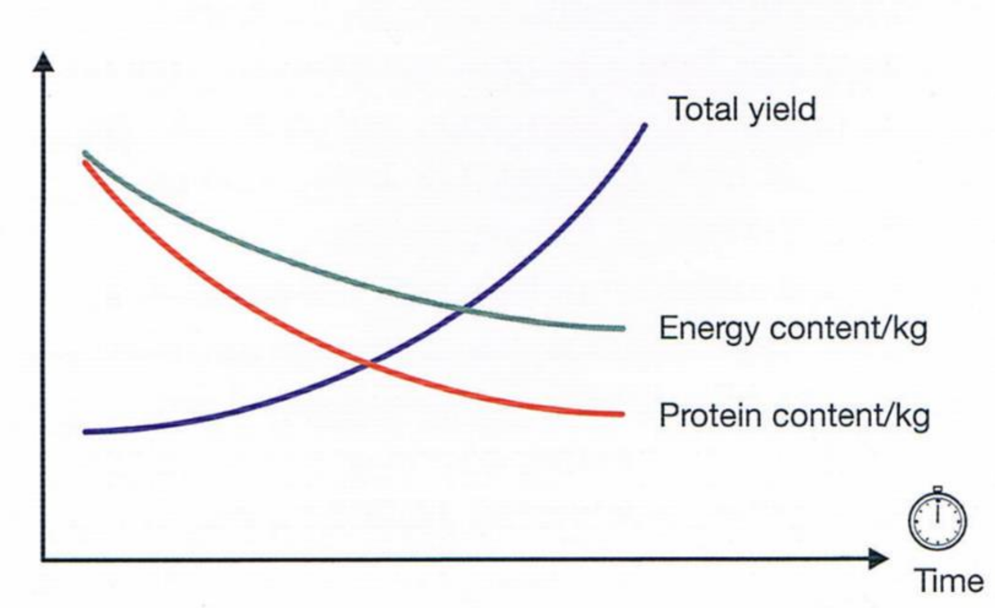
Currently a field assessment of the nutritional quality of fodder crops and conserved fodder in the market is the preferred method for livestock farmers to make decisions about where to graze and what and when to feed their livestock. Determining the quality of the available fodder needs to be followed by ration formulation to balance the ration (Rumen8, 2025) making use of supplemental fodder and/or concentrate ration ingredients. While laboratory analysis provides the most accurate data, several on-farm methods and visual cues can be used to make a preliminary assessment. However, for farmers in Kenya when buying commercial feed, the field performance is the key driver for repeated purchases (Feedtech *et al.,* 2024). Livestock farmers learn about feed quality by observing the animal response on the farm, farmer to farmer exchange and by word-of-mouth including radio, tv and videos on social media.

Visual field (on-farm) assessment (organoleptic observation)

This is a simple and practical method, relying on senses (sight, smell, and touch). It does not provide specific nutrient values but can be a good indicator of overall quality. Stage of maturity is the most important factor affecting forage quality.

Figure 8. Illustration that as grass matures Total (DM) yield increases and Energy (ME) and CP per kg dry matter drop

As grass matures, its nutritional value decreases. Early harvested forages (pre-bud or early head emergence) are more palatable and digestible, with higher protein and lower fibre content. As the grass ages, stems become coarser, and the proportion of components (stem versus leaves) that are difficult to digest (e.g cellulose) and indigestible (e.g. lignin) increase. This can be visually assessed by looking at the presence of flowers and seeds. Leaves on the other hand contain a high concentration of protein and other digestible nutrients to achieve a high-quality fodder when harvesting aims for a high leaf-to-stem ratio (See Figure 8 below). Leaves may crumble during hay making (e.g. especially important when harvesting leguminous crops like Lucerne, Desmodium, Lablab bean etc) and be lost in the field; which can significantly reduce the hay quality.



Source: CRV, (2011), Perdok H, (2019)

In the commercial forage market this phenomenon leads to contradicting interests. The forage producer, often the vendor wants high tonnage/ha and consequently produces low quality hay. While the livestock producer often the buyer wants high quality hay and consequently tonnage/ha drops, though more cuts per year are possible to close the yield gap.

Other visual assessment criteria for fresh fodder are a vibrant, dark, green colour indicating good nutrient supply from the soil and in case of hay, proper preservation and minimal nutrient loss. Brown, yellow, or faded colour can suggest sun bleaching, heating, or improper storage. A fresh, pleasant aroma is always a good sign. Hay should smell sweet and fresh whereas silage (including bio fermented feed) should have a fermented, slightly acidic (e.g. lactic acid), but not foul smell (e.g. butyric acid). A musty, mouldy, or "scorched" smell indicates spoilage, which can be harmful to livestock. The feel of the fodder gives clues about its fibre content and digestibility. Further the fodder needs to be absent of weeds, soil and dung, and other foreign materials.

The feedback from respondents was that they assessed the hay mostly of foreign material, woody material, stems in the hay and contamination. Pastoral livestock herders mentioned that when they purchase hay, mostly when other option of feeding their cattle are no longer feasible, the quality of hay in the forage market has severely deteriorated.

The ideal harvesting stage for tropical grasses is recommended by Roy *et al.,* (2025) at six(6) leaf stage to ensure a good quality feed for livestock while Snijders *et al.,* (2011) developed a model for Napier grass (L+1/H) which predicts digestibility in practice; where L is leaf content and H is the reverse of grass height (1/H) to predict digestibility (dOM) if leaf colour could be included that could probably make the model better but for older grass including dead leaf improves estimates (1/L+D+1/H).

Determining key nutritional parameters through laboratory testing

While laboratory capacity for feed testing in Kenya is still limited, testing facilities are available and a new technology using hand held NIRS scanners will bring feed testing closer to the farmers with a more affordable price tag. It is therefore essential to understand the parameters and interpret the results for day-to-day management decisions and ration formulation. Further advantage of laboratory feed test results is that the information is objective while the visual field assessment is subjective. The Box 2 below highlights key nutritional parameters for forage in laboratory test results.

Key nutritional parameters for forage in laboratory test results

Dry Matter (DM): The percentage of the fodder that is not water. All other nutrient analyses are typically reported on a dry matter (DM) basis to allow for comparison across different feeds.

Crude Protein (CP): An estimate of the total protein content, CP is higher in legumes and in younger, less mature forages.

Neutral Detergent Fiber (NDF): represents the total fibre in the plant cell wall (cellulose, hemicellulose, and lignin). NDF is negatively correlated with feed intake. The higher the NDF, the less an animal can consume.

Acid Detergent Fiber (ADF): A sub-fraction of NDF, composed mainly of cellulose and lignin. ADF is negatively correlated with digestibility. The higher the ADF, the less digestible the fodder.

Lignin: An indigestible component of the plant cell wall that increases with maturity. High lignin content directly reduces the digestibility of other fibre components.

Total Digestible Nutrients (TDN): A measure of the energy value of a feed, estimated from ADF.

Relative Feed Value (RFV) and Relative Forage Quality (RFQ): These are indices that combine NDF and ADF values to provide a single number for comparing the quality of different forages. They are useful for pricing and marketing hay.

Source: Rumen8, Undersander 201

4.5.5 Example of quality categories for tropical grasses and legumes

Evaluating forage in the commercial market is a process that goes beyond a visual inspection and assessment. It is a critical step for both buyers and vendors to determine the nutritional value, potential animal performance, and ultimately, the fair market price of the forage. Ultimately, the evaluation of forage in the commercial market is about translating its quality into a monetary value. The results from a (certified) forage lab provide the quantitative data needed for this. Buyers use this information to create a balanced, cost-effective ration to feed their ruminant livestock, while vendors use it to justify their price. For example, grass hay with low moisture content is more attractive than high moisture hay because the nutrients are contained in the dry matter. Hay with high moisture content is also more susceptible to mould growth and smouldering. High digestibility (low ADF and high OMD%), and high dry matter intake potential (low NDF%) relates to a high RFV (relative feeding value) – See explanation in Annex 9 - or high RFQ+CP (see Table 25, Table 26 and Graph 1 below). In a transparent functional forage market grass hay with high RFV or high RFQ+CP will command a premium price because it provides more nutrients and requires less supplementation. The price range in the domestic market of the USA for Lucerne hay ranges between 3,550 KES/MT to 63,990 KES/MT. With the prices common in the Kenyan market (25-35 KES/kg) for Lucerne hay the quality of a bale of hay should be at least in the Good (minus) to Good (plus) category. Lower quality should demand a lower price while better quality can demand a higher price. However, a price of 70-75 KES/kg Lucerne pellets would require at least a Premium (plus) quality category which is rare in the Kenyan market. The quality of grass hay needs to be in the Fair (minus) quality or above range. Based on samples taken by the authors, 75% of the grass hay samples was in the Poor (plus) to Extremely (poor) range. It is unlikely that livestock farmers can formulate cost-effective rations on such low-quality base feed at prices ranging between 10-27 KES/kg DM.

Table 25. Quality categories to evaluate the quality of grass hay in the forage market to determine cost effective prices

Quality Category	ME(ILRI)	Protein	ADF	NDF	OMD	DM	DMI	RFV	RFQ+CP
	MJ/Kg DM	%	%	%	%	%	%	index	index
Extremly Poor (minus)	6.0	<4	57.0	75.0	39.0	85.00	1.6	55	46
Extremly Poor (plus)	6.6	<4	56.0	72.0	43.0	85.00	1.7	58	52
Very Poor (minus)	7.1	4-6	55.0	70.5	47.0	85.00	1.7	61	58
Very Poor (plus)	7.3	4-6	54.0	69.0	48.5	85.00	1.7	63	63
Poor (minus)	7.5	6-10	53.0	67.5	50.0	85.00	1.8	66	66
Poor (plus)	7.7	6-10	52.0	65.0	51.5	85.00	1.8	69	75
Fair (minus)	7.9	10-12	51.0	62.5	53.0	85.00	1.9	73	80
Fair (plus)	8.1	10-12	50.0	61.0	54.5	85.00	2.0	76	86
Average (minus)	8.3	12-16	49.5	59.5	56.0	85.00	2.0	79	91
Average(plus)	8.6	12-16	47.5	57.0	58.0	85.00	2.1	85	103
Good (minus)	9.0	16-18	45.0	55.0	61.0	85.00	2.2	91	111
Good (plus)	9.4	16-18	42.5	52.5	64.0	85.00	2.3	99	123
Premium (minus)	9.8	>18	40.0	50.0	67.0	85.00	2.4	107	134
Premium (plus)	10.1	>18	37.5	47.5	69.0	85.00	2.5	117	145

Source: KEBS 2019, Undersander 2011, Adapted for HPI by Creemers J. 2025

Table 26. Quality categories to evaluate the quality of Legume hay in the forage market to determine cost effective prices

Quality Category	ME(ILRI)	Protein	ADF	NDF	OMD	DM	DMI	RFV	RFQ+CP
	MJ/Kg DM	%	%	%	%	%	%	index	index
Fair (minus)	8.5	14.0	36.0	45.0	57.1	83.50	2.7	126	125
Fair (plus)	8.5	15.0	35.5	44.5	57.6	83.50	2.7	128	129
Average (minus)	8.6	16.0	35.0	44.0	58.1	83.50	2.7	130	134
Average (plus)	8.8	17.0	32.0	40.0	59.2	83.50	3.0	149	151
Good (minus)	8.9	18.0	31.0	38.7	60.2	83.50	3.1	156	160
Good (plus)	9.0	20.0	29.5	36.7	61.2	83.50	3.3	167	175
Premium (minus)	9.1	21.0	29.0	36.2	61.7	83.50	3.3	170	181
Premium (plus)	9.2	22.0	27.2	34.0	62.3	83.50	3.5	185	197
Supreme (minus)	9.3	23.0	26.8	33.4	62.8	83.50	3.6	189	204
Supreme (plus)	9.3	24.0	26.0	32.4	63.3	83.50	3.7	197	214

Source: KEBS 2019, Undersander 2011, Adapted for HPI by Creemers J. 2025

The Graph 1 below further illustrates the relationship between Relative Feed Quality (corrected for Crude Protein) and Margin Above Feed Cost (MAFC).

Relation between Relative Feed Quality (corrected for Crude Protein) and Margin Above Feed Cost (MAFC) is Feed cost of grass, varying between 1-6 KES/kg 'As Fed'. Simulation: Grass with different Relative Feed Quality (corrected for CP) and related (DM, ME, CP, NDF) from a bigger database is used to feed to 450 kg crossbred cow, 140 days in milk (no liveweight change), 57 days pregnant, milk with 4.15% Fat and 3.15% True protein DMI estimated from NDF intake of 1.4% of body weight. Milk yield varies between 0 and 10L per day if fed grass only and Milk price 45 KES/L.

Graph 1. Relation between Relative Feed Quality (corrected for Crude Protein) and Margin Above Feed Cost (MAFC)

Relative Feed Quality (corrected for Crude Protein) (RFQ-CP) of tropical grasses needs to have at least and index above 100 and cost of production should not exceed 4 KES/kg 'As Fed' for farmers to achieve positive Margin Above Feed Cost. An RFQ-CP index below 90 irrespective cost of production is too low for dairy farmers to achieve a positive Margin Above Feed Cost (MAFC).

4.5.6 Market: Demand and supply versus quality awareness and sensitivity

Supply of information plays a critical role in forage marketing. Different actors (vendors, buyers, traders) in the forage market use different modes of communication to elicit information and contact their counterparts. Three types of communication are in practice. Mobile phones are an important mode of sharing information followed by verbal communication but social media and applications/apps on mobile phones appear to play an increasingly influential role. The role of efficient mode of communication is relatively critical when fodder scarcity becomes evident for the livestock feed traders or agents. While forage, for smallholder farmers is generally marketed through agrovets, during periods of scarcity bales of hay or extended bags of grass and crop residues are sold directly from trucks situated at strategic places near town centres or livestock markets.

The pattern of fodder movement that has emerged over time is that Narok, Nakuru, Uasin Gishu, Trans Nzoia. Laikipia counties and sometimes Meru County which at times have a relative (seasonal) fodder surplus are the main supply areas for hay, straw and silage to Isiolo and Kajiado counties.

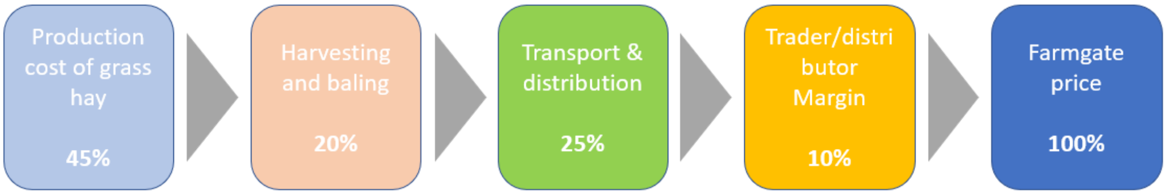
In Isinya, Kajiado county, some farmers joined hands to form the Hay Producer's Association which has the aim to provide agricultural mechanization contracting services to its members and other farmers related to hay production e.g. planting, mowing tedding and baling. In Bisil, Kajiado County, a large-scale hay producer with a storage capacity of more than 75,000 bales of hay has been supplying livestock farmers in the area for many years. However, the availability and reliability of agricultural mechanization contracting services for hay production in Kajiado is still scarce and often the equipment (e.g. tractor, tedder and baler), must be transported over long distances and sometimes breakdown during operation. As a result, planning (timing of the harvest), meaning mowing of the grass at the optimum maturity stage is difficult.

This said, utilization of fodder for supplemental feeding has numerous benefits for livestock farmers in Kenya. By providing a consistent feed supply, farmers can maintain and improve livestock productivity, even during adverse climatic conditions. Supplemental feeding intended to enhance the nutritional intake of livestock, leads to better health and higher yields of milk and meat.

Feeding systems in the rangelands is mainly rangeland-based but can be mixed, rangeland-based with supplementation of hay, crop residues and/or concentrate-based feeding systems, based on commercial compound feeds use or on-farm formulated mixes (e.g. Molasses-Urea Mix or MUMB's or single source concentrates'). Hay production appears to be a flagship project under drought risk reduction and climate change adaptation programs in pastoral livestock systems in Kenya (Kimaru *et al.,* 2021), but cost of production and quality of the hay when fed needs to be closely monitored. For example, hay production in Isiolo is most successfully practiced in Kinna ward in Garba Tulla Sub County which could reduce the price of hay for livestock farmers in the vicinity because of lower transport costs. In Kajiado county this could apply to hay, which is produced in Kajiado East, South, North and Central. Growing and storing hay is most cost-effective if produced by livestock farmers themselves or in the vicinity however, Auma *et al.,* (2019) report the inability of many farmers in the ASAL's to establish and preserve enough fodder for their livestock on-farm as a catalyser for the emergence of a commercial fodder sector in Kenya. Out of a group of 354 pastoralists only 6% grew grass to produce hay for their own farm use or commercially. Most pastoralists preferred buying hay rather than growing grass to produce their own hay (Kimaru 2021b).

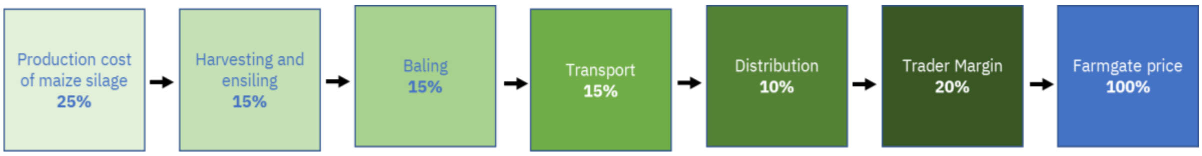
The results of our Rapid Appraisal (RA) show a distinct pattern of livestock feeding which is by and large common in all parts of the three counties. Declining rangelands, restricted entries in reserve forest (WWF in Kajiado, IDH in Nakuru) as well as the fact that the reduced area of common land resources are forcing the livestock farmers to shift from grazing to stall feeding according to some respondents, wherein a significant proportion of feed requirement is met by cultivated and preserved forage or feeds from the commercial feed market (e.g. fodder or concentrates). Lactating cows, goats and camels receive greater attention, and the bulk of available green fodder and concentrates are fed to them only. Bulls and dry animals and other livestock usually get dry fodder with some residual green fodder and concentrate. Although hay production has been receiving a lot of attention since 2016 through a project called the Hay Production Platform, 86% of livestock keepers buy hay only when their animals start dying at the severest period of the drought. Hay buying mainly occurs in drought years, and averagely for three months only (Kimaru *et al.,* 2021).

Figure 9. Composition of market price for grass hay



The demand for fodder is very much seasonal and next to this is that the forage market in Kenya is informal, not transparent and opportunistic because in the dry season and during periods of drought prices can easily double or triple. The most frequent reasons mentioned by different market actors for not engaging in feed trading is limited demand for feed outside the dry seasons, the high transportation costs due to the distant source of feed and poor road network, as well as lack of appropriate storage at local level. Transport cost estimates for hay are around KES 4/kg and for baled maize silage KES 2/kg. The difference is caused by the weight and density (kg/m³) of the baled silage. For concentrates for distances up to 50 km, transportation costs are typically included in the feed price. However, for distances beyond 50 km, additional fees apply, ranging from around KES 100-150 per 50kg bag per 100 km which is KES 2-3/kg extra. This variation in farm gate prices illustrated in the Figure 9 for grass hay and Figure 10 for maize silage.

Figure 9. Composition of market price for maize silage



Forage and concentrate for supplementation in the three counties face several constraints. Difficult storage and lack of appropriate, strategic, storage facilities seriously affect all year-round availability. Most of the marketable surplus of fodder (hay, cereal straw and silage) is generated by medium to large scale forage producers/farmers (Kimaru 2021a). Smallholder farmers and pastoral livestock farmers are the majority in the three counties, but they have limited storage capacity (see Picture 6). Due to difficulties in storage of conserved forages, and pre-financing stored fodder, some forage producers are forced to sell hay or silage immediately after harvesting or they resort to not harvest the excess biomass. It is also observed that even if it is stored a large proportion of fodder gets spoiled or destroyed due to improper storage facilities.

Unethical trading is another constraint which is regularly mentioned by respondents. The dependency and unawareness of hay producers (vendors) and hay users (buyers) are frequently misused by some agricultural contracting service providers and traders, for example to bale and/or re-sell bales lower weight to volume ratio is used (e.g. making 2 bales out of one, reducing the bale size below 15 kg etc.) because payments are demanded per bale (e.g. when baling or transporting the cost are calculated by the service provider per bale) rather than weight. Hence the smaller/lighter the bales the more costly it is for the producer and eventually the consumer/buyer.

Picture 6. A haybarn with Rhodes grass hay in Kajiado county

Some farmers who own livestock store fodder for their own use. The quantity of fodder stored varies in accordance with the number of livestock, storage capacity and space with the livestock farmers. Keeping these factors in mind, fodder producers who also own livestock store 20 to 100 percent of fodder produced at the farm. Commercial dairy farms and non-commercial milk producers in Nakuru county are the ultimate purchasers of fodder and concentrate and store a significant amount of fodder to meet their day-to-day requirement. Livestock farmers in the rangeland however do not store a significant amount of hay or silage. For storage, different types of practices are adopted, and different types of storage practices are used. Depending on the construction costs, this can vary from a simple tarpaulin to warehouse type of barn, effective storage capacity and movement of hay stock in and out the hay barn, the storage costs may vary between 1-10 KES/ 15kg bale.

4.6 Support services & legislation

The primary objective by the government of Kenya is to promote investment in the livestock sector, to ensure improved livelihoods, domestic self-sufficiency of animals sourced protein and targeting the export market for live animals, milk and meat. Government efforts, supported by livestock development organisations include provision of infrastructure, construction of cattle dips, livestock markets, sinking bore holes.

Mohamed *et al.,* (2020) and Mutuku *et al.,* (2023) found that pastoralists' decisions to purchase fodder are significantly influenced by access to credit, weather and market agreements, market distance, market information, land tenure system, exposure to shocks, off-farm income, age, experience, gender and proximity to towns. The amount of fodder purchased was significantly affected by access to weather information, exposure to shocks and livestock holdings. These results as presented may underscore the importance of improving pastoralists' access to pre-requisite institutional support services to enhance their access to fodder and livestock markets, basic services and increased integration into the broader market economy. However, prices of the feed and fodder market are not cost-effective in their livestock farming system, in other words, if they do not experience the physical evidence of improved animals' performance, it is unlikely this will boost the feed and forage market in the rangelands and increase supplemental feeding.

Support services need to extend to quality control of manufactured compound feed and concentrates and introduction of a price/quality mechanism. Most of the traders and consumers of commercial feeds feel that there should be a mechanism to ensure quality of manufactured feed and nutritional supplements. Some of the feed millers' express concerns that prices of raw materials escalate day by day, several millers/manufacturers feel. This forces them to use cheaper substitutes or even use inferior material. Effective technology for quality monitoring of manufactured feed along with private sector driven initiatives to declare the quality of the compound feed and single source feed ingredients is a prerequisite to transform the feed and forage market. The existing national feed strategy, the County Livestock Feed Strategy in Kajiado and the feed standards developed by KEBS do support such developments, but without budget allocation, implementation and enforcing market transformation is challenging. Hence the authors advocate a private sector lead approach.

Policies and land-use regulations often fail to recognize or support the principles of pastoralism, creating further challenges.

4.7 Technical know-how, gaps and utilization of forages

Despite the extensive traditional knowledge, pastoralist farming systems are under increasing pressure from climate change, land-use changes, and socio-economic shifts. This has created several critical knowledge gaps and challenges. The transmission of traditional knowledge from older to younger generations is being disrupted by social-cultural changes, formal schooling, urbanization, technology and a shift towards market economies. This leads to a loss of vital knowledge about vegetation, grazing strategies, and environmental indicators. For example, traditional methods of conserving pasture, such as designating specific areas as "fodder banks" or reserving certain rangelands for critical periods.

While pastoralists have deep traditional knowledge, there is often a disconnect with modern scientific and technical knowledge. Research on forages and rangeland management has not always been effectively tailored to or shared with pastoralist communities. This creates a gap in areas such as the potential of harvesting grass seed to rehabilitate rangelands, improved forage varieties which are drought-tolerant, more nutritious forage legumes and grasses, irrigation to support forage production, and cost-effective supplemental feeding. Creating awareness on these topics is a much needed first step while gradual adoption and integration of these technologies into pastoral farming systems is overlooked, done with little consideration or poorly implemented. While pastoralists have their own methods, modern tools like mobile smart phones, satellite imagery and remote sensing can provide comprehensive data on rangeland health and forage availability, but this information is not always accessible or understandable to them. Some respondents reported, however that weather applications and early warning systems on mobile (smart) phones did provide valuable information.

Other than knowledge or technology, they may also lack the resources, such as access to supplementary feeds, veterinary services, or legal support, to manage their herds effectively during periods of drought. Furthermore, the expansion of agriculture (like in Kajiado county), urbanization, and resource extraction is leading to a reduction in grazing lands and restricting the mobility of pastoralist herds. This limits their ability to access seasonally available range pastures of good quality, traditionally a core strategy for their livelihood.

A significant gap exists in understanding and quantifying the precise balance between livestock demand and available forage supply in the rangelands given the climatic changes over the years. Overgrazing, a major cause of rangeland degradation, often stems from this imbalance and while traditional knowledge guides stocking rates, more precise scientific data is needed to sustainably manage rangelands in this changing environment together with an understanding how to fit in commercially available feed and forage in the livestock farming system of the pastoral economy.

To ensure the long-term sustainability of pastoralism, it is crucial to bridge the gap between traditional and modern knowledge. This can be done by engaging pastoralist communities in research that combines and links their traditional knowledge with research findings. Transfer knowledge by developing culturally appropriate and accessible ways to share information on weather forecasts, improved forage varieties, rangeland management techniques, forage cultivation, agronomy and preservation techniques and ration formulation for more intensive feeding systems (feedlot, zero grazing) in (peri) urban areas.

At the same time providing access to services such as mobile agrovets, veterinary services, water points, transparent market systems and market information to improve the resilience of pastoralist livelihoods.

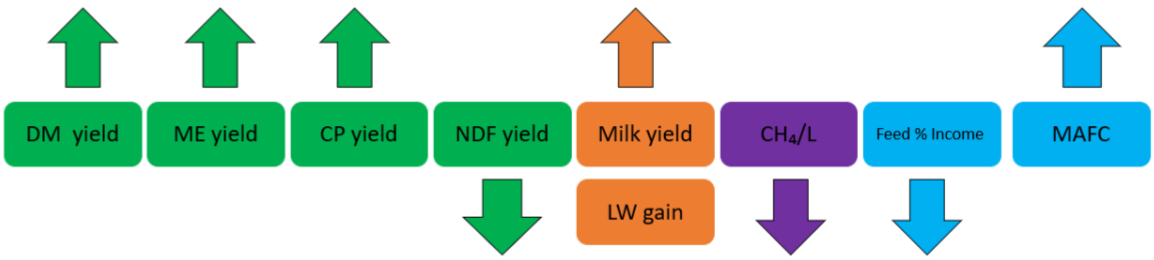
This integration of knowledge and accessible services will go a long way if policies that secure land tenure for pastoralists, protect their migratory corridors, and support their traditional governance structures are implemented.

4.7.1 Feeding balanced rations

Intake of poor-quality pasture grasses and cereal straws by ruminants is usually low and the nutrients left in these roughages is not enough to maintain bodyweight because of their high fibre content, poor digestibility and nutrient deficiency, all contributing to the low level of consumption. These roughages are deficient in readily available energy and nitrogen, which reduces the efficiency with which animals utilize them. Most of these deficiencies can be corrected by supplementation with high density feeds such as oil seedcakes. However, protein sources such as oil seed cakes and those of animal origin are produced in limited quantities in Kenya and are often beyond the financial reach of most livestock farmers in ASALs'. Making use of ration formulation (Rumen8 Download) allows livestock farmers to incorporate any feedstuff and relate their nutritional profile and quality to cost of production or market price and thus predict if a feeding strategy will be cost effective against income from milk or live weight gain (see Figure 11 below). By carefully selecting and combining ration ingredients, rations can be formulated to provide a balanced diet that meets the animals' specific needs for maintenance and production (e.g., milk, meat). This is particularly important when traditional grazing resources are scarce or of low quality. Properly formulated rations can improve feed efficiency, leading to faster growth rates and higher productivity per animal.

Livestock diets can be exclusively forage or largely forage with concentrate supplementation. Concentrate supplementation is used to compensate for nutritional deficiencies or increase animal performance such as growth per day or milk production (Figure 11). The scarcity and instability of these fodder resources, coupled with other factors such as manpower, financial resources, socio-cultural characteristics, etc., have led to a change in feeding systems. To cover the nutritional needs of their livestock or address market demand of livestock products such as milk and meat, a new livestock feeding system in ASAL counties has emerged, namely the (peri) urban livestock feeding system. Examples include Kajiado Masai Women Dairy Cooperative, Windy Ridge Youth group and Women members of the Queen of Peace Initiative

Figure 10. Linking feed and livestock production with higher income and lower methane intensity



Domestic animals utilize trees and shrubs (such as *Acacia tortilis* and its pods) both as browse and "cut and carried" branches in the stall. On rangelands animals have the advantage of selecting from a wide range of choices of browse and obtaining a high-quality feed. A few of the browses such as Tagasaste (*Chamaecytisus palmensis)*, Gliricidia (*Gliricidia sepium)* and Sesbania *Sesbania species* have adequate levels of Rumen Degradable Protein (RDP) and Intestine Degradable Protein (IDP). Browse species with high IDP such as *Calliandra calothyrsus* could be fed mixed with browses with high RDP and low IDP.

4.8 Environmentally Sustainable Forage Production

The economic cost of land and environmental degradation in Kenya, is estimated at USD 390 million or 3% of the national GDP annually. This does not account for the hidden costs of rehabilitation, loss of biodiversity, and the degradation of unique landscapes. Environmental degradation has far-reaching consequences, including reduced productivity, food insecurity, insufficient water supply, drying up of rivers, and regular loss of livestock. Producing forage sustainably in ASALs is a challenge due to the inherent water scarcity, high temperatures, and fragile ecosystems. However, it is also essential to support livestock production and the livelihoods of millions of people. Sustainable forage production in these environments focuses on practices that maximize productivity while minimizing environmental impact and building resilience to climate variability.

4.8.1 Restoration of rangelands

This involves selecting and promoting the use of drought tolerant forage species that are naturally adapted to low rainfall and high temperatures, such as native grasses, legumes, rangeland shrubs (e.g. *Acacia tortilis*), and drought tolerant forage crops like forage sorghum, forage pearl millet. Further involves establishing "fodder banks" by planting high-yielding perennial forages (e.g African Foxtail, Maasai love grass) in fenced-off areas to be used during dry periods (fodder storage). Developing better methods, including scaled mechanisation for conserving hay, haylage or silage from surplus forage to be used as a buffer during dry spells such that the costs do not exceed cost effectiveness in livestock farming systems in ASALs'. It also entails piloting and developing range mixtures of grasses, legumes, forage herbs (and fodder trees) to ensure a supply of feed even if one type of forage fails due to climatic stress. Browses, for example, serve functions beyond just providing feed. In many situations, they form part of complex interactions between soil, plants and animals. They help to balance the plant-animal soil ecosystem. The foliage of some are used as vegetables by humans while the roots, bark or stem and leaves of others are used for medicinal purposes. In ruminant nutrition, they provide rumen degradable nitrogen and/or bypass nitrogen, digestible energy and minerals when used as either supplements or as sole feed.

4.8.2 Water-Use efficiency

This involves implementing techniques to capture and store rainwater i) contour bunds and terraces - these are structures dug along land contours to slow down runoff, increase water infiltration, and reduce soil erosion combined with range grass seeds they can turn into 'fodder banks. ii) micro-catchments – are small depressions or basins around individual trees or shrubs to collect and concentrate water and allow it to infiltrate. ii) small barriers in gullies or ephemeral streams to slow water flow and encourage sedimentation, creating fertile areas for forage growth. iv) use spate irrigation. V) where irrigation is possible, using methods like drip irrigation, which delivers water directly to the plant roots, minimizing evaporation and maximizing water use. This water harvesting and management innovations also reduce loss of forage (grass) seeds by wind and increased fodder productivity.

4.8.3 Soil health management

The degradation process in the rangelands starts at the soil level, often unseen, leading to a loss of soil structure and aggregation, increased compaction, reduced soil pore space, and diminished microbial activity. This ultimately results in a loss of soil nutrients and fertility, which directly impacts forage production and quality of vegetation in the rangelands for livestock. This will require some form of tillage manual or mechanical to allow water to infiltrate before reseeding will be effective. In areas where cultivation of forages is feasible using no-till or minimum-tillage farming practices to preserve soil structure, retain moisture, and protect soil organic matter from oxidation is recommended.

In areas where cultivation of forages is feasible, managing soil health entails using no-till or minimum-tillage farming practices to preserve soil structure, retain moisture, and protect soil organic matter from oxidation. Also, incorporating crop residues, compost, and animal manure to improve soil fertility, water retention, and microbial activity. Mulching with plant material helps to reduce water evaporation from the soil surface while utilizing vegetative barriers, cover crops, and rotational grazing to protect the soil from wind and water erosion, which is a major problem in ASALs, are effective strategies to maintain and improve soil health.

4.8.4 Biodiversity and ecosystem services

The biodiversity and ecosystem services promote the health of natural rangelands by using sustainable grazing practices and native range pastures for reseeding and restauration of rangelands. This involves cultivating, harvesting range grass seeds, avoid overgrazing, which can lead to the loss of palatable species such as Guinea grass (*Megathyrsus maximus*) and the proliferation of invasive species. Integration of agroforestry systems is highly effective in ASALs. Woody species used by ruminant livestock for browsing can provide nutritious forage, especially during dry seasons (e.g., browse from Leucaena, *Acacia sp*), while also offering shade, reducing wind erosion, and improving soil fertility through nitrogen fixation. Furthermore, ensuring a diversity of plants to support local pollinators and wildlife, which are essential for a healthy ecosystem in the rangelands and can provide additional income (honey, tourism etc).

4.8.5 Heat Stress and its Physiological and Productive Impacts

Livestock in semi-arid regions are frequently exposed to severe environmental stresses, particularly intense heat and feed scarcity. Heat stress is a complex, systemic disorder that profoundly affects every part of a ruminant's body, compromising its welfare and productivity. A primary physiological response to heat stress is an increase in thermoregulation, which demands a significant amount of energy. This elevated maintenance energy demand diverts energy that would otherwise be allocated to productive functions such as growth, reproduction, or milk production leading to a direct reduction in output. Animals under heat stress typically exhibit decreased physical activity, reduced feed consumption, and less rumination, while concurrently increasing water consumption, sweating, and panting to dissipate excess body heat.

4.8.6 Breed selection and genetic improvement for resilient livestock farming in ASALs'

Working with or choosing livestock breeds that are inherently adapted to arid and semi-arid environments is critical to ensure their survival and productivity under challenging climatic conditions. Livestock adapt to extreme conditions through a combination of behavioural responses (e.g., seeking shade, altering feeding and drinking frequency), morphological characteristics (e.g., body size and shape, hair coat properties, skin pigmentation, sweat gland density, limb structure), physiological adjustments (e.g., increased respiration and sweating rates, reduced metabolic rate, altered endocrine function), and underlying genetic bases. Through breeding and cross breeding livestock farming systems can reduce reliance on external inputs (such as supplemental feed). This allows for the development of livestock herds that are intrinsically better suited to the harsh and changing ASAL environment, representing a long-term, sustainable strategy that complements feed interventions.

4.8.7 Community and social engagement

This involves creating awareness and consequently involving pastoralist communities in the planning and implementation of sustainable forage producing projects. This ensures that traditional knowledge and local needs are respected and integrated into solutions that serve their livelihoods and improved livestock farming systems in the rangelands. This needs to go along with providing training to farmers and pastoralists followed by a coaching trajectory on improved forage production techniques, such as proper seed selection, planting, harvesting and preservation methods and sustainable grazing management.

4.8.8 Forage quality and reduction of methane emission intensity

During ruminant digestion microbial communities in the gut produce (waste) methane, with livestock in the tropics producing significantly more emissions per unit of meat or milk than livestock in temperate regions. Livestock in Isiolo, Kajiado and parts of Nakuru counties are likely to be fed on low quality forages with higher fibre content (materials such as straw of cereal and pulse residues or grazing on range pastures throughout the year). Such material can have low digestibility and nutritional value, meaning livestock would have to eat more to achieve the same weight gain or produce the same amount of milk. However, their feed intake is limited because of live weight, rumen capacity, and passage time of the low-quality forage through the rumen resulting in not enough feed intake to produce that amount or achieve the weight gain. The lower the fibre content in the ration (within acceptable ranges to ensure rumen health) the lower the production of enteric methane by microbial communities in the gut (see Table 16 comparison of Brachiaria grass at different cutting stages). In addition, certain plants can cause a lower level of methane to be produced, due to the presence of 'anti-methanogenic' compounds. Anti-methanogenic compounds broadly work in two ways: i) they can directly affect the workings of methane-producing bacteria in the gut, or ii) they can alter the environment of the gut itself. But the forages containing anti-methanogenic compounds should be productive and easy to grow while when incorporated into the ration of livestock, the forages do not result in lower live weight gain and/or milk production. Otherwise, livestock farmers will find it is not cost-effective to include them in the ration (see Figure 12 below). However, more research is needed to identify or develop best options. The use of tannin-rich feed in animal diets requires great care, due to its possible detrimental effects on animal performance and induction of metabolic disorders. Although promising, the results of studies on the effects of tannins on animal performance and quality of their products are still controversial, probably depending on type and chemical structure of tannins, amount ingested, composition of diet, and species of animal (Jerónimo *et al.,* 2016).

Figure 11. Relation of quality forage production, feed efficiency and reduction of enteric methane emission intensity

Source Creemers et al., 2019

4.8.9 Carbon sequestration

A particularly significant benefit of restored rangelands and adapted grazing practices is its potential to enhance carbon sequestration in grasslands. Adapted grazing practices (described by respondents as holistic grazing, regenerative grazing, rotational grazing or rapid grazing) is not just a technique to prevent overgrazing but a grazing strategy that actively contributes to ecosystem restoration and climate change mitigation. The potential for carbon sequestration is partly due to the numerous ecological benefits associated with better rangeland management, such as improved soil health and water retention. It therefore offers a "multiple-win" scenario, simultaneously improving environmental health benefiting wildlife, enhancing soil health & fertility, and boosting livelihoods through livestock productivity.

CHAPTER FIVE: CONCLUSION, OPPORTUNITIES AND RECOMMENDATIONS

Livestock production in ASALs is inherently challenging, with a multitude of interconnected factors impeding animal health, productivity, and the livelihoods of dependent communities. These challenges are primarily driven by the harsh climatic conditions and are exacerbated by the ongoing impacts of climate change.

When a severe, long period of drought occurs, the loss of livestock (a live asset in pastoralist communities) can lead to a collapse of their livelihood and have severe, long-term impacts. During such periods, milk production drastically reduces, the market value of livestock plummets, birth rates decline, and mortality rates soar (see Box 1).

This means that effective interventions must be integrated, addressing the interconnectedness of environmental, animal, and socio-economic factors. A focus solely on fodder supplementation, for instance, without considering quality of the fodder, cost of the fodder, water access or rangeland health, will not yield optimal results if any. Remember that the feed balance (Table 3) showed not only a dry matter gap but also a gap in energy (ME) and protein (CP).

The effectiveness of innovations in fodder supplementation, for example bio-fermentation of grass straw from range pastures (Table 27), is amplified/more beneficial when integrated with sustainable rangeland practices and advanced water management. Strategic water point distribution and adapted grazing practices, for instance, not only conserve resources but also influence grazing patterns, prevent degradation, and enhance carbon sequestration, turning rangelands into active climate solutions. A summary of key environmental characteristics and challenges affecting forage production potential for livestock farming in ASALs' is shown in Table 28.

Table 27. Innovative use of grass straw from range pastures for improved livestock production

Cost Benefit Analysis of range pasture with bio fermentation of grass straw		
Annual yield and income comparison for a 1-acre field		
	Grass species	
Activity	African Foxtail	Maasai Love grass
Land Preparation	6,000	5,000
Seed purchase (1,500 KES/kg)	6,000	6,000
Labour for planting	1,500	1,500
Labour for weeding	1,500	1,500
Crop protection	0	0
Fertilizer/manure	0	0
Harvesting	0	0
Post Harvesting	0	0
Hay cutting, baling, handling (KES120/bale)	24,000	30,000
Seed harvesting	7,500	7,500
Gunny bags (90kg)	1,500	1,500
Total input costs	48,000	53,000
Produce	0	0
Seeds in kg/acre	35	50
Grass straw in bales of 15 kg	200	250
Seed sale (1,150 KES/kg)	40,250	57,500
Grass straw sale (140 KES/bale)	28,000	35,000
Total sales	68,250	92,500
Total income (KES) (total sales – total input costs)	20,250	39,500
Benefit Analyses of bio fermentation (Table 20)		
ME yield before Bio fermentation MJ/acre	14,025	17,531
CP yield before Bio fermentation kg CP/acre	51	64
ME yield after Bio fermentation MJ/acre	23,562	29,453
CP yield after Bio fermentation kg CP/acre	201	252
Total input costs for bio-fermentation (40% of sales price)	35,100	43,680
Strawlage sale (650 KES/50kg bale)	87,750	109,200

Total sales	128,000	166,700
Total income (KES) (total sales – total input costs)	**44,900**	**70,020**

Source: Adapted from MetaMeta - Kadenyi et al., 2019

When grass straw is valued as a crop residue such as wheat straw, rice straw or maize stover it can make economic sense to bio ferment the straw to increase digestibility for livestock. It would require water availability, extra labour and inputs for ensiling which are estimated to be 40% of the sales price of a bale of straw-lage. The process has the potential to generate employment, increase total income for range pasture production and improve livestock production beyond merely maintenance.

Table 28. Summary of key environmental characteristics and challenges affecting forage production potential for livestock farming in ASALs

Characteristic/Challenge	Description & Impact on Livestock farming
Low and erratic rainfall	Less than 650 mm annually; unpredictable patterns. Leads to severe water scarcity and reduced forage availability.
High temperatures and solar radiation	Frequent heatwaves and intense solar radiation. Causes heat stress in livestock, increasing maintenance energy demands and reducing productivity.
Poor soil health and fertility	Sandy/rocky soils with low water retention; marginal, bare, and vulnerable to erosion. Leads to reduced soil fertility, lower forage production, and poor nutrient cycling.
Frequent (re-occurring) droughts	Prolonged dry spells. Results in pasture/water scarcity, declining body condition of livestock, reduced milk production, lower birth rates, and increased mortality.
Rangeland degradation	Overgrazing combined with climatic hazards. Leads to reduced forage quantity/quality, shift to invasive species often plant species with low nutritional value, and compromised soil health.
Water quantity and quality	Reduces water and feed consumption, impacting animal health and performance. High concentrations of minerals (saline water), nitrogen, bacterial contamination, toxic algae.

Source: authors

5.1 Summary of SWOT analysis for the forage and forage seed value chain

The table below provides a summary of strengths, weaknesses, opportunities and strengths of the forage (seed) value chain as drawn from literature and our field findings.

Strength	Weakness
Inputs supply for forage production is generally good as most of the supplies that are required are also needed in the production of food crops. (Note that subsidized input programs such as fertilizer do not apply to acreage under forage production this may farmers to diverted to dual purpose food/feed crops).	There is a knowledge and skills gap around forage production. Generally, the perception, awareness and knowledge base on cost-effective forage production requires a fast-forward update from the more traditional approach of 'forage sourcing' (e.g in rangelands livestock producers consider NO grazing cost, in the forage market no price/quality price mechanism exists).
Youth and women population in the ASAL population presents opportunity start Agricultural Contracting Services. The agricultural sector, forage production on the forefront opens employment opportunities for the youth as farmers or agri-preneurs. Preferably linked to a coaching trajectory and based on the merit of cost-effective livestock production systems. Targeting youth and women groups with training,	The existing knowledge base with local and international research institutes is not effectively used or trickling down to farmer level (e.g. forage seeds, information on cost effective forage production, ration formulation, breed -feed interaction, mechanisation at scale solutions etc).

enterprise support, and value chain roles can drive inclusive sectoral growth.	
The livestock population has the potential to increase production if more and better forage quality can be made available, both in the rangelands (more grassland) and in the intensive production systems.	The variety of forage resources, available in the rangelands, gene banks and with research institutes as well as variety of forage resources outside the country which could address forage seed shortage and (bio) diversity of forage seeds in the market is underutilized.
High quality fodder produced as cost-effective prices or brought into the market at for the livestock farmer cost effective prices have high potential return.	Weak extension service (FAO recommendation 1 extension staff:400 farmers). A model of farmer coaching, guiding the farmer how to filter the wealth of information is non-existing. The weak extension services are taken over by social media, printed media, TV and radio stations where agricultural information is shared, (sometimes 'paid for' information) which at times ranges from incomplete to far from accurate.
Land is available in large tracts, some which are underutilized, can make production of quality and cost-effective production of forage possible, coupled with best agronomic practices. Rehabilitation of undegraded rangelands can result in more efficient land use.	Access to alternative finance is gradually improving but micro finance institutes and livestock insurance rarely link financial products to cost-effective management practices (including mechanization, farm structures, storage and feed sourcing) in livestock systems in Kenya).
There are a good number of active forage seed companies in the country interested to develop the forage market and introduce for Kenya novel forage seed varieties, which can be made available in ASAL and other areas.	Effective mechanization on smallholder farms is not feasible and knowledge and skills to operate machinery successfully is a challenge. Opening opportunities for youth to start Agricultural Contracting services.
Public and Private engagement: A developing network of government (policies), forage producing-, fodder trading companies and NGOs facilitate research, production, and dissemination of better-quality fodder.	Registration and listing process for certified seed needs review (see recommendation by forage working group, Forage Working Group 2024).
Public subsidies e.g. subsidy fertilizer by government and extension services support forage sector development and growth.	There is a low demand for perennial forage seed, which may be caused by unawareness of the potential of forage seed for rangeland rehabilitation (reseeding) as well as for improved forage seed in cultivated forage production systems.
Improved road network and infrastructure (markets for livestock, processing of hides and skins, processing of milk products (include soaps of camel and goat milk) in Kenya.	Mis-information on the potential of foreign vegetatively propagated grass varieties versus domestically produced and available grass varieties.
Currently, some agro-ecological areas are not used for forage production. These areas can become forage production locations and contribute to all year-round fodder availability, provided production is environmentally sustainable.	Difficult to quantify but the demand for foreign vegetatively propagated grass varieties appears to by high while the demand for domestically produced grass varieties is low.
Rangeland grasses dapted to harsh environmental conditions (*Cenchrus ciliaris, Eragrostis superba, Enteropogon machrostachyus)* provide a perfect suit for reclaiming bare/degraded lands through reseeding.	Limitation for increased forage production and rangeland rehabilitation is land ownership structures, access to land for young people interested to start farming or commercial forage production, subdivision of land in economic not sustainable units, and alternative land use which is economic more attractive.
Existence of comprehensive feed strategies for example Kajiado Livestock Feed Strategy, as well as Spatial Plans which spells out the vision, systemic bottlenecks and priority interventions for forage the county.	The link between ruminant livestock production and cost-effective forage production and forage utilization is not well understood. In grazing systems, feed costs are not considered (rated at zero) while in feed market price/quality mechanisms are not applied) resulting in overpriced feeds (fodder, by-products and concentrates) for supplementation.

Existence and growing network of farmer (youth) groups and cooperatives provide complementary forage extension services and markets.	Livestock farming and forage production are perceived as not attractive as profession (by youth) despite some young influencers on social media and efforts by development programmes.
	Accessibility to affordable scaled technologies/machineries is limited, while domestically produced machinery may be more robust is does not always deliver the required result.
	Frequently forage producers mention markets are not reliable
	Poor rural infrastructure, increases cost of transport for bulky (kg/m³) feeds
	Weak linkages among stakeholder along the seed to feed value chain
	Fresh, moist, dry or processed feeds in the commercial fodder market, need to be valued in dry matter, fibre, energy, protein content to assure profitability of the livestock production systems in Kenya
	Despite the immense benefits demonstrated by grasses suitable for ASAL areas like Kajiado and Isiolo (e.g. *Cenchrus ciliaris, Eragrostis superba, Enteropogon machrostachyus),* the potential of these grasses in ASALs remains unexploited.
	Low production and availability of forage seeds in Kenya.
	There is weak research–extension–farmer–industry linkage in the forage sub-sector.

Opportunities	**Threats**
Increasing population and growing demand for animal sourced protein associated with expanding middle class in Kenya, consequently causing increasing demand for forage due to increasing livestock population	Climate change with erratic rainfall reduces forage performance (e.g. more challenging/impossible to establish, crop failure when harvest is due). Droughts, erratic rainfall, and land degradation severely impact forage yields and land for grazing threatening supply stability and livelihoods.
Improved forage crops combined with best agronomic practices have the potential to improve forage production	Degraded land, pests and diseases, invasive species, lack of soil conservation are threat to rangelands, livestock and wildlife.
Storage facilities for strategic feed reserves and for Kenya novel preservation technologies (silage, haylage, bio fermentation), pellets, briquettes, MUMB, DTMRB.	Potential new forage diseases and existing diseases infecting newly introduced forage varieties. e.g., Head smut, Snow mould, Leaf spot, Red spider mite.
Adoption of Climate-smart and Best Agronomic practices as well as Climate-smart livestock nutrition practices (e.g. Precision Nutrition etc).	Feeding of livestock in Kenya, other than grazing where animals select their preferred browse, is trial and error. Ineffective rations fed to ruminant livestock which are not cost effective.
Intensification of forage production (increased DM yield/ha, ME yield/ha and CP yield/ha) aligning with increased meat and milk production which lead to higher profit margins and better livelihoods.	Business cases for forage production for start-ups are based on high market prices during periods of scarcity which do not provide reliable and consistent market.
Improving soil health and fertility in rangeland systems through implementing and following grazing plans hence avoiding over grazing. In intensive farming systems, this can be done by utilizing available natural resources (manure, compost,	Shortage of native and well as foreign (imported) forage seed. Note that a substantial amount of Rhodes grass, thought to be a native grass is imported.

legumes, intercropping) as well as corrective soil practices after soil analyses.	
Strong collaborations between international and local institutions provide opportunities for technical innovation and capacity building.	Costs of forage production because of high prices of agro-inputs in relation to the milk and livestock prices at farm gate.
Commitment by government to allocate and avail public land, not used or not effectively used, for use by commercial fodder producers e.g youth groups, startup forage producing groups/companies and large-scale investors. .	Cultural and land tenure, some pastoral communities show limited interest in rangeland rehabilitation (reseeding) and cultivated forage production due to traditional practices and land subdivision, further constraining large-scale pasture establishment for grazing and production of strategic feed reserve.
	Migration of labour force (youth and women) to seek employment in urban areas.
	Environmental concerns (continuous land degradation, increase CO_2 emission through livestock and other agricultural related activities.
	Access to affordable financial products from financial institutions (banking and insurance sector).
	Increasing urbanization and encroaching of common land, before used for grazing livestock and wildlife.
	Regulatory bottlenecks: Lengthy and costly seed registration processes, weak policy enforcement, unclear standards, and twilight zone between formal and informal feed/forage (seed) sector can discourage private sector investment.
	Forage production nearly entirely depend on rainfall. Support with irrigation can lengthen the growing season and, in some cases, entire irrigated production systems can be supported (e.g. Lucerne).

5.2 Recommended interventions: Improving Access to Feed for Livestock

This section discusses pathways to support improved access to feed and supplemental feed for livestock in the primary scenarios; Conservancy or ranch managed livestock (Scenario A), Youth and women's livestock market groups near livestock markets (Scenario B) and Village-level, women-managed milking herds and small ruminant flocks (Scenario C).

5.2.1 Optimizing Forage Production in Commercial Ranches and Community Conservancies linked to Ecosystem Resilience (Scenario A)

The challenge of ensuring reliable livestock feed access in an increasingly volatile world necessitates a departure from single-solution approaches. The most effective pathway is a holistic, integrated, and adaptive strategy that harmonizes economic goals with ecological health.

The analysis of ranching and community conservancy models reveals that their management philosophies, while seemingly different, share a common foundation: the recognition that livestock, when properly managed, are a force for ecological good. This shared principle allows for the application of key practices that enhance both productivity and biodiversity. Ranches and community conservancies first and most impactful action should be to prioritize on-site forage optimization through managed grazing and ecological restoration, building a resilient feed base from the ground upwards. This involves a commitment to practices like rotational grazing and restoration of native grassland, which create a positive feedback loop of soil health, plant vigour, and drought resilience.

Secondly, a strategic approach to supplemental feeding requires diversifying the feed portfolio to mitigate market risks. By incorporating cost-effective, nutrient-rich conserved forages and agricultural by-products and alternative forages, they can reduce their reliance on traditional, volatile commodity markets. This transforms a cost-saving measure into a strategic move towards a more sustainable, circular-economy model.

Thirdly, the adoption of modern technology is imperative. Remote sensing and smart systems provide the objective data (feed on offer, weather predictions) needed to move from reactive, experience-based management to a precise, data-driven approach, allowing for more efficient resource allocation and greater risk mitigation.

Finally, the success of commercial ranches and community conservancies is deeply connected to their ability to engage with the extensive ecosystem of external support. Proactively seeking out and applying for financial and technical assistance from governmental agencies and private organizations can provide the capital and expertise needed to implement these pathways.

5.2.2 Improving Supplemental Feed Access for Youth near livestock markets (Scenario B) and Women-Managed Livestock in ASAL Villages (Scenario C)

The Unique Position of Youth and Women

Women and youth play a substantial and often underestimated role in the livestock sector. Globally, women constitute two-thirds of the world's poor livestock keepers and perform the majority of daily animal management, processing, and marketing tasks. They are also the primary caretakers for household food and nutrition security. Similarly, youth are key agents of change, with youth engagement in Kenya’s food systems being a critical factor for economic development, with about 60 per cent of them actively participating across various agricultural value chains, and 40 per cent are employed in food-related sectors. Their inclusion and capacity building are not just a matter of social equity but is considered an essential strategy for sustainable agricultural development and a smart investment in the sector's most valuable asset: its people.

Despite their critical contributions, the work of women and youth is widely unacknowledged, under-reported, and under-invested. This invisibility has profound, systemic consequences. When the contributions of these groups are not recognized, their perspectives and needs are often overlooked in the design of agricultural interventions and policies. This neglect leads to a series of institutional biases among agricultural service providers, limiting their access to crucial resources like finance, land, and technology. For instance, gender research shows that women are often excluded from training on use of acaricides and helminthics, even though they are exposed in other ways. When projects are not specifically designed to address these gender- and age-based constraints, their effectiveness is compromised. A common pitfall is that projects may inadvertently impose an unequal work burden on women without providing the necessary support to mitigate it. This creates a vicious cycle where a lack of empowerment is both a cause and a consequence of ineffective programs, hindering overall agricultural development and perpetuating existing inequalities.

This assessment reveals that improving supplemental feed access for women-managed livestock in ASALs requires a nuanced and multi-faceted approach. The problem is intertwined with environmental, economic, and social factors. The persistent and worsening impacts of climate change, including rising temperatures and erratic rainfall, have led to severe seasonal feed scarcity and widespread land degradation.

The primary actors in this challenge, women, are also the most constrained. Despite their role in daily animal care and their traditional knowledge, they face systemic barriers to accessing productive assets, credit, knowledge, and decision-making authority. The economic landscape is equally challenging, with the high cost of commercial feeds and supply chains that are fragmented, making other financially attractive choices, difficult. These affect women managed livestock systems disproportionately.

Women play a pivotal and multifaceted role in the pastoralist way of life, particularly in the management of livestock near the homestead. Their responsibilities are extensive and fundamental to the daily operations of the household and the herd. While men and boys are often away tending to the main herds, women are responsible for collecting supplemental fodder for animals kept close to home, caring for pregnant and sick stock, and looking after calves, kids, and lambs. They are also the ones who milk lactating animals and process dairy products such as sour milk and butter, which are vital components of the family's diet and a source of income at local markets.

However, the analysis also highlights significant opportunities. Small-scale, community-led interventions—such as the cultivation of drought-tolerant forages, the utilization of alternative feed resources like crop residues, and the implementation of decentralized water management solutions—have proven to be both economically viable and environmentally sustainable. Furthermore, the evidence is clear that the most effective and sustainable interventions are those that actively empower women, positioning them not as passive beneficiaries but as central players in program design, leadership, and implementation.

The future of ASALs depends not on abandoning the pastoralist system but on strategically enhancing its inherent resilience. By building on traditional knowledge systems and introducing climate-smart agricultural practices, it is possible to create a more robust and sustainable livelihood model. The vision for this future is one where village-level, women-managed livestock operations are no longer defined by feed scarcity but are thriving, productive, and self-sufficient enterprises. This will be achieved through integrated farming systems that turn waste into resources, decentralized water infrastructure that builds local resilience, and a policy and program framework that actively invests in the community's most vital resource: its women. The goal is to pave the way for a "more sustainable future" where ASAL communities can withstand climatic shocks and achieve food security, dignified livelihoods, and long-term prosperity.

5.2.3 Enhancing Youth and Women's access to Livestock Feed

Social and Cultural Barriers

Youth and women's livestock groups experience social and cultural factors that can affect their access to feed. In some contexts, societal norms assigning women tasks such as land preparation, planting, weeding, and harvesting, while participation in trade and decision-making roles may be less common. Reports from certain communities note that women sometimes defer to men when negotiating prices, which can influence group leadership and management dynamics, including situations where men manage women-only associations.

Time presents a major obstacle for women, stemming from the dual responsibilities of household duties and agricultural work. These time limitations, along with mobility constraints and elevated transaction costs, substantially restrict women's access to distant or external markets where more competitive prices or greater feed variety may be available. Reduced participation in these markets diminishes their ability to influence livestock-related income, as limited exposure to external pricing information further hinders their financial autonomy.

Financial and Economic Barriers

Financial and economic barriers significantly restrict access to affordable feed. Limited control over financial resources and inadequate access to credit hinder both youth and women from investing in high-value agricultural inputs, such as improved forage seed or cost-effective quality feeds. As a result of these disparities, farms managed by women are generally smaller and utilize less advanced inputs than those overseen by husbands or men.

Women often have limited control over major financial decisions related to livestock, despite earning income, due to sociocultural norms. Their bargaining power is weak, and transaction costs are high, reducing profitability and access to quality feed. Youth face barriers to participating fully in livestock systems because they lack productive assets (e.g. machinery) and land.

Supply chain and market Failures

The broader market environment poses various challenges. Many local livestock markets are currently underdeveloped, lack organization, and provide limited marketing opportunities. Animal feed distribution is inconsistent, with higher prices in ASAL regions where a significant number of ruminant livestock farmers reside. The supply chain remains weak due to limited collaboration among farmers, feed millers, and distributors, resulting in inefficiencies. Additionally, price fluctuations for feed commodities such as hay and by-products contribute to market instability. There is also a general lack of confidence in feed products, which display inconsistent quality and can affect animal nutrition and productivity hence livestock farmers including women and youth buy only in times of emergency.

Environmental and Climatic Factors

Environmental and climatic factors add additional complexity. The research outlines specific periods known as "feed gaps" or "hunger seasons," which typically occur at the end of the dry season when forage is limited and has lower nutritional value. Extreme weather events, such as droughts, can disrupt agricultural production and supply chains, impacting feed availability and quality. Climate change may worsen the effect of extreme weather events further.

The interconnected nature of these barriers forms a self-reinforcing cycle. Socio-cultural norms that restrict women's mobility and confidence directly limit their access to market information and training. This, in turn, diminishes their bargaining power and reduces the income they can generate from their livestock. The resulting financial constraints make it difficult to purchase improved, high-quality feed, even if it were logistically available. This leads to sub-optimal animal performance, which further limits their potential for income generation. Consequently, the low income and productivity reinforce the initial social barriers, trapping women and youth in a cycle of disempowerment and low economic output. Addressing this requires a holistic, systemic approach that recognizes and intervenes across all these dimensions simultaneously.

Strategic pathways to improved feed access for supplementation

Pillar I: Strengthening collective action and group capacity

Collective action provides one approach for youth and women to address market challenges. Practices such as savings groups ('table banking') and labour-sharing groups ('fodder banks') are established in many communities. Expanding these models to include marketing or production-oriented cooperatives may help groups enhance their bargaining position, access market information, and facilitate shared labour.

Agribusiness cooperatives or groups offer various services, including seed supply, feed provision, and financial support. By pooling their members' purchasing capacity, these cooperatives or groups can reduce costs and obtain more favourable input prices, which can benefit individual participants. The operation of these organizations depends on capacity development. Women and youth may not always have access to organizational, leadership, or management skills necessary for effectiveness. Delivering training and coaching in technical assistance, and mentorship in financial literacy and market representation is important for developing start-up groups into sustainable cooperatives.

Pillar II: Enhancing Financial Inclusion and Resource Access

Improved feed access is directly linked to financial inclusion. Low-interest micro-loan programs, provide a crucial financial tool for small-scale farmers and youth. These loans, with their simplified applications and flexible repayment terms, can be used to purchase seed, feed and farm-equipment, thereby unlocking investment potential.

A comprehensive approach to financial inclusion involves more than the provision of capital. If training in financial management, record-keeping, and market analysis is not provided alongside loans, recipients may experience challenges in using funds efficiently or fulfilling repayment, which could result in debts. Integrating capital with capacity-building measures can support effective financial interventions. Combining loans with (technical) training can improve access to feed, understanding of feed quality, and cost effectiveness, while also potentially influencing income control, decision-making roles within households and communities, and participants' self-confidence.

Pillar III: Harnessing Innovation and Technology

Innovation in forage production is a vital pathway to addressing scarcity and high costs, rehabilitation of rangelands through production of range grass seed and establishing (native) rangeland grasses for grazing livestock. However closer to the possibilities of the youth or women managed livestock farm are other strategies such as utilizing locally available, unconventional feed resources, such as crop residues (straw and stover), invasive plant species (e.g. Mathenge), and waste products from food processing (e.g. Pineapple waste, Brewers spent grain). These resources can create employment opportunities, provide some nutrients and if further processed be turned into a cost-effective feed.

Other strategies could be to establish fodder banks (e.g. semi-circle fodder bunds) on degraded land or common wastelands. This low-cost, high-impact solution addressed fodder scarcity during lean periods and had the added benefit of reducing soil erosion and landscape rehabilitation. Another intervention strategy in peri urban areas and some areas in Nakuru county ‘living fences’ is using fast-growing, nutritious tree species like Leucaena and Gliricidia to create a dual-purpose barrier. The fences protect crops from roaming livestock while providing a perennial source of high-protein fodder, particularly during the dry season when feed is scarce.

Pillar IV: Forging Strategic Partnerships and Enabling Policies

The success of these pathways depends on a supportive institutional environment. Public-Private Partnerships (PPPs) can be instrumental in bridging market failures (e.g. working with established feed millers who understand feed quality) and sharing risks and resources (buying seed certified seed or seed from reputable private partners).

Government and institutional policies are involved in supporting these initiatives. This includes the development of targeted credit schemes for youth, provision of disaster assistance, and backing for conservation programs that contribute to landscape restoration, access to range grass seed, and other forage crop varieties, as well as management of feed resources including invasive species. Additionally, regulatory frameworks can be strengthened to maintain the safety and quality of animal feed and to ensure the germination and purity standards of forage crop seeds.

The full value of these four pillars is realized when they are integrated into a comprehensive strategy, resulting in a synergistic effect. For instance, a women's livestock group may choose to establish a community fodder bank (Pillar III). This effort is enhanced by the collective organization of the women into a self-help group (Pillar I), enabling resource pooling and collaborative management of the wasteland. To finance initial land preparation and planting, the group can obtain a micro-loan (Pillar II). The project is further supported through a public-private partnership with a local agricultural university and an NGO, which offer technical guidance and capacity building in areas such as cost of production, quality, and preservation of fodder (Pillar IV). Favourable policy frameworks that permit the use of communal lands also play a critical role. Each element’s effectiveness relies on the support provided by the others, illustrating that a holistic, integrated approach is essential for achieving sustainable development.

Further recommendations for improving access to livestock feed (for supplementation) under the targeted scenarios are discussed in the table below.

Technology/ Strategy/Practice	County	Targeted group	Impact	Remarks
Rangeland management: rotation grazing, reseeding, area protection (grazing blocks/ reserves), removal of invasive species	I – Yes K – Yes N – - Partly	*Conservancy or ranch managed livestock	Precondition is availability of seed of rangeland grasses Precondition for sustaining pastoral livelihoods. Precondition for rangeland rehabilitation Different technologies are applicable (e.g. half circle bunds, trenches, fencing)	It is being practiced by several Conservancies and group ranches supported by NGOs. The potential is undisputable; however, capacity of organizations that manage grazing needs to be strengthened, and communities need be sensitized and or organizations formed where they do not exist. -Reseeding is important as most of the rangelands are denuded and invaded by invasive species that are of minimal importance to the livestock.
Grass seed banks	I – Part K – Yes N – Yes	*Conservancy or ranch managed livestock *Village-level, women-managed milking herds and small ruminant flocks	Provides seed for rangeland rehabilitation Women need to be sensitized Perceived as typical work for women	It is being practiced by several Conservancies and group ranches supported by NGOs. The potential is undisputable and also recognized by organizations like IGAD and FAO; however, capacity of organizations that manage grass seed banks needs to be strengthened, and communities (including youth and men) need to be sensitized and/or organizations formed where they do not exist. -Reseeding is important as most of the rangelands are denuded and invaded by invasive species that are of minimal importance to the livestock.

Grass bulking sites	I – Part K – Yes N – Yes	*Youth and women's livestock market groups *Village-level, women-managed milking herds and small ruminant flocks * - in collaboration with Ewaso Ng'iro North Development Authority (ENNDA) - or PPP	Provides vegetatively propagated planting material for fodder production. Women and Youth need to be sensitized. Awareness creation among communities that Napier grass will only have a positive effect on livestock productivity if harvested at the right leaf stage, plant height and stubble (residual) height.	It is being practiced by some private companies (Crevation, Moo Fodder Supermarket, Christies Farm Gate) supported by NGO's or Government projects (NAVCDP). The potential is undisputable. Some of the Napier grass varieties can have, next to fodder, also contribute to prevention of soil erosion, use on saline soil, provide biomass for energy etc. However, capacity of organizations that manage grass bulking sites needs to be strengthened, and communities (including youth and men) need be sensitized and or organizations formed where they do not exist and create awareness about the potential for the different uses and the best management practices for each use (e.g. Fuel, erosion, saline soils). -Protecting soils through prevention of soil erosion is important as most of the rangelands are denuded and invaded by invasive species that are of minimal importance to the livestock.
Community hay/straw production	I – Yes K – Yes N – Yes	*Youth and women's livestock market groups *Conservancy or ranch managed livestock *Village-level, women-managed milking herds and small ruminant flocks	This is a good only way to address feed shortage. There are already groups dealing with hay production	It is done at a small scale by pastoralists hence can be up-scaled by mechanization; however, its implementation would require extensive sensitization. - It can help stabilize strategic feed reserves and enhance irrigated fodder production.
Use of appropriate feeding troughs	I – Yes K – Yes N – Yes	*Youth and women's livestock market groups *Conservancy or ranch managed livestock *Village-level, women-managed milking herds and small ruminant flocks	Low wastage Protection of feed from contamination Ease of access by all livestock Improvisation possible at farm level	This is practiced at a small scale for the animals that remain behind during migrations, which include sick, weak and young animals. This helps to minimize wastage of collected pasture fed to these animals.

Feed/fodder banks around drought prone areas (and in case of no drought supply for feeds to quarantine areas maintained for export animals)	I – Yes K – Yes N – Yes	Conservancy or ranch managed livestock	An attractive drought mitigation measure Provides stability of prices Quick response can be provided in emergencies	For Isiolo county listed in the county integrated development plans, as one of the ways of addressing feed shortage in the county. It is highly feasible; fodder as hay (pellet, blocks, bales) can be purchased and stored in fodder bank when it is available at a low cost (in times of plenty).
Large scale hay formation and storage	I – Partly K – Yes N – Yes	Conservancy or ranch managed livestock	There are already groups dealing with hay production	Hay production and conservation can be up-scaled by mechanization; however, its implementation would require extensive sensitization. It can help establish strategic feed reserves and enhance irrigated fodder production where possible. This is a good way to address feed shortage.
MUMB variant: MUMB containing PEG for inactivating tannins and along with business development around browse meal	I No K-Yes N-Yes	*Youth and women's livestock market groups *Conservancy or ranch managed livestock *Village-level, women-managed milking herds and small ruminant flocks	In Isiolo county blocks need to be supplied. Works well where ingredients are easily available. Demand of such blocks is expected to be high Technology available locally. Can be up-scaled	Browses are the only greens available during extreme droughts. Presence of tannins in these browses prevent use of these in situ available biomass. Polyethylene glycol (PEG)-containing blocks or oligoethylene glycol (OEG) given in water will help to improve the utilization of the range land browses and trees which are the only available feed materials during the periods of drought.
Forage & Tree nurseries	I – Yes K – Yes N – Yes	*Youth and women's livestock market groups *Conservancy or ranch managed livestock *Village-level, women-managed milking herds and small ruminant flocks	Can be particularly interesting for improved forages and fodder tree seedlings. Increases germination rate and chances of success when planted in the field in areas where rainfall is unreliable and periods of rainfall are short making full field broadcasting not successful	This has a lot of potential. It is already being practiced in a small scale in Kajiado. For example, in Isinya and in Taita Taveta improved Guinea grass varieties were successfully established from seedlings hence the technology is viable. It is one of the promising ways to lengthen growing period of the wet season. There is a need to upscale irrigation supported fodder production and its conservation as hay.
Agro-forestry (a mix of trees and forages)	I – Yes K – Yes N – Yes	Conservancy or ranch managed livestock	Technology is available. The World Agroforestry Centre (ICRAF) and Kenya Forestry = Browse shrubs and Trees can be used to produce browse meal in combination with MUMB	Its practicable and can be easily taken-up along the river by the agro-pastoralists and settled pastoralists. They can be encouraged to plant along the water pans embankments and in settlements. It will improve feeds availability and improve micro-climate of the areas.

MUMB variant: MUMB containing deficient minerals		*Youth and women's livestock market groups *Conservancy or ranch managed livestock *Village-level, women-managed milking herds and small ruminant flocks	In Isiolo county blocks need to be supplied. Works well where ingredients are easily available Technology available locally, Can be up-scaled	In the regions of severe mineral deficiency and during drought period, these could be invaluable supplements
MUMB variant: MUMB containing forage seeds for wide dissemination in pasture lands		Conservancy or ranch managed livestock		THOUGH THIS NEEDS FURTHER PILOTTING -If it is found practicable it will be key for reseeding the vast denuded range lands in the ASALs which are deficient of perennial grasses. -Pastoral communities are always on the move in search of pasture and water. The animals, through their faeces, will help disseminate the seeds far and wide.
Densified forage (straw/stover) based complete ration in block/pellet form See Note 2 and Annex 6		*Conservancy or ranch managed livestock *Youth and women's livestock market groups	Requires high level of mechanization which may (not yet) be available or for systems which are to scale, yet to be developed	Biomass available in the counties in the form of stover and straws from farms especially in the National Irrigation Board Bura Tana and Hola irrigation schemes (in Tana River County, these feed resources are often wasted and burnt) could be converted to blocks or pellets. This will make transportation and storage easier and help meeting deficiency of feeds in dry periods.
Forage chopping	I – Yes K – Yes N – Yes	*Youth and women's livestock market groups *Conservancy or ranch managed livestock *Village-level, women-managed milking herds and small ruminant flocks		The technology is viable and practicable but currently not used. Use of the technology at a small as well as large scale would be useful; however, extensive sensitization of (agro) pastoralist would be required.

Promotion of spineless (thorn less) cactus in dry areas, along with business development around cactus	I – Yes K – Yes N – No	Conservancy or ranch managed livestock	Drought tolerant Not invasive High energy source Has a potential to trigger a chain of agro-processing	There is potential for cactus production and utilization as the few that grows naturally are always invaded by ruminants during drought periods. - If produced commercially in plantations it will be a livelihood source. Cactus is drought resistant and can provide sustainable solution to recurrent feed shortage in the county
Hay production (spate irrigation, rainy season, protected areas, tsetse infested) areas)	I – Yes K – Yes N – No	*Conservancy or ranch managed livestock - in collaboration with Ewaso Ng'iro North Development Authority (ENNDA) - or PPP	Utilization of unutilized land like in tsetse prone areas Increase supply of animal feed increased productivity Conservation and an attractive drought mitigation measure	There needs to be enforcement of grazing management systems to support the hay production in protected or tsetse-infested areas. In Isiolo there is huge potential of production of irrigated pasture especially in the lower Ewaso Nyiro river (Lorian swamp). For example, in Wajir county irrigated fodder production is already being practiced.
Fodder production (spate irrigation, spread irrigation) in dry areas	I – Yes K – Yes N – No	*Conservancy or ranch managed livestock - in collaboration with Ewaso Ng'iro North Development Authority (ENNDA) - or PPP	Utilization of unutilized land like in tsetse prone areas Increase supply of animal feed increased productivity Conservation and an attractive drought mitigation measure	This has a lot of potential. It is already being practiced in a small scale. For example, in Tana River County, three irrigation schemes on seasonal rivers already exist and hence the technology is viable. This can be combined with construction of strategic feed reserves/ hay stores. It is one of the promising ways to meet feed shortage in dry areas. There is a need to upscale irrigated fodder production and its conservation as hay.
Ensiling (silage making) – including bio fermentation small scale	I – No K – Partly N – Yes	*Youth and women's livestock market groups *Conservancy or ranch managed livestock *Village-level, women-managed milking herds and small ruminant flocks	Availability of biomass Good conservation and preservation measure - can be stored for a long time Can be a good feed for the dry periods Technology is widely available However, need more capacity building at farm level	THOUGH BIO FERMENTATION NEEDS FURTHER PILOTTING Given the high temperature in some areas of the counties the technology is not viable. Where temperatures are feasible a good soil layer (30-50cm) needs to be used as cover. Only practical for agro pastoral/riverine areas. That said the technology of bio-fermentation gives opportunities to improve the use of grass straw and poor-quality hay provided it can be sourced at low prices.
Ensiling – including bio fermentation large scale	I – Yes K – Yes N – Yes	Conservancy or ranch managed livestock	Availability of biomass good conservation and preservation measure-can be stored for a long time Technology widely available	THOUGH BIO FERMENTATION NEEDS FURTHER PILOTTING Given the high temperature in some areas of the counties, the technology is not viable. Also, it requires high investment and skilled personnel, and is likely to have

				low adoption rate. That said the technology of bio-fermentation gives opportunities to improve the use of grass straw and poor-quality hay provided it can be sourced at low prices.

where I – Isiolo; K – Kajiado; N – Nakuru

Note 1: Ingredient sources for MUMB and DTMR (see Annex 5).

Note 2: Conventional bales, the width and height are standard across almost all conventional balers. 36cm high by 46cm wide. The length can be adjusted to anything from 30 – 130cm long. It is usually better to go by weight with hay bales weighing about 12 - 15 kg and straw about 10kg. See Annex 6 for a comparison between conventional and non-conventional bales.

5.2.4 Improving Livestock nutrition Isiolo, Kajiado and Nakuru counties

The defining characteristic of the arid and semi-arid lands in the three counties is their low and erratic rainfall, which directly leads to severe water scarcity. Drought conditions, a frequent occurrence in these regions, drastically reduce both the availability and quality of water necessary for productive farms, ranches, and grazing lands. Water is arguably the most critical nutrient for livestock, and its limitation reduces animal performance more quickly and dramatically than any other nutrient deficiency. Domesticated animals can survive longer without food/feed but then without water (less than 6 days), underscoring its paramount importance. When water is scarce, animals suffer from dehydration and stress, which in turn leads to a reduction in feed intake. This reduced intake then cascades into a decrease in energy available for productive functions, such as growth, reproduction, and milk production. Therefore, effective water management in ASALs is not simply about providing sufficient drinking water; it is a fundamental determinant of overall animal health, productivity, and an animal's intrinsic capacity to withstand other climate stressors like heat.

The improvement of rangelands and communal range pastures is complex and requires political, social, economic and cultural agreements and acceptance, next to significant financial and management resources (e.g. range pasture seeds, land preparation or half circle bunds etc). 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 large scale commercial farming (arable farming, horticulture or floriculture). Hence, strategies for sustainable rangeland management and rehabilitation need to take a multi-disciplinary and landscape approach.

Also, in the rangelands (ASALs) efficiency of the livestock farming system is becoming increasingly important. To sustain livelihoods in the rangelands the livestock farming system must comply to being profitable (e.g. giving the livestock farmer sufficient margin), increase productivity (to address competition over land use), produce healthy animals (reduce morbidity and prevent mortality) and being environmentally sustainable. This requires awareness and the possibility to optimize feeding of livestock farming systems where this is possible in intensive or semi-intensive feeding systems; towards driving increased productivity, enhanced resilience, and reduced Green House Gas emissions. This can be achieved in the following ways.

-
- Support upscaling and adoption of adaptive range pasture and forage crop technologies, including range pasture seed production, processing and storage as well as reseeding and range pasture and forage conservation (including bio-fermentation), storage and utilization in balanced rations. Additionally, conducting periodic exposure events such as field visits, field days and demonstrations in a participatory manner to help forage producers and livestock farmers learn, replicate and adopt the technologies they learn.
- Carry out capacity building on good agricultural practices (GAP) to enhance production of range pasture and novel forage crops the latter where climatic conditions allow. These include, suitable forage species, range pasture and forage crop establishment, soil management and land preparation practices and dissemination of range pasture and forage crop technologies (Kidake *et al.,* 2016). Additionally, embracing private-public partnerships are important and effective avenues of collaboration for dissemination of range pasture and forage production technologies. Each of these institutions possess unique strengths such as expertise, mobilization and resource endowments, that would help more farmers to be incorporated and benefit from range pasture related activities.
- The role and participation of women as trainers in forage and livestock production has been minimal which can be attributed to the labour intensiveness of forage production and their societal social responsibilities in the ASAL communities. This is exacerbated by the fact that most women in these regions do not control resources such as land, livestock and finances. Women participated in grass seed production and harvesting (Picture 7) and there are examples were women started dairy cooperatives. The gender inclusivity issue needs to be addressed during implementation since the impacts of projects are cross cutting to all gender.

Picture 7. Maasai women harvesting grass seeds

Source: Maasai women leading Kajiado's conservation transformation - Story | IUCN

- The emerging fodder value chain and markets presents more job opportunities particularly for women and youth. Fodder groups and individual pastoralists can be organised and assisted to undertake business activities involving conservation, processing, transporting and trading fodder to various nearby markets thus considering the high transportation cost of fodder. This establishment of effective market linkages between producer groups and potential buyers – through contract farming, will enable them to expand to ready markets both within and outside county borders.
- Drought-resistant forages (e.g. spineless cactus) are promising for arid regions. Further research into xerophytic and novel forages (e.g. in use in Australia, Brazil, Tunisia) is recommended due to their potential to address challenges related to water scarcity and climate change in animal production and agriculture, especially in arid and semi-arid regions.

5.2.5 Improving Forage seed availability, supplies and actors

Improving the supply and availability of forage seeds can be done through;

- Formalization of range pasture seed production (e.g. declaring quality parameters of the seed) and marketing through laid down legal and institutional procedures could provide a sustainable approach of availing forage seeds (range pasture seeds) to farmers in ASAL counties for planting and landscape rehabilitation.
- Community-based seed production through community integrated groups and farmer cooperatives in forage seed production and range pasture establishment as proven successful and economically viable models.
- Promotion of adapted range pasture and other forage varieties by fast tracking registration and listing of native as well as novel (exotic) drought-tolerant, nutritionally superior forage species suitable for ASALs.

5.2.6 Sustainability and Climate change: Forage Production, Productivity and Rangeland restoration

Sustainability and climate change critically impact forage production, productivity, and rangeland restoration by altering vegetation growth, forage quality, and ecosystem stability. Climate change influences forage availability through factors such as rising temperatures, shifting precipitation patterns, and elevated atmospheric CO_2, which can both enhance or reduce forage productivity depending on the region and conditions.

Kenya's forage sector is witnessing a trend towards the integration of climate-smart technologies, focusing on drought-tolerant and climate-resilient forage varieties. These efforts not only address variability in weather patterns but also support sustainable livestock nutrition, which is essential given the genetic base of livestock in the region. These trends indicate that Kenya's forage market can evolve from a traditional, domestic system into a more sophisticated, innovative, and resilient sector. The integration of improved adapted forage varieties, advanced technologies, and strategic partnerships can open new avenues for investment and sustainable growth.

Forage production and climate effects: Elevated CO_2 and more precipitation may increase forage production in some areas, potentially allowing higher productivity, but with risks of land degradation if overgrazed. Conversely, warmer and drier conditions predicted for many areas reduce forage yield and quality, increasing vulnerability to droughts and vegetation loss. On the other hand, in more humid areas gathered evidence indicates that Napier grass's yield and nutritive value may be improved by two simple management practices: increasing plant density (increasing sowing density 50 cm × 40 cm) and harvesting frequency (35-42 days) (Islam *et al.,* 2023). Compared to unfertilised pure Napier grass, use of organic manure, but also fertilizer N and Napier/Desmodium intercropping tended to improve soil carbon content (Snijders *et al.,* 2011).

Vegetation and forage quality: Climate-induced stress like drought shortens growing seasons and decreases palatable forage species, increasing less desirable, unpalatable or toxic plants. This reduces overall forage quality, affecting livestock nutrition and productivity, and contributing to rangeland desertification and degradation.

Soil and ecosystem impacts: Loss of vegetation cover due to climate stress increases soil erosion risk, reduces soil permeability, and raises salinity issues in some areas, intensifying land degradation and complicating restoration efforts.

Socio-economic dimensions: Declines in forage availability and quality raise the costs of livestock production by increasing the need for supplemental forage, commercial feeds and water, which burdens pastoralists economically and threatens traditional livelihoods. Adaptive management practices such as adjusting stocking rates, supplemental feeding, and sustainable rangeland management are essential to cope with these changes but needs to be implemented and encouraged against the backdrop that supplemental feeding will only be sustainable if the cost or price of the fodder (or concentrate) is a reflection of its nutritional value when fed.

Rangeland restoration: Restoration efforts should integrate local knowledge and research assessments to identify key native species for rehabilitation and monitor ecological health. Policy support for pastoral communities, employment alternatives, and subsidized resources can enhance restoration and sustainable management. Effective restoration is not just about replanting trees or rehabilitating degraded land—it is about ensuring that management practices lead to tangible, lasting ecological and socio-economic benefits. To achieve this, tracking the impact of restoration activities at both the plot and watershed level is essential. These localised assessments help determine whether interventions, such as agroforestry, soil conservation, or reforestation, are truly restoring ecosystem functions, improving land productivity, and enhancing resilience to climate change (Winowiecki *et al.,* 2024).

Modelling and prediction: Advanced tools like neural networks combined with climate projections are used to predict forage production (feed on offer - FOO) trends under different climate scenarios, assisting managers to plan restoration and adaptation strategies effectively. Other tools such as ration formulation software can be used to predict animal performance, improve margin above feed cost and reduce methane emission intensity.

5.2.7 Strengthening Government regulations and policy frameworks

Kenya recorded livestock losses between 2007-2023 due to drought-related causes amounting to approximately USD 1.08 billion, with over 70% of livestock mortality in ASALs. This translates to significant disruptions in income streams and loss of assets for pastoral communities. Projections indicate that Kenya risks losing about 1.7 million cattle, equivalent to 52% of the total cattle population in ASALs, in the next decade (2020-2030) due to drought and climate change effects, potentially costing farmers between KES 34 billion and KES 68 billion (GoK 2021).

Kenya's livestock sector faces a persistent feed deficit. The annual requirement is estimated at 55 million metric tonnes, but only around 40% of this demand is met. Compounding the challenge, nearly 46% of available feed is lost post-harvest before reaching the animals that could feed on it. The industry is heavily reliant on imported feed ingredients—over 80%—incl. soybean meal, sunflower cake, oilseed cakes, and distillers' dried grains with soluble (DDGS). White maize remains the most common feed base, though it competes directly with human consumption, creating further supply pressure. Over 70% of feed raw materials come from neighbouring countries, causing periodic shortages and price volatility.

The government has extended duty-free importation of key feed raw materials under the East African Community (EAC) framework to help stabilize the sector. There are also ongoing efforts to develop feed storage and distribution centres at ward level to ensure year-round availability, especially during seasonal shortages. Additionally, stakeholders are exploring diversification of feed ingredients, with trials using sorghum and DDGS to reduce dependence on maize while enhancing nutritional content.

However, the feed sector is highly concentrated, with the top four producers supplying about 75% of the poultry and dairy feed market. This concentration, along with dependence on imports, keeps feed prices in Kenya significantly higher than in comparable markets such as South Africa.

In 2023, Kenya launched its National Action Plan to Reduce Short-Lived Climate Pollutants (NAP), which is meant to contribute to decrease greenhouse gas (GHG) emissions by 32% of 2010 levels in 2030. The NAP is aligned to Kenya's Climate Smart Agricultural Strategy (KCSAS) 2017-2026 and Kenya's Climate Smart Agriculture Implementation Framework (KCSAIF) 2018-2027. The latter prioritizes moving towards a climate-resilient agricultural sector and taking actions to adopt practices that lead to reduced GHG emissions. Livestock – in particular ruminants – form the largest source of GHG emissions in the agricultural sector, accounting for over 50% of total agriculture-related GHG emissions mainly due to enteric fermentation.

The livestock sector is therefore – also - of key importance with regard to the Government's strategies and actions to reduce its environmental footprint and mitigate GHG emissions, and to achieve the relevant goals set for 2030 (UNIQUE/SDLD, Livestock sub-sector NDC report, 2019). Efforts are also underway to strengthen greenhouse gas monitoring, particularly in the dairy sub-sector, through the adoption of Tier-2 inventory systems. In addition, the government and stakeholders are investing in improving forage production and ensuring access to high-quality forage seed varieties to enhance ruminant productivity.

Despite high-level policy commitments, the forage sub-sector in ASAL's faces considerable obstacles stemming from fragmented policy implementation, insecure land tenure, pervasive market inefficiencies, and the escalating impacts of climate change. Our report identified successful climate-smart agricultural practices and community-led rangeland management initiatives that offer pathways for progress.

Key policy documents and strategies relevant to forage production in Kenya's ASALs:

National Livestock Policy 2019

The National Land Policy comprehensively addresses crucial aspects such as livestock feeds and nutrition, animal health, marketing, research, and food security. The policy explicitly acknowledges that over 80% of Kenya's landmass comprises ASALs, where livestock rearing is the predominant livelihood. A core objective of this policy is to drive the commercialization of the livestock sector, recognizing its potential for economic growth and foreign exchange earnings.

Agricultural Sector Transformation and Growth Strategy (ASTGS) 2019-2029

The ASTGS aims to achieve sustainable growth within the agricultural sector through modernization and commercialization. It seeks to increase opportunities for small-scale farmers, pastoralists, and fisherfolk by boosting agricultural output and enhancing food resilience. The ASTGS recognizes critical development challenges, including climate change, stagnating agricultural production, inefficient food systems, and land degradation. It emphasizes investments in climate-resilient technologies, integrated natural resource management, and sustainable land and water management.

Land Tenure and Community Land Act (CLA)2016

This legislation represents a significant attempt to formalize customary property rights and diverging from previous models, such as the repealed Group (Land Representative) Act of 1968, which often led to land enclosures and unsustainable resource use. A fundamental shift under the CLA is that land title is now vested in all members of the community in undivided shares, rather than in a few group representatives. This change mandates inclusive membership registers, specifically addressing the historical exclusion of women, and requires adherence to the two-thirds gender rule in Community Land Management Committees (CLMCs). These CLMCs are responsible for the day-to-day management and administration of registered community land, including coordinating land use plans. The Act also empowers Community Assemblies, comprising all adult community members, to approve land allocation or conversion and validate customary rights, thereby ensuring broader participation in decision-making.

Agricultural Sector Development Strategy (ASDS) 2010-2020

The strategy (ASDS) does not provide detailed, distinct sections specifically on "forage". The strategy recognizes agriculture's critical role in poverty reduction and food security, which includes livestock production that depends on forage. It aims to enhance productivity through improved access to quality inputs, which would encompass forage seeds and out of farm inputs for forage crops. It further promotes sustainable land and natural resource management, indirectly supporting improved forage availability and quality for livestock. While reforming agricultural services delivery, including research and extension, ASDS is important for disseminating better forage and livestock management practices.

Range management and pastoralism strategy 2019-2029

The strategy addresses challenges such as inadequate and fluctuating forage availability, rangeland degradation, climate variability impacts, and encroachment on pastoral lands. It promotes increasing and revitalizing forage resources through sustainable rangeland management practices, including restoration and conservation of pasture and fodder grass species adapted to local conditions. Emphasis is placed on community involvement in land ownership and decision-making, integration of indigenous knowledge, improved research on rangeland feeds and forage varieties, and enhancing resilience to drought and other climatic stresses.

Isiolo County Rangelands Management Bill

This bill is designed to promote land tenure security and influence good land stewardship through participatory processes. The bill, developed with support from organizations like the International Livestock Research Institute (ILRI), aims to establish guidelines on institutional structures and public participation in rangeland management and conservation.

Kajiado County Livestock Feed strategy (KCLFS) 2023-2033

The KCLFS is a comprehensive framework aimed at addressing the chronic livestock feed deficit worsened by climate change and drought conditions in Kajiado County. It seeks to enhance livestock productivity by increasing feed production, improving feed quality and safety, promoting processing and trade of livestock feeds, and fostering sustainable range pasture management. Key objectives include increasing feed production and conservation, ensuring feed quality and safety, developing value addition in feed processing, and safeguarding range pastures through integrated land use planning. The strategy also aims to reduce feed production costs, minimize post-harvest losses (which were noted at 54%), and create investment opportunities to support sustainable, climate-resilient livestock production systems.

Despite the existence of high-level policy documents that acknowledge the importance of ASALs and the livestock sector, a significant challenge lies in the fragmentation and weak implementation of specific policies related to the importance of forage production and fodder for the livestock sector in Kenya. There is a notable absence of explicit, detailed policy regulations for forage production, conservation, and marketing at county levels. This lack of specificity creates a void in actionable guidelines for sub-national/county governments and communities. The lack of specific forage regulations and weak enforcement reveals a significant implementation gap. This indicates that policy formulation is not adequately translating into actionable, enforceable frameworks at the operational level, leading to continued vulnerability and underdevelopment in ASALs.

The government should develop a dedicated comprehensive national policy and regulatory framework specifically for forage production and rangeland management in ASALs. This framework must be explicitly integrated into existing high-level strategies such as the National Livestock Policy 2019 and the Agricultural Sector Transformation and Growth Strategy (ASTGS 2019-2029). The new framework should provide clear, actionable guidelines for all stages of sustainable range pasture production and adaptive forage crop development, including production techniques, conservation methods, marketing strategies, and quality standards for feed and forage linked to a price mechanism that is fair for all. Domicile forages in State Livestock Department: forage experts should be integrated within government livestock departments for better technical input and policy execution. Furthermore, it is essential to promote the mainstreaming of rangeland restoration targets and forage development initiatives into County Integrated Development Plans (CIDPs) ensuring that national objectives are translated into localized, implementable actions with allocated resources.

5.2.8 Technical know-how: Access to Information and Training

The fodder market itself faces significant constraints. Demand for fodder in ASALs is highly seasonal, and current production levels fall far short of actual needs. Forage producers grapple with limited acreage for cultivation, knowledge and skills gaps, poor storage facilities with insufficient capacity, non-functional markets due to delinked price / quality mechanism and lack of critical technical support. These factors collectively limit the potential for fodder to become a consistent (not only during period of scarcity) and profitable commercial venture and a cost-effective alternative source of fodder for livestock farmers in ASALs. The Rapid Appraisal (RA) highlights that market inefficiencies, rather than only production challenges, significantly undermine the economic viability of commercial forage production which can be used for supplementary feeding. Policies that focus exclusively on increasing production without simultaneously addressing the functionality of and access to the forage market; while ensuring fair pricing for vendors and buyers and improving infrastructure to reduce cost for transport and storage will have limited impact. This underscores the necessity of policy interventions that actively strengthen market linkages, reduce transaction costs for vendors and buyers, and empower women, youth and existing forage producers to participate more effectively in the forage value chain.

This will also require steps to improve feed and forage testing to facilitate the sector with testing facilities (stationary or future handhelds), that have access to Near Infra-Red Spectrometer (NIRS) regression lines of tropical forages. These NIRS analyses reports can be linked to “ration balancing software” to 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 live weight gain. Added advantage of handheld NIR spectrometry is that it opens the possibility to measure soil nutrients, soil carbon, dung of livestock and possibly milk allowing livestock experts to monitor the nutrient cycle in livestock farming systems. By transforming forage production from a subsistence activity, from rangeland pasture as livestock feed source that has no economic value into a profitable commercial venture through targeted market-oriented policies, the economic resilience of ASAL communities can be substantially enhanced.

5.2.9 Scalable Innovations and Business opportunities for Youth, Women and Conservancies

Forage production, while critical, cannot be viewed in isolation; its success is intrinsically linked to the broader livestock value chain. Integrated approaches that connect forage production with conservation, processing, marketing, and financial services have proven highly effective in ASALs. Issues such as development of water resources, extension and education must be considered in addition to basic grassland principles.

Support for value-adding projects is essential to maximize the economic returns from livestock. This includes initiatives for processing meat, milk, hides, and skins including for small to medium sized enterprises.

Development of a permanent livestock feed database for planning, programming and monitoring of the livestock sector on sound footing would go a long way in enhancing resilience of the livestock sector.

The feed basket of most ASAL counties comprises of a large proportion of grazing biomass and hence use of good rangeland management practices e.g. reseeding of denuded lands, rotational grazing and rehabilitation of degraded range pasture land would increase biomass availability. Stimulating community common interest groups (CIGs) and community-based organisation (CBOs) to venture in grass seed production, reseeding and conservation (drying and storage) of grass hay and straw can make effective use of the biomass and as demonstrated in chapter 4 is the most cost-effective way to feed livestock in the rangelands until such time that the economic value of range pastures is valued in a better way than currently, having no economic value for feeding livestock (ILO 2025).

The use of sustainable stocking rates through policies, formulation and use of appropriate guidelines must be in place. In (agro) pastoral areas and counties (Nakuru) that have a greater proportion of crop residue, provision of forage chopping machines to farmers to reduce the size of fodder including straws, low quality hay, and overgrown Napier grass for easy storage and feeding, for increased feed intake and animal production would enhance efficiency of available feed resources.

Establishing integrated demonstration fields and farms that provide learning opportunities across the entire value chain of range pasture and adaptive forage production and related technologies and best practices. These farms showcase not only how to reseed rangelands and grow various forage crops but also how to conserve (e.g., hay, haylage and silage making) and understand cost of production, and benefits in cost-effective rations for livestock. This ‘holistic’ learning environment equips farmers with the knowledge, skills and tools necessary for adopting climate-smart livestock nutrition practices and overcome challenges.

Stimulating demand and facilitating financing are crucial for unlocking the full potential of the forage value chain but this should be directly linked cost effectiveness of feed and forages in rations for livestock. After all, if low-quality fodder is produced at high cost and the response of livestock is weight loss or a drop in milk production; livestock farmers will not be able to pay back the loans to the financial service providers. Successful strategies include the establishment of a dense network of strategic feed banks and a supply chain ecosystem. Boost demand for quality grass hay and densified crop residues (cereal straw) to encourage more participation in the supply chain, robust, qualified extension and coaching services, and innovative digital input credit schemes. Create a digital platform connecting farmers, feed banks, end-users, and other stakeholders involved in the forage supply chain to trade fodder. Focus on practical solutions in areas where there is a deficit in biomass demand or potential end-users. Blended finance and grants are also vital for supporting start up (early-stage) forage seed and forage production enterprises, helping them overcome initial capital barriers.

The success of forage for supplementary feeding is deeply intertwined with the development of the entire forage and livestock value chain. Policies must therefore adopt a holistic approach, supporting not just the cultivation of forage, conservation and marketing but an enabling environment for the feed and forage market to be functional and transparent which requires and effective price /quality mechanism and access to financial services. To achieve this, facilitate and promote a private sector driven price/quality mechanism for forages (hay, silage and crop residues and fodder-based products). Map and publish a database of end-users in the counties with their annual fodder demand. This integrated perspective ensures that increased forage availability translates into vibrant markets and tangible economic benefits for livestock farmers and contributes meaningfully to overall food security and livelihood resilience.

As mentioned before water is crucial for livestock and forage production, in most of the pastoral areas, water harvesting technologies should be explored to support fodder production systems (extending the growing season). Use of spate and spread irrigation for fodder production along with fodder production on the sides of river banks, and their conservation could play an important part in alleviation of feed shortage during the dry seasons.

Linking pastoral economies with commercial domestic and international markets by creating awareness of and encouraging market driven approaches among (agro) pastoralists is vital. Such efforts should go together with capacity building of (agro) pastoralists on range pasture/forage crop production, management, conservation and use of feed supplementation technologies. Similar training is required for county extension staff, but their training should also include ration formulation, feed planning and budgeting.

Equally important is to enhance capacity of the county staff to effectively manage community-based organization/group dynamics. Promotion of cross county training and sensitization on range pasture conservation would help minimizing the livestock influx/outflux during dry spells and in preventing conflicts.

Furthermore, hiring of more extension staff by the counties who act as farm coaches must be considered. Establishment of a county livestock feed security unit, to implement the county feed strategy (e.g. Kajiado) and oversee development of livestock feeds and capacity building of extension staff on feed and forage management is important.

Control of invasive species through selective bush clearing (e.g. uproot or cut exactly or slightly below surface level) and biological control and increase of security in the conflict prone areas through community policing and frequent mobilization of peace building meetings are expected to enhance accessibility of animals to forage.

Genetic improvement of animals, though not the focus of this report is important, to obtain, adaptive, resilient higher yielding and faster-growing animals with higher feed conversion efficiency (keep the breed that matches the feed); and identification of locally adapted forage species and establishment of their production systems.

Processing to utilizable form of unconventional potential feedstuffs that are currently wasted (e.g. coffee pulp and husk, banana pseudo-stems and leaves, avocado skin and kernel, mango peels and kernels, detoxified castor seed residue etc) and increase in cereal milling, oil seed processing, insect protein (black soldier fly, crickets) and feed processing units would all increase supplementary feed availability.

Capacity building of women in Community Common Interest Groups (CIGs), Community Based Organization (CBOs) and cooperatives to procure and run agro-processing plants would create jobs and empower women. Enhancing skills of agro-pastoralists as well as extension staff on feed supplementation strategies and use of total mixed ration are also promising steps for enhancing livestock production in the agro pastoral areas. There is also a need to strengthen linkages between farmers and (agro) pastoralists for co-existence and peace building, which would result in sharing of natural resources promoting crop residue utilization and sustainable use of rangelands.

Conclusion

Traditionally, livestock production in ASALs have relied primarily on natural vegetation for sustenance. However, increasing climate variability, prolonged droughts and water scarcity are making this model less reliable. As a result, the cultivation of fodder and the reseeding of rangelandsare increasingly being adopted as a critical adaptation strategy and proactive approach to building resilience.

Fodder supplementation and range pasture production offers multifaceted benefits. First, they provide a more reliable feed source during periods of feed scarcity, which are becoming more common due to erratic rainfall patterns. Second, they contribute to the rehabilitation of degraded and over-stressed rangelands, helping restore ecological balance and productivity. Third, the cultivatation of forage seed and forage crops can act as an important complementary source of income for households, diversifying their economic base and reducing reliance solely on livestock sales.

However, the reliance on low-quality hay in the commercial forage market during scarcity is economically unsustainable for most livestock farming systems in ASALs. When scarcity drives prices upward, feeding costs often exceed the economic return from livestock production. Another alternative is strategic stockpiling, setting aside designated rangeland pasture for dry-season feeding, a practice that allows forage to accumulate in the pasture and be used when growth is limited or non-existent.

Evidence from reseeding initiatives and the adoption of adapted, cultivated forage varieties demonstrates positive impacts on livestock performance. Some projects report significant increases in liveweight gain, milk yield and overall animal health, directly translating into higher household incomes and improved food security for livestock farmers in ASALs. For example, the sale of grass seed and crop residues can generate an average return of KES. 13,500 per acre for fodder farmers, with grass sales often representing a significant contributor to household income (Metameta, 2019). This demonstrates that forage seed production and the sale of the residue, or grass straw, can be an economically attractive venture where markets are functional.

Neverthless, caution is warranted regarding livestock performance when livestock rations are largely based on crop residues (Rumeth, 2019). While crop residues can form part of the feed basket, their low digestibility limits animal productivity unless improved through methods, such as bio-fermentation. Introducing such technologies requires farmer training, structured coaching, and demonstration-based learning (see table in section 5.2 in this chapter). Given the high costs of off-farm inputs, including commercial feed and hay, forward planning for dry periods is essential to reduce dependence on expensive market fodder while ensuring that the nutritional requirements of different livestock categories are met.

Across varying climatic zones and production systems, tailored approahes to are required. Technical solutions will need to be aligned with local social and cultural constraints, climatic and soil conditions, rainfall patterns and livestock objectives. Upscaling forage production and transitioning toward more resilient feeding systems will require improved production practices, mechanisation, coordinated grazing management and, in some instances, changes in in land-use planning. Such transitions may extend beyond individual farm boundaries and intersect with semi-(agro) pastoral communities and wildlife corridors. Therefore, forage development must be embedded in local, regional and national development policies.

Forage production can be significantly increased through improved grazing management, forage production practices and rangeland rehabilitation, and more effective use of currently underutilized land. Timely conservation of excess biomas, structured out-grower models, and the applicatio of ration formulation tools can make year-round feeding both technically feasible and economically viable.. The selection of adapted forage species must consider soil type, weather conditions, animal nutritional requirements, production goals of the livestock farming system, production costs, knowledge and skill levels, availability of equipment, and in particular in rangeland systems, well-designed grazing management plan and practices.

Beyond feed provision, forage systems contribute to enhanced resilience against climate shocks, particularly droughts and floods, by providing alternative feed sources when traditional, natural growing fodder in the rangelands is scarce. These improved forage systems contribute to the possibility of fodder conservation of excess biomass, carbon sequestration in soils through their extensive and deep rooting systems, thereby playing a role in climate change mitigation. They also improve soil health, enhance nitrogen fixation (as seen with legume forage crops, such as Cowpea, Lablab bean, Sunn hemp and others), and contribute to effective control of soil erosion, improving overall land management practices. When best practices are followed, investments in in forage production generate compounding ecological, economic, and socio-economic dimensions.

Policies should therefore integrate forage development within broader sustainable land management initiatives and foster cross-sectoral collaboration among among livestock, environment, water, and land-use institutions. A dedicated forage strategy should be developed at county level, aligned with national frameworks (GoK 2021). Conservancies, ranches and commercial farms should be encouraged to develop forage master plans aimed at increasing self-sufficiency in fodder production.

Based on this thorough assessment, we propose a series of strategic recommendations. These recommendations advocate enhanced policy coherence, targeted investments in extension and research, robust mechanisms for securing communal land rights, sustainable market development, and the comprehensive integration of ecosystem health into policy design. The overarching objectiive is to guide robust policy reforms that will foster a more resilient, productive, and equitable future for ASAL communities and the national economy.

REFERENCES

Agroforestry (CIFOR-ICRAF) and Catholic Relief Services, Baltimore, MD.

Alulu, V.H., Shikuku, K.M., Lepariyo, W. et al. (2024). The impact of forage condition on household food security in northern Kenya and southern Ethiopia. Food Sec. 16, 1265–1289 (2024). https://doi.org/10.1007/s12571-024-01473-w.

Auma J., Omondi I., Githinji J., Rao E.J., Lukuyu B., and Baltenweck I., (2019) USAID-Kenya Crops and Dairy Market Systems Activity, Technical Report: Feed and Fodder Value Chain Assessment, RTI International, Retrieved May 15, 2025 from https://www.researchgate.net/publication/330789090 doi:10.13140/RG.2.2.14770.66249.

B., Magaju, C., & Onuska, R. (2025). Restoration Monitoring Guide: A field technicians' manual for monitoring restoration across watersheds.

Becerra-Pérez, L.A.; Rincón, L.E.; Posada-Duque, J.A. (2022). Logistics and Costs of Agricultural Residues for Cellulosic Ethanol Production. Energies 2022, 15, 4480. https://doi.org/10.3390/en15124480.

Bedelian C, Levine S.; (2025). Transforming pastoral livelihoods through market interventions: does the impact match expectations? Lessons from a decade of investments in Somali Region, Ethiopia**.** Technical report.

BRAINTEC (2025) Learning Study for Resilient Arid Lands Partnership for Integrated Development Plus (RAPID+) Program, Braintec consulting, Swiss Agency for Development and Cooperation SDC, February 2025.

Burkart, S.; Mwendia, S., (2024). Forage Seed Systems to Close theRuminant Feed Deficit in Eastern Africa. Grasses **2024**, 3, 333–354. https://doi.org/10.3390/grasses3040025.

Capstaff N.M., Miller A.J. (2018), Improving the Yield and Nutritional Quality of Forage Crops.

Chalie W. Taye, Misbah A. Hussein, Ayenew D. Ayalew, Tewodros T. Assefa, Nicola Fohrer, Fikadu T. Riga, Melkamu B. Derseh, Aberra Adie, Seifu A. Tilahun, (2025). Evaluating irrigation and fertilizer strategies for sustainable forage productivity and improved nitrogen efficiency in the sub-humid highlands of Ethiopia, Journal of Agriculture and Food Research, Volume 23, 2025, 102242, ISSN 2666-1543.

Cheng Y., Garg M.R., Hu G., Padmakumar V., Makkar H.P.S., (2025). Ensiling rice straw in China and India : when bio-fermentation turns crop residues into valuable animal feed resources, Broadening Horizons N°59, June 2025.

Choge S., Mbaabu P.R., Muturi G.M., (2022). Prosopis as a Heat Tolerant Nitrogen Fixing Desert Food Legume, Chapter 5 - Management and control of the invasive *Prosopis juliflora* tree species in Africa with a focus on Kenya, Academic Press, 2022, Pages 67-81, https://doi.org/10.1016/B978-0-12-823320-7.00024-9.

Competition Authority of Kenya, CAK. (2025). Animal Feed Market Inquiry Report, 2024.

Creemers J. J. H. M., Aranguiz A.A., (2019). Quick Scan of Kenya's Forage Sub-Sector, SNV-NEADAP, Nairobi, Kenya.

Creemers J., (2025) Livestock Production Plan, Kasigau Ranch, Taita Taveta, African Wildlife Foundation, Nairobi, Kenya.

Creemers J., Chege P.M., (2024) Working Paper NEADAP Approach for Year-Round Fodder Availability for Farmers of Kitise Farmer's Cooperative Society., FAO Nairobi Kenya.

Creemers J., Jansen A., (2025) Lessons Learned from Selected Cases of ICSIAPL's Innovation Fund, SNV/KALRO - Integrated & Climate Smart Innovations for Agro-Pastoralist Economies and Landscapes Kenya's ASAL, Nairobi - Kenya, April 2025, Retrieved May 23, 2025 from https://livestock.africa/.

Creemers J., Maina D., Opinya F., and Maosa S., (2021) SNV/KALRO - Integrated & Climate Smart Innovations for Agro-Pastoralist Economies and Landscapes Kenya's ASAL, Forage Value Chain Analysis for the Counties of Taita Taveta, Kajiado and Narok, Retrieved May 10, 2025 from https://livestock.africa/.

Creemers J., Nelle S.L., (2025) Investing in the Feed and Livestock Sectors in Eastern Africa: Working Paper for East African (Ethiopia, Kenya, Somalia And Uganda)., FAO, Nairobi, Kenya.

Creemers J., Opinya F.A., (2023) Forage production and utilization: economics and barriers to adoption in high dairy potential areas of Kenya, Venture 37, Land o Lakes, Nairobi, Kenya.

D'Alessandro S.P., Caballero J., Lichte J., Simpkin S, (2015) Kenya Agricultural Sector Risk Assessment, World Bank Group.

FAO (2013), Climate Smart Agriculture Source book https://www.fao.org/climate-smart-agriculture-sourcebook/ Retrieved August, 2025.

FAO 2006 Kenya Country Pasture/Forage Resource Profiles, by A.B. Orodho, Rome, Italy.

FAO. (2012). Crop residue based densified total mixed ration – A user-friendly approach to utilise food crop by-products for ruminant production, by T.K. Walli, M.R. Garg & Harinder P.S. Makkar. FAO Animal Production and Health Paper No. 172. Rome, Italy.

Larive/Lattice, (2020), FeedtechKenya, Animal feed sector study Kenya, Final report.

Flórez F., Karimi P., Paredes,J.J.J., Ángel, N. T., Burkart S., (2024) Alliance Bioversity & CIAT, Opportunities and challenges for improved forage seed market development: Insights from Kenya and other East African countries, Retrieved May 19, 2025 from https://hdl.handle.net/10568/151855.

Florez, J. F., Karimi, P., Paredes, J. J. J., Ángel, N. T., & Burkart, S. (2024). Developments, bottlenecks, and opportunities in seed markets for improved forages in East Africa: The case of Kenya. Grassland Research, 3(1), 79–96. Retrieved May 10, 2025 from https://doi.org/10.1002/glr2.12073.

Front. Plant Sci. 9:535. doi: 10.3389/fpls.2018.00535.

Fuglie K., Michael R., Stefan B., (2021), The Extent and Economic Significance of Cultivated Forage Crops in

Developing Countries, Frontiers in Sustainable Food Systems, Volume 5 – 2021, DOI=10.3389/fsufs.2021.712136.

Fushai F, Chitura T and Oke OE (2025) Climate-smart livestock nutrition in semi-arid Southern African agricultural systems. Front. Vet. Sci. 12:1507152. doi: 10.3389/fvets.2025.1507152.

GoK (2019) Kenya Population and Housing Census, Volume I: Population by County and sub-County, Nairobi, Kenya, ISBN: 978-9966-102-09-6 Retrieved May 21, 2025, from https://www.knbs.or.ke/.

GoK (2019) National Livestock Policy, Ministry of Agriculture, Livestock, Fisheries and Irrigation State Department for Livestock.

GoK (2021) National Feed Inventory and Feed Balance Assessment: The Case of 47 Counties of Kenya, Final Report - Draft – 010, Prepared by Ministry of Agriculture, Livestock & Fisheries (State Department for Livestock), Submitted to the Council of Governors (CoG), November 2021.

GoK (2021) Range Management and Pastoralism Strategy 2021 – 2031, Ministry of Agriculture, Livestock, Fisheries and Cooperatives, Nairobi, Kenya.

GoK (2023a) National Animal Feeds Strategy 2022 – 2030, Ministry of Agriculture and Livestock Development State Department for Livestock. August 2023.

GoK (2023b) Isiolo County Integrated Development Plan 2023-2027, Equitable and Prosperous County Retrieved May 21, 2025, https://nipfn.knbs.or.ke/isiolo.

GoK (2023c) Kajiado County Integrated Development Plan 2023-2027, A transformed and Sustainable Kajiado, Retrieved May 21, 2025, https://kajiadoassembly.go.ke/.

GoK (2023d) Nakuru County Integrated Development Plan 2023-2027, Sustained economic growth for a shared prosperity, Retrieved May 21, 2025, https://nakuru.go.ke/.

GoK (2024), The Kajiado County Livestock Feed Strategy 2 0 2 3 – 2033, County Government of Kajiado, Kajiado, Kenya.

Hayat K., Zhou Y., Menhas S., Bundschuh J., Hayat S., Ullah A., Wang J., Chen X., Zhang C., Zhou P, (2020). Pennisetum giganteum: An emerging salt accumulating/tolerant non-conventional crop for sustainable saline agriculture and simultaneous phytoremediation, Environmental Pollution, Volume 265, Part A, 2020, 114876, ISSN 0269-7491, https://doi.org/10.1016/j.envpol.2020.114876.

Health and performance and reduce methane emission. Front. Anim. Sci. 5:1296203.

Houda R., Mohamed J., Chaker S., Supplemental feeding on rangelands: New dynamics of the livestock in the El Ouara rangelands in southern Tunisia, Regional Sustainability, Volume 4, Issue 4, 2023, Pages 359-368, ISSN 2666-660X, https://doi.org/10.1016/j.regsus.2023.10.001.

IGAD (2024) Centre for Pastoral Areas and Livestock Development (ICPALD), Participatory rangeland management: Guidelines for practitioners. Nairobi: ICPALD and ILRI. https://hdl.handle.net/10568/145167.

Ikanya L.W., Maina J.G., Gachuiri C.K., Owino W.O., Dubeux J.C.B., (2022), Chemical Composition and Digestibility of Preferred Forage Species by Lactating Somali Camels in Kenya, Rangeland Ecology & Management, Volume 80, 2022, Pages 61-67, ISSN 1550-7424, Retrieved May 17, 2025 from https://doi.org/10.1016/j.rama.2021.10.003.

ILO (2025). Gachuiri, C.K., Lang'at, J., Lukuyu, M., Mwangi, D., Karugia, J., Lukuyu, B., Rao, J. and Rabar, B. 2025. Reducing the cost of livestock feeds in Kenya: Policy options and recommendations. ILRI Policy Brief 50. Nairobi, Kenya: ILRI.

Islam MR, Garcia SC, Sarker NR, Islam MA and Clark CEF (2023) Napier grass (Pennisetum purpureum Schum) management strategies for dairy and meat production in the tropics and subtropics: yield and nutritive value. Front. Plant Sci. 14:1269976. doi: 10.3389/fpls.2023.1269976.

Ismail A.S., Osman N.B., Patrick D.O., Trial of Biopellet Prepared by Napier Grass, ACS Omega 2022 7 (50), 46037-46050, DOI: 10.1021/acsomega.2c03434.

Jerónimo E., Pinheiro C., Lamy E., Dentinho M.T., Baptista E.S., Lopes O., Capela e Silva F., (2016) Tannins in Ruminant Nutrition: Impact on Animal Performance and Quality of Edible Products In book Tannins: Biochemistry, Food Sources and Nutritional Properties Chapter: 5Publisher: Nova Science Publishers Inc, New York, USA.

Joseph, J., Tramberend, S., Kabi, F., Fischer, G., & Kahil, T. (2025). Sustainable intensification of fodder crop production can mitigate feed shortage and seasonality in East Africa. Environmental Development, 54, 101158.

Kabirizi, J., (2024). A Review of Packchong 1 and Juncao Hybrid Napier Grass Varieties.

Kaitho R.J., (1997), Nutritive value of browses as protein supplement(s) to poor quality roughages, Thesis Landbouw Universiteit Wageningen (WUR). ISBN 90-5485-735-8.

Kariuki, J.N., (1998), The potential of improving Napier grass under smallholder dairy farmers' conditions in Kenya, Thesis Landbouw Universiteit Wageningen (WUR), ISBN 90-5485-964-4.

KEBS (2019a) Fodder hay — Specification Part 1: Grass hay, KS 2832-1:2019, 8th January 2019.

KEBS (2019b) Fodder hay — Specification Part 1: Legume hay, KS 2832-2:2019, 8th January 2019.

Kidake B K, Manyeki J K, Kubasu D and Mnene W N (2016) Promotion of range pasture and fodder production among the pastoral and agro-pastoral communities in Kenyan rangelands: Experiences and lessons learnt. Livestock Research for Rural Development. Volume 28, Article *#151.* Retrieved May 17, 2025, from http://www.lrrd.org/lrrd28/8/kida28151.html.

Kimaru J., Mutembei H., Kaunga J.M, (2023), Policy Recommendations for Promoting the Viability of Hay production in the Arid Rangelands of Kenya, Afr. J. Food Agric. Nutr. Dev. 2023; 23(3):22751-22769 https://doi.org/10.18697/ajfand.118.23045.

Kimaru, J., Mutembei, H. and Muthee, J.K. (2021a) Analysis of Hay Demand from Pastoralism Systems.

Kimaru, J., Mutembei, H., & Muthee, J. K. (2021b). Effectiveness of Drought Risk Reduction Policies: Effectiveness of Drought Risk Reduction Policies: Case Study of Hay Production in Kajiado County, Kenya. DOI https://doi.org/10.4236/ajcc.2021.104026.

Kimiti D.W.,Ganguli A.C., Herrick J.E., Bailey D.W., (2020) Evaluation of Restoration Success to Inform Future Restoration Efforts in Acacia reficiens Invaded Rangelands in Northern Kenya, Ecological Restoration Vol. 38, No. 2, 2020 ISSN 1522-4740 E-ISSN 1,543-4079 ©2020.

KMT, (2019) Contextualizing Pathways to Resilience in Kenya's ASALs under the Big Four Agenda, Nairobi, April 2019.

KNBS (2019). The 2009 Kenya population and housing census. Nairobi: Kenya National Bureau of Statistics.

KNBS, (2024), National Agriculture Production Report: 2023-2024. Nairobi, Kenya.

Koech O., Kibet S., (2021) Pasture Production and Conservation Training Manual, IDRC Grant/ Subvention du CRDI: 109213-001-Socially inclusive adaptation knowledge for resilient livelihoods in northern Kenya, Retrieved May 17, 2025.

Kurinji L. S, Sankalp Kumar. (2021). Is Ex-situ Crop Residue Management a Scalable Solution to Stubble Burning? A Punjab Case Study. New Delhi: Council on Energy, Environment and Water.

Macdonald C.I., Zhanxi L., (2010). Giant Juncao Grass cultivation in Kwazulu-Natal, Agri Update: Information from the KZN Department of Agriculture, Environmental Affairs & Rural Development, October 2010.

Mganga K.Z., Munyoki B.S., Bosma L., Kadenyi N., Kaindi E, Amolo K.O., Kioko T., Musyoki G.K. · Steenbergen van F., (2024), Pasture farming for climate change adaptation in a semi-arid dryland in Kenya: status, challenges and opportunities Discover Sustainability, (2024) 5:508, https://doi.org/10.1007/s43621-024-00760-y.

Mohamed Sala, S., Otieno, D.J., Nzuma, J., Mureithi S.M., (2020), Determinants of pastoralists' participation in commercial fodder markets for livelihood resilience in drylands of northern Kenya: Case of Isiolo. Pastoralism 10, 18 (2020). https://doi.org/10.1186/s13570-020-00166-1.

Morrison, R., Teufel, N., Duncan, A., & Barnes, A. (2023). An innovation systems approach to understanding forage adoption intensity in the dairy systems of Kenya and Ethiopia. Outlook on Agriculture, 52(4), 371-381. https://doi.org/10.1177/00307270231171712.

Muktar M.S., Bizuneh T., Anderson W., Assefa Y, Negawo A.T., Teshome A., Habte E., Muchugi A., Feyissa T., Jones C.S., Analysis of global Napier grass (Cenchrus purpureus) collections reveals high genetic diversity among genotypes with some redundancy between collections, Sci Rep. 2023 Sep 4;13(1):14509. doi: 10.1038/s41598-023-41583-7. PMID: 37667017; PMCID: PMC10477186.

Mutuku S.M., Opondo F.A., Lagat J.K., (2023). Determinants of Farmers' Choice of Fodder Market Outlets in Laikipia County, Kenya, African Journal of Agricultural Research, Vol. 19(5), pp. 501-507, DOI: 10.5897/AJAR2023.16368.

Mwangi P.M., Eckard R., Gluecks I., Merbold L., Mulat D.G., Gakige J., Marquardt S. Pinares-Patino C.S. (2024) Supplementation of a tropical low-quality forage with *Calliandra calothyrsus* improves sheep

Mwendia S; Notenbaert A; Paul B. 2016. Forage seed systems in Kenya. Working Paper. Centro Internacional de Agricultura Tropical (CIAT). Nairobi, Kenya. 12 p.

Mwendia S., Ohmstedt U., Peters M., (2020). Forage Seed Systems in Kenya report. CIAT-Biodiversity Alliance. June 2020.

NFA (2022) Nyeri Fodder Alliance, Strategic Plan 2022-2027, "Accelerating adoption of feed production and preservation innovations.

Noor, I. M., Bebe, B. O., Guliye, A. Y., & Muliro, P. S. (2007). Feeding Strategies in Isiolo Peri-Urban Camel Milk System of Northern Kenya. In Proceedings of the Second Research week and International conference (pp. 1-6).

Nyambati E.M., Muyekho F.N., Onginjo E., Lusweti C.M., (2013) Production, characterization and nutritional quality of Napier grass [Pennisetum purpureum (Schum.)] cultivars in Western Kenya, African Journal of Dairy Farming and Milk Production Vol. 1 (2), pp. 028-033, September 2013.Available online at www.internationalscholarsjournals.org © International Scholars Journals.

Omollo E.O., Wasonga O.V., Chimoita E.L., (2023), Use value of indigenous range grass species in pastoral northern Kenya, Ethnobotany Research and Applications 25:16 (2023), Retrieved May 17, 2025 http://dx.doi.org/10.32859/era.25.16.1-16

Ouko E. , Omondi S., Mugo R., Wahome A., Kasera K., Nkurunziza E., Kiema J., Flores A., Adams E.C., Kuraru S., Wambua M., (2020) Modeling Invasive Plant Species in Kenya's Northern Rangelands, Frontiers in Environmental Science, Volume 8 – 2020, https://doi.10.3389/fenvs.2020.00069.

Paul, Birthe K. Koge, J., Maass, B. L., Notenbaert, A. Peters, M. Groot, J. C.J. Tittonell, P. (2020), Tropical forage technologies can deliver multiple benefits in Sub-Saharan Africa. A meta-analysis, Agronomy for Sustainable Development.

Ponnampalam E.N., Jairath G., Alves S.P., Gadzama I.U., Santhiravel S., Mapiye C., Holman B.W.B, (2025). Sustainable livestock production by utilising forages, supplements, and agricultural by-products: Enhancing productivity, muscle gain, and meat quality – A review, Meat Science, 2025, 109921, ISSN 0309-1740, https://doi.org/10.1016/j.meatsci.2025.109921.

Rambau M.D., Fushai F., Callaway T.R., Baloyi J.J., (2022). Dry matter and crude protein degradability of Napier grass (Pennisetum purpureum) silage is affected by fertilization with cow-dung bio-digester slurry and fermentable carbohydrate additives at ensiling. Transl Anim Sci. 2022 Jun 23;6(2): txac075. doi: 10.1093/tas/txac075. PMID: 35769454; PMCID: PMC9225817.

Roy, A., Roy, B. K., Clark, C. E. F., Bashar, M. K., Sarker, N. R., Sultana, N., Billah, M. M., Al-Mamun, M., & Islam, M. R. (2025). Management Strategies for Napier Grass (Pennisetum purpureum Schumach cv Pakchong): Impact on Dry Matter Yield, Nutritive Characteristics and Cattle Growth. Animals, 15(9), 1235. https://doi.org/10.3390/ani15091235.

Rumen8 2025, https://www.rumen8.com.au/training/index.html.

RuMeth International Ltd, (2019), USAID-Feed the Future Kenya Crops and Dairy Market Systems Activity, Abridged Technical Report: Dairy Animal Nutrition Study in Priority Counties, RTI International, Retrieved May 10, 2025.

Sagala P.J.I., Gachuiri C.K., Kuria S.G., Wanyoike M.M., (2022). Forage Preferences by Lactating Camels in the Periurban Area of Marsabit Town, Kenya, Journal of Agricultural and Crop Research Vol. 10(4), pp. 60-66, July 2022, doi: 10.33495/jacr_v10i4.22.110, ISSN: 2384-731X.

Sircely, A. and Eba, B. 2021. Land health integration for improved One Health outcomes: Status and prospects. Nairobi, Kenya:ILRI.

Slayi, M., Jaja, I.F., (2024) Integrating Mixed Livestock Systems to Optimize Forage Utilization and Modify Woody Species Composition in Semi-Arid Communal Rangelands. Land 2024, 13, 1945. https://doi.org/ 10.3390/land13111945.

Snijders, P. J. M., Wouters, B. P., Kariuki, J. N., (2011). Effect of cutting management and nitrogen supply on yield and quality of Napier grass (Pennisetum purpureum): nitrogen supplied by fertilizer, cattle manure or Desmodium intortum. Wageningen UR Livestock Research (544): 98 p.

Sombroek, W.G., Braun, H.M.H. van der Pouw, B.J.A. (1982) Exploratory Soil Map and Agro-Climatic Zone Map of Kenya, 1980. Scale: 1:1,000,000. Exploratory Soil Survey Report No. E1. Kenya Soil Survey Ministry of Agriculture, National Agricultural Laboratories, Nairobi.

Sonwai A., Pholchan P., Pholchan M.K., Pardang P., Nuntaphan A., Juangjandee P., Totarat N., Tippayawong N., (2022). Biogas production from high solids digestion of Pennisetum purpureum x Pennisetum typhoideum: Suitable conditions and microbial communities, Journal of Environmental Management, Volume 299, 2021, 113570, ISSN 0301-4797, https://doi.org/10.1016/j.jenvman.2021.113570.

SSN, (2021), Seed Savers Network, Seed Security Survey in Baringo, Kakamega and Machakos Counties of Kenya.

Staines *et al.,* (2023), Dairy cattle nutrition in the tropics using Rumen8, https://www.rumen8.com.au/training/index.html.

TechnoServe (2016) Business Solutions to Poverty: The Transformation of the Fodder Market in Kenya, December 2016.

Tegemeo (2022). Kenya's Animal Feeds Manufacturing Competitiveness. Tegemeo Institute Technical Report.

Undersander, D. (2006). Uses and abuses of NIR for feed analysis. In Florida Ruminant Nutrition Symposium, Gainseville. [Online, accessed July 13, 2011] URL: http://dairy. ifas. ufl. edu/rns/2006/Undersander.

Vernooy, R.; Sthapit, B.; Bessette, G. (2020) Community seed banks: concept and practice. Facilitator handbook (updated version). Rome (Italy): Bioversity International. 150 p. ISBN: 978-92-9255-068-4

Wafula M.W., Kirui G., Kibet S.K., Koech O.K., (2018). Impacts of invasive *Argemone mexicana* species and the management strategies in Oloitokitok, Kajiado South Sub-County of Kenya, Conference: 3rd One Health Central and Eastern Africa (OHCEA) International One Health Conference 24-26 July 2019, Kampala, Uganda. Theme: "Harnessing One Health for Global Health Security."

Wasonga, O.V., Ngoyawu, W. M., Elhadi, Y.A.M., (2016) Fodder production for enhanced pastoral and agro-pastoral resilience in the drylands of Southern Kenya, RUFORUM Working Document Series (ISSN 1607-9345) No. 14 (2): 819 - 825.

Welfle A., Chingaira S., Kassenov A., (2020). Decarbonising Kenya's domestic & industry Sectors through bioenergy: An assessment of biomass resource potential & GHG performances. Biomass and Bioenergy, Volume 142, 2020, https://doi.org/10.1016/j.biombioe.2020.105757.

Wouters A.P., Snijders P.J.M., Silage quality and losses associated with ensiling of Napier grass, Columbus grass and maize stover under smallholder conditions in Kenya. https://www.fao.org/4/X8486E/x8486e0e.htm.

WFP, 2018. Pastoral and Agro-pastoral Production System in the Arid and Semi-Ari Areas. Field Practitioners Guide No. 3. World Food Programme, Nairobi.

Winowiecki, L., Vågen, T., Subagadis, Y., Worku, A., Trautman, S., Hagazi, N., Ahmad, M., Onkware,

Yu Z., Junqin L., Xiangtao W., Yuting Y., Zijun Z., Xiaolin D., Yang G., Puchang W., (2024) A bibliometric analysis review of the Pennisetum (1970–2023), Frontiers in Sustainable Food Systems, Volume 8 – 2024, https://www.frontiersin.org/journals/sustainable-food-systems/articles/10.3389/fsufs.2024.1405684, DOI=10.3389/fsufs.2024.1405684.

Zailan, M. Z., Yaakub, H., & Jusoh, S. (2016). Yield and nutritive value of four Napier (Pennisetum purpureum) cultivars at different harvesting ages. Agriculture and Biology Journal of North America, 7(5), 213-219.

Articles & presentations

101158, ISSN 2211-4645, https://doi.org/10.1016/j.envdev.2025.101158

Bizna (2025) https://biznakenya.com/australian-red-napier-in-kenya/, 5th August 2025.

Citizen (2025) https://citizen.digital/news/kenya-targets-over-ksh500-billion-fodder-market-in-landmark-investment-push-n361915, 30 April 2025

CSAI (2018) http://www.snv.org/project/feed-future-east-africa-catalytic-sustainable-agribusiness-investment-csai

CSIRO (2023) Anameka Saltbush - CSIRO accessed July 2025

Forage Working Group (2025). Situational analysis of Kenya's Forage and Forage Seed sub-Sector. ICSIAPL and NEADAP Projects.

https://doi.org/10.1016/j.jafr.2025.102242

https://www.ilri.org/tags/gender

Invasive species: Acacia reficiens https://www.nrt-kenya.org/rangelands Retrieved May 23, 2025.

IUCN (2025) International Union for Conservation of Nature https://iucn.org/story/202505/community-conservation-action-protecting-kajiados-biodiversity

Just diggit (2025) Regreening work in Kuku, Kenya | Projects | Justdiggit accessed July 2025

KALRO - AMRI Katumani Annual Report - FY 2022-2023.pdf

KIPPRA. June (2025). Economic and Social Impact of Youth Engagement in Kenya's Food System – KIPPRA (June 2025)

Musyoki R., Seed Production MOUs Between Seed Merchants and KALRO, KALRO HQ, Pasture meeting, 27th November 2024.

Seed Savers Network Kenya, Community Seedbank Establishment Guidelines, Retrieved May 10, 2025.

Standard (2016) : https://www.standardmedia.co.ke/business/article/2000196669/farmers-eye-sh33b-in-hay-production-plan

Westgate Community Conservancy, https://www.westgateconservancy.org/ accessed August 2025

Why Kenyan farmers are fighting for seed rights | Daily Nation, Retrieved June 1, 2025

www.unwomen.org/sites/default/files/Headquarters/Attachments/Sections/Library/Publications/2018/SDG-report-Fact-sheet-Sub-Saharan-Africa-en.pdf

ANNEXES

Annex 1. Abstract from the National Crop Variety List, 2023

Listed dual purpose crops and forage crops Listed in green >= 2015

4. National Sweet Potato Variety List

Species: *Ipomea batatas* - 32 varieties (all KARI/KALRO)

Sweet potato vines (dual purpose)

11. KAP0084, 2010, KARI

13. Mwavuli-1, 2011, KARI

25. NASPOT-1, Double Double, 2015, KALRO

30c.Shock 5, Shock 5, 2019, KALRO

9. National Maize Variety List

Species: Zea Mays. 421 varieties no specific forage varieties

16. National Sorghum Variety List

Species: Sorghum bicolor - 46 varieties.

Dual purpose (6) forage variety (1):

3. BJ28, 1978, KARI

8. Ikinyaluka, 1996 (fodder only), KARI

12. E1291, 2000, KARI

14. Sila, 2006, AgriSeedCo Ltd, SeedCo Zambia

18. Karia SH 12, 2008, KARI

19. Kibuyu, 2011, Leldet

34. KS Sweet Sorg 14, 2016, ICRISAT/Kenya Seed Company

38. EUSS10, 2016, Egerton University

24. National Cow Pea Variety List

Species: Vigna Ungulculata L. Walps - 19 varieties (KALRO and Simlaw, 1 for Western Seed)

Dual purpose varieties (9):

2. 27-1, 1989, KARI

6. Machakos66, 1998, KARI (promoted by KALRO as forage crop)

7. K80, 2000, KARI

10. Kunde 1, ND, Western Seed Co

13. 1002/1005/3 Kunde Faulu, 2017, KALRO

14. 1005/1002/1, Kunde Tamuu, 2017, KALRO

15. 1005/1003/3, Kunde KAT, 2017, KALRO

16. 1005/1002/1/1/1, Kunde Soho, 2017, KALRO

17. 1005/1004/3, Kunde Timaini, 2019, KALRO

25. National Dolichos Bean Variety List

Species: Dolichos pupureum - 7 varieties (4 University of Eldoret and 3 KARI)

Dolichos Lab lab (dual purpose, promoted as forage)

3. KAT/DL-3 1995, KARI

27. National Rhodes Grass Variety List

Species: Chloris guyana - 3 varieties

1. Mbarara Rhodes, 1960), KARI/KSC, maintainer seed source KSC

2. Boma Rhodes, 1975, KARI/KSC

3. Elmba Rhodes, 1976, KARI/KSC

28. National Setaria Grass Variety List
Species: Setaria sphacelata – 2 varieties
1. Nandi setaria (1956) KARI/KSC
2. Nasiwa setaria (ND) KARI/KSC (KSC maintainer)

29. National Pannicum Grass Variety List
Species: Pannicum spp – 1 variety
1. Coloured Guinea (1955) KARI/KSC
(KSC maintainer)

30. National Soya Bean Variety List
Species: Glycine max – 12 varieties (2 dual purpose)
6. DPSB 19, 2010, KARI/ITTA varieties
7. DPSB 8, 2020 KARI/ITTA

36. National Lucerne Variety List
Species: Lucerne (Medicago sativa) 5
(all KALRO of which 2 brought in by
Forage Genetics)
1. WL625HQ, 2015, KALRO, 2. WL414, 2015, KALRO 3. KKS9595, 2015, KALRO, 4. SA Standard 2015KALRO 5. KKS 3864, 2015, KALRO

42. National Pasture Variety List *(*Species: Pasture (Brachiaria spp) – 6 varieties)

Variety name/code	Release name	Year release	Owner	Maintainer/Seed Source
1 Cayman hybrid	Cayman	2016	Advantage Seeds	ACL /Tropical Seeds LLC
2 Cobra hybrid	Cobra	2016	Advantage Seeds	ACL /Tropical Seeds LLC
3 Mulato II hybrid	Mulato II	2016	Advantage Seeds	ACL /Tropical Seeds LLC
4 Forage Sorghum (Sugargraze)	Sugargraze	2019	Advanta Seeds	Advanta Seed Internat.
5 Forage Pearl Millet (Nutrifeed)	Nutrifeed	2019	Advanta Seeds	Advanta Seed Internat.
6 Mombasa (Panicum maximum)	Siambasa	2021	Advantage Seeds	ACL//Tropical Seeds LLC

49. National Oat List
Species: Oat (*Aven sativa)* – 2 varieties (of which one dual purpose)
1. 011 A06, KS Oat16B, 2018, Kenya Seed Company

50. National Triticale List
Species: Triticale (*Triticosecale)* 1 variety
1. Foddatriticale, 2021, suitable for silage and grazing

51. National Urochloa List
Species Urochloa (*Urochloa sp*.) – 6 varieties

Variety name/code	Release name	Year release	Owner	Maintainer & Seed Source
Urochloa Decumbus cv	Basilisk	2021	KALRO	KALRO
Urochloa Brizantha cv	Piata	2021	KALRO	KALRO
Urochloa Xaraes cv	Toledo	2021	KALRO	KALRO
Urochloa Brizantha cv	MG4	2021	KALRO	KALRO
Brachiaria Brizantha cv KISII	KS1	2021	KALRO	KALRO Lanet
Bracharia Brizantha cv BUSIA	BS1	2021	KALRO	KALRO Lanet

52. National Horsetail grass list
1. Horse grass (*Chloris roxburghiana*), 2021, KALRO

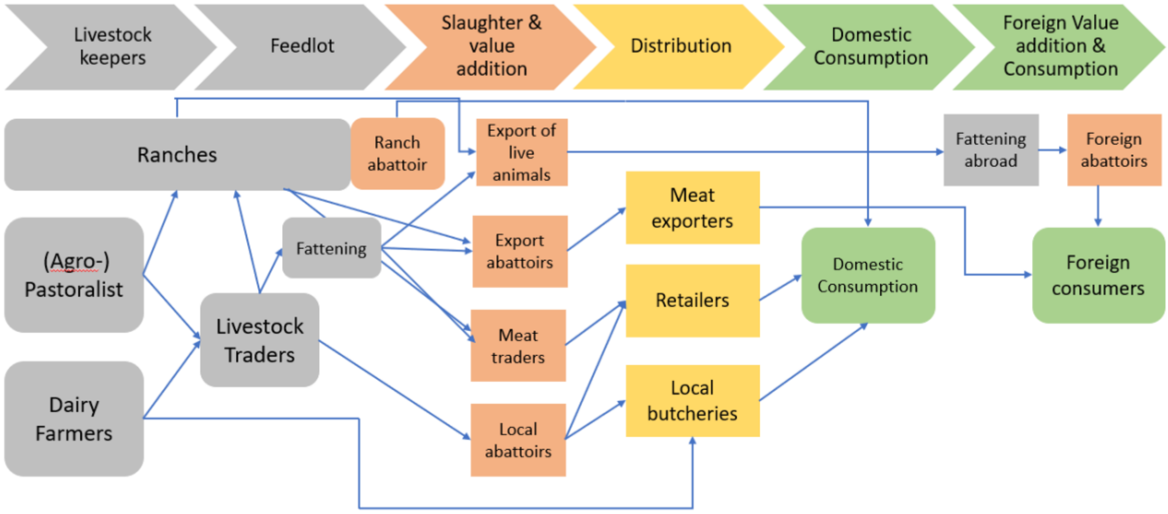
53. National Bushrye grass list
1. Bushrye grass (*Enteropogon macrostachyus*), 2021, KALRO

54. National Buffel grass list Buffel grass
1. Buffel grass (*Cenchrus ciliaris*, MGD-1), 2021, KALRO
2. Buffel grass (*Cenchrus ciliaris*, TVT-3), 2021, KALRO

Annex 2. Recommended forage crop seeds for demo plots

Climatic zone	Forages
Arid Rainfall (100-400mm)	**Forage grain crops:** *Pennisetum glaucum* (Pearl millet) variety Nutrifeed; *Sorghum bicolor* var. Sudanese (Sudan grass); *Sorghum drummondii* (Forage sorghum) variety Sugar graze. **Rangeland grasses:** *Cenchrus ciliaris* varieties Baringo, Gayndah (Buffel grass/African Foxtail); *Chloris roxburghiana* (HorseTail); *Cymbopogon pospischilli; Elymus hystrix* variety Wollie (Bottle brush grass); *Enteropogon macrostachyus* (Bush Rye); *Eragrostis superba* (Maasai Love grass); *Sehima nervosum.* **Rangeland trees:** Acacia nilotica; Acacia senegal; Acacia tortilis
Semi-Arid Rainfall(400-600mm) Altitude (1,000-1,800mm)	**Improved forage grasses:** *Chloris gayana* (Rhodes grass) varieties Katambora, Boma; Hybrid Brachiaria varieties Mulato II, Cayman, Cobra, Camello; Cultivar Brachiaria varieties Xaeres, Piata, Basilisk, MG4; *Panicum maximum* varieties Siambaza/Mombasa. **Forage grain crops:** *Pennisetum glaucum* (Pearl millet) variety Nutrifeed; *Sorghum bicolor* variety Sudanese (Sudan grass); *Sorghum drummondii* (Forage sorghum) variety Sugar graze. **Rangeland grasses:** *Cenchrus ciliaris* varieties Baringo, Gayndah (Buffel grass/African Foxtail); *Cymbopogon pospischilli; Elymus hystrix* variety Wollie (Bottle brush grass); *Enteropogon macrostachyus* (Bush Rye); *Eragrostis superba* (Maasai Love grass); *Sehima nervosum.* **Rangeland trees:** Acacia nilotica; Acacia senegal; Acacia tortilis. **Legumes:** Crotalaria juncea (Sunn hemp); Desmodium intortum (Green leaf); Medicago sativa (Lucerne/Alfalfa).
Warm, Wet (Sub-humid) Medium Altitude Rainfall (600-1,200mm) Altitude (1,200-1,850mm)	**Improved forage grasses:** *Chloris gayana* (Rhodes grass) varieties Katambora, Boma; Hybrid Brachiaria varieties Mulato II, Cayman, Cobra, Camello; Cultivar Brachiaria varieties Xaeres, Piata, Basilisk, MG4; *Panicum maximum* varieties Siambaza/Mombasa, Gatton (White Buffalo grass). **Forage grain crops:** *Pennisetum glaucum* (Pearl millet) varieties Nutrifeed, Hy Pearl Millet; *Sorghum bicolor* var. Kowkandy; *Sorghum drummondii* (Forage sorghum) varieties E6518, Sugar graze. **Rangeland grasses:** *Cenchrus ciliaris* varieties Baringo, Gayndah (Buffel grass/African Foxtail); *Cymbopogon pospischilli; Enteropogon macrostachyus* (Bush Rye); *Eragrostis superba* (Maasai Love grass); *Sehima nervosum.* **Rangeland trees:** Acacia nilotica; Acacia senegal; Acacia tortilis. **Legumes:** *Crotalaria juncea* (Sunn hemp)*; Desmodium intortum* (Green leaf)*; Digitaria eriantha* variety Irene (Smutsfinger grass)*; Medicago sativa* variety HL9, HL10, Al-fac (Lucerne/Alfalfa); *Vicia villosa* (Hairy vetch). Agro forestry trees: *Sesbania sesban.*
Cool, Wet (Sub-humid) Medium Altitude Rainfall (600-1,200mm) Altitude (1,850-2,400mm)	**Improved forage grasses:** *Chloris gayana*(Rhodes grass) varieties Katambora, Boma; *Dactylis glomerata* variety Athos (Cock's foot); *Festuca arundinacea* variety Kora (Tall Fescue); Hybrid Brachiaria varieties Mulato II, Cayman, Cobra, Camello; Cultivar Brachiaria varieties Xaeres, Piata, Basilisk, MG4; *Panicum maximum* varieties Siambaza/Mombasa **Forage grain crops:** *Pennisetum glaucum* (Pearl millet) variety Nutrifeed; *Sorghum drummondii* (Forage sorghum) variety Sugar graze; *Triticosecale* (Triticale). **Rangeland trees:** Acacia kirkii; Acacia nilotica; Acacia senegal; Acacia tortilis; Acacia xanthopholea **Legumes:** *Crotalaria juncea* (Sunn hemp)*; Desmodium intortum* (Green leaf)*; Medicago sativa* variety HL9, HL10, Al-fac (Lucerne/Alfalfa); *Trifolium pratense* variety Oregon Red (Red clover); *Trifolium repens* variety Klondike (White clover); *Vicia villosa* (Hairy vetch). Agro forestry trees: *Sesbania sesban.*

Annex 3. Meat Value chain in Kenya



Source: Adapted from IKEA Foundation Assessment of the cold chain market in Kenya, March 2023

Annex 4. List of Respondents for the study

Name seed stakeholder (Company/distributor/Group)	Location	Contacts / Contact person
Isiolo County		
Department of Agriculture, Livestock and Fisheries Development (Livestock Directorate)	Isiolo	Director of Livestock Production including fodder, feedlots and abbattoir.
Nakupratt Gotu Community Conservancy	Isiolo	Manager Nakuprat-Gotu@nrt-kenya.org Tel: +254 / 722 518 476
Piers S.	Camel farmer, Independent Consultant	-
Nasuulu Community Wildlife Conservancy	Isiolo	P.O Box RT-Private bag – 60300, Isiolo Tel: 0717838411 / 0792152622 Email: nasuulu@nrt-kenya.org
Queen of Peace Initiative	Isiolo	Founder / Director
Northern Range Trust	Isiolo	-
Grevys Zebra Trust	Isiolo	-
Merti Integrated Development Programme (MID-P)	Isiolo	P.O Box 687- 60300 Isiolo Email: info@midpkenya.org
Commercial Fodder Producer	Laikipia / Isiolo	John M. Ex. MoALD
Kajiado County		
Department of Agriculture, Livestock and Fisheries Development (Livestock Directorate)	Kajiado	
Nasaru-Olosho Conservancy Trust	Amboseli Kajiado	P.O. Box 111-90121 Ilkelunyeti Town Center, Kajiado. Phone: (+254) 757 368-366 WhatsApp: (+254) 757 368-366 Email: info@nasaruolosho.org / secretariat.nasaruolosho@gmail.com
World Wide Fund for Nature Kenya (WWF-Kenya)	Loitoktok Kajiado	Email: info@wwfkenya.org
Kimana Wildlife Sanctuary	Amboseli Kajiado	-
Maasai Kajiado Women Dairy Cooperative Society	Kajiado	-
Just Diggit	Kajiado	-
Kuku Group Ranch	Amboseli Kajiado	-
Olorika Grass Seed Bank	Kajiado	C/O Maasai Wilderness Conservation
Maasai Wilderness Conservation		
Windy Ridge Youth group	Kajiado	-
Amboseli Land Owners Conservancies Association (ALOCA)	Loitoktok Kajiado	-
Commercial Fodder Producer	Kajiado	Rev. S
Nakuru County		
Department of Agriculture, Livestock, Fisheries, and Veterinary Services (Livestock Directorate)	Nakuru	-
Nyongi Youth group	Rongai, Nakuru	-
Crevation International / Juncao Grass Farm - Lenginet and Rongai Farms	Lenginet and Rongai, Nakuru	-
Rift Valley Hay Growers Association	Nakuru	-
Dalamere Estates – Soysambu Ranch	Nakuru	-

Technology Farm	Soilo, Nakuru	-
Seed Savers Network-Kenya	Gilgil	Diatomite, Off Nakuru – Nairobi Highway, Gilgil, Kenya. P.O. Box 334 -20116 Tel: +254-712-451777 Email: info@seedsaverskenya.org
Barenbrug - Interplant	Naivasha	-
Research institutions		
KALRO (Lanet)	Lanet Nakuru	KALRO Beef, Lanet www.kalro.org
CIAT	Nairobi	-
University of Nairobi	Nairobi	-
ILRI	Nairobi	C.J

Annex 5. Fodder for supplementation and sources of concentrate ingredients for MUMB or DTMRB

High-quality forages and fodders	Comments on quality	Source
Green chop- young maize or forage sorghum/millet	Very high effective fibre; high moisture; needs to be cut into lengths of 2-3cm or less; low-moderate protein.	Local Farmers (irrigation)
Napier grass (incl Pakchong, Juancao, Australian Red and Dwarf Napier)	Quality declines rapidly with age – cut at 35 - 42 days (6 leaf stage) regrowth for best combination of yield and quality	On-farm grown / irrigation
Guinea grass (incl Siambaza)	Quality declines rapidly with age – cut at 35 - 42 days (6 leaf stage) regrowth for best combination of yield and quality	On-farm grown / irrigation
Leucaena leucocephala leafs (other browse leaf meal)	leaf High quality protein. Generally, highly palatable, Contains mimosine (up to 12% DM in young shoots)	On-farm grown -range browses
High-energy silage		
Forage maize or sorghum silage	Very high energy, high palatability, good source of effective fibre; about 30-35% dry matter; needs to be chopped into lengths of 1-1.5 cm; low protein.	Uasin Gishu, Trans Nzoia / Commercial forage traders
Crop residue and straws		
Rice straw	Low quality roughage used as maintenance feed with additional protein supplements	Mwea / Tanzania
Maize stover	Low quality roughage used as maintenance feed with additional protein supplements	Local Farmers
Wheat straw	Low quality roughage used as maintenance feed with additional protein supplements	Narok/Eldore/Kitale
Bio fermented crop residue	Attractive when crop residue is low priced and available in large quantities, extra expenses but improved quality (digestibility)	e.g. rice straw or low-quality natural grass straw
Sugarcane by-products		
Molasses	High energy and palatability, low protein. Used to increase palatability and intake of low-quality roughages	Western Kenya
Bagasse	Low quality roughage used as maintenance feed with additional energy and protein supplements	Western Kenya
Agricultural by-product	**Comments on quality**	**Source**
Castor (Ricinus communis), oil cake, detoxified, oil < 5%	Castor seed meal is a high-protein, high-fibre ingredient However, it should be noted that castor seed meal contains ricin, a toxic compound that can be harmful to both humans and animals, so it should be used with caution and according to recommended guidelines.	ENI - Makueni/Taita/Coast
Coconut meal (Copra)	High palatability; medium oil content and protein; low starch so safe	Mombasa
Cotton seed hulls	Low quality roughage- high fibre; low starch, protein and energy	ENI - Makueni
Cotton seed meal	Good Palatability, high protein quality, fat, protein and fibre may depend on process. Cottonseed meal usually contains gossypol.	Meru, Tanzania

Maize bran	High fibre; low starch; palatable.	Thika /Mombassa
Pineapple pulp	High energy, low protein by-product. Very high-water content - 85%. Low-moderate palatability with novice cattle but eaten readily eventually	Thika
Soyabean meal	High palatability, high protein quality, medium starch. Fat may depend on process	Ethiopia/Zambia/Malawi/India
Sunflower seed cake/meal	Good Palatability, fairly high protein, fat, protein and fibre may depend on process	Eldoret/Nakuru/Uganda/Tanzania
Rice bran	High fat, medium protein and high energy although energy mostly from oil	Mwea / Tanzania
Rice hulls	Low quality roughage- high fibre; low starch, protein and energy	Mwea / Tanzania
Wheat bran	High starch, medium protein; highly palatable and can lead to acidosis if fed too much	Eldoret, Nairobi, Thika , Mombassa
Wheat pollard	High starch, medium protein; highly palatable, low fibre and can lead to acidosis if fed too much	Eldoret, Nairobi, Thika , Mombassa
Grains crops		
Maize grain	High palatability, high energy, high starch.	Eldoret/Nakuru/Tanzania
Sorghum grain	High palatability, high energy, high starch.	Makueni/Kajiado/Kitui
Wheat grain	High palatability, high energy, high starch.	Eldoret/Nakuru/Tanzania

Annex 6. Comparison between compaction density of conventional and non-conventional balers or compaction technology

Hay balers		
Hay baler	**Krone**	**Claas**
Height: 36 cm	Height: 0,9 meter	Height: 0,7 meter
Width: 46 cm	Width: 1,2 meters	Width: 1,2 meters
Length: 80-120 cm	Length: 2,2 meter – 2,8 meters	Length: 2,2 meter – 2,8 meters
Volume: 0,2 m3	Volume: 2,59 m3	Volume: 2,00 m3
Typical weight: 10-20 kg	Typical weight: 500 kg	Typical weight: 350 kg
Density: 80 – 100 kg/m3	Density: 180 – 200 kg/m³	Density: 160 – 180 kg/m3

Rice straw	
Rice straw	**Dry matter**
Loose rice straw	Density: 13 – 18 kg/m³
Chopped rice straw (2-10 mm)	Density: 50 – 120 kg/m³
Rice straw bale	Density: 60 – 90 kg/m³
Rice straw briquettes	Density: 350 – 400 kg/m³
Rice straw pellets	Density: 600 – 700 kg/m³

Annex 7. Questionnaire for Fodder producer

INTERVIEW GUIDE | Fodder for supplementation

INTRODUCTION

Livestock development is strategic for substantial economic opportunities for smallholder farmers and pastoralists in Kenya, but productivity is constrained by scarcity of quantity and quality forage. This setback has lately ignited collective efforts from the Kenyan government, African Union, Development partners, livestock keepers and other forage value chain stakeholders; to reverse the situation and support forage value chain development for supplementary feeding during periods of scarcity (drought or land) and help in shaping a vibrant forage seed sector.

In so doing, improved forage production, utilization, economics and barriers to adoption need to be effectively understood in different Agro-Ecological Zones (Arid, Semi-Arid and Semi-Humid), purposing this information gathering exercise amongst stakeholders in three counties, Isiolo, Kajiado, Nakuru including commercial forage producers. Through this interview guide, we seek to identify working modalities and pathways for enhanced availability, accessibility, affordability and use of suitable forage seed varieties by livestock producers and commercial fodder producers. It further evaluates the economic feasibility and drivers of behavioural change towards uptake of improved, nutrient -rich forage (seeds) crops in Kenya.

We kindly request for about 45 minutes of your time to take you through and have a discussion on the following questions. Your responses will be treated confidential and will only be used for this purpose.

Thank you in advance for your cooperation,

ProDairy EA Ltd
Nairobi, June 2025.
Date of filling the questionnaire (dd/mm/yy): ___________________

BIO DATA

Farm/Business/Institution name: ____

Name of respondent: ____

Designation: ____

Gender: ☐ Male ☐ Female

Contacts: Email and/or telephone number: ____

Location: County ______________________________ Sub- County_________________________

Number of years in operation: ____

Nature of business ☐ Sole proprietor / Individual ☐ Private company ☐ Producer group / CIG ☐ Cooperative

☐ Other(specify) ____

Nature of operation ☐ Forage producer only ☐ Mixed – Dairy & forage ☐ Mixed – Beef & forage ☐ Repacking and distribution

Scale of operation ☐ Large scale ☐ Medium scale ☐ Small scale

Number of acres farmed for forage ____

QUESTIONS

1. Forage produced and Cost of production

Probing questions:

Forage crop selection & Establishment

- What are the reasons (challenges) that cause feed scarcity in your area (limited availability)?
- Which forage crop varieties do you produce on your farm for sale / supplementation? Tick as appropriate.

  ☐ Grazing on rangeland ☐ Rhodes grass ☐ Napier grass ☐ Kikuyu grass ☐ Brachiaria ☐Fodder Sorghum
  ☐ Fodder maize ☐ Oats ☐ Vetch ☐ Desmodium ☐ African Foxtail ☐ Horsetail ☐ Bush Rye
  ☐ Maasai Love Grass ☐ Sesbania ☐ Calandria ☐ Other ____

- Why / On which basis do you decide which forage crop to grow?
- So, how did you start (commercial) forage production and trade – what motivated you?

- Where do you obtain forage seeds for planting? ☐Agrovet ☐ Fellow farmers ☐ Produced on farm/Farm saved seeds ☐ Seed Multiplication Centres ☐ Directly from the seed company ☐ Others (Specify)
- Do you have challenges in obtaining forage seeds or planting material?☐ Yes ☐No
- If yes, list the challenges. How can the challenges identified above be solved?
- What quantities are produced per year/hectare for each of the forage crops you grow? Volume of forage produced distributed / sold / used per year____
- Do you grow any forage varieties that are in the actual sense food crops but are widely used by farmers as forage crops (maize, sorghum, beans or peas)? If yes, please list the crops and how they are used.
- Nutrient density of the forage crops is becoming increasingly important for livestock keepers (dairy and beef farmers) as farm size (land) is increasingly becoming smaller. Which species in your portfolio, do you consider as being a Nutrient dense forage crop? (Please explain in detail).

Sustainable production & Cost

- What constraints do you face while producing forages on your farm?
- List the invasive weeds you encounter during production and how do you control them?
- What agronomic/soil improvement practices are you employing to increase yields or realize full potential of forages you produce? ☐ Cover cropping ☐ Intercropping e.g Nitrogen fixing varieties vs grasses ☐ Fertiliser / organic manure application ☐ Zero and/or minimum tillage ☐ Mulching ☐ Irrigation
- What gaps do you and other forage producers experience, regarding agronomic or soil conservation techniques, that would otherwise contribute to sustainable land, forage production and increased yields?
- Please share, if possible, an example calculation for “your” forage crop which shows cost of production from seed to feed.

Stakeholder access

- How easy is it to access the following stakeholders for forage production on a scale of 1- 5? (5, Very easy and 1, Very difficult [Forage seed suppliers, Other input suppliers, Skilled mechanized forage contractors, Farmer training and extension services, Forage buyers]
- What challenges do you experience while accessing the stakeholders above? How can the challenges above be overcome in your opinion?

2. Packaging, transport & distribution

Probing questions:

- What machines (and mechanization systems) and technologies do you use on your farm for forage production, harvesting and packaging? ☐ Ploughs and tillers ☐ Choppers ☐ Grass hay balers ☐ Mowers ☐ Tractors and Trailers ☐ Silage balers ☐ Others (Specify).
- Where do you obtain equipment for forage production, harvesting and packaging on the farm? ☐ Owned ☐ Service providers /Sub-contractor ☐ Both.
- In what form do you sell your forages? ☐ Hay ☐ Silage ☐ Fresh cuts ☐ Other (specify).
- How do you sell your forages in the market - Per kilogram, per bale (volume), per kg dry matter, or nutrient content? Is nutrient content declared on the packaging label?
- Do you have calibration for sizes and quantities; or follow standard sizes when packaging forages for sale?
- Which distribution channel do you use to sell your forages? ☐ Farm gate sales ☐ Auction markets ☐ Distribution agents ☐ Other (describe).

3. Pricing of forage in the market (quantity vs quality)

Probing questions:

- What are the main factors that trigger farmers to buy forages? ☐ Land scarcity ☐ Drought and seasonality ☐ non-availability of planting materials for required forage ☐ Buying forage cheaper and less laborious than growing ☐ Lack of skilled labour to grow on the farm.
- Do your customers enquire about the quality of forages before buying? ☐ Yes ☐ No
- If yes, do you charge higher prices depending on quality?
- How do you determine the quality of forages produced on your farm?

- Do you send forage samples for laboratory nutrient analysis? Suggest ways in which the quality of forages produced within your farm can be improved.
- How do you calculate or determine the price at which you put your forages in the market?

4. Market description

Probing questions:

- Who are your main customers in forage business? ☐ Smallholder farmers ☐ Medium scale farmers ☐ Large scale farmers ☐ Pastoralists ☐ Ranches & Conservancies ☐ Other (specify)
- Interest vs Adoption: How do you rate farmers interest and adoption of commercial forages? Is return on investment – from cost of production, yields and livestock productivity, enough trigger to increasing adoption?
- What is your understanding on farmers perceived challenges to interest and adoption?
- Demand: In your view is the market for improved forage varieties now demand driven or more supply driven? Is the demand by farmers growing?
- What can be hindering adoption, e.g. finances, mobility (transport / infrastructure), time.
- In your opinion, how do farmers get information regarding origin, volumes, quality and prices of forages traded in the market? Tick as appropriate [Information Materials (Fliers, Brochures etc), Television, social media (Facebook, X etc), Radio, Informal channels (Word of mouth), Field days, Visit to the sales outlet, No information is available]. What works best, are there language barriers – also in terms of easy access by farmers?
- Do you have any trading agreements/partnerships with forage customers? ☐ Yes ☐ No
- If yes, describe one of these agreements and how it has impacted the performance of your forage business?
- What kind of developments/opportunities do you see and where is according to you to biggest potential for growth in sales and uptake or adoption of improved forage varieties in Kenya?
- Do you have specific current activities targeting market development? If not, what are the plans regarding this?
- Looking at the forage sector in Kenya as a whole, what are, according to you the main challenges/barriers to growth? What suggestions do you have to circumvent these challenges?
- Cognisant of the challenges you face in the business and competition, what strategies have you put in place to ensure steady supply to your customers and stay afloat for the long-term?
- What type of support is needed to make the forage market more transparent and functional all year round? [Create a diverse pricing system between quantity and quality].

5. Collaborations and New opportunities

Probing questions:

- In what ways does government policies and regulations (both national and county governments) affect your forage business?
- Do you have existing collaborations/support received from the county government or donor project to improve the quantity and/or quality of forage produced or sold from your farm? ☐ Yes ☐ No If yes, explain nature of collaboration/support.
- In your view, does the forage value chain receive enough development support from the national and County governments – for instance improving productivity and access by farmers, giving subsidies, creating awareness platforms.
- Suppose there are opportunities with the government, research or development partners to support commercial forage producers to increase market share and improve farmers uptake of forages. What measures would you propose?
  - ☐ Support forage demonstrations/field days.
  - ☐ Support forage demonstrations plus training (lead) farmers in their farms.
  - ☐ Facilitate MoU between seed producers and cooperative unions, ranches and other commercial farms in combination with support for forage production (demos/trainings).
  - ☐ Increase in public weighing scales and laboratory capacity country wide.
  - ☐ Publish information on forage weekly on internet, newspapers and/or on radio of prices of forages and feeds per county.
  - ☐ Feeding trials/demonstrations to show/proof the increase in animal performance.
  - ☐ Other measures (describe).

****END - THANK YOU****

Annex 8. Questionnaire for Forage Seed producer

INTERVIEW GUIDE | Forage Seed Suppliers

INTRODUCTION

Livestock development is strategic for substantial economic opportunities for smallholder farmers and pastoralists in Kenya, but productivity is constrained by scarcity of quantity and quality forage. This setback has lately ignited collective efforts from the Kenyan government, African Union, Development partners, livestock keepers and other forage value chain stakeholders; to reverse the situation and support forage value chain development for supplementary feeding during periods of scarcity (drought or land) and help in shaping a vibrant forage seed sector.

In so doing, improved forage production, utilization, economics and barriers to adoption need to be effectively understood in different Agro-Ecological Zones (Arid, Semi-Arid and Semi-Humid), purposing this information gathering exercise amongst stakeholders in three counties, Isiolo, Kajiado, Nakuru including commercial local or informal forage seed suppliers. Through this interview guide, we seek to identify working modalities and pathways for enhanced availability, accessibility, affordability and use of suitable forage seed varieties by livestock producers and commercial fodder producers. It further evaluates the economic feasibility and drivers of behavioural change towards uptake of improved, nutrient -rich forage (seeds) crops in Kenya.

We kindly request for about 45 minutes of your time to take you through and have a discussion on the following questions. Your responses will be treated confidential and will only be used for this purpose.

Formal Seed suppliers are defined for the sake of this study as private seed companies, research institutions, government bodies, parastatals, or any other service provider involved in supporting breeding, selection, registration, distribution and sales of registered and listed forage seeds or vegetative materials (either/or).

Informal seed suppliers are defined for the sake of this study as private company, research institutions, government bodies, parastatals, farmers or any other service provider involved in supporting individuals, producer groups in outgrowing, harvesting, aggregation, selection, storage, distribution and sharing, exchanging or sale in informal packaging of forage seeds or vegetative materials (either/or).

Date of filling the questionnaire (dd/mm/yy): ___________________

BIO DATA

Name of Proprietor / Company / Research organization / Institution name: ________________________________

Name of respondent: ____

Gender: [ ] Male [ ] Female

Contacts: Email and/or telephone number: ____

Designation: ____

Category of forage seed supplier:

[ ] Formal. [ ] Informal (*Note that questions will be formulated slightly different for producers of formal or informal seed)

QUESTIONS

1. Portfolio of forage seeds

Probing questions:

- What role(s) do you play in the forage seed sector?

  [ ] Seed selection [ ] Breeding and/or Multiplication [ ] Seed collection [ ] Importing, repackaging, distribution & marketing [ ] Other: ______________________

- Which forage crop seeds do you produce on your farm for sale / use?
- How did you acquire the parent seed / planting material that you select and multiply from?
- Can you give us for these forage seeds the recommended seeding rate per acre or per hectare and the current price per kilogram (including Value Added Tax in case of formal seed sector)?
- (For formal seed sector) Which forage seed varieties are you planning to enter in the National Performance Trials in the next 2 years?
- Do you stock any seeds that are in the actual sense food crops but are widely used by farmers as forage crops (maize, sorghum, beans or peas)? If yes, please list the varieties.

- Give a ranking in importance in terms of uptake, interest and use of the seed varieties used for forage that you are marketing/sharing with other farmers in Kenya, both in high potential dairy areas and in ASALs.
- What are your main end consumers/target group for these forage seeds? [Small holder farmers/agro-pastoralists, medium-large scale farmers, ranches, commercial forage producers]?
- Which are the most promising forage varieties (native or improved) according to you and why are they promising?
- High nutrient density of the forage crops is becoming more and more important as farm size (land) is increasingly becoming smaller. Which species in your portfolio, do you consider as being a high nutrient dense forage crop.
- In Kenya cost of feeding is frequently mentioned by farmers as a constraint to improve profitability of the farm. How will the forages which you mentioned as promising, contribute to reduction of feed cost and increased milk or meat production?
- What kind of developments do you see and where is according to you to biggest potential for growth in sales or (exchange with other farmers) and uptake of forage seeds in Kenya?
- What are the main barriers for growth of the forage seed market in Kenya?

2. Sales/distribution network, market growth

Probing questions:

- Briefly take us through your seed production or multiplication methods from (parent) seed to seed, including field management and techniques of improving seed quality before distribution (if any).
- What channels do you use for distribution for sales/target beneficiaries? Do you distribute directly to individual farmers, groups or cooperatives?
- Do you make specific arrangement with resellers or stockists for different crops in terms of credit sales, margin, stocks, handling out of date seeds, any other?
- Do you and in case you do, how do you assess the quality of your seeds before selling them?
- Do you think farmers are aware of the presence of improved forage seeds and how to use them?
- Please tick the method(s) you use to increase awareness/disseminate information on your forage seed products to customers and rank on a scale of 1 to 5 the most effective. [Printed information materials (leaflets, brochures, fact sheets etc), Extension service providers, Demo plots, Radio, TV, Social media, Apps]. What works best – also in terms of easy access by farmers?
- Do you have specific current activities targeting market development? If not, what are the plans for the future regarding this?
- What are the most pressing challenges/problems you face when trying to increase your market share for forage seeds.
- Cognisant of the challenges you face in the business and competition, what strategies have you put in place to ensure steady supply and stay afloat for the long-term?
- Looking at the forage seed sector as a whole, what are, according to you the main challenges? What suggestions do you have to circumvent these challenges?

3. Demand/Adoption

Probing questions:

- What is the targeted category of livestock for your forage crops? [Beef, Dairy, Dual purpose, small ruminants, Camels, Donkey, others]
- Interest vs Adoption: How do you rate farmers interest? Adoption? Is return on investment – from cost of production, yields and livestock productivity, enough trigger to increasing adoption?
- What is your understanding on their perceived challenges to interest and adoption?
- Demand: In your view is the market for native or improved forage seeds at the moment demand driven or more supply driven? Is the demand by farmers growing?
- Price: What price do you charge for your seed, and how does it compare to the market? Is there willingness to pay for good quality / improved seed varieties. Are current prices and packaging sizes an issue to farmers affording native or improved forage seeds? Please explain.
- Supply: Do you think there is difficulty for farmers to acquire/access improved forage seeds in or near their locality? If yes, could you suggest (business) models to get seeds closer to the farmer?
- Which forage varieties in your portfolio have the most interest those promising a high yield (biomass) or those promising a high nutritive value for ruminant livestock.
- Grasses that perform well or have farmer preference are likely to be locally multiplied either through true seeds or vegetatively propagated seed. Do you see this as a serious threat for business development to the formal sector or is this an accepted practice? How does yields from true seed versus vegetative propagation compare?

4. Knowledge and Training

Probing questions:

- Are you, satisfied with the results in the field, after farmers have planted some of your forage varieties? If yes can you quantify these results? If no, what do you think needs to be addressed for farmers to be more successful when making use of your forage seeds?
- Do you have information about the actual realized yield by farmers (e.g. 25%, 50% 75% of potential)? Explain.
- Where did you learn about seed production?
- Do you have access to extension services or other support for your forage seed production?
- What are your biggest challenges in terms of knowledge and skills for forage seed production?
- Do you think the knowledge of yourself and/or group members can be improved as regards forage production and animal nutrition (from seed to feed)? If yes, how will you do this or what support is needed and from who?
- The key performance indicator when it comes to fodder is how efficient ruminants can turn the fodder into milk and growth *vis a vis* the cost of production. Furthermore, agronomic practices on the farm greatly influence the yield and quality of fodder production. In this regard, do you/your group members make efforts to know and advise your clients (farmers) on:
  - the best ways to prepare the land?
  - the best or suitable agro ecological zone (rainfall, altitude) and soils (e.g pH) to plant your forage seeds?
  - What agronomic/soil improvement practices do you or other farmers employ to increase yields or realize full potential of forages you produce? ☐ Cover cropping ☐ Intercropping e.g Nitrogen fixing varieties vs grasses ☐ Fertiliser / organic manure application ☐ Zero and/or minimum tillage ☐ Mulching ☐ Irrigation
  - What gaps do you and other forage producers experience, regarding agronomic or soil conservation techniques, that would otherwise contribute to sustainable land, forage production and increased yields?
  - the best practices of forage production, harvesting stage, conservation and utilization of forages? If yes explain.

5. Collaborations and New opportunities

Probing questions:

- In your view, does the forage seed sector development receive enough support from the national and County governments – for instance improving productivity and access by farmers, giving subsidies, creating awareness platforms. Do you have existing collaborations with the government?
- Suppose there are opportunities with the government, research or development partners to support improving uptake for farmers of forage seeds. What measures would you propose?
  - ☐ Support forage demonstrations/field days
  - ☐ Support forage demonstrations plus training (lead) farmers in their farms
  - ☐ Support 50% voucher for farmers
  - ☐ Support 50% voucher for starter kit-seed and fertilizer
  - ☐ Support grant for agrovets to keep/improve stocks of forage seeds
  - ☐ Facilitate MoU between seed company and dairy cooperative unions, ranches and other commercial farms in combination with support for forage production (demos/trainings).
- What <u>other</u> measures would you recommend if forage seed suppliers were to be supported to increase market share and for farmers to increase adoption rate of improved forage seeds?

****END THANK YOU****

Annex 9. Equations used to calculate RFV and RFQ

dDM%	=88.9-0.779*ADF(%DM)
DMI	=120/forageNDF(%DM)
RFV (Relative Feed Value)	=dDM*DMI/1.29
Reference Hay of 100 RFV	41% ADF and 53% NDF
RFQ	DMI * TDN/1.23
ME	= 4.184((1.01*(0.04409*TDN%) -0.45))
TDN _CP correction	TDN + (CP × 0.87) − 10
RFQ-CP	DMI * TDN_CP/1.23

RFQ-CP correction

Purpose

This formula adjusts Total Digestible Nutrients (TDN) to more accurately reflect the net energy available to the animal, particularly when crude protein (CP) levels are high. It accounts for the energy cost of metabolizing excess protein, which is not fully captured in standard TDN values.

Component Explanations

- TDN (Total Digestible Nutrients): A measure of the total amount of digestible nutrients in a feed, including digestible fibre, protein, lipids, and carbohydrates. It is often used as a proxy for energy content.
- CP (Crude Protein): Represents the total protein content of the feed, calculated from nitrogen content (typically using the factor 6.25). - 0.87 (Energy value of protein): This factor reflects the metabolizable energy (ME) value of protein. On average, protein provides about 0.87 Mcal of ME per kg of CP.
- - −10 (Correction factor): This is a fixed deduction to account for the inefficiencies in protein metabolism, such as:
    - Energy lost as heat during deamination and urea synthesis.
    - Energy used for excreting nitrogenous waste.
    - Reduced efficiency of protein use compared to carbohydrates or fats.

Interpretation

The formula increases TDN based on the energy contribution of protein (CP × 0.87) but then subtracts 10 units to correct for metabolic inefficiencies. This results in a more realistic estimate of usable energy, especially in high-protein diets.