Innovation Opportunities in Dairy Livestock in Kenya

Felister Makini, Lawrence Mose, Geoffrey Kamau, Wellington Mulinge, Beatrice Salasya, Margaret Makelo, Elkana Nyambati and Fatunbi A Oluwole
Innovation Opportunities in Dairy Livestock in Kenya

Felister Makini, Lawrence Mose, Geoffrey Kamau, Wellinton Mulinge, Beatrice Salasya, Margaret Makelo, Elkana Nyambati and Fatunbi A Oluwole

April 2019
## Contents

<table>
<thead>
<tr>
<th>List of figures</th>
<th>vi</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of acronyms</td>
<td>vii</td>
</tr>
<tr>
<td>Foreword</td>
<td>ix</td>
</tr>
<tr>
<td>Acknowledgement</td>
<td>xi</td>
</tr>
</tbody>
</table>

### 1 Chapter One: General Introduction

#### 2 Chapter Two: Dairy Cattle

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Dairy Cattle Production Areas and Systems</td>
<td>4</td>
</tr>
<tr>
<td>2.2 Dairy Cattle Breeds</td>
<td>5</td>
</tr>
<tr>
<td>2.3 Dairy Cattle Breeding</td>
<td>7</td>
</tr>
<tr>
<td>2.4 Pasture and Fodder Production</td>
<td>8</td>
</tr>
<tr>
<td>2.5 Dairy Cattle Health</td>
<td>16</td>
</tr>
<tr>
<td>2.6 Milk Hygiene</td>
<td>17</td>
</tr>
<tr>
<td>2.7 Production Constraints and Hindrances to Productivity</td>
<td>18</td>
</tr>
<tr>
<td>2.7.1 Production constraints</td>
<td>18</td>
</tr>
<tr>
<td>2.7.2 Distribution and marketing of dairy cattle and products</td>
<td>19</td>
</tr>
<tr>
<td>2.7.3 Social constraints and hindrances to dairy cattle</td>
<td>20</td>
</tr>
<tr>
<td>2.7.4 Policy and Legislation Challenges</td>
<td>20</td>
</tr>
<tr>
<td>2.8 Innovation in Dairy cattle</td>
<td>21</td>
</tr>
<tr>
<td>2.8.1 Cattle Breeding</td>
<td>21</td>
</tr>
<tr>
<td>2.8.2 Feed formulation</td>
<td>22</td>
</tr>
<tr>
<td>2.8.3 Production (Calf rearing, replacement stock)</td>
<td>23</td>
</tr>
<tr>
<td>2.8.4 Feed quality determination</td>
<td>23</td>
</tr>
<tr>
<td>2.8.5 Natural pasture improvement</td>
<td>24</td>
</tr>
<tr>
<td>2.8.6 Cattle health</td>
<td>25</td>
</tr>
<tr>
<td>2.9 Dairy Cattle Value Chain Analysis</td>
<td>27</td>
</tr>
<tr>
<td>2.9.1 Input and service providers</td>
<td>27</td>
</tr>
<tr>
<td>2.9.2 Producers</td>
<td>31</td>
</tr>
<tr>
<td>2.9.3 Cattle Milk Trading/Marketing</td>
<td>32</td>
</tr>
<tr>
<td>2.9.4 Processors</td>
<td>33</td>
</tr>
<tr>
<td>2.9.5 Value chain enablers</td>
<td>34</td>
</tr>
<tr>
<td>2.9.6 Consumer</td>
<td>34</td>
</tr>
</tbody>
</table>

### 3 Chapter Three: Dairy Goats

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Background</td>
<td>36</td>
</tr>
<tr>
<td>3.2 Dairy Goat Producing Areas</td>
<td>36</td>
</tr>
<tr>
<td>3.3 Dairy Goat Breeds</td>
<td>37</td>
</tr>
<tr>
<td>Section</td>
<td>Title</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>3.4</td>
<td>Breeding</td>
</tr>
<tr>
<td>3.5</td>
<td>Pasture and Fodder Production</td>
</tr>
<tr>
<td>3.6</td>
<td>Feeds and feeding</td>
</tr>
<tr>
<td>3.7</td>
<td>Dairy Goat Health</td>
</tr>
<tr>
<td>3.8</td>
<td>Milk Hygiene</td>
</tr>
<tr>
<td>3.9</td>
<td>Importance of goat milk in food and nutrition security</td>
</tr>
<tr>
<td>3.10</td>
<td>Production Constraints and Hindrances to Productivity</td>
</tr>
<tr>
<td>3.10.1</td>
<td>Production constraints</td>
</tr>
<tr>
<td>3.10.2</td>
<td>Marketing challenges and hindrances to dairy goats</td>
</tr>
<tr>
<td>3.10.3</td>
<td>Social challenges and hindrances in dairy</td>
</tr>
<tr>
<td>3.10.4</td>
<td>Policy and legislation challenges and opportunities</td>
</tr>
<tr>
<td>3.11</td>
<td>Innovation in Dairy Goat Production</td>
</tr>
<tr>
<td>3.11.1</td>
<td>Breeding</td>
</tr>
<tr>
<td>3.12</td>
<td>Dairy Goat Value Chain Analysis</td>
</tr>
<tr>
<td>3.12.1</td>
<td>Input suppliers</td>
</tr>
<tr>
<td>3.12.2</td>
<td>Service providers</td>
</tr>
<tr>
<td>3.12.3</td>
<td>Producers</td>
</tr>
<tr>
<td>3.12.4</td>
<td>Traders</td>
</tr>
<tr>
<td>3.12.5</td>
<td>Processors</td>
</tr>
<tr>
<td>3.12.6</td>
<td>Consumers</td>
</tr>
<tr>
<td>3.12.7</td>
<td>Value chain enablers</td>
</tr>
<tr>
<td>4</td>
<td>CHAPTER FOUR: DAIRY CAMEL</td>
</tr>
<tr>
<td>4.1</td>
<td>Background</td>
</tr>
<tr>
<td>4.2</td>
<td>Camel Producing Areas</td>
</tr>
<tr>
<td>4.3</td>
<td>Camel Breeds</td>
</tr>
<tr>
<td>4.4</td>
<td>Breeding</td>
</tr>
<tr>
<td>4.5</td>
<td>Feeds and Feeding</td>
</tr>
<tr>
<td>4.6</td>
<td>Camel Health</td>
</tr>
<tr>
<td>4.7</td>
<td>Pasture and Fodder Production</td>
</tr>
<tr>
<td>4.8</td>
<td>Importance of Dairy in Food and Nutrition Security</td>
</tr>
<tr>
<td>4.9</td>
<td>Milk Hygiene</td>
</tr>
<tr>
<td>4.10</td>
<td>Production Constraints and Hindrances to Productivity and Profitability</td>
</tr>
<tr>
<td>4.10.1</td>
<td>Production constraints</td>
</tr>
<tr>
<td>4.10.2</td>
<td>Market challenges and opportunities in dairy</td>
</tr>
<tr>
<td>4.10.3</td>
<td>Social challenges and hindrances in dairy camel production</td>
</tr>
<tr>
<td>4.10.4</td>
<td>Policy and legislation challenges and constraints</td>
</tr>
<tr>
<td>4.11</td>
<td>Innovations in Dairy Camels Production</td>
</tr>
</tbody>
</table>
List of Tables

Table 2.1: Proportion (%) of dairy cattle breeds kept across the different production systems and the average milk yields (litres).

Table 2.2: Recommended ley grasses and fodder crops for different dairy producing areas in Kenya.

Table 2.3: Types and proportions of forages used across the different production systems.

Table 2.4: Recommended herbaceous legumes and multipurpose fodders trees for growing in different dairy producing areas in Kenya.

Table 2.5: Types and proportions (%) of other feed resources used across the different production systems.

Table 3.1: Goat breeds and their characteristics.

Table 3.2: Problem experienced by producers in forage production.

Table 4.1: Camel breeds and their characteristics.
List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Annual Milk Production from Dairy Cattle, Goats and Camels from 1996 to 2016</td>
<td>2</td>
</tr>
<tr>
<td>2.1</td>
<td>Dairy Cattle Value Chain Map</td>
<td>27</td>
</tr>
<tr>
<td>2.2</td>
<td>Cow Milk Marketing Channels in Kenya</td>
<td>32</td>
</tr>
<tr>
<td>2.3</td>
<td>Milk Intake by Processors</td>
<td>33</td>
</tr>
<tr>
<td>3.1</td>
<td>Dairy Goat Value Chain Map</td>
<td>46</td>
</tr>
<tr>
<td>3.2</td>
<td>Generalized Goat Milk Marketing Channels in Kenya</td>
<td>47</td>
</tr>
<tr>
<td>4.1</td>
<td>Camel Dairy Value Chain Map</td>
<td>60</td>
</tr>
<tr>
<td>4.2</td>
<td>General Camel Milk Marketing Channels in Kenya</td>
<td>62</td>
</tr>
<tr>
<td>Acronym</td>
<td>Definition</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>ADC</td>
<td>Agricultural Development Corporation</td>
<td></td>
</tr>
<tr>
<td>AFC</td>
<td>Agricultural Finance Corporation</td>
<td></td>
</tr>
<tr>
<td>AI</td>
<td>Artificial Insemination</td>
<td></td>
</tr>
<tr>
<td>ART</td>
<td>Assisted Reproductive Technologies</td>
<td></td>
</tr>
<tr>
<td>ASAL</td>
<td>Arid and Semi-arid lands</td>
<td></td>
</tr>
<tr>
<td>ASARECA</td>
<td>Association for Strengthening Agricultural Research in East and Central Africa</td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>Calcium</td>
<td></td>
</tr>
<tr>
<td>CAHW</td>
<td>Community Animal Health Worker</td>
<td></td>
</tr>
<tr>
<td>CBO</td>
<td>Community Based Organization</td>
<td></td>
</tr>
<tr>
<td>CBPP</td>
<td>Contagious Bovine Pleuropneumonia</td>
<td></td>
</tr>
<tr>
<td>CCPP</td>
<td>Contagious Caprine Pleuropneumonia</td>
<td></td>
</tr>
<tr>
<td>Cl</td>
<td>Chloride</td>
<td></td>
</tr>
<tr>
<td>DAP</td>
<td>Di-Ammonium Phosphate</td>
<td></td>
</tr>
<tr>
<td>DGAK</td>
<td>Dairy Goat Association of Kenya</td>
<td></td>
</tr>
<tr>
<td>DM</td>
<td>Dry Matter</td>
<td></td>
</tr>
<tr>
<td>DMI</td>
<td>Daily Matter Intake</td>
<td></td>
</tr>
<tr>
<td>ECF</td>
<td>East Coast Fever</td>
<td></td>
</tr>
<tr>
<td>F1</td>
<td>First filial generation of offspring of distinctly different parental types</td>
<td></td>
</tr>
<tr>
<td>FA</td>
<td>Fatty Acids</td>
<td></td>
</tr>
<tr>
<td>FM</td>
<td>Frequency Modulated</td>
<td></td>
</tr>
<tr>
<td>FMD</td>
<td>Foot and Mouth Disease</td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
<td></td>
</tr>
<tr>
<td>GIZ</td>
<td>Gesellschaft für Internationale Zusammenarbeit</td>
<td></td>
</tr>
<tr>
<td>GOK</td>
<td>Government of Kenya</td>
<td></td>
</tr>
<tr>
<td>GoK</td>
<td>Government of Kenya</td>
<td></td>
</tr>
<tr>
<td>GTZ (GIZ)</td>
<td>Gesellschaft für Internationale Zusammenarbeit (GIZ)</td>
<td></td>
</tr>
<tr>
<td>Ha</td>
<td>Hectare</td>
<td></td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Communication Technologies</td>
<td></td>
</tr>
<tr>
<td>ISLP</td>
<td>Integrated Small Livestock Project</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Potassium</td>
<td></td>
</tr>
<tr>
<td>KALRO</td>
<td>Kenya Agricultural and Livestock Research Organization</td>
<td></td>
</tr>
<tr>
<td>KARI</td>
<td>Kenya Agricultural Research Organization</td>
<td></td>
</tr>
<tr>
<td>KCA</td>
<td>Kenya Consumer Organization</td>
<td></td>
</tr>
<tr>
<td>KDB</td>
<td>Kenya Dairy Board</td>
<td></td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td></td>
</tr>
<tr>
<td>KEPHIS</td>
<td>Kenya Plant Health Inspectorate Service</td>
<td></td>
</tr>
<tr>
<td>KES</td>
<td>Kenya Shilling</td>
<td></td>
</tr>
<tr>
<td>Kg</td>
<td>Kilograms</td>
<td></td>
</tr>
<tr>
<td>KWS</td>
<td>Kenya Wild Life Service</td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>Metres</td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>Magnesium</td>
<td></td>
</tr>
<tr>
<td>mm</td>
<td>Millimeters</td>
<td></td>
</tr>
<tr>
<td>Mn</td>
<td>Manganese</td>
<td></td>
</tr>
<tr>
<td>MOLD</td>
<td>Ministry of Livestock Development</td>
<td></td>
</tr>
<tr>
<td>MoLD</td>
<td>Ministry of Livestock Development</td>
<td></td>
</tr>
<tr>
<td>NCPB</td>
<td>National Cereals Produce Board</td>
<td></td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Governmental Organization</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>Phosphorous</td>
<td></td>
</tr>
<tr>
<td>PACIDA</td>
<td>Pastoralist Community Initiative and Development Assistance</td>
<td></td>
</tr>
<tr>
<td>SEAG</td>
<td>Small East African Goat</td>
<td></td>
</tr>
<tr>
<td>SNV</td>
<td>Netherlands Development Organization</td>
<td></td>
</tr>
<tr>
<td>TST</td>
<td>Triple Supper Phosphate</td>
<td></td>
</tr>
<tr>
<td>VC</td>
<td>Value Chain</td>
<td></td>
</tr>
<tr>
<td>VCML</td>
<td>Vital Camel Milk Limited</td>
<td></td>
</tr>
<tr>
<td>VSF</td>
<td>Vétérinaires sans Frontières</td>
<td></td>
</tr>
</tbody>
</table>
FOREWORD

Persistent food shortage is a common occurrence in many sub-Saharan African countries. Several initiatives have been implemented to address this problem where some of them have recognized the role of innovations in spurring agricultural development. Hence, the use of innovations in agriculture and development in addressing the challenges of feeding an increasingly populous and resource-constrained Africa is receiving prominence. Creating an innovation system is therefore critical in establishing favourable networks of organizations within an economic system that are directly involved in the creation, diffusion and use of scientific and technological knowledge, as well as the organizations responsible for the coordination and support of these processes. The actors involved focus on bringing new products, new processes, new policies, and new forms of organization into economic use.

The Forum for Agricultural Research in Africa (FARA), in partnership with the German Government represented by the Center for Development Research (ZEF) of the University of Bonn under its ‘One World No Hunger’ initiative, is implementing the “Programme of Accompanying Research for Agricultural Innovations (PARI)” (2014-2019). PARI has taken cognizance of the successes of research and innovation initiatives in African agriculture and through FARA developed a sub grant agreements with the identified National Agricultural Research Institutes (NARI) in 12 African countries. One output of this research collaboration with the Kenya Agricultural and Livestock Research Organization (KALRO) is publication of a “Dairy Innovation Opportunities Book”. The book was produced by a multi-disciplinary team of scientists from KALRO, who synthesized available up-to-date secondary information on technologies, innovations and management practices in major dairy (cattle, goats and camels) enterprises in Kenya. The secondary data were complemented and triangulated with data and information based on value chains actor surveys conducted in 2017.

The book is divided into four main chapters. Chapter one gives an overview of the dairy industry in Kenya focusing on production areas, breeds kept, pasture and fodder production, feeding and animal health while Chapters two, three and four are on cattle, goats and camels, respectively. Each of the three chapters focus on the main constraints and challenges faced, innovations available and practiced, and value chain analysis, for the respective value chains. Finally, the book provides salient conclusions and recommendations.

Application of innovations offers important opportunities to African farmers and consumers; and therefore publication of the book is an important means of communicating current dairy research findings to a wider audience. The book which also has information on
utilization and marketing as well as existing innovations, and opportunities for further innovations will be shared widely with academicians, researchers, policy makers, development partners and practitioners, and other value chain actors, as a reference material on innovations and other aspects of the dairy value chain. It is expected that the information in the book will impact positively on the dairy value chain actors once the identified challenges / constraints are minimized; and identified opportunities exploited. I encourage all dairy stakeholders to have access to this “must read book”.

Executive Director,
Forum for Agricultural Research in Africa
ACKNOWLEDGEMENT

The authors thank all stakeholders who provided data and information contained in this book. Specifically, they are grateful to the KALRO dairy scientists namely; Dr. Francesca Lusweti, Dr. Innocent Kariuki, Dr. Michael Njunie, Dr. Evans Ilatsia, Dr. Simon Kuria, Mr. Amos Adongo, Ms. Olipha Oteng and Mr. Tura Isako for the information on available technologies and innovations. The authors also thank the key value chain actors who through interviews or Focus Group Discussions provided further insights on the operations of the value chains.

The development and publication of this book was made possible through financial and technical support from the Forum for Agricultural Research in Africa (FARA) inspired by Dr. Fatunbi Wole within the framework of One World No Hunger through the Programme for Accompanying Research in Innovations (PARI).

The authors acknowledge the facilitative support of the Director General, Dr. Eliud Kireger, the project accountants, Mr. James Karanja and Ms. Rose Wafula and the project secretary Ms. Irene Mogaka for their logistical support that led to the successful preparation and production of the book. Materials in this book have been sourced and referenced to the best of our knowledge. Every effort has been made to ensure that the originality of the source of the copyright material has been provided in the text.

The authors also acknowledge all those who in one way or the other provided any support during the preparation of this book.
Commercial dairy in Kenya was introduced by the settler farmers in the early 20th Century while indigenous Kenyans got involved in the 1950s. Currently, Kenya has one of the most developed dairy sub-sector in Sub-Saharan Africa and has an annual growth rate of 4 to 5%. The sub-sector contributes 40% of the agricultural gross domestic product (GDP) and 4% of the national GDP estimated at over KES 100 billion (Kenya, 2014).

The Kenyan milk production systems can be categorized into large and small-scale systems based on size of operation, level of management and use of inputs. After independence, the sub-sector was dominated by small-scale systems (small holders) who now account for 70% of the total milk production that was estimated at 5.3 billion litres in 2013 (KDB, 2014). This is confirmed by the surveys undertaken by the Smallholder Dairy (Research and Development) Project (SDP) which indicated that there are more than one million smallholder dairy farmers contributing more than 70 percent of gross marketed production from farms (FAO 2011).

In general, smallholders have 3 to 5 acres (1.2 to 2.0 ha) each of land; although some have slightly more than 20 acres (8 ha) and others less than 0.5 acre (0.2 ha) (Salami et al., 2010). They own about two to five head of cattle yielding about 5 kg of milk per cow per day with low milk sales at less than 10 kg per day and low use of inputs, although this varies depending on community traditions and the level of market orientation (FAO, 2010). Similarly, GoK, (2010) describes smallholders as those who own holdings averaging 0.2 to 3.24 hectares with one to three 3 cow each.
Over the years, there has been a gradual increase in milk production for all the dairy livestock types (Figure 1). Total milk produced is mainly from 13.5 million improved and indigenous cattle, 1.1 million camels and 14.5 million goats (Kenya Bureau of Statistics 2009). Camels, local goats, crosses and exotic goats are important for dairy production especially in the ASALs where camels are particularly important in North Eastern Kenya and bordering areas.

The Small Holder Dairy Project also found dairy products to be important food budget items for many Kenyans where households spend an average of 18 percent of their incomes on those products especially in the form of liquid milk where the annual per capita consumption of milk ranges from 19 kg in rural areas to 125 kg in urban centers (FAO, 2010; Lokuruka, 2016) while per head of population annual consumption averages 115 litres (KDB 2012). It is also a source of nutrition especially for children and elderly people. Other milk products include butter, cheese and ghee as well as yoghurt and mala (fermented milk).

Dairy provides income and creates employment for producers and others actors in the whole value chain process (Herrero et al., 2012; Smith et al., 2013). However, more than 75% of milk in Kenya is marketed through informal channels where only about 400 million liters a year goes through 30 processors and other formal milk marketers. This is evident in the number of jobs created where 40,000 jobs are created in the informal sector while in the processing sector only a total of 15,000 jobs are created. It has been estimated that for every 1000 liters produced at farm level daily, there are 77 direct farm
Innovation Opportunities in Dairy Livestock in Kenya

jobs created which translates to 841,000 full time jobs country wide.

Dairy also produces manure which can be used directly in crop production or after fermentation to produce biogas (fuel) for home use. Among the actors in the dairy sector are regulators, input suppliers, service providers, market agents, research and development organizations and dairy farmers and their organizations.

A general description of the dairy cattle, camel and dairy goat characteristics is provided in subsequent chapters. Information used in the following sections was obtained from data collected in 2017 from a sample (n=342) of dairy cattle, goats and camel keepers in 6 counties (Kiambu, Nyandarua, Kisii, Kakamega, Trans Nzoia and Nandi) of Kenya on key aspects of the respective value chains. The data collected were supplemented by secondary data focusing mainly on technologies, innovations and management practices obtained from 8 key KALRO livestock scientists representing major dairy regions of Kenya.
2. Chapter Two: Dairy Cattle

2.1 Dairy Cattle Production Areas and Systems

Dairy cattle distribution in Kenya is influenced by the climatic potential, human population density, and market access (Wanyoike et al., 2005). These factors also determine the production systems practiced in different production areas. Based on the climatic factors, the agro-ecological zones are classified into high, medium, and low rainfall zones resulting in environments ranging from high potential to marginal arid and semi-arid lands under which dairy cattle are reared. Due to increasing population pressure especially in the high rainfall areas, dairy production is moving more to lower rainfall areas albeit with poorly matched technologies resulting in low productivity.

The dairy cattle industry in Kenya is based on exotic breeds and their crosses with local cattle breeds. The pure and crossbred cattle are kept in the high rainfall areas under intensive and semi-intensive production systems in smallholder farms while in large scale farms they are kept under extensive grazing systems. Tethering is also practised among smallholder keepers of local or cross-bred cattle (Table 2.1). These production systems; intensive, semi-intensive and extensive also mean zero-grazing, semi zero-grazing and open grazing respectively. Zero grazing involves confining cattle to a limited physical space where they are managed, fed often with supplemental feeds, watered and milked while open grazing involves free grazing by the cattle on natural or improved pastures often with no supplemental feeds. Semi zero-grazing falls in the middle and involves the combination of the two systems. While zero-grazing requires higher investment in fixed infrastructure and closer management of cattle, it normally produces higher yields per cow (Table 2.1) whereas semi zero-grazing and open range are less labour and investment intensive, but normally produce lower yields.
In the medium and low potential areas, pastoral, agro-pastoral or developed ranching cattle production systems are practiced. In pastoral systems cattle keepers move the animals from place to place in search of forages and water whereas the agro-pastoral system involves a combination of the pastoral system with crop production where water is available. Developed ranching involves large-scale animal production mainly for beef where grazing is controlled / rotational in nature among available paddocks or fields. In these systems, the preferred breeds include the East African Zebu, Sahiwal, local and improved Boran as well as their crosses.

In majority of the smallholder dairy farms in high rainfall areas, mixed farming systems are practiced where the food crops grown and their by-products supply a substantial proportion of the feeds for dairy cattle. For example, where cereals are grown in these farms, their crop residues contribute over 20% of the roughage available to dairy animals.

2.2 Dairy Cattle Breeds
The preference of cattle breeds by the smallholder farmers is dependent on the choice of the grazing system and the agro-ecological zone. Additionally, attributes such as high milk yield, hardiness, high butterfat yield etc. contribute to the choice of breed (Bebe et al., 2003). According to Kahi et al. (2000) and Wakhungu (2000), the use of large breeds has been discouraged in favour of smaller ones. This is because large breeds have higher nutritional demands and lower adaptive characteristics and production efficiency.

Farmers preferences include exotic (Bos taurus) pure breeds, local (Bos indicus) zebu and Boran cattle, and the crosses between exotic and local cattle breeds. The main pure breeds kept in the high potential areas include Friesian, Ayshire, Guernsey, and Jersey (Table 2.1; Plate 2.1). Other pure breeds include Simmental and Fleckvieh which is bred from Simmental and Brown Swiss breeds for dual purpose (milk and meat) production.

In the high potential areas, the proportion of farmers keeping Friesians is about 37% compared to those keeping Ayrshires (26%), whereas those keeping crosses are 23% (Table 2.1), an indication that these are the most popular breeds. A small proportion of farmers keep Guernsey (about 4%), Jersey (3%) and local breeds (6.4%). Farmers keeping cross-breeds show a desire to upgrade their local breeds for milk production since pure breeds produce higher quantities of milk, although their forage requirements are high. The majority of Bos taurus breeds are kept under zero grazing (Table 2.1) and have high butterfat yields, heavier bodyweight, and unselective feeding behavior (Bebe et al., 2003). The milk production under zero and semi-zero grazing systems are higher compared to extensive systems (Table 2.1).
Table 2.1: Proportion (%) of dairy cattle breeds kept across the different production systems and the average milk yields (litres).

<table>
<thead>
<tr>
<th>Production System</th>
<th>Friesian</th>
<th>Ayrshire</th>
<th>Guernsey</th>
<th>Jersey</th>
<th>Crosses</th>
<th>Local</th>
<th>Milk Yield (after calving – All breeds)</th>
<th>Milk Yield (mid lactation – All breeds)</th>
<th>Milk Yield (before drying – All breeds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensive grazing</td>
<td>25</td>
<td>34</td>
<td>17</td>
<td>23</td>
<td>34</td>
<td>58</td>
<td>8.0</td>
<td>5.0</td>
<td>2.3</td>
</tr>
<tr>
<td>Semi zero grazing</td>
<td>28</td>
<td>37</td>
<td>44</td>
<td>15</td>
<td>47</td>
<td>19</td>
<td>10.7</td>
<td>7.0</td>
<td>3.7</td>
</tr>
<tr>
<td>Tethering</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>23</td>
<td>9</td>
<td>13</td>
<td>8.5</td>
<td>5.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Zero grazing</td>
<td>44</td>
<td>24</td>
<td>39</td>
<td>38</td>
<td>10</td>
<td>10</td>
<td>17.3</td>
<td>11.5</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Overall

<table>
<thead>
<tr>
<th>Breed</th>
<th>Extensive grazing</th>
<th>Semi zero grazing</th>
<th>Tethering</th>
<th>Zero grazing</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friesian</td>
<td>25</td>
<td>28</td>
<td>3</td>
<td>44</td>
<td>37.4</td>
</tr>
<tr>
<td>Ayrshire</td>
<td>34</td>
<td>37</td>
<td>6</td>
<td>24</td>
<td>26.4</td>
</tr>
<tr>
<td>Guernsey</td>
<td>17</td>
<td>44</td>
<td>0</td>
<td>39</td>
<td>3.7</td>
</tr>
<tr>
<td>Jersey</td>
<td>23</td>
<td>15</td>
<td>23</td>
<td>38</td>
<td>2.7</td>
</tr>
<tr>
<td>Crosses</td>
<td>34</td>
<td>47</td>
<td>9</td>
<td>10</td>
<td>23.1</td>
</tr>
<tr>
<td>Local</td>
<td>58</td>
<td>19</td>
<td>13</td>
<td>10</td>
<td>6.4</td>
</tr>
</tbody>
</table>

Source: Household Survey 2018

Plate 2.1: Exotic and Local Dairy Cow Breeds

Friesians  Ayrshire  Guernsey cow

Jersey  Sahiwal  Zebu

Innovation Opportunities in Dairy Livestock in Kenya
Preferred breeds under open-grazing production systems are mostly crossbreds and the Bos indicus breeds comprising of Sahiwal, East African Zebu and Boran. These are distributed in various agro-ecological zones including the high rainfall zones implying that over time they have adapted to many areas as a result of natural selection under different environmental conditions (Rege, 2001). The Sahiwal, Zebus and their crosses with the pedigrees have relatively low milk output but are suitable for marginal areas. They are considered dual purpose for meat and milk and are hardy and tolerant to diseases with low maintenance requirements and hence suitable for resource-constrained farmers.

2.3 Dairy Cattle Breeding

Breeding is the regulation of the offspring by control of the parents to improve productivity. The best dairy cow is the one that yields more milk, has the best feet, legs, udder support and the one that combines performance of these traits in a sound optimal way. Animals are bred such that their descendants are better than their parents. Natural mating was initially preferred by most farmers, however, with time the recommended breeding method was artificial insemination (AI) which allowed the use of best bulls within and outside the country to improve the quality of the subsequent cows.

In Kenya, until the mid-1980s, AI was a well-organized government dairy cattle breeding system which contributed immensely to germplasm improvement and growth of the smallholder dairy farming as well as the large national dairy population. Artificial insemination (AI) was used effectively to upgrade zebus and accelerate the uptake of dairy production by smallholder farmers. This has been enhanced further by the introduction of assisted reproductive technologies (ARTs) which are techniques that manipulate reproductive-related events or structures to achieve pregnancy in bovine females. Among others, these include semen sexing, multiple ovulation, embryo transfer, in vitro production of embryos, in vitro assisted fertilization and cloning.

2.4 Pasture and Fodder Production

Pasture production

Ruminant production systems including dairy, are to a large extent based on pasture grasses, particularly in the extensive grazing production systems (Wilkins, 1993; Payne, 1990). The majority of dairy herds on smallholder farms in Kenya, largely depend on both natural tropical and improved grass pastures as the basal diet. Kenya and indeed the whole of Eastern Africa region is widely recognized as the home of many important pasture grasses, and the region is the origin of 8 to 10 of the most economically important tropical and sub-tropical pasture species contributing 20 - 25% of the total sown pasture species (Hartley and Williams, 1956). The grasses are recognized for their outstanding yield, quality and daily milk production where about 8 litres/cow can be supported by good quality pasture/fodder. The optimum stage of grazing pastures
or making best quality hay are at 10-50% bloom while about a 50-day regrowth period is recommended (Keftasa, 1990).

Continuous pasture research in Kenya has resulted in superior pasture grasses which are recommended for various agro-ecological zones (Table 2.2). The recommended grasses for high potential areas are Rhodes grass \((Chloris gayana)\), Setaria \((Setaria sphacelata)\), guinea grass \((Panicum maximum)\), Kikuyu grass \((Pennisetum clandestinum)\) and star grass \((Cynodon dactylon)\).

The recent re-introduction and evaluation of improved Brachiaria grasses has recently led to the recommendation of three Brachiaria grass cultivars, namely cultivars xareas, MG4 and Basilisk (Njarui et al., 2017). In the medium and low potential areas (arid and semi-arid), the recommended grasses include Cenchrus ciliaris, Eragrostis superba and Panicum maximum. To enhance the nutritive value of these grasses, they can be sown together with herbaceous forage legumes. Both the pure grasses and grass-legume mixtures can be grazed directly in the field or harvested and baled as hay with a potential to produce 250-300 bales of hay per acre per harvest as shown by a study on cultivated Rhodes grass in Narok County (Irungu et al., 2016).

Grass species suitable for ASALs are many and include Cenchrus ciliaris, Chloris roxburghiana, Eragrostis superba and Enteropogon macrostachyus. These grasses grow very fast during the wet season and attain flowering stage at 3-4 weeks after onset of rain. They are drought tolerant and are tolerant to intensive grazing under normal weather conditions. They perform well in agro-ecological zones 4, 5 and 6. Agro-ecological zoning (AEZ) refers to the division of land into smaller units, which have similar characteristics related to land suitability, potential production and environmental impact. Zone groups are temperature belts defined according to maximum temperature limits within the main crops in Kenya. Details of such zonations are found in Maingi, P.M. (2008).
Table 2.2: Recommended ley grasses and fodder crops for different dairy producing areas in Kenya.

<table>
<thead>
<tr>
<th>Region</th>
<th>Altitude (m) and Annual Rainfall (mm)</th>
<th>Ley Grasses and Fodder</th>
<th>DM yield/year/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-arid areas</td>
<td>1000-1800 and &lt; 650 mm</td>
<td>Cenchrus ciliaris&lt;br&gt;Eragrostis superba&lt;br&gt;Andropogon gayanus&lt;br&gt;Panicum maximum&lt;br&gt;Chloris roxburghiana</td>
<td>9.8, 4.3, 5.3, 10.0, 10.3</td>
</tr>
<tr>
<td>Warm and wet medium altitude areas</td>
<td>1200-1850 and 1000-2500 mm</td>
<td>Napier grass (Pennisetum purpureum)&lt;br&gt;Giant setaria (Setaria sphacelata)&lt;br&gt;Giant Panicum (Panicum maximum)&lt;br&gt;Guatemala Grass (Trifolium laxum)&lt;br&gt;Sudan grass (Sorghum sudanense)&lt;br&gt;Columbus grass (Sorghum almum)&lt;br&gt;Boma and Elmba Rhodes (Chloris gayana)&lt;br&gt;Setaria (Setaria sphacelata)&lt;br&gt;Coloured guinea (Panicum coloratum)&lt;br&gt;Star grass (Cynodon dactylon)&lt;br&gt;Guinea grass (Panicum maximum)</td>
<td>17 - 25, 9.1, 11.8, 8.4 - 10.3, 12, 15, 10 - 18, 10 - 16, 12 - 18, 10, 9 - 14</td>
</tr>
<tr>
<td>Cool and wet medium altitude areas</td>
<td>1850-2400 and 1000-2500 mm</td>
<td>Napier grass (Pennisetum purpureum)&lt;br&gt;Giant Panicum (Panicum maximum)&lt;br&gt;Giant setaria (Setaria sphacelata)&lt;br&gt;Guatemala grass (Trifolium laxum)&lt;br&gt;Sudan grass (Sorghum sudanense)&lt;br&gt;Columbus grass (Sorghum almum)&lt;br&gt;Oats (Avena sativa)&lt;br&gt;Rhodes grass (Chloris gayana)&lt;br&gt;Setaria grass (Setaria sphacelata)&lt;br&gt;Coloured guinea (Panicum coloratum)&lt;br&gt;Star grass (Cynodon dactylon)&lt;br&gt;Kikuyu grass (Pennisetum clandestinum)&lt;br&gt;Congo signal (Brachiaria ruziziensis)</td>
<td>12 – 17, 9, 6.6 – 10.5, 6.4 – 8.4, 6.9 – 12, 8 – 13.5, 5.1 – 6.5, 7 – 15, 7 – 10, 7 – 18, 5 – 10, 5 – 8</td>
</tr>
<tr>
<td>Cold and wet high altitude</td>
<td>2400-3000 and 1000-2500 mm</td>
<td>Oats (Avena sativa)&lt;br&gt;Kikuyu grass (Pennisetum clandestinum)&lt;br&gt;Perennial ryegrass (Lolium perenne)&lt;br&gt;Tall fescue Festuca arundinacea</td>
<td>7.0, 7.0, 6.16 – 8.13, 5.0</td>
</tr>
</tbody>
</table>
Fodder Production

Different fodder crops are widely distributed across various ecological zones depending on the adaptability characteristics (Table 2.2). These fodders include Napier (*Pennisetum purpureum*), Guatemala grass (*Trifolium laxum*), Sudan grass (*Sorghum sudanense*), Oats (*Avena sativa*), and Sweet potato (*Ipomea batatas*). The forage sweet potato cultivars include 99/1, K049, K158, Marooko, Mugande and Wagabolige (Irungu et al., 2015).

Napier is the most preferred fodder grass and constitutes about 50% of forage used by smallholder dairy farmers (Table 2.3). The most common varieties developed and grown in East Africa were Clone 13, French Cameroon and Bana (Boonman, 1997). Napier has desirable attributes that include high dry matter yield (35 tons of dry matter per hectare per year) compared with other grasses, it is relatively drought resistant and withstands frequent cutting (Nyambati et al., 2010). However, it requires high and well distributed rainfall although it can tolerate moderate dry seasons (Orodho, 2006).

Napier can be established using the conventional planting at 50 cm by 100 cm or by ‘tumbukiza’. The ‘tumbukiza’ method of planting involves digging holes that are 60 cm wide, 60 cm long and 60 cm deep, refilling the holes half way with a mixture of top soil and farm yard manure and planting 4 to 6 canes or root splits in each hole. The holes should not be filled with soil to the top (Nyambati et al., 2011).

Fertilizer rates are 25 kg of Triple Super Phosphate (TSP) or 50 kg of Di-ammonium Phosphate (DAP) or 5 tons of farm yard manure per acre. Napier grass is ready for harvesting 3-4 months after planting and harvesting can continue at an interval of 6-8 weeks or when the Napier is 100-120 cm tall for 3-5 years. Average Napier grass yields can be 12 to 25 tons ha-1 of dry matter (NAFIS, 2017). Previous work (Abate et al., 1985) has also shown that the dry matter productivity of most of the fodder crops was about five times that produced by a common pasture species such as Rhodes grass (*Chloris gayana*) while the estimated yields for Napier and Sudan grass are 12 – 17 and 9 tons ha-1 per cut, respectively.

Currently, there are disease challenges that are curtailing Napier production and reducing the performance of smallholder dairy due to inadequate fodder. These diseases are Napier grass head smut (in Central, Rift Valley and Eastern Kenya) and stunting (in Western Kenya). Head smut disease is caused by a fungus *Ustilago kameruniensis* (Farrell, 1998). The disease is characterized by early flowering and the inflorescences covered with black spores (Plate 2.2) (Farrell, 1998). This disease causes reduction of Napier biomass yield by up to 46% and an estimated milk reduction of up to 40%. Stunting disease is caused by a phytoplasma that causes stunted growth and reduction in biomass (Plate 2.3; Jones et al., 2004). These diseases can cause up to 90% losses of forage yield (Lusweti et al., 2004; Mulaa et al., 2010).
Several napier accessions were introduced from ILRI Gene Bank, and were screened for tolerance/resistance to emerging diseases such as Napier stunt and head smut (Jones et al., 2004, 2007; Farrel and Hillocks, 2001). Recent studies have identified Napier grass varieties, Kakamega I, Kakamega II and Kakamega III as suitable for production in the medium and high rainfall areas (Orodho, 2006, Mwendia et al., 2006). Other important fodder grasses include Guatemala grass (Tripsacum laxum), Giant Panicum (Panicum maximum), Giant Setaria (Setaria splendida), Fodder Sorghums (Sorghum sudanese, Sorghum vulgare, Sorghum almum) and Columbus grass, vars. 6518 and oats (Avena sativa).

<table>
<thead>
<tr>
<th>Forage type</th>
<th>Production System</th>
<th>Extensive grazing</th>
<th>Semi zero grazing</th>
<th>Tethering</th>
<th>Zero grazing</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Napier</td>
<td></td>
<td>46</td>
<td>46</td>
<td>54</td>
<td>55</td>
<td>49</td>
</tr>
<tr>
<td>Rhodes grass</td>
<td></td>
<td>9</td>
<td>14</td>
<td>3</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Nandi Setaria grass</td>
<td></td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Kikuyu grass</td>
<td></td>
<td>8</td>
<td>6</td>
<td>9</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Maasai love grass</td>
<td></td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Lucerne</td>
<td></td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Desmodium</td>
<td></td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Leucaena</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Calliandra</td>
<td></td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sesbania</td>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sorghum</td>
<td></td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Bracharia grass</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>20</td>
<td>16</td>
<td>23</td>
<td>10</td>
<td>16</td>
</tr>
</tbody>
</table>

Source: Dairy Household Survey 2018

Plate 2.2. Napier grass head smut disease

Plate 2.3 Napier grass stunt
Production of forage legumes

Different forage legumes are recommended across various agro-ecological zones depending on their adaptability characteristics (Table 2.4). The major forage legumes include, Desmodium (Desmodium intortum and D. uncinatum), Lucerne (Medicago sativa), Lupins (Lupinus albus), Stylo (Stylosanthes guianensis) and Vetch (Vicia dasycarpa). These legumes are mostly integrated into the cropping systems by simultaneous intercropping, relay intercropping, rotations, and improved fallows (Weber, 1996). The use of legumes in cropping systems offers considerable benefits because of their ability to fix atmospheric N2 (Weber, 1996; Giller et al., 1997).

In addition to herbaceous legumes, there are leguminous fodder trees that can be grown in different niches without affecting crop production. These include Calliandra calothyrsus, Sesbania sesban and Leucaena leucocephala. Leguminous trees and shrubs have root nodules that can often fix nitrogen from the atmosphere (Franzel et al., 2003) thus improving soil fertility. Several of these fodder trees are also well adapted to marginal environments and have the capacity to reverse degradation. They are able to tap water and nutrients from deeper soils than grasses and are better at recycling leached nutrients than grass. They also stay green longer into the dry season, hence they are ideal for dry season feeding.

Table 2.4: Recommended herbaceous legumes and multipurpose fodders trees for growing in different dairy producing areas in Kenya.

<table>
<thead>
<tr>
<th>Region</th>
<th>Altitude (m) and annual rainfall (mm)</th>
<th>Suitable Forages</th>
<th>DM Yield/year/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-arid areas</td>
<td>1000-1800m and &lt; 650 mm</td>
<td>Stylosanthes scabra, Siratro (Macroptilium atropurpureum)</td>
<td>0.6 - 1.5</td>
</tr>
<tr>
<td>Warm and wet medium altitude areas</td>
<td>1200-1850m and 1000-2500mm</td>
<td>Desmodium (Desmodium uncinatum and D. intortum), Stylo (Stylosanthes guianensis), Dolichos (Lablab purpureus), Leucaena leucocephala, Calliandra calothyrsus, Sesbania sesban</td>
<td>6.3 - 8.4, 2.7 - 3.4, 0.5 - 1.5, 3.9 - 6.0, 2.5 - 6.0, 3.0 - 5.0</td>
</tr>
<tr>
<td>Cool and wet medium altitude areas</td>
<td>1850-2400 m and 1000-2500 mm</td>
<td>Desmodium (Desmodium uncinatum and D. intortum), Stylo (Stylosanthes guianensis), Dolichos (Lablab purpureus), Lupins (Lupinus albus), Lupins (Lupinus angustifolium), Mucuna (Mucuna pruriens), Lucerne (Medicago sativa), Vetch (Medicago sativa)</td>
<td>5.5 - 7.0, 2.7, 6.3, 6.0 - 9.9, 1.6, 3.0 - 8.0, 3.8</td>
</tr>
<tr>
<td>Cold and wet high altitude</td>
<td>2400-3000 m and 1000-2500 mm</td>
<td>Kenya white clover (Trifolium semipilosum), Vetch (Vicia dasycarpa), Lucerne (Medicago sativa)</td>
<td>2.5, 3.6 - 3.8, 4.5</td>
</tr>
</tbody>
</table>
In Kenya, a major cause of low milk yield is inadequate feeding of dairy cattle as a result of low availability and/or accessibility of feeds. This is exacerbated by the heavy dependency on rain-fed forage production and poor adoption of conservation of forage and crop residue feed resources that could ease seasonal fluctuations in milk production. It is further worsened by the cost of feeds which constitute the largest percentage of the cost for milk production. In the intensive systems, feed costs account for over 60% of the total production cost leading to the inability of most smallholder farmers to provide sufficient and quality feed to sustain high milk production throughout the year.

For the extensive production systems, it is most critical during the dry season when dairy herds are forced to rely on low quality feed resources, which are nutritionally deficient in energy, nitrogen, minerals and vitamins, with little or no supplementation.

In such seasons, when the availability of good quality pasture/fodder is low, most farmers turn to crop residues and agro-industrial by-products as the main dairy cattle feed (Preston, 1995). The utilization of these crop residues is limited by low quality that cannot support satisfactory milk production and reproduction performance (Smith and

Plate 2.4: Improved forages

Dairy cattle feeding

In Kenya, a major cause of low milk yield is inadequate feeding of dairy cattle as a result of low availability and/or accessibility of feeds. This is exacerbated by the heavy dependency on rain-fed forage production and poor adoption of conservation of forage and crop residue feed resources that could ease seasonal fluctuations in milk production. It is further worsened by the cost of feeds which constitute the largest percentage of the cost for milk production. In the intensive systems, feed costs account for over 60% of the total production cost leading to the inability of most smallholder farmers to provide sufficient and quality feed to sustain high milk production throughout the year.

For the extensive production systems, it is most critical during the dry season when dairy herds are forced to rely on low quality feed resources, which are nutritionally deficient in energy, nitrogen, minerals and vitamins, with little or no supplementation.

In such seasons, when the availability of good quality pasture/fodder is low, most farmers turn to crop residues and agro-industrial by-products as the main dairy cattle feed (Preston, 1995). The utilization of these crop residues is limited by low quality that cannot support satisfactory milk production and reproduction performance (Smith and
Poor handling (harvesting, conservation/storage, processing) at farm level further exacerbate deterioration of their feeding value in terms of palatability and quality. The nutrient content and digestibility of the crop residues is low and feed without supplementation results in low milk production. Efforts to improve the utilization of the crop residues has been on-going in the region and results indicate that crop residue could be improved using chemicals such as sodium hydroxide or ammonia or combining them with other feed ingredients before feeding.

Under small scale intensive systems, farmers also use other feed resources (Table 2.5). These feeds include sweet potato vines, multipurpose tree fodder, dried poultry waste and silage. These farmers are normally also encouraged to compound their own on-farm feed rations. For example, when multi-purpose tree fodders such as Calliandra calothyrsus are used as supplements, three kg of fresh fodder has the same effect on milk production as one kg of commercial dairy meal (Paterson et al., 1998). Up to about 500 trees (250 m of hedgerow) can produce enough fodder to supplement one dairy cow for a complete lactation. Tree fodders contain high levels of nutrients, protein and minerals included. The major limitation to the use of fodder trees is the widespread presence of anti-nutritive factors.

It is important to note that natural forage constitute the bulk of dairy cattle feed followed by cultivated fodder with Napier grass being the most common. A dairy cow needs a basal diet in form of roughage feed that provides sufficient amounts of nutrients to meet the animal’s daily basic energy needs but may not provide all nutrients required for production and reproduction. This diet is commonly obtained from pasture grasses, fodder or silage and crop residues. The expected daily consumption of energy feeds depends on the quality of the feeds, the size of the animal, level of milk production, quantity of supplements given and dry matter content of the feed material. Supplementary feeds such as concentrates do not replace the basal diet.

Generally, ruminant cattle consume a daily feed intake equivalent to 2-3% body weight. Adequate protein in the diet helps microorganisms in the rumen (stomach) convert the roughage into nutrients. It is important for farmers to ensure that they supplement the forage diet with proteins. Protein supplementation to low quality roughages including pastures and fodders such as Napier grass-based diets increase feed dry matter (DM) intake (Muia et al., 2000; Nyambati et al., 2003). Other benefits of using protein-rich forages as supplements include improved energy and protein intake, improved feed efficiency, increased availability of minerals and vitamins, improved rumen function, and generally, enhanced animal performance (Norton and Poppi, 1995). Lack of protein in the animal’s diet results in poor growth, reduced milk production, loss of weight and late maturity.
Feed requirements for a cow weighing 500kg are 5,000 kg of dry matter per year allowing for around 5% wastage. Under the intensive system, this is equivalent to 5,900 kg hay, or 25,000 kg fresh Napier. For practical purposes, 1 acre of Napier can sustain a cow, a heifer and a weaner. Under the extensive system in a typical Upper Midlands 4 (UM4) agro-ecological zone the farmer needs at least 4 acres of natural pasture or 2 to 3 acres improved pasture per cow. Fodder crops have a low nutrient density and cannot support a high milk production. Good quality Napier grass can support a milk production of about 7 litres/cow/day (Thomas and Sumberg, 1995). Production above this level can only be supported with the feeding of high-density supplement feeds or forage legumes.

For in-calf cows in their 3rd trimester, the supplement can be changed to dairy meal and in the last 6 weeks of pregnancy, they should gradually be given an increasing rate of supplementation such that by the time they are calving they are consuming 3 to 6 kg dairy meal per day. This will ensure proper udder and calf development.

Lactating cows should be fed good quality fodder/forage or grazed on quality pasture and dairy meal at the rate of 1 kg dairy meal for every 1.5 kg milk produced above 5 kg. Since commercial concentrates are expensive, cheaper sources of high protein feeds can be used such as leguminous forages that include, Desmodium, lucerne, sweet lupins, and bean straw. Fodder trees such as calliandra, sesbania and leucaena also provide protein for animals. Research has shown that 3kg of tree fodder and other legumes such as sweet potato vines give the same milk yield as 1kg of dairy meal. Therefore, the farmer can give the cow 12kg of legumes instead of 4kg of dairy meal.

During the first days after calving, the calf is fed colostrum (milk produced by the cow in the first 3 days) which is important because it contains vitamins and minerals that assist in bone formation. In addition, it contains many valuable nutrients such as proteins and sugars for growth and antibodies that protect the young calf against diseases, and assists it in producing the first dung. Thereafter, a calf from large breeds such as Friesians and Ayrshires, needs to be given at least 4 litres of milk per day, and introduced early to weaner pellets to avoid setbacks in growth as well as provided with good quality fodder (like Napier, sweet potato vines or a mixture of both), and clean drinking water.

After the calf is weaned from milk, it should continue being fed with green fodder and concentrate supplement. After the age of six months, the calf can then be fed with a cheaper young stock supplement at the rate of 1 to 2 kg per day depending on its (calf) condition and the quality of fodder up to its first insemination at the age of 15 to 18 months. Water and appropriate mineral supplements should be provided all day every day.
### Table 2.5: Types and proportions (%) of other feed resources used across the different production systems

<table>
<thead>
<tr>
<th>Type of feed resource</th>
<th>Extensive grazing</th>
<th>Semi zero grazing</th>
<th>Tethering</th>
<th>Zero grazing</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize Stover</td>
<td>28.18</td>
<td>25.8</td>
<td>34.48</td>
<td>21.26</td>
<td>25.63</td>
</tr>
<tr>
<td>Legume residues</td>
<td>15.12</td>
<td>12.77</td>
<td>17.24</td>
<td>3.65</td>
<td>11.01</td>
</tr>
<tr>
<td>Molasses</td>
<td>7.9</td>
<td>7.18</td>
<td>6.9</td>
<td>8.97</td>
<td>7.89</td>
</tr>
<tr>
<td>Dairy meal</td>
<td>16.84</td>
<td>18.35</td>
<td>10.34</td>
<td>26.58</td>
<td>19.88</td>
</tr>
<tr>
<td>Silage</td>
<td>1.72</td>
<td>5.32</td>
<td>0</td>
<td>4.98</td>
<td>3.9</td>
</tr>
<tr>
<td>Sweet potato vines</td>
<td>3.78</td>
<td>8.24</td>
<td>12.07</td>
<td>2.33</td>
<td>5.46</td>
</tr>
<tr>
<td>Mineral supplements</td>
<td>25.43</td>
<td>20.48</td>
<td>17.24</td>
<td>24.58</td>
<td>22.9</td>
</tr>
<tr>
<td>Other</td>
<td>1.03</td>
<td>1.86</td>
<td>1.72</td>
<td>7.64</td>
<td>3.31</td>
</tr>
</tbody>
</table>

Source: Dairy Household Survey 2018

### 2.5 Dairy Cattle Health

The ability of the country to fully exploit its potential in dairy production is seriously hampered by occurrence of diseases and pests. The health of the animal is one of the most critical factors in animal productivity and returns on investment can adversely be affected by inadequate focus on animal health. Exotic dairy animals, which produce over 70% of the total milk output in Kenya are vulnerable to a wide range of infectious and reproductive diseases and conditions which are a threat to a vibrant dairy industry. Some of these diseases are trade sensitive and directly impact negatively on the local and export markets. Therefore, animal health management is critical to the prevention, control and eradication of diseases that adversely impact the quantity, quality and marketability of both dairy breeding animals and milk.

Some of the diseases affecting the dairy herd include those transmitted by vectors such as ticks, fleas and mites, helminths, and bacterial diseases such as mastitis, pneumonia as well as diseases transmitted by tsetse flies. Infectious and contagious diseases that spread fast while causing heavy economic losses require prompt attention. The most notifiable diseases in Kenya include, Foot and Mouth Disease (FMD), Anthrax, Contagious Bovine Pleuropneumonia (CBPP), Rabies, Lumpy Skin disease, Contagious Caprine Pleuropneumonia (CCPP), East Coast Fever, Rift Valley Fever and Trypanosomosis. East Coast Fever, Trypanosomosis and Rift Valley Fever are vector-borne and are transmitted by ticks, tsetse flies and mosquitoes respectively. These diseases limit livestock productivity, movement, trade and overall returns to investment in the dairy industry. The infestation of large areas of the country by tsetse flies limits the use of some valuable land for livestock production.

Traditional management of various cattle ailments are highly practiced by most of the farmers in the country (Njoroge et al., 2006). Acaricides are mostly used for tick...
control to avoid ECF by either dipping or spraying although this is often misused thus complicating its effectiveness. Acaricides require to be changed immediately after tick resistance is noticed. Conversely, vaccination can be used to control some diseases such as FMD and Lumpy skin disease although other diseases have no vaccines and further research is required. Tsetse fly which is a vector of trypanosomiasis can be controlled through bush clearing and trapping of the flies while worms can be controlled through mature cattle deworming which should be done every three (3) months.

2.6 Milk Hygiene

Milk handling, preparation, storage and marketing is a public health priority to prevent contamination by potentially harmful health hazards. Residues and contaminants commonly found in milk and other dairy products include antibiotics, pesticides, anthelmintics, mycotoxins, heavy metals and other undesirable chemicals. These residues and contaminants including their metabolites can persist at unacceptable levels thus exposing consumers to them (Codex Alimentarius Commission (CAC), 1998). To protect consumers, regulatory levels have been established for drug residues in foods in the form of Maximum Residue Limits (MRLs) (Lee et al., 2000).

Veterinary drugs used either therapeutically or prophylactically in milk producing animals can be secreted in milk. These drug residues in milk cause undesirable effects in humans such as acute or chronic toxicities from the metabolites while in the long-term they can be carcinogenic, teratogenic, genotoxic, and can cause reproductive and developmental disorders (Mitema, 2004). Antimicrobial residues in milk are also known to cause allergic reactions (like penicillin allergies) and can select for antimicrobial resistance. Further, antibiotic residues are also undesirable from a processing perspective, since they can interfere with starter culture activity thus disrupting the manufacturing process (Broome et al., 2002).

Conversely, milk can also transmit diseases from animals to people, among people and serve as a growth media for micro-organisms that cause food poisoning. Bacteria, viruses and other pathogens that originate from animals and animal products cause a number of new infectious diseases affecting humans. Many of these diseases are frequently related to improper handling of infected dairy products during production and in food markets. The major milk safety concerns also include spread of microbiological hazards such as Salmonella and Escherichia coli as well as chemical contaminants. Another milk hygiene concern is the prevalence of mastitis in dairy herds, especially in its sub-clinical form resulting to decrease in milk yield (up to 33% per quarter infected) and a public health risk due to consumption of unsafe milk, and less efficient processing of milk.

Proper disease control will ensure that animal products that are consumed or marketed meet the highest safety and nutritional standards. This will also ensure that diseases, disease-causing and disease-carrying agents are not transmitted between animals and
humans as humans continue to interact with animals and animal products. As a perishable commodity, raw milk has to be chilled shortly after milking to maintain its quality and prevent spoilage. In Kenya, poor milk handling at the farm level and long distances to market result in significant losses due to spoilage. This is often compounded by the poor road infrastructure hindering timely access to markets especially during the wet season (Lore et al., 2005).

2.7 Production Constraints and Hindrances to Productivity

2.7.1 Production constraints

**Technical challenges for pasture and fodder production**

Dairy cattle feed supply is a challenge in Kenya that is caused by a combination of factors that include erratic rainfall, shrinking grazing lands due to competition for land for crop production and changing land use patterns that favour urbanization and settlement (Gebre Mariam et al. 2010; Ayele et al. 2012). In addition, most farmers do not use certified seeds for planting, they borrow or buy planting material from other farmers which are often of low quality and are usually infected by diseases and pests. Improved varieties of Bracharia, maize for silage and Napier are often affected by head smut and stunting diseases leading to losses and lowering the quality (Farrell 2002). Napier head smut disease for example gradually reduces dry matter yields and causes losses of up to 46% (Farrell 2002). Poor pasture establishment and management also result in overgrazing, reduced carrying capacity and hence reduced productivity.

Across all production systems, the use of herbaceous legumes in animal production is limited (Lukuyu et al., 2011). Farmers have small acreages of planted fodder on their farms because historically they depended mainly on natural pastures either on their farms and/or on public or communal land where they hire labour to gather the livestock feeds (Lukuyu et al., 2009). Other challenges included limited knowledge on water harvesting, forage disease control and on farm feed planning. Farmers attributed lack of knowledge to scarce extension materials and personnel (Weinard, 2002).

Feed conservation either as hay or silage is important as it extends feed availability and quality for livestock during the dry season. However, expensive machinery is required to harvest hay and to make silage. In addition, operating them is costly because of the fuel consumption. Limited land and labour to produce feeds is also a constraint to feed conservation (Lukuyu et al., 2011). Consequently, most dairy farmers do not conserve feeds for use during the dry season while among those who do so, some lack knowledge on proper silage making and utilization techniques resulting in a high percentage of rotting (Njarui et al., 2011).

Some farmers leave grass in the field as standing hay although standing hay is low in quality and sometimes a large proportion of it is destroyed by termites especially during the dry season (Njarui et al., 2011). Currently, there are simple and cheaper methods
for conserving feeds but they have not been promoted widely. They include use of polythene tubes (Methu et. al., 2005) to make silage and hand boxes (Massawe et al., 1998) to make hay and these do not require mechanization.

**Technical challenges and hindrances for dairy production**

The average milk production in smallholder dairy farms is generally low (Owen et al., 2005; Musalia et al., 2007; Lukuyu et al., 2011), and higher productivity is limited by feed scarcity, infectious diseases and parasites, poor animal husbandry practices, and limited access to extension and veterinary services (Ayantun de et al., 2005; Njarui et al., 2011; Onono et al, 2013). The low productivity is also attributed to inadequate and inefficient breeding services, inefficient dairy research, poor animal husbandry, inadequate feeding, low quality feeds, environmental, socio-economic/cultural factors, ineffective disease control and veterinary services, poor infrastructure and high cost of inputs/labor among others (Njonge, et al., 2017). Poor access to output markets also contributes to low incentive to increase production, and hence low demand for the requisite inputs (Muia, et al., 2011). The challenges stem from low spending on agriculture by most African governments (Ter-Hemen, 2015).

Acquisition of improved dairy cattle is a challenge in many regions with the cost of a dairy cow being very high due to high demand. A study by Mburu et al., 2016 at the coastal region showed that the two main routes towards acquiring an improved dairy cow were by purchasing an upgraded or grade cow (75.9%) and through a development project (20.2%). The rest (2.2% of farmers) upgraded their local cows and 1.7% got dairy cows as a gift. Artificial insemination (A.I) is recommended to control breeding diseases and improve milk production. However, there were widespread cases of repeat inseminations at a cost, which discouraged farmers. Farmers attributed repeats to unethical practices, poorly trained personnel as well as poor accessibility during the wet season which further aggravated the A.I. services (Mburu, 2016).

Inadequate extension and advisory services could partly be solved through information communication technologies (ICT). The ICT infrastructure is enabling the development of dairy-specific applications that assist information and knowledge sharing (Rademaker et. al., 2016). For instance, iCow provides an agricultural information service through which dairy farmers via text messages can access information on good dairy husbandry. According to Irungu et al. (2015), iCow’s platform has enabled users to increase milk production by 50% and incomes by 42%. However, not all farmers can access information through such platforms, especially the older ones and less educated ones.

### 2.7.2 Distribution and marketing of dairy cattle and products

Most of the milk is marketed fresh through the informal sector. Milk traders offer prices that are about 25% higher than those offered by processors and this impacts negatively on the quantities processed (Casaburi and Macchiavello, 2015). Raw milk retails for
roughly half the price of packaged pasteurized milk with farmers receiving a 15-50 percent premium when selling through the raw milk distributors (Ngigi et al., 2010). Consequently, there is a relatively poor milk intake by the formal milk chain which is also exacerbated by the management fees deducted by cooperatives (Kimenju, 2016).

Poor milk handling at the farm and long distances to market, often compounded by the poor road infrastructure hinder timely access to markets, especially during the wet season resulting in significant losses due to spoilage (Lore et al., 2005). This is because milk is highly perishable and farmers do not have the means to invest in milk cooling equipment which is critical especially during the wet season when high volumes of milk are produced resulting in high post-harvest losses (Muia et al., 2011). Storage and poor transport infrastructure are therefore a great challenge to milk traders where the cost of transport and storage constitute 26% and 22% respectively (Bayesian Consulting Ltd., 2016).

Poor organization of milk collection, processing and marketing systems also seriously undermine the potential of smallholder dairy producers to exploit urban markets (Njarui et al., 2010). Conversely, lack of reliable electricity makes the storage and preservation of animal health (medicines, vaccines) and breeding (semen) supplies more expensive (Casaburi and Macchiavello, 2015).

### 2.7.3 Social constraints and hindrances to dairy cattle

Women’s responsibilities increased with the adoption of dairy cattle especially in the coastal lowlands although financial payments also increased (Mullins et al., 1996). The wife did most of the daily tasks on dairy cows, except spraying for disease control and herding. Although eighty-four percent of the dairy operators were women at the coastal region, they did not have full control of the revenues earned from dairy cows which could dampen their enthusiasm (Mullins et al., 1996).

Conversely, the prevalence of rural poverty is more than 50% in most households of Kenya (GoK, 2010). This means that most farmers do not have the resources required to adopt improved dairy technologies. Studies of dairy farming at the Kenya coastal region have suggested that only wealthier households and those with significant non-agricultural income could afford investing in dairy cows particularly with the prevalence of high mortality (Leegwater et al., 1991).

### 2.7.4 Policy and Legislation Challenges

Regulations are legal instruments that regulate social and market interactions and are typically obligatory, with threats of sanctions in cases of non-compliance (Borrás and Edquist, 2013). Animal feeds are currently regulated under “Fertilizers and Animal Foodstuffs Act” (CAP 345, Laws of Kenya) although fertilizers and animal feeds are unrelated. As a result, the Act is administered in different institutional set-ups. There is
therefore need to separate fertilizers and animal feeds and put them under different legal and institutional frameworks.

Also, most of the raw materials needed for manufacturing animal feeds are usually imported and thus subjected to VAT making them expensive. Though the VAT Act 2012 and the subsequent amendment in 2013 provided for VAT exemptions for compounded feeds, and the VAT (Amendment) Bill 2016 hoped to exempt maize bran/pollard; wheat bran/pollard; cotton seed cake and sunflower seed cake, most raw materials remained subject to VAT. The feeds therefore remain expensive. Conversely, the standards for quality control of the raw materials imported into the country have been inadequate, making it difficult to enforce controls on the quality of the by-products (VAT amendment Bill 2013). There is therefore need to exempt all the raw materials for manufacturing animal feeds from VAT and to also standardize and enforce the quality control.

2.8 Innovation in Dairy cattle
The household survey (Makini et al. 2017 unpublished) and other literature revealed that most innovations were on feed formulation, improved breeds, ethno-veterinary medicine and value addition.

2.8.1 Cattle Breeding
Although local Zebu cattle are adapted to the semi-arid environment, their productivity is low. Other problems with the Zebus include, low milk production, short lactation period and low mature weight. Therefore, development of crossbreds which guarantee improvement in body size and milk production within the existing production systems provide a promising approach of increasing production efficiency and competitiveness of cattle with other species in the different production systems in semi-arid areas.

Upgrading Zebu cows using Sahiwal germplasm
The local zebu cattle cows are mated by sahiwal sires and the resulting crossbred cows which are 50% Sahiwal and 50% Zebu are bred to a different Sahiwal sire to produce crossbred cows which are 75% Sahiwal and 25% Zebu. After attaining sexual maturity, the crossbred cows are bred to a different Sahiwal sire to produce crossbred cows which are 87.5% Sahiwal and 12.5% Zebu. In the fourth generation the crossbred cows are mated to a Sahiwal sire to produce crossbred cows with 93.75% Sahiwal inheritance and 6.25% zebu inheritance. The results are; increased milk yield (1543kg/ lactation); calving interval 446 days; and age at first calving 41 months respectively.

Breeding strategy for Sahiwal/Friesian cattle in Kenya through F1 Friesian x Sahiwal Crosses for smallholder dairy in the semiarid and coastal areas
Breeding Sahiwal and Friesian cows is undertaken to address low milk production and the poor adaptation of Friesian to the hot and dry climatic conditions in the coastal region as well as to tap the Friesian heterosis. It involves mating Friesian cows with
Innovation Opportunities in Dairy Livestock in Kenya

proven Sahiwal registered sires and backcrossing to such sires to the third generation. The result is a decrease of genes of the dam breed, the Friesian, and an accumulation in the animals of each generation of the genes of the Sahiwal breed (Plate 2.5). This increased milk yield (1,850 kg/lactation); calving interval 450 days and age at first calving to 32 months respectively.

![Herd of sahiwal bulls for farmers](image)

**Plate 2.5: Sahiwal bulls and the cross with Friesian**

### 2.8.2 Feed formulation

**Calf feed formulation**

Maize, bean and milk mixture and maize, cowpea and milk respectively are recipes used to make gruel for pre-weaner calf feeding in dairy production. Maize and cowpea flour are mixed at a 1:1 ratio and boiled until frothing ceases (45 min). The gruel is cooled to about 40°C and mixed with an equal volume of fresh milk. The mixture is fed to the calf at a rate of 10% of the calf’s bodyweight in the morning and evening two days after birth until weaning. High quality pre-weaner calf diet reduces calf mortality,
increases calf growth rates, reduces time of first calving and increases productive life of the resultant cow.

‘Jua kali machicha’ (‘Local brewers waste’ using maize germ)
In an effort to increase milk yield, farmers in Kiambu County mix maize germ, maize bran and cotton seed cake and soak it in warm water. This mixture is put in a container for four days in order to ferment and then fed to lactating cows. Although not yet quantified, farmers reported that this innovation increased milk yield.

2.8.3 Production (Calf rearing, replacement stock)
AI heifer calf selection
Artificial insemination is an important service that dairy cattle keepers use in Kenya. However, farmers raised concerns due to the frequency of getting bull calves when unsexed semen was used (Dairy Household Study, 2018). To ensure that the cows sire female calves, farmers in Kiambu involve timing of the AI service where on detecting that the cow is on heat, they wait for 10 – 12 hours after which the inseminator is called in.

2.8.4 Feed quality determination
Checking adequacy of the feed ingredients
Overall, 25 % of farmers reported poor quality feeds as the main challenge (Makini et al., 2017, unpublished). To confirm the quality of feeds without laboratory analysis, dairy farmers soak feed samples in water and leave it for three hours to settle. The thickness of each of the ingredients in the sample is then examined. Through experience, farmers can ascertain ingredients that have been reduced or lacking and either accept or reject the feed consignment.

Checking for the presence of excess lime in feed
Some unscrupulous feed manufacturers often add excess lime to the animal feed to increase the weight. Flashing a torch light on the feed at night reflects the lime and based on the density of the shiny spots in the feeds, excess lime is determined. These tests have ensured that poor quality or adulterated feeds are rejected by farmers/farmer cooperatives and as a result feed suppliers are forced to deliver good quality feeds to avoid this rejection.
2.8.5 Natural pasture improvement

*Kiboko range crescent-shaped pits for water harvesting*

![Image of Kiboko range crescent-shaped pits for water harvesting](image)

Plate: 2.6: Kiboko range crescent-shaped pits for water harvesting

The Kiboko Range crescent-shaped pits are made through the following steps:

i. Select appropriate hoe and shovel.

ii. Mark the pits in a line along the contour. Then dig the pit starting from the centre working outwards, ensuring the centre is deeper (max 0.15m) and the ends are shallow.

iii. The crescents should be spaced within the rows where the rows are staggered. The spaces between the pits within the row allows the overflow to run off to pits down the slope. The crescent shaped pits placed in staggered rows harvest runoff water.

iv. Pile most of the soil in the middle. Compact the soil inside the slope of the crescent with the back of the shovel. Runoff will then be retained on the targeted area thus allowing greater infiltration; higher soil moisture which can support better pasture establishment.

v. Place grass seeds on the crescents.

*Natural pasture improvement through reseeding*

Areas targeted with this innovation are those with bimodal mean annual rainfall between 250 - 400 mm and up to 36°C temperatures where soils are mostly sandy, sandy clay and sandy loam. Degraded natural pasture is fenced and over sown with selected grasses on micro catchments such as furrows made by oxen plough or pits. The following are the steps for reseeding; i) Fence the area; ii) Construct the micro-catchments; iii) Broadcast the seed evenly or place it on the crescents pits or between ox plough furrows at onset of the rains then monitor periodically; iv) Allow first season seed to fall for self-seeding, v) Open for light use at end of second growing season. Stocking should always be moderate and periods of rest allowed to avoid the reoccurrence of degradation.
Use of micro catchments aid in better establishment, while reseeding is best at onset of short rains. To spread the risks, more than one grass species should be used in reseeding.

**Conservation of crop residues**

Wheat straw, maize stover, sweet potato vines, banana pseudo-stems and bean trash are stored for use during dry season. Lusweti et al., (2012) showed that over 60% of dairy farmers store crop residues for use as feed where over 80% chop the residues before feeding their livestock. Sweet potato vines and banana pseudo-stems are usually fed fresh.

### 2.8.6 Cattle health

![Plate 2.7: A sick animal](image)

Ethno-veterinary medicine is about people’s knowledge, skills, methods, practices and beliefs about the care of their animals (McCorkle, 1986). Unlike conventional medicines, which are only approved for public use after careful laboratory research followed by field trials on animals both for toxicology and effectiveness, ethno-veterinary medicines depend only on historical utilization as proof of safety and effectiveness since the knowledge is acquired through practical experiences that are traditionally passed down orally from generation to generation. Ethno-veterinary medicine is accessible, easy to prepare and administer, and is free in some cases. However, there is the risk of incorrect diagnosis, imprecise dosages, low hygiene, poor standards, secrecy of some healing practices, absence of written records, and some treatments can be ineffective or harmful.

**Pink-eye (keratoconjunctivitis)**

Pink-eye is where one or two eyes are affected, discharge from the eye is clear or grey/white, the mucous membranes under the eyelid becomes red and the animal avoids...
strong sunlight and blinks a lot, and a white spot can develop in the eye. To treat the
pink eye, two tablespoons of salt are dissolved in 250 ml of fresh milk. Using a clean
syringe (without a needle) the affected eye is washed with the milk solution twice a day
until the animal recovers. For poison in the eye, 3-5 drops of fresh milk are applied using
a syringe into the eye every 2-3 hours until the pain disappears.

**Worms in the eye (thelazia)**
The fresh fibrous bark of Pilostigma thonningii are pounded and the liquid collected is
applied directly to the eye daily for 3-7 days.

**Streptothricosis (dermatophilosis)**
These are skin lesions, mostly on the back, shoulder and hindquarters, around the ears,
groin and between the legs. Papules, which leak serum, appear and form crusts with a
raw bleeding surface beneath the crusts. A seriously affected animal is emaciated and
weak.

Treatment 1: 1 kg each of the bark of Khaya anthoteca and Psorospermum febrifugum
are pounded and one handful of limestone powder is added. 0.5 kg of *Ricinus communis*
seeds are roasted and ground into powder. The two ingredients are then mixed and
butter is added to make a paste. Any hard crusts are removed from the skin of the
affected animal. The paste is then applied on the affected area daily for 3-7 days,
depending on the severity of the infection. New crusts may appear but they normally fall
off and new hair grows on treated areas in about 2 weeks.

Treatment 2: *Solanum aculeastrum* fruits are roasted and sliced into halves. Crusts are
removed from affected areas and rubbed with the fruits for 1-3 days. The crusts then fall
off and new hair starts growing on the affected area.

**Flies**
*Azadirachta indica* seeds are pounded until they turn brown and sticky and water
added to make a paste. The paste is squeezed to remove all the oil out of the seeds.
This oil is rubbed on the animals to repel flies and other biting insects.

**Lice**
5 kg of *Tephrosia vogelii* leaves are pounded, 2 kg wood ash is soaked in 3 litres of
water and stirred. The pounded *T. vogelii* leaves and the ash mixture is filtered and
mixed with 1 litre of urine. The affected animal is then bathed or sprayed with the
solution. Parasites die within one day.

**Ticks**
*Adenium obesum* is crushed and mixed with water. The affected animals are washed with
the preparation. NB: *A. obesum* is potentially very poisonous and must be handled with care.
2.9 Dairy Cattle Value Chain Analysis

The dairy cattle supply chain in Kenya shows a large variation in terms of size, geographical distribution, degree of licensing, relative rewards, quality perceptions and long-term potential. The dairy cow value chain is a complex system of stakeholders and processes (Figure 2.1).

![Dairy Cattle Value Chain Map](image)

Figure 2.1: Dairy Cattle Value Chain Map

To improve the performance of the value chain, it is necessary to understand the roles and linkages of the stakeholders (individuals and institutions) through a sound analysis. Highlights on the nodes in the value chain are described below:

### 2.9.1 Input and service providers

Input and service providers include agro-vets and other shops, breeding service providers e.g. AI, suppliers of breeding stock, dairy recording and stud book service providers, veterinary service providers, and extension and advisory service providers (FAO 2011).

**Input Suppliers**

Several inputs are required in a functional dairy value chain. These include dairy cows, semen, natural and commercial feeds and supplements, mineral salts, acaricides and animal health drugs. Other inputs include pasture and forage seeds and fertilizers; dairy equipment and machinery. The suppliers of these inputs tend to be limited in their ability to provide appropriate services to farmers across the country.
Over 90% of feed manufacturers are small scale operators producing less than 1000 tonnes per month (Githinji et al, 2009; KMT, 2017) with only 7% producing 1000 – 5000 tonnes per month and 2 – 3 % producing over 5000 tons per month. Most of the big feed producers are based in Nairobi and neighbouring counties (KMT, 2017). Conversely, the Kenyan feed manufacturers operate below optimum levels at 48 to 65% utilization (Githinji et al, 2009).

The potential annual production of animal feeds in the country is about 1,126,656 tonnes, and the manufacturers are only able to utilize two thirds (69%) of the installed capacity (Githinji et al, 2009; KMT, 2017). Dairy feeds (39%) form the second largest proportion of the total animal feeds manufactured after poultry (41%). However, the feed industry has a weak regulatory framework and this is encouraging an influx of trade malpractices where substandard feeds are being offloaded in the retail markets. Consequently, farmers are shifting from purchasing manufactured feeds to making their own home made concentrates.

The livestock feed industry is further affected by regulations such as the Biosafety Act that restricts the importation of yellow maize from countries such as USA. Yellow maize can be used in the production of feeds but as a result of the restriction, humans and animals have to compete for the insufficient locally produced maize grain thus affecting availability of feeds. Other factors inhibiting the livestock feeds industry include; importation of materials that require special clearance (e.g. Bone Meal), those related to taxation (e.g. VAT Act) as well as those related to environmental conservation such as restriction of fishing to allow breeding at certain times of the year reducing the supply of the silver cyprinid (Rastrineobola argentea) also known as the Lake Victoria sardine (“omena” in Luo and “dagaa” fish in Kiswahili) (KMT, 2017).

Long distances between input suppliers and the farmers they serve limits their ability to effectively service smallholder farmers (USAID-KAVES, 2015) thus hindering the accessibility of feeds.

**Service Providers**

Several services are offered along the dairy value chain, these include transportation and distribution; milk chilling and cooling; extension breeding and veterinary provision; credit services; processing and packaging; and quality control. A lack of access to finance and technical expertise severely limits the quantity and quality of services they can provide to farmers (USAID-KAVES, 2015).

i. **Veterinary Services:** These services are provided by the private, NGO and public sectors respectively where, the private veterinary services are mostly offered where milk is commercially produced while NGO services are mostly offered in the ASALs areas where infrastructural development is low. Conversely, Government
veterinary services mainly focus on disease surveillance, diagnosis, vaccinations and control with varying levels of effectiveness and is dependent on the levels of infrastructural development and adoption of marketed milk systems (GoK, 2010). However, it is notable that policies exist on unauthorized use of, and restriction on veterinary drugs (GoK, 2010) although, self-prescribed and administered drugs are a common practice.

ii. Milk Collection Centres (MCC)/Milk Chilling Plants (MCP): These are centres/plants for bulking milk that have cooling facilities established by major processing firms to minimize the cost of collecting milk from small producers who are scattered. Although they can also be owned by producers, sometimes they are donor funded. These MCCs/MCPs have emerged as important business hubs for producers. Currently there are about 200 centres/plants in the country although poor management and lack of efficient operational systems have led to prohibitive start-up costs and significant losses.

Many MCCs/MCPs do not actively manage transportation although in some cases they collect the milk. Milk can also be delivered by producers/members, brokers or other suppliers. After delivery, milk is tested for quality and if accepted, it is placed in a cooling tank to reduce its temperature to approximately four degrees Celsius. Milk has to be cooled within 2-4 hours from the moment it is milked to preserve its quality while raw as well as reduce spoilage before further processing. After cooling, it is usually dispatched to processors and transported to their chilling or processing plant although there are some minimal value-addition activities at the MCC level.

Most of the costs of chilling and labor are fixed in the short term while the main components of operating expenses are salaries and electricity/power. The electricity needed to run the cooling operation is somewhat lower if the volume is lower, but it is not proportional to the milk in the tank. Additionally, some chilling plants are not connected to the power grid, or have unreliable power supply and thus need diesel powered generators. Utilization is the main driver of profitability where milk bulking centers earn 15 percent margins per liter of milk (USAID-KAVES, 2015) while all chilling plants charge a fixed rate of 2 Ksh per liter (EADD, 2008).

Milk is transferred through two main channels: from the farm to a Milk Collection Centre (MCC) or trader (inbound), or from MCC/trader to processor or retail (outbound) (Katothya, 2017). Some milk transporters also serve as milk vendors, aggregating milk from several producers or traders and marketing it in other centres.

iii. Transportation: Poor transportation and marketing infrastructure is a common feature in most milk producing areas. Due to poor market accessibility, especially during the rainy season, dairy farmers sometimes lose their entire afternoon/evening milk production (USAID-KAVES, 2015). For example, it takes smallholder
farmers in Nyandarua and Nakuru counties an average of about 5.7 hours to sell milk after milking, ranging from zero (immediately) to 17 hours (USAID-KAVES, 2015). Without proper on-farm storage and cooling equipment, the higher time estimates pose increased risk of milk spoilage. This is observed when there are delays in delivering milk to bulking and cooling centers where substantial spoilage and poor quality occurs.

Given the remoteness of most of the producers and the poor state of infrastructure, the first means of transportation used is usually a bike (Plate 2.8), walking or for particularly inaccessible areas a donkey (USAID-KAVES, 2015). A bike being the most prevalent means of transportation, this study has focused on its cost dynamics. A bike can transport up to a maximum of about 100 kg and travels an average distance of about 10-30 km (EADD, 2008). Milk is purchased early in the morning and delivered either to a chilling plant or sold to a larger broker by 9-10 am. Most bike transporters use plastic jerry cans to transport milk. This is unhygienic as they are more difficult to clean than the more expensive aluminum cans.

Plate 2.8: Mode of Milk Transportation

Since volume is the main driver of profitability, transportation by producers directly will in most cases be cost inefficient due to low volumes, unless the distance is small. Most milk purchased by bike hawkers is sold to larger traders who operate
pickup trucks (Plate 2.8) and collect milk from milk surplus areas to transport it to milk deficit areas [USAID-KAVES, 2015]. Some of the pick-up trucks also operate on behalf of processors. Transportation margins are high and can go up to 50% of the revenue per liter of milk transported, and this margin is often shared among two or three individuals. The cash outflow needed to start the business for the first month of operation is about Ksh 2m; Ksh 1m for the purchase of the vehicle and Ksh 1 m to cover fuel, labor and raw milk expenses, at 21 shillings per liter of raw milk purchased (EADD, 2008).

However, large processors are able to drive the cost of transport down to 1-2 Ksh per liter, with spillage and utilization being the main cost drivers (USAID-KAVES, 2015; EADD, 2008). These processors mostly use transportation that is more sophisticated with specialized tankers although, those tankers must be licensed by the Kenya Dairy Board (KDB). The tankers can be owned by private entrepreneurs, MCCs or the processors and are mainly associated with the formal value chains systems (EADD, 2008).

### 2.9.2 Producers

Kenyan milk producers are categorized as large, medium and small scale (also described as smallholders) farmers and pastoral with small scale farmers being the majority (EADD, 2008; USAID-KAVES, 2015). The large scale private farms include firms such as Sasini and public farms such as the Agricultural Development Corporation (ADC). Medium and large scale farmers account for less than 25% of the total domestic milk production although they keep large herds ranging from 20 to over 100 milking cows and attain milk productivity twice higher than those attained in smallholder herds with high external input use and production technologies (EADD, 2008). They produce high quality breeding stock for the industry although because of their high cost they are unaffordable to smallholders.

They sell their milk in the formal sector, to processors. However, these farmers are vulnerable to the inefficiencies in the processing node of the value chain, exposing them to stiff competition from smallholders and cooperatives that can supply bulk milk directly to processors.

In contrast, the smallholders use low external inputs and production technologies, preferring those which demand low costs and operational technical skills although a large majority (60%) hire labour for dairy activities. As a result, they obtain averagely 5 litres per cow per day during lactation relative to the 17 to 19 litres in large scale herds (EADD, 2008).

The main variable determining profit efficiency in dairy farming in Kenya is the cost of feed as indicated previously. Other major costs are direct labour (27%), transport to
the market and water (SNV, 2013). Potential for milk productivity improvement exits as indicated by large variation in performance ranging from 1 to 7.2 litres reported for smallholder farmers. Smallholder milk producers realize a price margin of 56 percent per liter of milk. Dairy farmers receive the highest share of the final price, at 35 percent (USAID-KAVES, 2015). Zero and semi-grazing systems of production can be profitable at 10-15% margin (EADD, 2008). There are minimal value-addition activities at the producer level.

2.9.3 Cattle Milk Trading/Marketing
Trading in cattle milk is undertaken both formally and informally where formal trading is mostly through farmer cooperatives who deal in processed milk and is based on agreed prices using standard units of measure (kg or litre). Conversely, informal milk trading is undertaken by traders who collect milk from farmers and sell either to dairy processors or directly to consumers (institutions, hotels, restaurants, and ultimate consumers). These informal milk traders are the most important marketing actors in the dairy value chain, controlling over 70 percent of marketed milk (USAID-KAVES, 2015). Theses traders realize 10-20 percent bulking margins of the price per liter of milk. Figure 2.2 is a schematic representation of the major dairy cattle marketing channels in Kenya.

**Figure 2.2: Cow milk marketing channels in Kenya**

The value chains of both formal and informal markets are fragmented with a large number of players at each step with minimal vertical integration. In the formal value
chain, the milk is usually transported to chilling and bulking centers, then to a processing plant. Once milk is processed, agents or distributors deliver it to the point of sale. In contrast, informal markets connect producers to consumers normally via a number of brokers.

Despite the strong competition for milk between formal and informal markets, the farm gate price remains on average the same. Producers mostly prefer the informal markets since payments are upfront on cash basis whereas in the formal markets, processors pay on a monthly basis. Considering that milk is often the only recurrent revenue, the need for cash to cover daily expenses creates a strong preference for producers to sell to informal traders/hawkers. In addition, there is no quality control in the informal market allowing producers to sell poor quality milk that would be rejected by processors.

2.9.4 Processors

Although milk intake by processors has relatively been on the rise (Figure 2.3), there are only thirty active milk processors in Kenya with the largest being Brookside, New KCC, Githunguri and Daima respectively (USAID-KAVES, 2015). Together they process 85 percent of the 1.5 million kilograms of milk that is processed daily (EADD, 2008; USAID-KAVES, 2015). The market leader is Brookside, in which Danone has held a 40 percent stake since 2014 (USAID-KAVES, 2015). Brookside applies a strategy of taking over other brands to increase its market share, in both Kenya and the wider East Africa region. Although the market for processed milk and milk products has been growing steadily over the past fifteen years, an estimated 70 percent of all marketed milk still finds its way to the consumer through the raw milk market channel where marketed milk covers 50 percent of the total milk produced. In dairy processing in general, raw milk is the most significant cost category, accounting for approximately 50% of the ex-factory price where the processors make an average of 10% unit profit margin for pouch packaging and 20% for TetraPak Container (TC) packaging (EADD, 2008). In general, processors in Kenya receive mean profit margins between 10% and 20%, in line with international standards (EADD, 2008).

![Figure 2.3: Milk Intake by Processors](source: KDB)
Besides processors, there are about 58 mini-dairies and 72 cottage industries that process and sell milk products through over 1,100 milk bars, institutions and direct consumers (KDB, 2014).

**Milk Dispensing**

Milk dispensing enterprises have emerged as a popular alternative source of milk, providing low income consumers with quality milk at affordable prices. They present significant opportunities to develop the dairy value chain but require interventions to identify safety issues and facilitate investments in more dispensing units, especially in lower income urban areas (USAID-KAVES, 2014). Milk dispensers receive 33 percent share of the final price and 30 percent margins per litre of milk (USAID-KAVES, 2015).

### 2.9.5 Value chain enablers

These are a country’s formal (legislation or laws) or informal (cultural practices, business cartels) institutions that facilitate or limit the development of the value chain at different levels (ASDSP, 2014). The laws governing the dairy industry include: The Dairy Act Cap 336 of Revised 2012 (1984); Animal diseases Act Cap. 364; Public Health Act Cap.242 Laws of Kenya; Food Drugs & Chemical Substances Act Cap. 254 and the Standards Act Cap 496. These include research in which all aspects of dairy cattle are undertaken by the Kenya Agricultural Livestock and Research Organization (KALRO), public agricultural universities, and private and international non-governmental organizations as well as foreign agencies in collaboration with Kenyan Agencies. Other enablers include the Kenya Dairy Board who regulates, develops and promotes the dairy industry in Kenya.

### 2.9.6 Consumer

The per capita milk consumption is projected to increase to 220 litres by 2030 due to envisaged better incomes and better marketing. This will translate into an increase from the current annual production of 4.5 billion litres to 12.76 billion litres of milk (GoK, 2010). Direct marketing of milk by farmers due to historical problems of delayed payment by formal buyers, dairy farmers find local informal markets more attractive than formal markets (USAID-KAVES, 2015). Under farmer/trader direct marketing, there tends to be little regard for quality standards across local markets due to a lack of knowledge, as well as a lack of testing technology. The milk is exchanged in its raw form with high variability in quality across market centers leading to increased risks of milk spoilage, contamination, and adulteration. Under these conditions, the consumer is at risk of contracting diseases such as brucellosis and tuberculosis, also known as zoonoses (Omore et al., 2005).

Generally, processors have not adequately invested in milk quality save for adulterations with foreign materials and levels of bacterial load. Processors have put limited efforts in investing in milk quality at milk collection centres due to lack of incentive to improve milk
quality as the market is not demanding better quality milk and the risk of milk assemblers diverting milk to other marketing channels such as milk bars. On the other hand, smallholder farmers are skeptical about investing in quality milk due to lack of payment incentives and risk of rejection in glut periods. Capacity utilization of processing firms is low, and the formal market is facing daily competition from a fluid, cash-based informal market. For processors, the largest cost is that of the raw milk itself.
3. Chapter Three: Dairy Goats

3.1 Background
Goats form an integral component of the livestock enterprise in Kenya and play an important role in the economic and social life of the population. Many communities who practice mixed crop-livestock production systems where farm sizes are small, and crop yields are low, keep dairy goats whose estimated population currently stands at over 251,100 (MOLD, 2011). Kinuthia (1997) concurs and states that dairy goats offer an alternative to dairy cattle where land holdings are small since they require less feed. These goats can be a source of survival and well-being of people with insufficient food, basic nutrition and income (Haenlein, 2001) and are critically important as a source of milk where there are no cows (Devendra and Burns, 1970).

Exotic dairy goats were introduced to Kenya in the 1990s through various government and non-government projects across the country where exotic bucks were crossed with the local goats in a buck exchange programme coordinated by the Dairy Goats Association of Kenya (Kaberia et al., 2003; Ahuya et al., 2008). They comprised of Alpine, Toggenburg, Saanen and Anglo-Nubian (Kaberia et al., 2003) where the crosses were upgraded from foundation stage up to a 94% pedigree state. Currently, goat milk constitutes 4.7% of the milk consumed in Kenya (MOLD, 2010) where dairy goats account for about 6.4 million litres and local goats, 109 million litres respectively (MOLD, 2006).

3.2 Dairy Goat Producing Areas
The agro-ecology is an important determinant of the distribution of exotic goats and their crosses where they are currently found in Mt Kenya (Central), Western, Rift Valley, Nyanza, Eastern and Coastal regions of Kenya (Cheruiyot 2004; Ahuya et al., 2008)
with the majority (about 85%) being in the higher rainfall areas of Central, Eastern and Rift Valley (MOLD, 2010). The demand for goats is therefore very high in those regions including some peri-urban zones of big urban centers where land sizes have become very small due to high human population pressure. A unique characteristic of goats is their good ecological adaptation and the many uses for which they can be kept (Lokhit et al., 2005; Kipserem 2011). They require less investment (Onim et al., 1990), and are mostly kept under the crop-livestock mixed farming systems, under intensive and semi-intensive systems where more can be carried per acre especially where fodder resources are limited, compared to cattle (Devendra and Burns, 1970). Additionally, in the arid and semi-arid lands (ASALs) of Kenya indigenous goats are also reared mainly by pastoral communities under extensive systems.

### 3.3 Dairy Goat Breeds

In Kenya, goats that are milked include; exotic dairy goats, indigenous goats, and the crosses of the exotic and indigenous goats. The exotic dairy goats include the Toggenburg, Saanen, Alpine, and Anglo Nubian breeds, while the main indigenous breeds are the Small East African Goat (SEAG) and the Galla (MOLD, 2011) (Plate 3.1).

#### Table 3.1: Goat breeds and their characteristics

<table>
<thead>
<tr>
<th>Breed</th>
<th>Characteristics</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| Small East African Goat (SEAG) | - Diverse in type and body size.  
- Low milk yields  
- Short lactation periods  
- Slow growth rates  
- Disease and drought tolerance | Resistance to gastrointestinal parasites, infectious diseases, drought tolerance and rapid body weight gain |
| Galla (aka Somali, Borana) | - White with dark skin pigmentation  
- Higher milk yield than SEAG  
- Continues to gain weight up to 8 years of age  
- Breed and rear kids up to 10 years of age | - Can lose up to 10 kgs body weight during lactation and regain in 2 months  
- Strong dental system, are docile and easy to handle and thrives best in low altitudes |
| Saanen           | - Whitish with pinkish skin pigmentation  
- Males weigh 80-100kgs  
- Females 63-77kgs  
- Produce up to 7 litres/day  
- Short fur, no horns  
- High twinning ability  
- Performs better in cool areas | - |
<table>
<thead>
<tr>
<th>Breed</th>
<th>Characteristics</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toggenberg</td>
<td>- Brown in colour with white line on face, tail and legs&lt;br&gt;- Male weighs 70 - 110kg&lt;br&gt;- Female weighs 70-110&lt;br&gt;- Produces up to 5 litres/day&lt;br&gt;- Has high butter fat content</td>
<td>Full chested with large deep wedge shaped body</td>
</tr>
<tr>
<td>Anglo Nubian</td>
<td>- White or spotted with drooping ears&lt;br&gt;- Male weighs 70-110 kgs&lt;br&gt;- Female weighs 60-70 kgs&lt;br&gt;- Milk has high butter content&lt;br&gt;- Produces up to 5 litres/day&lt;br&gt;- Milk good for making cheese</td>
<td>- very upright and proud stance&lt;br&gt;- capacity to adapt to hot climates</td>
</tr>
</tbody>
</table>
3.4 Breeding

There are social breeding mechanisms that are usually deployed in local goats breeding. These are socially embedded in the customs and influence the animal gene pool which can either consolidate the population or create boundaries with other populations. Animals are distributed within the community and it is a taboo to sell female animals to people outside the community which is a practice that is scorned by pastoralist communities. Goats are therefore passed on from generation to generation as gifts during various events.

This breeding system has similar rules as the breeding associations found in developed countries where for effective breeding, a buck must have a well-developed body frame and reproductive organs, a masculine head and neck and should be noisy (Kaberia et al., 2003). Conversely, the doe should exhibit high milk production; be well built with strong legs, a soft udder to the touch and uniform teeth.

For the exotic dairy breeding programme, initially GTZ (now GIZ) spearheaded the upgrading of local goats to 87.5% (7/8) exotic blood level for dairy production, which was subsequently followed by the formation of the Dairy Goat Association of Kenya (DGAK). The Dairy Goat Association of Kenya (DGAK) then took over the coordination of these breeding activities and currently acts as the umbrella body that advises and organizes buck stations where bucks are coordinated in a specific area. The bucks are rotationally used by groups and group members at a fee to serve the does with care being taken to avoid in-breeding (Ahuya et al., 2008). Recently, the association introduced artificial insemination to curb in-breeding and reduce the cost of importing bucks from Europe. This has reinvigorated the dairy goat industry and has already started having an impact on the dairy goat sub-sector although AI is still at its infancy.

3.5 Pasture and Fodder Production

Local goats normally feed on natural browse although the ASALs of Kenya have some mountainous pockets, riverine areas and oases where crops and high quality fodders are possible. However, these pockets are currently areas of high human settlements and the traditional livestock extensive system is no longer practical. For example, the traditional extensive livestock husbandry on Mt. Marsabit is in conflict with crop production, wildlife conservation, forest reserve and human settlements that have eaten into what used to be dry season fallback areas for livestock (Tura, 2007). As a consequence, most livestock are reared in the lowlands and the few that are kept on the farms are grazed in the park and forest reserves which are highly forbidden by the Kenya Wildlife Services (KWS) and the Forest Department.
Although farmers have established pasture and fodder for exotic and indigenous goats, over reliance of natural pasture is still very high. Similarly, there is over reliance on the extensive production system as a result of the recurring droughts and availability of natural grasses while efforts to establish pastures and fodder are frustrated by those droughts.

3.6 Feeds and feeding

Goats need energy for their body functions and normal temperature to remain active as well as to grow, reproduce and produce milk respectively. Energy sources include carbohydrates in leafy and stalky feed, roots and tubers, bananas etc. which are locally available and normally form the bulk of a goat’s feed (Muthiani et al., 2013, Otieno et al., 1992). Carbohydrates can also be sourced from fats contained in oil crops seeds such as soya, cotton, sunflower, groundnut and coconut. The by-products of oil extraction are also very rich in energy (NRC, 1989).

Goats also need proteins for growth, building up body fat, and for the essential bodily functions. Although, protein requirements are provided by its own digestive system, which is enough to keep the goat alive, the proteins are inadequate to produce good meat or lots of kids and milk. The goat requires extra protein and this has to be provided by the keeper (Devendra and Burns, 1970). Sources of protein include young vegetable leaves, cabbages, grasses, shrubs etc. In addition, tree leaves especially those of pod-bearing and N-fixing trees like Leucaena, Sesbania and Gliricidia, (Masama et al., 1997) have a high protein content all the year round. Legume crops such as soya and groundnuts are also very rich in protein while residues left after cereal and cotton seed processing are also protein rich (Norton and Poppi, 1985).

To avoid a high mortality of the kids, they should be well managed and immediately suckled after birth. The colostrum is very nutritious and protects the kid from diseases and ensures that the digestive system starts working. Depending on size, kids should be fed with up to one litre of milk and roughage such as sweet potato while Napier should be fed at two weeks followed by supplements at the fourth week. After three months, kids can live entirely off high quality roughage, and can be weaned (Devendra and Burns, 1970).

Another important ingredient of goat feed are minerals which include salt, calcium, phosphorus, and trace elements such as iron, copper and iodine (Silanikove, 2000). These minerals help to maintain and regulate the bodily functions, and also help to strengthen the teeth and bones. Young kids also need minerals as well as pregnant and milking does because lack of minerals can lead to poor appetite, a dull coat, poor growth and reduced fertility. When there is deficiency, the animals draw on their own reserves and this should be avoided by supplying a varied diet. Salt licks should be availed with care being taken to avoid excess mineral supply. Goats also need
vitamin A because lack of it causes eye disorders, skin flaking, breathing and digestive problems. Sources of Vitamin A include carotene found in green and yellow/red plant parts like sweet potatoes although these decline sharply in storage (NRC, 1989).

3.7 Dairy Goat Health

Endemic and emerging diseases and pests constrain goat production in both pastoral and mixed crop livestock systems. Causes of diseases and death are known although there are new unknown emerging diseases that arise. Conversely, ineffective disease management can contribute to losses experienced in pastoral production systems where the most critical include; pneumonia whose common symptoms are sneezing, coughing, heavy breathing and withdrawal as well as mastitis (Ndegwa et al., 2016). Early diagnosis of sick goats is important for successful treatment and hence a veterinarian needs to be consulted quickly when pneumonia is suspected. Other diseases include Contagious Caprine Pleuropneumonia (CCPP) and tetanus. Another serious challenge is worms whose presence is manifested by worms or eggs in goat’s droppings and a thin and rough hair coat. General poor health is the end result and a drop in milk production occurs. To control worms, a dewormer should be used. Goats should also be sprayed when fleas and ticks are detected.

3.8 Milk Hygiene

Milk contamination can occur at any point in the milk production process with key sources of contamination being the udder and udder flanks, the hands of the person milking or is sick, dirty milking, storage and transportation equipment, and unhealthy goat (Ahuya et al., 2008; Ndegwa et al., 2016). Milk from goats showing signs of udder disease should not be used for human consumption. This also applies to milk from animals undergoing medical treatment until after the prescribed withdrawal period. The sleeping areas should be kept dry and clean while teats and hands should be cleaned before milking. During transfer and storage, milk should be protected from contamination. The milk should be boiled as soon as possible after milking and in cases of bulk milk, it should be cooled immediately.

3.9 Importance of goat milk in food and nutrition security

Goat milk has unique nutritional (Haenlein, 2001; Devendra and Burns, 1970) and health benefits to humans and because of this, there has been an increase in the use of goat milk in many areas (Devendra and Burns, 1970). The medicinal value (Haenlein, 2001; Greppi et al., 2008; Mele et al., 2008) is of significance in nursing newborns, curing food allergies and gastrointestinal disorders respectively (Haenlein, 2001), in addition, there are anti-carcinogenic agents in goat milk e.g. lipids (Greppi et al., 2008; Mele et al., 2008). Goat milk also contains fat globules that are smaller (Haenlein, 2001; Devendra and Burns, 1970), friable and the coagulum is light compared to that of cow’s milk (Devendra and Burns, 1970), making it easily digestible in humans thus favourable to infants and the sick (Devendra and Burns, 1970). Goat’s milk is
also much higher in short- and medium-chain fatty acids (FAs) (Haenlein, 2001) which constitutes 70.4% of milk FAs (Meles et al., 2008), and these are established medical treatments (Haenlein, 2001). Goat milk has also been found to alleviate some medical conditions such as lowering cholesterol levels, improving digestive and sleep disorders in children (Haenlein, 2001); production of hypoallergenic formulas in infants with cow milk intolerance (Greppi et al., 2008; Haenlein, 2001), reducing hyperacidity condition (Devendra and Burns, 1970), and neutralizing carcinogenic agents (Greppi et al., 2008; Mele et al., 2008). Nutritionally, compared to cow’s milk, goat milk is higher in minerals such as K, Mg, Cl, Mn (Haenlein, 2001), Ca, P, Chlorine (Devendra and Burns, 1970), Vitamins A and D, nicotinic acid, inositol (Attfield, 2007), and in glycerol esters (Haenlein, 2001).

3.10 Production Constraints and Hindrances to Productivity

3.10.1 Production constraints

Technical challenges and hindrances for pasture and fodder

Dairy goats in many areas browse on whatever vegetation that is available. However, according to Muthiani, (2013) dairy goat keepers in arable crop systems rely on pasture and fodder however, they experience various challenges in attaining sustainable fodder production for their dairy goats hence lower productivity and profitability. The constraints include;

- Frequent droughts and unreliable rainfall;
- Lack of quality germplasm;
- Lack of land or small land sizes;
- Competition from other cash crops;
- Pest infestation and disease infection on various fodders;
- Inadequate planting material/and or poor quality planting material;
- Damage of fodder by livestock;
- Insecurity in the communal land;
- Lack of water to irrigate pasture;

The challenges faced by pastoralists engaged in forage production differ depending on the regions where they are situated as summarized in Table 3.2.
Table 3.2: Problem experienced by producers in forage production

<table>
<thead>
<tr>
<th>Problem</th>
<th>Taita Taveta</th>
<th>Kajiado</th>
<th>Narok</th>
<th>Bura</th>
<th>Garissa</th>
<th>Baringo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unavailability of forage seed</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Lack of planting equipment</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Lack of market information</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Lack of harvesting equipment</td>
<td>√</td>
<td></td>
<td>√</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disturbance by livestock</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvester ants eating seeds</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proper timing of planting</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor germination of grass seeds</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate storage facilities</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate capital resources</td>
<td>√</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate skills</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor soil/climate</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High price of inputs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wildlife invasion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate water</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
</tbody>
</table>

Source: Muthiani, 2013

From Table 3.2, it is clear the main challenges included unavailability of forage seed and planting equipment respectively as well as lack of market information which occurred in all the reference counties except Kajiado.

Technical challenges and hindrances for dairy goat

The main problems experienced by dairy goat farmers include: lack of markets for milk and goats (45%), diseases (33%), high cost of concentrates (25%), lack of feed (19%), unreliable buck rotation program (16.5%), and insecurity (1.8%) (Mbindyo et. al., 2018). The unreliable buck rotation program is partly because there are no dairy goat breeding programs as well as no organized dairy goat farmers’ groups (Tura, 2007). If such groups existed, they could have helped the farmers to jointly draw bucks’ rotation schedules for breeding. Additionally, many dairy goat farmer groups are not registered with the Kenya Dairy Goats Association, which could help them in pedigree selection and marketing (Mbindyo et. al., 2018).

Limited technical knowhow on managing improved dairy goats is also a challenge and could lead to poor feeding and inadequate control of diseases and pests. Housing of dairy goats is also a major challenge because if it is not done properly it predisposes the goats to cold, predators and rains. Conversely, in most ASAL areas farmers do not house their goats yet dairy goats need proper housing without drafts, with good drainage,
feeds troughs and easy to clean.

![Model goat house and feed troughs](image)

**Plate 3.2: Proper Goat houses with feed troughs**

### 3.10.2 Marketing challenges and hindrances to dairy goats

Physical infrastructure in terms of roads is a major constraint to the development of the dairy production system including dairy goats. Roads and telecommunications are poor in all ASAL areas making access to information about vital markets in both ASAL and non-ASAL areas difficult and expensive (Tura, 2007). Other impediments to marketing livestock and their products for producers from northern Kenya include: poor quality roads, lack of reliable market information, stock rustling and general insecurity, and absence of consistent livestock marketing policies, and hence dependency on private traders (Chabari and Njiru, 1991).

### 3.10.3 Social challenges and hindrances in dairy

Goats are more adapted to ASALs although there are frequent droughts occasioned by variability in rainfall and temperature. Droughts and sometimes floods cause major animal losses. Floods in ASALs are sometimes associated with disease outbreaks such as Rift Valley Fever, which further result in loss of animals while insecurity due to banditry restricts livestock movement in search of better pastures or markets.

Across all production systems (pastoral, extensive and small holder systems), farmers keep pure flocks of goats together with sheep with a majority preferring to keep sheep only. In smallholder and pastoral/extensive farming systems, small ruminants are owned by men, but feeding and milking is done by women and youth. However, since the start of compulsory Free Primary Education (2003), it has become necessary for most stock owners to hire laborers, necessitating a commercial orientation to the livestock enterprises in order to deal with the increasing cost of production. However, market information is available to men, women and the youth, through mobile phones, FM radios and other ICT gadgets.
3.10.4 Policy and legislation challenges and opportunities
Policy attempts at developing the ASALs have been made in 1979, 1992 and 2001. In 1979, the policy thrust was to change the nomadic lifestyles of the people although this policy failed to seek the views of the beneficiaries. The 1992 policy initiative emphasized drought contingency planning with the involvement of beneficiaries. However, its main weaknesses were lack of political support and an inappropriate implementation strategy framework. In 2001, the Government of Kenya developed a rural development strategy (KRDS) and although its design looked appropriate, it was not implemented. Except for the Kenya Rural Development Strategy 2001, the major weakness of the other policies was that they lacked implementation frameworks and had limited stakeholder participation. In addition, they lacked clear targets and timeframes (Tura, 2007).

3.11 Innovation in Dairy Goat Production
The dairy goat industry has a current population of approximately 251,000 dairy goats (pure bred and cross breeds) and have received increasing attention from both research and development workers in the last two decades. This is due to their suitability and performance in small farm systems in Kenya.

3.11.1 Breeding
Social and traditional innovations in goat rearing
Social institutions and cultural traditions provide the context that determines the animal management choices available to farmers. Goats are considered the property of the community as a whole and not as private goods (Tura 2007). There are therefore rules that (1) ensure animals are distributed within the community; (2) animals remain a long-term asset over generations and (3) control breeding. Traditional pastoralist societies have strict rules about the exchange of animals where for instance, richer people may be socially obliged to help poorer families and clan members by loaning goats to them. They have fixed rules for giving animals as gifts at certain events, such as births, circumcisions and puberty, and as dowry or bride wealth at weddings.

Buck exchange breeding strategy
The Dairy Goat Association introduced an innovative buck leasing breeding scheme that involves rotation of bucks between the groups to avoid inbreeding. The lease fee for a buck is Ksh 4000 per buck where this buck is kept by an identified buck keeper in the group who maintains a buck service book. The buck stays in one station for 15-18 months before rotation by which time its first female off springs would be due for service. Through this scheme, farmers have been able to systematically upgrade their goats (DGAK 2017).

Goat health care
Community Animal Health Workers (CAHW) ensure easy access to goat health services, and it is an innovative health provision strategy that was introduced (Peacock, C 2011).
The CAHW are trained to diagnose ailments and either offer advice or refer the owner to the veterinary officers in case of serious cases. The services are offered at a fee to enable mobility of the CAHW and this has helped the goat keepers to maintain healthy flocks.

Fodder conservation
Dairy goat farmers have adopted feed conservation methods such as hay baling, silage making and pod harvesting to feed their goats during feed scarcity.

3.12 Dairy Goat Value Chain Analysis
The value chain for goat milk includes input supply; production; product assembly; transportation; processing; retail trading, and consumption. Forage producers are also key to the value chain.

Figure 3.1: Dairy Goat Value Chain Map

3.12.1 Input suppliers
These are mainly stockists and agrovets who provide veterinary drugs, mineral salts and supplements.

3.12.2 Service providers
Several services are provided along the value chain and these include milk bulking, transportation, and provision of veterinary services.

3.12.3 Producers
The producers of goat milk are generally small-scale who own a few goats in land scarce areas for cattle production. Dairy goat production, especially pasture-based production,
Innovation Opportunities in Dairy Livestock in Kenya

offers the opportunity for profitable and sustainable diversity on small farms (Kamau et al., 2008). It is the most lucrative business where land fragmentation has resulted in small parcels of land that cannot support dairy cattle farming. Consequently, there is an increasing demand for small ruminants, predominantly the dairy goats (Kinyanjui et al., 2006). Conversely, in the ASALs the main goat producers are pastoralist communities.

3.12.4 Traders
Goat milk is rarely sold among traditional goat keepers. However, milk traders are basically producers who sell milk directly to rural consumers and a few itinerant traders who sell to consumers in urban centres (Tura 2007). The milk is highly seasonal and is only available during rainy season in extensive pastoral production systems that is in short rains (October –December) and long rains (April–June) and it is sold fresh or yoghurt or ghee. However, the volumes of milk produced are low and as a consequence prices are extremely high ranging between 60 cents to one US dollar per litre.

![Figure 3.2: Generalized goat milk marketing channels in Kenya](image-url)

Innovation Opportunities in Dairy Livestock in Kenya | 47
3.12.5 Processors
There has been limited extension advice and capacity building on value addition activities such as milk handling and tasks undertaken by women such as quality control: proper sanitation, and packaging particularly in the ASALs (CARE International, 2014). The limited extension services offered, mainly focus on improving production although there are a few small scale processors. Traditionally, goat milk is used in times of plenty to make ghee which is sold in local markets alongside the fresh milk. This minimal milk processing (e.g. production of ghee, sour milk and yoghurt) is generally undertaken by women (CARE International, 2014).

3.12.6 Consumers
Goat milk is consumed by a niche market composed of people and infants who are allergic to cows’ milk, although infants of all species generally thrive on goat milk (Lagat and Bwisa, 2012). There is also a growing demand in the dairy market for value-added products such as cheese and yoghurt which is processed by dairy goat producer groups. The main local markets for dairy goat milk do exist, however, the respondents revealed that they also sell their milk on special demand from specific individuals mainly suffering from ailments such as diabetes, AIDS and those sensitive to cow milk (Mburu et al., 2014).

A little of goats’ milk is traded outside the producing areas while the bulk of the milk (57%) is consumed in homes, given to infants, convalescents and the aged (Kinyanjui et al., 2006). Part of the goat milk is marketed informally while raw to neighbors although where farmers are organized into producers’ groups, the milk is bulked for transportation to external markets. Major markets for goat milk include hospitals, tourist hotels and individuals especially in urban areas.

3.12.7 Value chain enablers
Value-addition of goat milk has contributed to the growth of the dairy goat sub-sector. Conversely, research on all aspects of dairy goat milk undertaken by the Kenya Agricultural Livestock and Research Organization (KALRO), public agricultural universities, and private and international non-governmental organizations, foreign agencies in collaboration with Kenyan Agencies contributes to increased productivity through provision of technologies and innovations. Other enablers include the Kenya Dairy Board who regulates, develops and promotes the dairy industry in Kenya, and the Dairy Goat Association of Kenya (DGAK) (Mburu et al., 2014). Others include Non-Government Organizations such as Farm Africa and donor agencies (FARM-Africa, 1997; Okeyo et al., 1999; Peacock, 2005)
4. Chapter Four: Dairy Camel

4.1 Background
The camel (Camelus dromedarius) is potentially the most important animal source of food in pastoral areas with its unique physiological, anatomical and ecological adaptations enabling it to produce and supply milk to pastoralists throughout the year (Schwartz and Dioli 1992; Farah 1996). A camel has the potential to produce 5-10 times as much milk per lactation as a cow in a similar environment although the total amount of protein and energy it produces annually under traditional management is about 2½ times the quantity produced by cattle (Farah 1996). This makes the dairy camel an important asset for pastoralist communities in various Arid and Semi-Arid Lands (ASALs) of Kenya. During prolonged droughts when cattle and goat milk ceases, camel milk contributes up to 50% of total nutrient intake of some pastoralists groups (Herren, 1990).

4.2 Camel Producing Areas
Camels are found in areas with high temperatures, water scarcity and considerable seasonal variations in available forage quantity and quality (Schwartz, 1992a). Its survival surpasses any other domestic livestock in the arid lands (Farah et al., 2004a).

4.3 Camel Breeds
There are four camel breeds in Kenya namely Somali, Rendille/Gabbra, Turkana and Pakistani (Plate 4.1) which are different in physical, productive and genetic characteristics (Table 4.1) (Hülsebusch and Kaufmann, 2002).
Table 4.1: Camel breeds and their characteristics

<table>
<thead>
<tr>
<th>Breed</th>
<th>Characteristics</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Somali</td>
<td>• Largest body, weighing 450 - 850 kg.</td>
<td>Due to its high superior characteristics in terms of meat and milk</td>
</tr>
<tr>
<td></td>
<td>• Milk yield of 3-5 litres a day; Hoor type camels produce 6-8 litres per day.</td>
<td>yield many pastoral households are currently acquiring it to upgrade</td>
</tr>
<tr>
<td></td>
<td>• Heavy feeder, needs good pasture.</td>
<td>other breeds such as Gabra and Rendille.</td>
</tr>
<tr>
<td></td>
<td>• Not suited for hilly terrain because of its size and weight.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Mostly cream coloured coat.</td>
<td></td>
</tr>
<tr>
<td>Rendille/Gabbra</td>
<td>• Relatively smaller (300-550kg)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lower in milk yield (average 1-3 litres a day).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Can withstand poor pasture conditions and on rough hilly terrain.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Coat colour is mainly creamy or brown</td>
<td></td>
</tr>
<tr>
<td>Turkana breed</td>
<td>• It is the Smallest in size (250-500 kg).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lowest in milk yield (1-2.5 litres a day)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Does well in very poor pasture conditions and on rough terrain.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Coat colour is mainly grey.</td>
<td></td>
</tr>
<tr>
<td>Pakistani</td>
<td>• Smaller in body size than Somali but larger than Gabbra/Rendille</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• It has an average weight of 400kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Highest milk yielder with 10lts average</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Gross feeder, mainly grey in colour</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Genetically distinct</td>
<td></td>
</tr>
</tbody>
</table>

Plate 4.1: Camel Breeds
4.4 Breeding

Most pastoral households use bulls for breeding based on natural selection although, due to a high demand for milk, camel keepers are using the Somali breed to upgrade the Rendille/Gabra breed. However, camels are seasonal breeders where the onset of the breeding season is triggered by the availability of fresh green feed (Evans et al., 1995). Their reproduction is different from other livestock in that both male and female come into heat during the breeding season and their gestation period is 390 days with an average birth weight of 35-40 kgs (Khanvilkar et al., 2009). As a result of the seasonal breeding it is important to ensure successful conception hence repeat mating is good practice and should be allowed.

The gestation period for camels is 1 year and 3 weeks where three weeks to calving, in-calf dams are given more attention with the more experienced herders being put in charge of such animals. The purpose is to keep the in-calf dam under observation for any possible sign of parturition as well as to care for it, avoiding grazing in hilly/stony areas, thicket thorny bushes and predator prone areas. During calving seasons, two persons are normally assigned to herd because a dam showing signs of parturition has to be driven back to the homestead (Hulsebusch et al., 2002; Khanvilkar et al 2009). Dams with a history of prolapse are plastered on the pelvic muscles with wet soil (thulban) dug from watering springs during watering days to stiffen the muscle to contain the uterus.

4.5 Feeds and Feeding

Camels are selective feeders where they prefer browsing although they can also feed on herbs and grasses where there is no browse. Their feed intake depends on its selective feeding of the wide variety of vegetation and the different parts of browse which differ in quality (Farah et al., 2004; Guliye et al., 2007, Noor 2013). Camels usually require 8-10 hours of grazing daily in a good season and up to 12 hours during droughts as well as 30-60 grams of salt a day which is much higher than what other livestock species require (Kuria, 2004).

Detailed nutritional studies in the arid lands of northern Kenya have shown that the small-bodied Rendille/Gabbra camels consume daily 1.67% of their live weight. Consequently, the daily dry matter intake (DMI) calculated using mean live weight resulted in 5.02 kg per day (Field, 2005).

They are traditionally reared mainly by subsistence pastoralists usually in communally owned rangelands. This system is characterized by low production inputs/investments, low productivity/output, seasonal migration as well as herd and household mobility in search of pastures, water and mineral licks. The mobility enables pastoralists to utilize rangeland resources more efficiently (Farah et al., 2004; Guliye et al., 2007; Noor et. al 2013).
The calf is allowed unlimited access to colostrum within the first 3 to 6 hours after birth. After the third month, when the calf is able to graze actively, its milk allowance is reduced depending on the quantity and quality of forage available and its growth performance (Farah et al. 2004, Kuria, 2004).

4.6 Camel Health
Despite being hardy, the camel is prone to a variety of diseases which include Rift Valley Fever, camel pox, brucellosis, anthrax and rabies all of which can be managed through vaccines. Other diseases and conditions include wounds and abscesses, orf, mange, contagious skin necrosis, tick infestation/paralysis, eye infection, gastro-intestinal worm infections, hydatidosis, respiratory infection pneumonia, trypanosomosis, abortion, wry neck, swollen glands/haemorrhagic septiceamia, camel sudden death and, mastitis (Guliye et. al. 2007). These diseases can be treated with albendazole (worms), Ivermectin (skin), Gentian violet (wounds), Hydrogen peroxide and iodine (abscesses), and a variety of antibiotics. However, diseases like haemorrhagic septiceamia and camel sudden death are yet to be understood and require further research (Dirie, 1999).

4.7 Pasture and Fodder Production
Several fodder species can tolerate low amounts of rainfall owing to their deep rooting habits, however, they must have sufficient water during seedling stages (Ellis 1988; Farah, 1996). Coppicing also often induces flowering at a suitable height for harvesting and is recommended to avoid difficulties of harvesting from tall trees (Tengnas, 1994). Fodder from trees normally constitute the primary feed source for livestock in ASAL areas during the dry season, when browse constitutes more than half of the diet.

Plate 4.2: Camel accessing browse from a tree
Plate 4.3: Coppiced Acacia tree for easy harvesting browse fodder
Source: Tengnas, 1994

4.8 Importance of Dairy in Food and Nutrition Security
Camel milk and milk products contribute significantly to the food basket of pastoral households. According to Elhadi (2014), camel milk is consumed by 60.9% of the pastoral population where an average pastoralist household requires up to about 7
litres per day for their consumption as a major part of their diet (Musinga et. al., 2008). The milk is mostly consumed fresh or as a naturally fermented product, although recent research advances show a variety of products that are either being promoted or validated but are yet to reach the Kenyan market (Musinga et. al., 2008). Other milk products include fermented milk generally called ‘Susa’ in northern Kenya, yoghurt, cheese (soft cheese), butter, ice creams, puddings and chocolates of different flavors.

Camel milk has a high nutritional value, with vitamin C, which is three times more than the cow’s milk, iron content that is ten times and B vitamins that are present in reasonable amounts (Akweya et al., 2012, Barbour et al., 1985; Elagamy et al., 1992; Arrowal et al., 2005). Conversely, camel meat is a delicacy among pastoral communities and is sold in butcheries in Kenya’s major towns. Utilization of camel manure is unknown and there is lack of information on its contribution to food and nutrition security.

4.9 Milk Hygiene

Traditional buckets that are properly sanitized by heat treatment (smoking) are hygienic and can be used while quick transportation of the milk to market is required because delays can lead to spoilage especially in the heat of arid and semi-arid areas. Technologies like cooling hemp (wet gunny bags used to wrap milk containers keep milk cool during transportation) are recommended while the alternative is a refrigerated vehicle. Value added milk products such as pasteurized milk, yoghurt, fermented milk (“mala”), condensed milk, camel milk sweets can also be made (Musinga et. al., 2008).

4.10 Production Constraints and Hindrances to Productivity and Profitability

4.10.1 Production constraints

Technical challenges for pasture and fodder production

Thornton (2010), reported that poor nutrition of livestock in Africa is a major challenge to productivity despite the research undertaken in pastures, utilization of crop residues and even supplementation. In addition, inadequate feed availability is a major concern in the ASALs of Kenya which is exacerbated during dry seasons with drought conditions being the most constraining factor (Gikaba, 2014).

Several technologies such as natural pasture improvement, range pasture establishment, pasture seed production, feed processing and storage; range fodder/pasture utilization, conservation and preservation geared towards improving livestock productivity in the ASALs have been developed. However, there is inadequate knowledge on suitable species, pasture establishment, management and harvesting, hay bailing, storage and business approach to commercialization of pasture and fodder technologies in the ASALs (Mnene, 2006; Kibet et. al., 2006).
Conversely, socio-cultural factors amongst most pastoral communities find commercialization of pasture production unacceptable because they believe grass and trees are God given hence they should not be planted nor their use restricted. This is exacerbated by the land tenure system which does not promote responsible utilization of arable land because communal land is open to grazing by the whole community (Kassily, 2002). There is also competition for irrigation water where there are springs or boreholes leading to conflict between pasture producers and livestock herders.

Therefore, the need for increased participatory approaches to disseminate the available technologies as well as educate the communities on the benefits of some of the practices they have rejected cannot be overemphasized.

**Technical challenges and hindrances to camel dairy production**
Camel milk production is influenced by a number of factors which include; feed quantity and quality, breed, climate, watering frequency, stage of lactation and frequency of milking (Ramet, 2001). In Kenya, it is highly likely that the reported milk production levels fall below the genetic potential of the camels (Onjoro, 2004). This is because camels in Kenya are kept in marginal areas and receive no feed supplementation, little or no disease control, and they are kept for subsistence rather than commercial purposes (Simpkin, 1995). According to Wernery (2003), good camel milkers can produce 20 to 30 litres daily. However, Simpkin and Atkins 1995, estimated the milk yield in camels in Kenya to be between 3 to 7 litres per day. Onjoro (2004), states that the yield can be improved to over 10 litres per day with better feeding. Other constraints include lack of capital or liquidity, for example, insufficient funds to purchase drugs or vaccines led to high morbidity and mortality (Ibrahim and Olaloku, 2002).

**4.10.2 Market challenges and opportunities in dairy**
Although camels play a significant role in the livelihood of pastoralists in Kenya, current production figures indicate low milk production resulting in high milk prices an indication that supply does not meet the demand. Conversely, on average, farmers take 7.4 hours to cover 80 km to market in most ASAL peri urban markets (Adongo et. al., 2013) where a majority of consumers prefer fresh hygienic milk (Adongo et. al., 2010) and are willing to pay more for quality milk (Wayua et. al., 2007).

The unhygienic handling practices in traditional camel milk production as well as in the informal camel milk trade presents serious obstacles for the introduction of modern dairy processing and marketing (Younan, 2003). The successful adoption of an improved camel milk production and marketing system will depend, to a large extent, on safeguarding the milk quality at production, during transport, processing and marketing. However, adapting hygienic practices and guidelines to the pastoral situations remains a challenge due to non-availability of safe clean water.
There are a number of impediments to livestock marketing for producers from northern Kenya. These include: a poor road network, lack of reliable market information, stock rustling and general insecurity, absence of consistent livestock marketing policies, and hence dependency on private traders (Chabari and Njiru, 1991). Marketing of raw milk in Garissa, an urban town in the ASALs is also faced with problems ranging from low milk production, poor hygiene (dirty containers and poor milk handling), transportation with a poor road network, lack of proper packaging, and low demand during glut periods (Dirie, 1999). However camel milk, which has been consumed for centuries by nomadic people for its nutritional values and medicinal properties, is now experiencing greater attention in the western world (Wernery and Wernery, 2010).

4.10.3 Social challenges and hindrances in dairy camel production

**Social challenges and hindrances in dairy production**

Marketing of camel milk is still confined to relations and family friends. This constrains the quantities of milk a household can take to the market since it depends on the financial capacity of the relative/friend receiving milk at the market level (Musinga et al. 2008). Traditional preservation methods among pastoralists especially in the use of fumigants from special trees could also hinder value addition interventions aimed at widening the camel milk market beyond pastoralists consumers.

**Social challenges in pasture and fodder**

In the past, camels solely depended on natural forage and pasture in communally owned land under the extensive production system. Over time however, high human and livestock population pressure and sedentarisation increased incidences and severity of drought, insecurity and external influences that led to inadequate pasture and fodder and a decline in land and camel productivity in this production system (Njanja, et. Al., 2003). Conversely, creation of the colonial administrative boundaries, constituency boundaries and inappropriate development approaches also interfered with traditional patterns of resource use (Ndungu et al., 2003). In addition, the increased incidence and severity of drought, fast changing lifestyles and erosion of pastoralists’ culture displaced the traditional coping mechanisms and made the human population increasingly dependent on emergency intervention (Ndungu et. al., 2003).

4.10.4 Policy and legislation challenges and constraints

Currently the Kenya Dairy Policy (GoK 2013a) and Livestock Production Policy Papers (GoK 2015), just mention camel and its products as emerging issues and therefore lacks a framework for development of the camel dairy industry. The ASAL Development Policy (GoK, 2015) puts more emphasis on the meat value chain and not dairy where the camel milk value chain would have played a major role. Conversely, a lack of
available data on pastoral milk production and its contribution to the economy causes policymakers to underestimate its economic value (Hatfield and Davies, 2006; Krätli and Swift, 2014).

The study by Yazan et al., 2015 estimated the annual value of marketed camel milk from Isiolo County at Ksh. 187,362,000, which is in excess of the public funds spent on Isiolo County’s entire agriculture and livestock sector in 2013/2014 (Government of Kenya 2013b). When the milk that is consumed by producers and herder households is taken into account, the total value of milk production will be double the current public expenditure for the sector. If the benefits are added to non-pastoralists along the value chain, the contribution of camel milk to the local economy could be further amplified across the country. There is therefore need to emphasize the development of dairy camels, particularly in the ASALs (Musinga et al., 2008).

4.11 Innovations in Dairy Camels Production

The camel is considered to be potentially the most important animal source of food in pastoral areas. Unique physiological, anatomical and ecological adaptations enable the camel to produce and supply milk to pastoral households throughout the year.

4.11.1 Feed formulation

*Modified chumvi Kuria for camels*

This formulation consists of 1 dicalcium phosphate: 0.992 Chalbi salt: 0.873 calcium carbonate: 0.001 Magnesium sulphate and when fed to camels this technology improves milk yield of camels by 17%. (Kuria, 2004).

4.11.2 Housing

All categories of camels are housed together in kraals that are made up of thorny bushes to protect them from predators except calves which are kept in calve pens. Kraals are cleaned every two weeks although during the wet season, they are changed almost monthly to reduce muddiness which might harbor flies (ILRI, 2015).

4.11.3 Milk transportation and storage

The innovations described below are recommended for Northern Kenya that is arid with an annual bimodal rainfall that ranges from 120 to 500 mm, varying temperatures from 23°C to 35°C and evaporation that exceeds 2600 mm annually. These innovations guarantee more fresh milk available for consumption and sale to more consumers.

*Sisal cooling technology for camel milk marketing in northern Kenya*

This is a fabric made from sisal fiber where clean sisal is wrapped around the metal milk can (Plate 4.1). The “clothed”/wrapped container is soaked in clean water for at least 30 minutes before the milk is introduced and this assists in cooling the milk through water evaporation where it cools faster over short distances when exposed to wind. However, if exposed over a longer distance it can dry quickly and may require re-soaking. With
this technology, the milk temperature is reduced by 13% and the total bacterial count by 44%.

Plate 4.4: Sisal cooling technology for camel milk marketing

_The Donkey carrier technology for hygienic hauling of camel milk_

This is a tool designed to assist pastoralists to hygienically transport milk using improved metal cans with animal packs. The tool is made of canvas which withstands tensile stress and comprises of 4 chambers for carrying 4 metal cans, two on each side of the animal. The bottom of each compartment is flat and semi-circular to allow the milk cans to stand before being placed on the animals (donkey or camel). It has six straps for tying around the animal and a soft padding to enhance comfort on the back of the donkey.

Plate 4.5: Donkey carrier technology for hygienic hauling of camel milk
**Evaporative charcoal milk cooler**

This is a 0.75 m³ cabinet made of galvanised angle iron frame reinforced with wire mesh inside and out leaving a 10 cm-wide cavity filled with charcoal. A water reservoir at the top keeps the charcoal wet through a drip system while a wind driven fan on the roof enhances air movement through the wet charcoal walls by sucking out the air in the cooler keeping the storage space below ambient temperature. Charcoal has to be moist for effective cooling while the water dripping at the bottom can be recycled. Other materials e.g. sand can replace charcoal.

![Evaporative charcoal milk cooler](image)

**Plate 4.6. Evaporative charcoal milk cooler**

### 4.11.4 Value addition

**Fermented milk**

The only traditionally made camel milk product that is sold is fermented milk. Increased acidity resulting from bacterial fermentation of lactose sugars in milk prevents the activity of other harmful bacteria for about a week, which allows for transportation and marketing of the product.

**Condensed milk**

This preserves surplus milk during wet season for consumption in the dry season. One part of sugar with four parts of milk (1:4) is mixed and boiled over an open fire until the mixture is reduced to half its original volume. The milk will remain fit for human consumption for six months or more without refrigeration. The condensed milk can be mixed with porridge then consumed.
**Camel meat products**

“Nyiri nyiri” (deep fried meat) biltong and sausages. Nyiri nyiri and biltong were well accepted although sausage processing was considered too expensive (USAID-KAVES, 2014).

4.11.5 Calf rearing

Pastoralists can easily monitor the growth performance of their camel calves and be able to take corrective actions in a timely manner for enhanced herd growth. The estimation is influenced by environment in terms of feed availability, terrain, temperatures, disease challenge and the breed. This involves estimating the live weight of camel calves using linear body measurements where body weight \( k = 200.86 + 105.91 \text{ TG(m)} + 79.63 \text{ HG(m)} + 56.22 \text{ SH(m)} \). and TG – thoracic girth, HG – heart girth, SH – shoulder height (Annual report, 2010).

4.11.6 Feed quality determination

The Borana pastoral communities feed camels on Euphorbia tirucalli plants that are used to make live fences and are readily available in Isiolo County and Meru County. This has promoted peri-urban camel rearing (Rademaker, 2015).

4.11.7 Camel Health

Pastoralists do not receive any government or private professional veterinary services in the management of camel health (Lamuka et. al., 2017), but they are able to treat their sick camels despite having limited knowledge and information on camel health management.

**Strategies for managing diarrhoea in camel calves**

1. Rehydrating the calves using a mixture of honey (3 table spoons), table salt (1½ table spoons) and water (3 litres).
2. Using eggs from chicken that interact with or pick parasites from livestock including camels.
3. Orally administer one stirred egg per day until the diarrhoea stops although further study is needed to understand the actual science behind the functioning of the eggs.

**Tick management**

The pastoral communities move from place to place frequently as a way of breaking tick cycles and avoided hilly mountainous areas where tick loads are high. In addition, they handpick ticks or shave the fur to expose the ticks. In case of tick paralysis, healthy camel is bled and calf fed on blood meal mixed with milk. This meal was observed to effectively assist calves even when they were in recumbent state (USAID_KAVES, 2014).
4.12 Dairy Camel Value Chain Analysis

The value chain for camel milk involves several distinct value adding activities which go into the production of the milk and its delivery to final consumers in the market. These activities include input supply; production; bulking and product assembly; processing; transportation; and wholesale and retail trading.

![Camel Dairy Value Chain Map](source: KARI, 2014)

### 4.12.1 Input Suppliers

These mainly include pastoralists who provide germplasm or breeding stock and agrovets/chemists who provide veterinary drugs (antibiotics, trypanocides, anthelmintics, etc.), acaricides, minerals such as common salt, syringes and injection needles. Veterinary drugs, often sold at high prices are found mainly in major towns although some camel owners complained about high prices.

### 4.12.2 Service Providers

Several services are provided along the value chain and these include milk bulking, transportation, chilling and grading, in addition to provision of veterinary services. Transporters are critical as intermediaries between producers and vendors. Camel milk is transported by (a) public transport with drivers collecting up to 30 containers of milk from producers at bus stops, and returning empty containers where the vendors pay the driver. However, buses can be unreliable, especially when heavy rain affects the road...
conditions, (b) motorcycles which are a rapidly expanding alternative because they can pick up directly from producers’ homesteads, (c) donkey carts which are used by producers who travel to markets to sell directly to vendors, often because they cannot afford mobile phones hence vendors are unable to contact them. (Mershark, 2016).

Grading, bulking and cold storage activities are undertaken by major town-based camel milk traders (over 90% women). Distribution involves cold storage, pasteurization by boiling, packaging, transportation, and advertising products to wholesalers, retailers and consumers. The biggest demand for camel milk in Kenya is fresh milk, therefore it is important that it reaches consumers while still fresh. To achieve this, milk assembled from pastoralists is channeled to cooling hubs in major towns such as Isiolo from where it is transported to major urban consumption centres such as Nairobi on buses or trucks with cold storage (Musinga, 2008). There is a severe lack of veterinary stores or services and extension advice.

4.12.3 Producers
The producers of camel milk can generally be put into three broad categories: small-scale pastoral herders; medium and large-scale pastoral herders; and ranchers, where most of them are found in Laikipia County (Musinga, 2008). Most producers are pastoralists, keeping camels as a source of milk, income and prestige owning 5–10 camels each. Milk production varies depending on season and availability of fodder. Production can be as high as 30 litres/day/camel, but the average is around 15 litres. The value chain for camel milk production at the farmer level can be divided into four distinct activities (a) acquisition of milking camel heifers either through raising of young female calves or through purchase of mature camel heifers, (b) herding, (c) health care; and (d) milking. The main cost element of camel herding, are cost of herders which accounts for 82% of herding costs per camel (Musinga, 2008).

4.12.4 Traders
Two types of traders are common: primary camel milk traders and motor-bike riders/camel milk bulkers. The primary milk traders are located at village level and are handled mainly by women. These traders provide empty containers to motor-bike riders for collecting milk at remote aggregation centres. Each of the motorbike riders handle between 10 to 60kg of milk daily. It is mainly dominated by male traders who individually handle about 120 litres of milk daily (Musinga, 2008).
Camel milk wholesale and retail activities are best analyzed under the various market segments or channels. The first relates to the raw milk market to urban areas while the second is for the high quality pasteurized milk to urban and international markets. Kenya produces 340 million litres of camel milk annually constituting 8% of the national production (MoLD 2012; Musinga et al., 2008), worth KES. 8 billion based on a farm gate price of KES 20 per litre (Kenya Dairy Board, 2011; Kuria et al., 2010) although, only about 12% gets to the urban markets where the price is about KES. 80 per litre. The annual demand for camel milk was estimated to be 320 million litres in 2008 (Kimeny et al., 2008). The current actual demand figures may not be available but the high price of camel milk (KES. 50 – 200) compared to KES. 25 – 40 for cattle milk is a proxy indicator of high demand. The fact that camels are reared in remote arid and semi-arid areas, it means the distance to markets is by default long. Although consumers prefer hygienically produced and handled fresh milk for direct consumption, there are no standards for camel milk. There are middlemen in the camel milk value chain while public service transporters (boda bodas and vehicles) provide nearly 100% transport for camel milk to the markets.
4.12.5 Processors
Vital Camel Milk Limited (VCML) plant based in Nanyuki, Laikipia County was established in 2005 with the aim of sourcing camel milk from Isiolo District and other neighbouring districts to process it largely for high-end urban consumers in Kenya and the international market (Musinga et al., 2008). It is the only camel milk processing plant and has a daily processing capacity of 1,200 litres on a one 8-hour shift. The plant is currently having excess capacity operating on a weekly average of 2,000 litres (Musinga et al., 2008). The milk is sourced from accredited farmers only and it produces fresh milk (in half litre units), fermented milk (mala/susa), yoghurt and cheese (Musinga et al., 2008). Although it has a machine for making ice-cream this product is not produced.

In recent years, processing levels have declined largely as a result of problems faced in the supply of milk into the international market, initially to South Africa and Chile, and lately to California (USA) where substantial losses have been incurred due to quality issues (Musinga et al., 2008).

4.12.6 Consumers
This market segment comprises of consumers from camel keeping communities, mainly the Somali, now living in various urban areas in Kenya and, indeed, other parts of the World (Muli et al., 2008). Little camel milk is traded outside the production areas. The importance of the camel milk is critical for food security and sustainable income for marginalized communities in ASALS. Musinga et al. (2008) characterized the demand for camel milk into four distinct market segments namely: (a) Home consumption by camel owning households and camel herders; (b) Rural households in camel keeping communities (largely restaurants and households with dry camel herds or no camels at all); (c) Raw milk urban consumers largely from camel keeping communities and (d) High-end health market segment of consumers both in the national and international markets.

Camel milk production in Kenya in 2016 was estimated to have stood at over 849 million litres (FAOSTAT, 2018). Only about 12% of the milk is marketed, with 10% being sold to rural consumers and 2% being sold to urban consumers (Muli et al., 2008). Thirty-eight percent (38%) of the camel milk that does not reach the market, is directly used by camel keeping households and their herders as part of their food requirements, while 50% goes to waste representing a great opportunity for commercialization. The perceived therapeutic properties of camel milk are making it popular with niche market consumers (Akweya et al., 2012; Rao et al., 1970; Yagil, 1982). The demand for camel milk by most consumers in urban areas is claimed to be driven by perceived superior quality compared to cow milk in both flavor and need for little milk: water ratio when making tea (Muli et al., 2008) as well as the acclaimed medicinal value.
4.12.7 Value chain enablers

Research in all aspects of dairy camel milk are carried out by the Kenya Agricultural and Livestock Research Organization (KALRO), public agricultural universities, and private and international non-governmental organizations, foreign agencies in collaboration with Kenyan Agencies. Other enablers include the Kenya Dairy Board who regulates, develops and promotes the dairy industry in Kenya, and the County and National Governments for policy, regulations and security.
Innovation Opportunities in Dairy Livestock in Kenya

Dairy is an important sub-sector both for food security and nutrition as well as employment creation and income. It contributes to manufacturing through the agro-processing industries such as milk, feed and leather and plays an important role in the livelihoods of the rural people as well as those engaged along the whole value chain. It is expected to contribute significantly to the Government of Kenya’s Big 4 agenda which includes Food and Nutrition Security; Manufacturing; Universal Healthcare; and Affordable Housing.

Dairy contributes to the wellbeing of the population with several nutritional benefits where hidden hunger and malnutrition are still a serious constraint among the people of Kenya. This is confirmed by the recent UNICEF Kenya Humanitarian Situation Report, 19 June 2017 which indicated that out of 37,096 children under 5 years screened for acute malnutrition in nine counties in May 2017, 7% were identified as severely malnourished and 25.4% as moderately malnourished. Conversely, dairy is a source of nutrition for children and the elderly and has several nutritional and health benefits. It is a source of proteins and several other elements whereas both goat and camel milk have medicinal value.

However, although there is an upward trend in production for all the three value chains, productivity remains low due to several challenges including, poor access to improved breeds, high cost of manufactured animal feed, inadequate pasture and fodder and in some cases poor nutritive values for livestock, diseases and pests, droughts, lack of information due to poor extension services and lack of veterinary services especially for the camel value chain etc. It is important that more resources are given to research to address these constraints.

To improve access to improved breeds, a low cost breeding programme is required
where the producers could be involved. In addition, the artificial insemination (AI) needs to be strengthened for all dairy animals with service centres established closer to the producers. However, producers will require to be well trained on the importance of AI and timeliness of heat detection.

Dairy animals depend on natural pastures and fodders which are mainly rain-fed and are affected by frequent droughts. It is important that extension services are strengthened and farmers/producers trained in conservation of feed resources. In addition, drought tolerant pastures and fodders which are high yielding, are required to alleviate dry season feeding. In the rangelands, it is necessary for action to be taken to ensure that degradation of those lands due to overgrazing are addressed with the involvement of the communities for acceptance and sustainability. Consideration of quality and nutrition of the animals will be key to improved productivity.

Although producers utilize ethno-veterinary practices which are also the main source of disease and pest management amongst pastoralists, it is important for research to establish the efficacy of those herbal or indigenous treatments. In addition, it is important for veterinary services to be provided in all the key dairy producing areas to ensure prompt treatments of sick animals. Where possible, research should develop more vaccines especially for the major diseases and pests assailing the dairy animals.

With the increasing awareness on issues of nutrition as well as the medicinal value of some of the dairy products, the demand for those products has also increased. However, supply falls far short of this demand as well as food safety and quality have not been considered. An updated and refined analysis of these value chains is necessary to identify the critical nodes that require intervention to increase efficiency. In addition, most of the milk is sold raw with long distances to markets, poor storage and inefficient transportation affecting delivery leading to high losses. This is exacerbated by poor infrastructure such as roads where some are impassible during the rainy seasons.

More collection centres with cooling facilities are required and transportation should be improved. All these facilities need to be established closer to the producers with fair prices and assured prompt payments to provide incentives to farmers to use the more formal marketing systems. Quality and food safety has to be emphasized although this is easier in the more formal marketing channels. More processing also enhances the milk and products shelf life and reduces spoilage hence they should be considered.

Most innovations for all the three value chains were mainly on breeding, disease and pest management. Additional areas of innovations for camels were housing, feed formulation, storage and transportation while for cattle they were pasture production and conservation of crop residues. It is clear that when farmers/producers are faced with challenges they become innovative and find their own solutions. Opportunities to innovations are normally created by a challenge faced by the individual who innovates.
References


Nairobi, Kenya: Tegemeo - Kenya Dairy Board.


Innovation Opportunities in Dairy Livestock in Kenya


Peacock C., (2011) Making livestock service accessible to farmers in Africa world-agriculture.net #1114


Animal Frontiers 3, 6-13.


The Milk Run: Newsletter for ILRI’s Smallholder Dairy Network; Issue 5; ILRI,


USAID, (2015). USAID-KAVES Dairy Value Chain Analysis August 2015 Fintrac Inc. prepared this publication for review by the United States Agency for International Development.

USAID-KAVES. (2014). Dairy Value Chain Analysis


ANNEXES
Annex 1: Camel Distribution in Kenya

The approach adopted by farmers is communally managed utilization of locally available goat genetic resources among the resource-poor farmers. The Galla and the East African goat are used as a local goat gene pool for the arid and semi-arid lands of Kenya, which the local community is exploiting to harness positive traits.

The breeding material is acquired by selecting from the existing flocks. The poor-performing bucks are castrated and the females culled. The farmers are left with the best performers for breeding. This is a prerequisite for introduction of other genetic material of Galla origin.

Existing farmers’ by-laws stipulate that:

- All the poor-performing East African bucks in a farmer’s flock have to be castrated before introduction of the group Galla buck.
- Those members unwilling to castrate their East African bucks should ensure physical separation once the Galla buck is introduced. They should relocate them to their distant relatives or close friends.
- Each farmer within a group should put up a housing structure for all his goats to protect them against extreme weather and predators (the Tsavo national reserve is nearby).
- In order to allow for procurement of the Galla buck, each farmer has to make a monetary contribution as stipulated by the group.

For quicker results, farmers have targeted the Galla buck rather than the doe for cross-breeding with the East African. After castration of all the poor performers and physical separation of the other East African bucks in the flock, the only mating option for their does is the group’s Galla buck. However, should the need arise, the East African goats can always be accessed for breeding purposes.

The Galla goat is procured for breeding purposes from the neighbouring districts. The last batch was purchased from the Orma Borana of Tana River district. Useful background information on the breeding stock is also provided.

Since the rearing system is semi-intensive, the goats graze on natural pastures. Each group member is allocated the Galla buck to utilize and mate with the rest of the herd for one month. The choice of one month is to ensure that other members do not wait too long before getting a chance to have the buck. After one month, the farmer hands over the buck to the next beneficiary. To determine who the next beneficiary will be, members carry out a ballot every month. Those who have already benefited are usually excluded from this ballot. If a member wins the ballot and for some reason does not require the buck during that month, he can pass it on to a member of his choice. Reasons why
members sometimes forfeit their chance include: pregnancy of all their does, not having fulfilled the group’s conditions (such as castration and selection of their bucks), and failure to have a housing structure for their goats.

The buck is supposed to rotate among all members in the group. During the period when the goat is in the custody of one member, access should not be denied to other members. Members present their does on heat to the buck for mating and then take them back once they have mated. Once all members have had a chance, after a full rotation, the members exchange their bucks with other groups to prevent inbreeding.

Two economically viable group members have purchased their own Galla bucks. They graze these bucks with their other flock and they are not free for rotation to other members. These members have the long-term intention of being Galla breeders for multiplication and distribution to the other farmers for breeding.

The following measures are taken to prevent uncontrolled breeding:
Bucks are exchanged among the groups once all members of a group have had custody of the Galla buck. So far, a full rotation has not yet been achieved. Individual members intend to exchange their bucks with each other once the F1s are mature enough to be mated.

Each farmer ensures that he grazes his animals separately to avoid mixing them with those of his neighbours, so that only the Galla buck is allowed to mate.

Watering is either done at home or at a nearby river. To avoid mixing, farmers water their animals after other community members have finished. However, this is not foolproof and accidental uncontrolled breeding may still occur.

To prevent goats mixing at the salt licks, most of which are communal, some farmers have opted to purchase the locally made salt from Ngiluni farmers group.

Records are kept of the bucks used for breeding, especially the Galla bucks.

The breeders’ association is a steering committee that coordinates all the activities of the breeding group. Each of the nine groups has representation in the breeders group. The group deals centrally with all procurements and also links the breeders to other service providers. The breeders’ association was the founder of this initiative. This is a forum in which the interests of group members are discussed. They form linkages with other partners in goat breeding.

**NOTE:** Community-based knowledge and practices represent a strong tool in community livestock-breeding programmes. This leads to a demand-driven participatory planning approach where the interests of the community are well catered for.
About PARI

PARI brings together partners from Africa, India and Germany to contribute to sustainable agricultural growth and food and nutrition security in Africa and India as part of One world, No Hunger Initiative (SEWOH) by the German government. To this end, PARI research seeks to identify investment opportunities in the agriculture sectors and rural areas of Africa with the aim of improving food security and creating employment and income opportunities. To this end, PARI strategies include:

- Analyses of the potential and impact of innovations (which innovations to invest in, where and for whom)
- Identification and assessment of supportive measures to strengthen the framework / policy conditions for the generation and dissemination of promising agriculture and rural areas development–related innovations
- Engaging with food, nutrition, agriculture and rural areas development policy makers to inform reforms and investment decisions that an improve job creation and food and nutrition security.

Thematic focus areas include:

1. Targeting investments in innovations and framework conditions
2. Mechanization and skill development for productivity growth, employment and value addition
3. Digitalization in agriculture, food and nutrition
4. Enhancing opportunities for the youth in the rural economy

PARI is funded by the German Federal Ministry for Economic Cooperation and Development (BMZ).

For further information, see https://research4agrinnovation.org.
About FARA

The Forum for Agricultural Research in Africa (FARA) is the apex continental organisation responsible for coordinating and advocating for agricultural research-for-development (AR4D). It serves as the entry point for agricultural research initiatives designed to have a continental reach or a sub-continental reach spanning more than one sub-region.

FARA serves as the technical arm of the African Union Commission (AUC) on matters concerning agricultural science, technology and innovation. FARA has provided a continental forum for stakeholders in AR4D to shape the vision and agenda for the sub-sector and to mobilise themselves to respond to key continent-wide development frameworks, notably the Comprehensive Africa Agriculture Development Programme (CAADP).

FARA’s vision
Reduced poverty in Africa as a result of sustainable broad-based agricultural growth and improved livelihoods, particularly of smallholder and pastoral enterprises.
FARA’s mission: Creation of broad-based improvements in agricultural productivity, competitiveness and markets by continental-level strengthening of capacity for agricultural innovation.

FARA’s Value Proposition
Strengthening Africa’s capacity for innovation and transformation by visioning its strategic direction, integrating its capacities for change and creating an enabling policy environment for implementation.

FARA’s strategic direction is derived from and aligned to the Science Agenda for Agriculture in Africa (S3A), which is in turn designed to support the realization of the CAADP vision. FARA’s programme is organized around three strategic priorities, namely:

- Visioning Africa’s agricultural transformation with foresight, strategic analysis and partnerships to enable Africa to determine the future of its agriculture, with proactive approaches to exploiting opportunities in agribusiness, trade and markets, taking best advantage of emerging sciences, technologies and risk mitigation and using the combined strengths of public and private stakeholders.

- Integrating capacities for change by making the different actors aware of each other’s capacities and contributions, connecting institutions and matching capacity supply to demand to create consolidated, high-capacity and
effective African agricultural innovation systems exploiting relative institutional collaborative advantages to mutual benefit while also strengthening their own human and institutional capacities

- Enabling environment for implementation, initially through evidence-based advocacy, communication and widespread stakeholder awareness and engagement and to generate enabling policies, and then ensure that they get the stakeholder support required for the sustainable implementation of programmes for African agricultural innovation

Key to this is the delivery of three Key Results, which respond to the strategic priorities expressed by FARA’s clients. These are:

**Key Result 1:** Stakeholders determine how the sector should be transformed and undertake collective actions in a gender-sensitive manner.

**Key Result 2:** Strengthened and integrated continental capacity responding to stakeholder demands within the agricultural innovation system in a gender-sensitive manner.

**Key Result 3:** Enabling environment for increased AR4D investment and implementation of agricultural innovation systems in a gender-sensitive manner.

FARA’s donors are the African Development Bank (AfDB), the Danish International Development Agency (DANIDA), the Department for International Development (DFID), the European Commission (EC), The Consultative Group in International Agricultural Research (CGIAR), the Norwegian Agency for Development Cooperation (NORAD), Australian Agency for International Development (AusAID) and the World Bank.
Innovation Opportunities in Dairy Livestock in Kenya