1. INTRODUCTION

Background Information on the dairy industry

Kenya is one of the largest producers of milk in Africa. Dairy is a type of livestock farming whereby cattle are kept for milk production with sole purpose of selling the milk to the consumers. Dairy farming is one of the fastest growing sub-sectors in agriculture at an estimated rate of 3 to 4% annually (National Livestock Policy, 2008). Dairy contribution to national GDP is estimated at 4.5%, which is part of the 10 to 12% from livestock and 40% from agriculture. Currently, milk based enterprises are attractive in Kenya and support over 1.8 million smallholder households and many more throughout the entire value chain. Dairy production offers regular incomes and asset accumulation to families, thereby contributing to MDG one of poverty reduction. The common breeds in Kenya are; Freisian, Jersey, Aryshire and Guernsey. Milk production at the moment does not satisfy the demand hence the need to increase production.

There are two types of dairy farming in Kenya namely commercial dairy farming and domestic (subsistence) dairy farming. Smallholders’ dairy production contributes 80% of marketed milk and milk products and provides a pathway out of poverty through enhanced household incomes, nutrition and employment. Generally, informal milk outlets absorb most of the milk from smallholder farmers accounting for over 86% of the total milk sold, while formal market handles 14% of all the total milk produced.

Kenya is one of the largest producers of dairy products in Africa with an estimated herd of 3.5 million improved dairy cattle, 14 million zebras, 27 million goats, and 2.9 million camels which are the main sources of milk in the country. The milk is primarily produced from cattle (84%), camels (12%) and dairy goats (4%). The demand and supply projections indicate that the current milk production will rise from the current 5.2 billion litres (2014) to a high of 12 billion litres by the year 2030 while the consumption will rise from 4 billion litres to 11 billion litres during the same period.

It has environmental advantages of enabling the use of green energy by using manure to produce biogas for cooking and lighting and to fertilize fish ponds while slurry recovered from ponds is dried to fertilize soil for improved crop production.

Milk production in the country is concentrated in highland eco-zones with high and bimodal rainfall of central and Rift valley provinces (Table 1 below). Dairy farming in the highland eco-zones is favoured by low temperatures (15–24°C) moderated by high altitude, lower risk of diseases and a bimodal rainfall pattern that support high biomass production for forage-based dairying.

<table>
<thead>
<tr>
<th>REGION</th>
<th>AREA/COUNTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>Nyeri, Nyandarua, Muranga, Kirinyaga, Muranga, Kiambu</td>
</tr>
<tr>
<td>Rift Valley</td>
<td>Trans-Nzoia, Uasin Gichu, Nandi, Bomet, Kericho, Buret, Sotik, Ngong</td>
</tr>
</tbody>
</table>
Eastern | Machakos, Embu, Meru  
Coast  | Taita Taveta, Kilifi, Kwale  
Western | Lugari, Bungoma, Kakamega, Vihiga, Busia, Teso  
Nyanza | Lugari, Bungoma, Kakamega, Vihiga, Busia, Teso

The medium and high rainfall zones have high population pressures and farmers have to stall-feed animals on farm fodder, mainly Napier grass. This zone supports large-commercial dairy herds on pasture grazing.

2. INPUT

The input in the dairy enterprise includes:

i. Dairy herd (animals)
ii. Dairy structures
iii. Feeds, fodders & supplements
iv. Machinery & Equipment
v. Acaricides and Drugs

(i) Dairy Herd

The productivity of a herd depends on the quality of the cows and the replacement heifers. The herd is selected for high milk production and good fertility based on the following characteristics;

- The cows must portray good to excellent conformation through the parities and lactations
- The production potential of the cows must be well above the computed herd average reproduction
- The cow’s reproductive ability should be high, calving once every year with a lactation length within the normal 305 days
- The udder should be tightly attached to the body and be soft to touch with four functional teats placed squarely and symmetrically on the udder. Long pendulous udder is highly heritable and females with this should not be used for breeding. Big udders are difficult in suckling the young and also difficult milkers. Big udders are also predisposed to injury and mastitis infection.
- The cow needs to be officially registered with the Kenya Stud Book (KSB) and milk recording with the Dairy Recording Service of Kenya (DRSK) and have its pedigree known and production and reproduction performance quantified to qualify as a breeding female
- Cows are culled based on physical deformities (e.g. poor body conformation, bad feet, poor udder and teat quality, blindness) should not be selected for breeding.

Desired Dairy herd composition
Cows milk 45%
Dry cows 9%
Pregnant heifers 8%
Heifers (weaning to first service) 14%
Heifers (birth to weaning) 24%

(ii) Dairy Structures

The housing depends on the farming system where animals under the intensive are confined in a zero grazing unit all the time, semi intensive are partly confined and partly grazed; while in extensive they are left free range.

Figure 1: Zero Grazing Unit

A calf pen should be constructed where possible from locally available materials. It should be constructed to:

- Allow approximately 2 m² (1.2 X 1.5m) space per calf
- Be well drained or bedded
- Be well lighted (artificial or natural).
- Be well ventilated
- Strong to stand predator invasion
(iii) Feeds, Fodder and Supplements

There are several categories of feeds for dairy cattle namely; fodder, commercial feeds, home-made rations and salts/vitamin supplements.

(iv) Machinery and Equipment

For hygienic production and handling of milk the farmer is advised to use approved machinery and equipment. This includes; milk cans, milk testers, cooling tanks and even processing plants. This will also help extend the storage life of milk and enable value addition. Other
equipment include chaff cutter, pulverizer, weighing band, dehorning gadgets and Branding bar used for routine management of the dairy herd.

Figure 5: Milking Cans

Figure 6: Buddizo

Figure 7: Block making Equipment
(v) Acaricides and Drugs

The common dairy animal diseases in Kenya are 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 Trypanosomiasis. To prevent and cure the diseases, the farmer is advised to use available and effective acaricides and drugs as recommended by the veterinary practitioner in the locality.

3. DAIRY PRODUCTION

Milk production in Kenya is concentrated in highland eco-zones with high and bimodal rainfall of central and Rift valley provinces. Dairy farming in the highland eco-zones is favoured by low temperatures (15–24°C) moderated by high altitude, lower risk of diseases and a bimodal rainfall pattern that support high biomass production for forage-based dairying.

Information on gross margins at various levels of investment and the anticipated benefits of various production systems will guide in making production decisions. In dairy production the farmer needs to be knowledgeable on breeds and breeding; production systems; feed, feeding and supplementation; fodder establishment and management; routine management; clean milk production; and pests and disease management.

(i) Gross Margin

To start a dairy enterprise one needs to do cost-benefit analysis so as to make informed decision on level of investment and the anticipated benefits. Owing to the high cost of inputs and desire to maximize profits, it is becoming increasingly necessary for dairy producers to view dairy farming as a business with a view to minimizing the cost of production while increasing yields through use of appropriate management techniques. These include: feeding according to animal maintenance and production requirements, use of quality breeds, good health and ensuring cow comfort as well as rearing heifer to calf at 24months.

It is important that a farmer maintains proper records on the enterprise. The records involved will include; history of the animals, milk production, butter fat content and other historical issues of the animal. Income generated by one animal may differ from the other and the need to keep production records per animal is important.
Breeding is the application of genetic principles to improve passing of economically important traits from one generation to the next in domestic animals. Example is improvement of milk production in dairy cattle. Selection is the primary tool for generating directed genetic changes in animals. Therefore, main purpose of breeding in dairy animals is to produce milk, reproduce to provide replacement stock for the future and most of all to provide a means of living for farmers in the dairy business by providing the most milk at the least possible cost. All cows can produce milk but the most suitable for commercial milk production are few. The most important dairy breeds of cattle in Kenya are Friesian, Aryshire, Guernsey and Jersey breeds. The rest are either good for beef or as dual purpose animals.
Table 2: The characteristics of the common dairy breeds

<table>
<thead>
<tr>
<th>Breed Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FRIESIAN</strong></td>
<td>High milk production potential with low butter fat content of about 3.2% &lt;br&gt; <strong>Note:</strong> Milk production will depend on level of feeding and other management.</td>
<td><strong>Heavy feeder</strong> (requirements high (90-110Kg fresh forage/day)  &lt;br&gt; Susceptible to diseases, &lt;br&gt; Susceptible to milk fever, &lt;br&gt; Susceptible to high temperatures &lt;br&gt; Large amounts of water requirement (minimum 60 lts/day, more for heavy yielders)</td>
</tr>
<tr>
<td><strong>Distinctive Features</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Description:</strong> Black and white short haired coat, short horns</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Potential yield:</strong> 40-60 litres milk/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average body size:</strong> Large (500-550kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>High milk production potential (30 litre/day)</strong></td>
<td><strong>Feed requirements are high (90-110 kg fresh forage/day)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>The cow's milk has moderate butter fat content 4.0%</strong></td>
<td><strong>Need plenty of clean water (60 litres/day)</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Fairly hardy and adaptable to varied climatic zones.</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>They are relatively resistant to diseases.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Ayrshire</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Distinctive Features</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### The Guernsey

#### Distinctive Features

- **Average body size:** Medium (average live-weight 400kg). The cow weighs 450 to 500 kg.
- **Description:** The colour varies from yellow to reddish-brown with white patches.

  They have a finely tuned temperament, not nervous or irritable.

- **High milk production potential (25 litres/day) and has moderate butter fat content 4.3%**
- **Feed requirements:** Moderate (65-85Kg fresh forage/day)
- **Efficient converters of feed to product, being of intermediate size, Guernsey produce their high quality milk while consuming 20 to 30 percent less feed per pound of milk produced than larger dairy breeds**
- **Reach reproductive maturity at an early age and can calve at 22 months of age. This provides an early return on investment**
- **Well known for having the minimum of calving complications**
- **Adaptable to all climates and management systems and lack any known undesirable genetic recessives.**

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### Potential yield: 30 litres/day

**Average body size:** Large (average live-weight 450kg)

**Description:** Brown and white patches in almost equal amounts with some cows tending to dark mahogany colour

- No major ones
Jersey

Distinctive Features

**Average yield:** 20 litres/day and about 5.3% butter fat.

**Average body size:** Small - medium (350 Kg)

**Description:** Jerseys in Kenya are typically light brown in colour, though this can range from being almost grey to dull black.

- They can also have white patches which may cover much of the animal. A true Jersey will however always have a black nose bordered by an almost white muzzle.
- They have protruding eyes.

- Feed requirements is relatively low (65-85 Kg fresh forage/)
- Milk has high butter fat content 5.3%
- It is hardy and adaptable to varied climatic zones
- The Jersey's hard black feet are much less prone to lameness
- They perform well under a wide range of systems and are well-known for their high feed conversion efficiency
- Jerseys generally produce milk components at a lower cost
  - Milk quality is high and is particularly richer in protein, minerals and trace elements
- They stay in the herd longer than any other dairy breed. Their milk has greater nutritional value, plus the highest yield and greater efficiency when processed into cheese and other value-added products
- The breed has little or no calving problems, greater fertility, a shorter calving interval, and earlier maturity

- Susceptible to milk fever and tick borne diseases

Milk production in the low rainfall zone utilizes Boran, Sahiwal and Zebu cattle, camels, goats and sheep in the pastoral, semi-pastoral or ranching systems. Milk marketing is to a very limited extent, except for a growing market of camel milk linking pastoral to urban markets. Feed availability for ruminants is a major challenge due to recurrent droughts and lack of
forage conservation strategies, which limits livestock productivity and is a cause for economic losses through mortality and loss in weight and market value.

Mating (Breeding) methods

Mating can be achieved through natural service or artificial insemination, and irrespective of the method, the aim should be to achieve increased chances of conception.

Natural service:
This is where the cow is taken to a bull and left for some time for the bull to serve. The advantages of natural service:

1. The cow has an opportunity to be served more than once; this increases the chance of conception.
2. The semen is fresh and of good quality since there is no handling.
3. Where the farmer does not own a bull, cost of service is lower compared to A.I.

The disadvantages of natural service:
1. Rearing a bull is not economical especially to a smallholder farmer
2. There is risk of spreading breeding diseases.
3. There is risk of inbreeding if the bull is not changed frequently
4. There is no opportunity to select the type of bull the farmer wants.
5. The bulls can be very dangerous.

Increasing the chances of conception through natural service:

a) Take the cow to the bull as soon as it is detected to be in heat and leave it for at least twelve hours.

b) Young inexperienced heifers should be mated with old experienced bulls.

c) Young inexperienced bulls should be given to old experienced cows.

d) The bull should be kept fit and in good health particularly the legs and feet.

Natural mating can be done in two ways:

Free/pasture mating - This method of mating is practised by farmers who own bulls which run full time with the cows. One bull can serve 20-25 cows.

It has the advantage that no heat detection is required and disadvantage of lack of accurate records and possibility of transmission of reproductive diseases e.g. brucellosis.

Pen mating - The bull is enclosed in its pen and the cows are brought in when they show signs of heat. Most small-scale farmers will practice this method since bulls are owned by few farmers and others bring their cows for service at an agreed fee. The advantage is keeping accurate records while the disadvantage is the farmer has to detect heat.

Artificial Insemination

Artificial Insemination popularly referred to as AI is one of the breeding methods that has contributed to the development of the dairy sector in the last sixty years in Kenya and also worldwide. The process of artificial insemination starts with a healthy bull, that is disease free and producing ample quantities of high quality semen. The fertility of the cow is also
important, the competency of the inseminator and a clean environment. Farmers are encouraged to use semen from proven bulls, which is obtained from AI centers and registered service providers.

Advantages of Artificial Insemination (AI)
1. Prevention of venereal diseases
2. Indefinite preservation of genetic materials at low cost
3. Enhances genetic progress as best bulls are used widely nationally and internationally.
4. Small scale farmers through AI can access superior genetics at affordable cost
5. One is able to select the bull of interest.
6. When handled properly, there is no chance of spread of breeding diseases.
7. With records, it is easier to control inbreeding.
8. A.I. is the best method of improving the genetic make-up of animals because it enables semen from the very best bulls to be widely available.

Disadvantages of AI
1. It requires very accurate heat detection and proper timing of insemination for greater chances of conception.
2. The inseminator must be trained on the technique.

Estrus synchronization
Sometimes for ease of management, it is desirable for a group of animals to calve at the same time necessitating that animals come on heat at the same time. To achieve this, the animals are synchronized using hormones. Synchronization is dependent on manipulation of hormonal events occurring during normal oestrous cycle. It is achieved via premature luteolysis using prostaglandins (PG) or simulation of corpus luteum (CL) function by administering progesterone followed by abrupt withdrawal.

Sexed semen
Semen where sperms have been separated into the X and Y chromosomes using a special machine. The X chromosomes results into females while Y chromosome results into male offsprings. Farmers using sexed semen can choose whether they want male or female offspring. Heifers and first calvers are preferred when using sexed semen but should not be used difficult breeders.

Embryo transfer
Embryo transfer is a process through which an embryo is harvested from one cow and transferred to another cow to complete the pregnancy. The process involves super-ovulation of the donor genetically superior cow (cow injected with hormone to stimulate development of many eggs), insemination of cow with high quality semen and synchronization of oestrous cycle of donor and recipient cows. It also involves flushing out the embryos from donor cow and transfer of embryo to recipient cow. Ideal ambient temperature for reproduction for pure exotic animals is between 4-24°C. In areas of high temperature it is important to provide a suitable environment (shading, spraying water).
Semen quality and handling
To maintain a good dairy herd, the farmer must use semen of proven sires all the time. Handling semen involves retrieving semen from the tank without damaging what remains in the tank, thawing and loading an AI gun and successfully inseminating the cow with semen that is still alive and viable.

Table XX: The services of breeding institutions in Kenya

<table>
<thead>
<tr>
<th>Institutions</th>
<th>Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenya Livestock Breeders Organisation (KLBO)</td>
<td>• KSB-Registration of all breeds of domestic livestock</td>
</tr>
<tr>
<td></td>
<td>• maintains an upgrading programme</td>
</tr>
<tr>
<td>Livestock Records Centre (LRC)</td>
<td>• Runs National Dairy cattle breeding programme with two schemes: contract mating and progeny testing</td>
</tr>
<tr>
<td></td>
<td>• Estimation of Breeding values</td>
</tr>
<tr>
<td>Kenya Animal Genetic Resource Center (KAGRIC)</td>
<td>• Semen production and distribution maintains AI bulls</td>
</tr>
<tr>
<td></td>
<td>• Bull purchasing committee</td>
</tr>
<tr>
<td>Kenya National Artificial Insemination Service (KNAIS)</td>
<td>• Distributes AI services to dairy farmers across the country</td>
</tr>
<tr>
<td>Dairy Recording Services of Kenya (DRSK)</td>
<td>• Keep and process official milk records, butter and fat produce lactation certificates.</td>
</tr>
<tr>
<td>Breed societies</td>
<td>• Safeguards the purity of various breeds</td>
</tr>
<tr>
<td></td>
<td>• Set standards for the herd book register to promote the interest of specific breeders</td>
</tr>
</tbody>
</table>

All these breeding institutions focus on improving performance of the national dairy herd for farmers, but their activities are presently ineffectively coordinated to efficiently capture their individual service to the benefit of farmers.

(iii) Production Systems

(a) Intensive Dairy Cattle Production System

This is a system in which the dairy cattle are confined at all times and forages and water are brought to them. The cattle are kept enclosed and fed a complete ration in the enclosure. This means collecting feed, taking to the animals and supplemented with concentrates. This is referred to as zero-grazing system. Zero grazing is a good system for keeping dairy cattle in
densely populated, high rainfall areas, where land per farm family is small. Other dairy cattle rearing systems are semi-zero grazing and free grazing. Different dairy cattle rearing systems have different requirements for housing although they share some common needs.

Majority of dairy animals are kept by smallholder farmers under zero grazing or semi zero grazing systems. The zero grazing housing system has various areas some of which are essential and therefore must be included in the structure while others are optional and need not necessarily be part of the unit. Accordingly, these parts or areas are as listed below;

**Table 3: Parts of a Zero-grazing Unit**

<table>
<thead>
<tr>
<th>Basic (Essential) parts:</th>
<th>Basic (Optional) Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The cubicles</td>
<td>1. The store</td>
</tr>
<tr>
<td>2. The walking area</td>
<td>2. The manure storage</td>
</tr>
<tr>
<td>3. The feed and water troughs</td>
<td>3. Fodder cutter</td>
</tr>
<tr>
<td>4. The milking place</td>
<td>4. Roof water catchment</td>
</tr>
<tr>
<td>5. The calf pen</td>
<td>5. Water tank</td>
</tr>
<tr>
<td>6. The fodder chopping area</td>
<td>6. A holding crush</td>
</tr>
</tbody>
</table>

Below is a list of the recommended number of cubicles for a given number of cows (including followers – heifers or bulls)

**Table 4: Cubicles for a given number of cows**

<table>
<thead>
<tr>
<th>Number of cows:</th>
<th>Number of cubicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 cow</td>
<td>2 cubicles</td>
</tr>
<tr>
<td>2 cows</td>
<td>3 cubicles</td>
</tr>
<tr>
<td>3 cows</td>
<td>5 cubicles</td>
</tr>
<tr>
<td>4 cows</td>
<td>6 cubicles</td>
</tr>
<tr>
<td>5 cows</td>
<td>7 cubicles</td>
</tr>
<tr>
<td>6 cows</td>
<td>9 cubicles</td>
</tr>
</tbody>
</table>
Fig 8: Cows in cubicles

Table 5: Materials required for a 5-cubicle zero grazing unit

<table>
<thead>
<tr>
<th>Item description</th>
<th>Units</th>
<th>Unit cost (Kshs)</th>
<th>Amount</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cedar posts 18 ft long</td>
<td>No</td>
<td>250</td>
<td>24</td>
<td>6000</td>
</tr>
<tr>
<td>3&quot; x 3&quot; timber running rails</td>
<td>Inches</td>
<td>35</td>
<td>60</td>
<td>2100</td>
</tr>
<tr>
<td>3&quot; x 2&quot; timber running rails</td>
<td>Inches</td>
<td>30</td>
<td>55</td>
<td>1650</td>
</tr>
<tr>
<td>2&quot; x 2&quot; timber running rails</td>
<td>Inches</td>
<td>25</td>
<td>50</td>
<td>1250</td>
</tr>
<tr>
<td>6&quot; x 2 ½&quot; half board</td>
<td>Inches</td>
<td>100</td>
<td>50</td>
<td>5000</td>
</tr>
<tr>
<td>off cuts</td>
<td>Pieces</td>
<td>150</td>
<td>40</td>
<td>6000</td>
</tr>
<tr>
<td>corrugate iron sheets 28G, 3m long</td>
<td>No</td>
<td>800</td>
<td>25</td>
<td>20000</td>
</tr>
<tr>
<td>Lorry load hard core 7 tons</td>
<td>No</td>
<td>3000</td>
<td>1</td>
<td>3000</td>
</tr>
<tr>
<td>Lorry load ballast 7 tons</td>
<td>Tons</td>
<td>1,500</td>
<td>7</td>
<td>10,500</td>
</tr>
<tr>
<td>Cement</td>
<td>Bags</td>
<td>850</td>
<td>20</td>
<td>17000</td>
</tr>
<tr>
<td>Labour</td>
<td>Various</td>
<td>7,250</td>
<td>7,250</td>
<td>7,250</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>79,750</strong></td>
</tr>
</tbody>
</table>

**Note:** Material requirements and estimated building costs as in June 2014

The **concrete** should be mixed in the following ratio:
1 bag cement + 2 wheelbarrows sand + 3 wheelbarrows ballast
Figure 9: A zero grazing unit complete with a sun shade structure

To prevent high investment costs, it is advisable to make use of locally available materials from the farm. Other structures will include feed stores, drug and other chemical store, spray crutch, milk equipment drying stand etc.

Note: Dairy cattle will be more efficient in the production of milk and in reproduction if they are protected from extreme heat, and particularly from direct sunshine. This can be achieved through provision of shade in tropical and subtropical climates. If dairy cattle are confined, the area should be free of mud and manure in order to reduce hoof infection to a minimum. Concrete floors or pavements are ideal where the area per cow is limited. However, where ample space is available, an earth yard, properly sloped for good drainage is adequate.

Advantages of Intensive Dairy Cattle Production System

- High milk production
- Does not need a large amount of land for pastures
- Can use many farm by-products; maize thinning, beans husks, etc
- Less death amongst the calves and mature cows
- Easier to plan and manage breeding
- Makes collecting manure very easy
- Helps in controlling some diseases (e.g., tick borne, intestinal worms, etc)

Challenges of Intensive Dairy Cattle Production System

- Labour intensive as the feeds are cut and carried to the animals
• The cattle may get stressed if the feeding space is inadequate and poorly constructed
• Disease spread is faster if they are overcrowded
• Requires heavy capital investment in procuring the animal and construction of the dairy structure

(b) Semi Intensive Dairy Cattle Production System

Figure 10: Dairy Cattle under Semi-Intensive Production System

The animals are partly confined and partly grazed in this system. The animals are left to graze for part of the day but are brought into the dairy sheds to be fed part of their ration.

In the dry season the cattle under the semi-intensive system will only find dry vegetation or crop residues in the fields. These supply some energy, but have very low protein content. Such feeds cannot meet the requirements of the dairy animals. There is therefore need for supplementation.

(c) Extensive Dairy Cattle Production System

In this system, which is also called free-range, the cattle are left to graze on their own or tethered (tied up to a fixed pole or tree). Under this system, the cattle will look for the best
pasture to feed on. Generally, this feeding system is common in the Arid and Semi-Arid areas. However, it is also practiced in agro-pastoral areas, in high potential areas or in peri-urban areas. When the rangelands have fresh and green plant materials, the cattle get enough for their needs by grazing. However, during the dry periods, the cattle will feed on dry forages as well.

![Figure 11: Dairy Cattle under Extensive Production System](image)

**Advantages of extensive dairy cattle production system**

- Cattle reared under this system are extremely hardy and adaptable to a wide range of feeds
- Minimal investments are involved for fencing, tick control and deworming apart from buying the animals
- Minimal labour is required compared to other production systems
- Minimal cost incurred on feed supplementation

**Challenges of extensive dairy cattle production system**

- Free-range cattle take long before attaining the optimal weaning and breeding weight
- Cattle are always at high risk of contracting tick borne diseases and worms as they roam freely looking for feeds and water
- There are little disease control measures in place and out-breaks occur causing devastating effects
- High death rate out of natural calamities such as drought
(v) Feeds and Feeding

Animal nutrition entails feeding farm animals to obtain maximum production at least-cost. It involves providing approximately 70% forages and 30% concentrates to produce a total mixed ration (TMR). In this approach, concentrate feeds are mixed with forages such as Rhodes, Columbus, or Napier grasses, oat straw, etc. The cost of feed is typically 50 to 70% of the total cost of milk production, and has the most impact on animal health, production and reproduction. It is the key determinant of the enterprise profitability. Similarly, the major cost of heifer rearing aimed at first calving within 24 months of age is feeds. The feed requirement for a mature cow is quantities which will supply dry matter equivalent to 3% of its body weight.

<table>
<thead>
<tr>
<th>Types</th>
<th>Production (Kgs Per Lactation)</th>
<th>Average Body Weight (Kgs)</th>
<th>Feed requirement (Kgs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friesian</td>
<td>7800</td>
<td>500</td>
<td>(90-110Kg fresh forage/day)</td>
</tr>
<tr>
<td>Jersey</td>
<td>6800</td>
<td>350</td>
<td>(65-85 Kg fresh forage/)</td>
</tr>
<tr>
<td>Aryshire</td>
<td>6600</td>
<td>450</td>
<td>(90-110 kg fresh forage/day)</td>
</tr>
<tr>
<td>Guernsey</td>
<td>6650</td>
<td>400 kg</td>
<td>(65-85 Kg fresh forage/day)</td>
</tr>
</tbody>
</table>

Basically, dairy cattle obtain nutrients from both forages and concentrates. These are broadly divided into five basic types of feeds. The animal must be fed on the right quantity and quality feeds which provide energy, protein, minerals and vitamins.

Examples of the feeds include:

- Bulk forages for energy;
- Supplementary forages for energy and proteins;
- Concentrates for energy and proteins;
- Mineral supplements;
- Water

(a) Bulk forages for energy

Commonly grown grasses include; Napier, Rhodes, Coloured guinea, Guatemala, Setaria, Ley grasses, maize fodder and other fodder forages. In intensive and semi-intensive systems, these forages are cut and provided to the dairy cattle as fodder and are usually not grazed directly. These forages can be used fresh or conserved as hay or silage. In order to ensure effective planning of feeding of dairy cattle, conserved feeds are important especially during the dry periods when scarcity of feeds occurs. The forage can be grown on the farm or out sourced.
Napier Grass

Napier Grass or Elephant Grass (*Pennisetum purpureum*) is a species of grass native to the tropical grasslands of Africa. It is a tall perennial plant, growing to 2 – 4.5 metres (6.6 – 14.8 ft) tall, rarely up to 7.5 metres (25 ft), with leaves 30–120 centimetres (12–47 in) long and 1–5 centimetres (0.39–2.0 in) broad. In Kenya, the main varieties grown are: Bana grass, French Cameroon, Uganda hairless, and Kakamega (I, II, etc). Where it is available for use as a feed, the following could be practiced:

- Plant Napier along river beds, along soil conservation terraces, roads reserves etc.
- Where a farmer has a big farm, Napier is planted as pure stand near the home to save time and work when taking to the animals.
- Napier grass may be planted using the conventional method where one places a 3-node cane at a slanting position in the soil, ensuring that two nodes are covered by the soil or places the root splits into the planting holes and cover with soil. The spacing is 3 ft (90 cm) between rows x 2 ft (60 cm) between plants rows and at depth of 15-20 cm. In each hole apply one or two handfuls of farm yard manure (10 tons/ha FYM) or 2.5 bags (50 Kgs) of DAP/Ha.
- Napier can also be planted using the “Tumbukiza” method. In this method, the farmer will put several splits or canes in big round or rectangular pits. For round pits the spacing is 60 cm between rows that have a diameter of 60 cm and a depth of 60 cm. For rectangular pits the spacing is 90 cm between the rows of pits that are 60 cm deep and width of 60-90 cm wide. The length of the pit can vary depending on available land.
- Napier needs manure and top dressing with a nitrogen fertilizer and needs weeding
- Where new fields are being planted, inter cropping with desmodium improves the quality of the fodder
- Napier planted around maize stops maize stalk borer
- Napier is cut 3 to 4 months after planting when it is about 1 metre high
Figure 12: Napier inter-cropped with desmodium

- Cutting and managing Napier regularly will yield up to 8 tons of fresh matter per cut per acre
- Fresh materials are commonly fed in stalls under cut and carry system. It is usually chopped before feeding to avoid wastage
- Excess Napier can be made into good quality silage.

Sweet potato vines
This is a very palatable fodder which can produce both tubers and vines that are liked very much by calves as they are rich in protein (19 % CP). The other advantages include:
- They do not need a lot of work once they are growing and established
- They give tubers for the family to eat and the leaves can be fed to the calves
- It can be planted beside riverbeds, steep parts of the farm and roadside edge for soil conservation.

Ley grasses
These are planted grasses and includes the Rhodes, Setaria, Guinea and Guatemala grass. They have the advantage of being palatable and nutritious to dairy cattle. Their protein content is generally higher (9 – 12 % Digestible crude protein - DCP) compared to other grasses. They are established from seed on a fine seed bed and in furrows that are 25 cm apart. Use 3 - 4 kg per acre of certified seed and apply 1 (50 Kg) bag/acre of NPK fertilizer during planting. However, where certified seeds are not available and there is a plot of the grass that is already well established within the reach of the farmer, splits/cuttings can be used to establish the grasses. However, this should be done when there are adequate rains.

Well established grass leys are harvested as soon as they start flowering or after about 4 months from the time of planting and thereafter harvested at intervals of 3 months. They are good producers of biomass and yield 10 – 20 tons per acre of fresh material. They can also be conserved and fed as hay or for use during the dry season. A well managed ley can enable a farmer to make 450 - 600 bales of conserved hay from one (1) acre of land.

Maize
Fodder from maize is a good alternative when Napier regenerates too slowly as can happen after a severe drought or frost. It is possible to produce as much as 16 tons of green forage per year per acre by planting maize densely. The maize can be achieved by reducing the spacing of maize or by planting 4 to 5 seeds instead of 2 per hole to increase the number of plants and hence the amount of available fodder.

- While maize is grown for farmer's food, there is a lot of fodder which can be used for feeding the cattle which will not stop the farmer from a good maize yield
- Maize thinning are of high nutritive value (containing up to 9 % CP) and can be obtained even after flowering so that only one or two plants in a hole/hill are left to mature for grain production. The thinned maize fodder is wilted a little before being
fed to the cattle.

- Removing extra leaves - this should start with the leaves below the cobs as soon the cobs are formed.
- Leaf stripping and topping can also be a source of fodder. It involves removing the bottom leaves and cutting off the plant top soon after the dough stage (when the grains have hardened).
- Where fresh maize forage is available, it can also be conserved as silage to be fed as part of the feed resource on the farm and/or for use during the dry season.

b) Supplementary forages for energy and proteins

These are used as supplements to provide both energy and proteins and to some extent minerals. Just like bulk forages, they are fibrous plants. Most are legumes and include herbaceous plants (e.g. Desmodium, Lucerne, etc), shrubs and trees. During feeding, they are given together with the bulk forages but often in smaller quantities. They are used to supplement either poor quality bulk forage or can be used as substitute of concentrates.

**Fodder Shrubs and Trees**

Fodder shrubs provide a valuable feed supplement for dairy animals especially under stall feeding and during the dry season. The leaves contain higher quantities of proteins compared to bulk feeds such as grasses and crop residues. They therefore provide needed nutrients to enable production of more milk if in lactation or for faster growth after weaning. These forages can be fed fresh, dried as hay (dry leaf meal) or preserved as silage when mixed with grasses. But they should be fed with caution as feeding large amounts of some supplementary forages which are lush/succulent can cause bloat. If fed in large amounts for a prolonged period, they also cause other problems such as poisoning due to the presence of anti-nutritive compounds. They should therefore comprise not more than 30 % (or one third) of the feed ration given to the animal.

The most common shrubs grown include: Calliandra, Leucaena, Sesbania, Mulberry and Gliricidia which are all exotic species. In addition to planted fodder, farmers use leaves from naturally occurring tree species such as Ficus, Acacias, etc. Generally, leguminous forages have the following characteristics that make them useful feeds:

- Rich in proteins (at least 20 % CP) and hence needed only in small amounts as feed
- Used to substitute commercial concentrates. It has been shown that 1 kg of commercial concentrates can be successfully replaced by 3 Kg of fresh fodder trees (Calliandra)
- Can be planted in a hedge of 50 metres (single row) along the fences and terraces

In addition, leaves from shrubs such as Leucaena, Sesbania, Moringa, Calliandra and Albizia can also be dried to make convenient high protein supplementary forage called a leaf meal. To make a leaf meal, the fresh leaves are cut during hot dry weather and dried on a large sheet of polythene under a shade until they become dry and brittle. This process of drying takes around 3 days. The dried leaf meal can then be stored in sacks kept in a dry place until needed. For proper storage and to avoid spoilage, the leaves and twigs should be dried to 10 - 13 % moisture content. This level is attained when the leaf meal is dry but still looks green in colour.

However, while using the different fodder trees and shrubs and especially the indigenous ones,
caution must be exercised since not much research has been done on the optimal feeding levels. It is recommended that they should be fed mixed rather than as single feed over a prolonged period.

**Herbaceous legumes**

**Desmodium**

Desmodium is a high quality protein (18 % CP) rich perennial forage which can be planted on its own plot but can also be inter-cropped with Napier. There are two varieties of Desmodium in Kenya: Green leaf (*Desmodium intortum*) and Silver leaf (*Desmodium uncinatum*). Generally Desmodium has the capacity to fix nitrogen in the soil and hence where intercropped, helps increase yields of Napier. After establishment, whether in its own plot or intercropped, it should be first cut after at least 4 months when Napier is about 1 metre high and at an interval of 4 to 10 weeks thereafter. During feeding it should be given in small quantities (usually up to 1/3 of the ration) mixed with bulk forages as this will minimize bloating and poisoning. Therefore harvest only what is needed and wilt where possible. Usually, 3 Kgs of fresh Desmodium is equivalent 1 Kg of a commercial concentrate.

Where well managed, 600 – 700 Kg/acre of fresh matter can be obtained per cutting and hence 8 – 10 tons/acre of fresh matter are obtainable annually. Depending on availability and feeding levels, where there is excess fresh biomass, Desmodium may be cut, dried under shade for 2 – 3 days and baled into hay and used as a protein supplement. Additionally, it can also be mixed with ley grass when making hay.

**Lucerne**

Lucerne is a perennial herbaceous legume used as supplementary forage for dairy animals. It is high in nutrients (19 % CP) and highly palatable. It can be used both fresh as a fodder but primarily as hay. When fed as fresh fodder, the cut forage is wilted and mixed with other forages in order to avoid bloat. However, Lucerne hay can be fed directly without any restriction.

When well managed and with adequate water, Lucerne can be cut monthly and during each cut it can yield 670 Kg of fresh matter per acre. It has the potential to produce up to 8 tons of fresh matter per acre per year, and excess Lucerne can be conserved as hay. For the best quality hay, cut the crop in the early bud stage. This dried Lucerne can also be processed into cubes, pellets or meal.

**Hydroponic Fodder Production**

Hydroponic is a method of growing plants using mineral nutrient solutions, in water, without soil. Terrestrial plants are grown with roots in the mineral nutrient solution only. With hydroponic, one has the ability to produce high yields of fodder over a shorter period in a smaller area and the system is not dependent on climatic conditions hence fodder can be produced throughout the year.
Plants absorb essential mineral nutrients as inorganic ions in water. In natural conditions soil acts as a mineral reservoir but the soil itself is not essential to plant growth. When the required mineral nutrients are introduced into plants water supply artificially, soil is no longer required for the plant to thrive. It is a compact, simple, and cheap way to produce high quality green forage for farm animals.

**Figure 13: Hydroponic Fodder**

- A space 20 feet long and 10 feet high can turn out 500kg of greens every day all year around.

- Any kind of grass or cereal grains can be sprouted – oats, barley, wheat, alfalfa, etc. the nutrient solution increases the food value of the final product.

- It takes about five to eight days to grow from seed to an 8 inch mat of grass, packed with vitamins and minerals.

**Growing animal feeds in 6 days**

**Figure 14 (a): Growing animal feeds**

**Figure 14 (b): Growing animal feeds**
Description of the system

- Hydroponics fodder technology has a cycle of eight days producing up to 50 kgs of the fodder in a 20 by 10 feet space
- Enough to feed 20 mature cows or 120 goats all year round
- Hydroponics fodder technology, due to its ability to grow fodder and other crops without the soil
- It has been embraced by Kenyan livestock farmers as a solution to land scarcity
- As a factor of agriculture production is continually becoming limited in the face of population pressure and skyrocketing cost of commercial feeds

Production specifications

- A 144M² greenhouse can hold about 1800 trays and produce an average of 1200kg per day using only 800 to 1000 liters of water
This amount of fodder can be used to supplement 100 heads of cattle or 500 heads of sheep or goats per day.

It requires about two liters of water to produce one kilo of fodder compared to 80 to 90 liters required to produce one kilo of green grass.

Hydroponics fodder technology also saves Kenyan livestock farmers the agony of expensive fodder storage facilities because the innovation guarantees a constant supply of high quality fodder.

Figure 17: Ready Hydroponic Fodder

Benefits of feeding hydroponic fodder

- Fodder grows from seed to forage in just 7 days
- Uses 80% less water
- One needs very small area to grow fodder
- Guaranteed of feed supply throughout the year
- Irrespective of rain or sunshine
- Less labour required
- Nutritive and replaces feed constituents like dairy, pig and poultry concentrates
- Highly palatable and nutritious
- Reduces feed costs
- Increases digestibility of nutrients

Feed Conservation

Fodder conservation is a means of preserving roughage while at its highest nutritive value—during the period of surplus, for later use.

There are basically three forms:

i) Hay

Material is harvested and dried-while turning, for three days. It is thereafter baled or stacked. With fodder trees, drying is done under shade, and then the dry material bagged. As an example, Lucerne is harvested at 25% flowering (23% CP content, or at 28 days in Naivasha) in order to ensure optimal quality. Twenty five per cent (25%) flowering is also applicable to Rhodes Grass. The weather also determines the success. It should be noted that it is not practical to dry Napier because stems take a long time and the leaves will have fallen by then.

ii) Standing Hay

The material can be left on the farm, or underground, then harvested when required.
iii) Silage
Material, at its optimal nutritive value, is harvested, chopped and conserved in an anaerobic environment. Some of the materials suitable for silage are Napier, (whole) Maize (See Fig.19 below) & Sorghum.

Type of Silos:
- Above the ground
- Trench silo (below the ground)
- Tube silage: the recommended tube is 2.5m of gauge ‘1000’, which can hold 450-500kg of Napier, or, 500-550 of (whole) maize crop. However, it is cumbersome to make and store.

Silage making:
There are many methods for silage making but use of plastic tube is among those suitable for a farmer with one-two cows and limited Napier acreage, Rhodes grass and maize thinning. Surplus Napier, maize thinning or grasses can be made into silage, during the rainy season; if the weather is not favorable for hay making and the Rhodes grass has reached harvesting age it can be made into silage. Standard tube of 2.5 m length/100 gauge has a 450-500 kg capacity Napier.

It should be realized that other than molasses, maize germ can be used, but the cost of the preservative and the succulence of the material should be put into consideration.

Fortification: Napier or whole maize could be fortified with urea, together with molasses to enhance protein levels.
Steps in silage making:

- Cut the material for ensiling and leave it spread in the farm to wilt for 2 to 3 days.
- Chop forage (using a chaff cutter or a panga) into chops of 1-1/2 inch;
- Spread a canvas or plastic sheet of 500 gauge on a flat surface and spread 70 kg (about two half sacks of chopped and compacted Napier grass) of the chopped material into a thin layer;
- Take 1 kg molasses (about 1 kg Kasuku tin-full) and dilute with 3 lt of water (1 lt Kasuku tin-full x 3). If there is need to improve the CP content of Napier, add 200 grams of urea into the molasses and dissolve completely;
- Using nursery watering can, or 2 lt Kasuku tin perforated at the bottom, spread the molasses/water mixture on the Napier evenly and mix thorough to ensure an even spread. If the weather is not conducive for Napier wilting or when the molasses is very expensive spread 1.5 kg of maize germ on to the chopped Napier and mix as above;
- Tie one end of the 2.5 m plastic tube (width 1.5 m) to make a large plastic bag. Place the 70 kg of forage already mixed with molasses, or maize germ, into the plastic tube and compacted as much as possible.
- Repeat first five (5) bullets as many times as is necessary to fill the plastic bag;
- Tie the top of the plastic bag tightly to ensure air tight;
- Place heavy objects on the tied plastic tube to maintain the compaction.

Note: the filled silage plastic bag is very heavy and it is recommended that its filled at the point of storage: or alternatively use smaller tubes of 1.5 m length which will contain less material, will consume more plastic tube to make 2.5 m and also double the number of tubes, posing storage problem.

Figure 20: Tube silage making

Equipment:

- Manual hay-baler (box: measurements 2 x 2 x 3.5 ft, or, 48 x 55 x 90 cm).
- Motorized: forage cutter and hay baler.

Forage Storage
• Material should be stored away from water (store under shade);

**Treatment of maize stover/wheat straw/rice straw/barley/standing hay:**

This is done to improve the nutritive value, as well as digestibility. The steps are:-

• The dry material is chopped (chaff cutter/panga);
• Spread 100kg of the above material;
• Take 4kg urea and mix with 100kg water to dissolve;
• Sprinkle the above solution on the material;
• Tie one end of polythene tube, 100 gauge 2.5 by 1.5m diameter, to make a bag;
• Fill the material while compacting;
• When full, tie the other end of the bag and store for 21 days to mature;
• To feed, add molasses/maize germ to improve palatability;
• Some cows might refuse, for acceptance, scoop what to feed and leave it for a while for ammonia to evaporate;

![Figure 21: Preparing Materials for making Silage](image)

c) **Concentrates for energy and protein**

Concentrates are feeds that contain relatively higher (concentrated) nutrients than forages. Concentrates are feed supplements that supply extra energy, proteins and minerals/vitamins. They are low in fiber and easy to digest. Examples of concentrates include commercially formulated and processed feeds such as dairy meal, and cereal by-products (Pollard, wheat and maize germ meal, wheat and maize bran, etc) and other high energy and/or high protein feed stuffs (e.g. molasses, fish meal and brewer spent grains or ‘machicha’). Cereal grains (maize, wheat and barley) also fall in this category but their use depends on whether they are economical to feed. Concentrates are relatively expensive and hence are fed in small amounts to the goats.

**Compounded Feeds**

a) **Commercial Dairy Feeds**

This is produced on an industrial scale that involves the combination of many ingredients blended and mixed in proportions in accordance with dairy cattle feeding specification outlined by KEBS. Supplementation to the diet can have a dramatic effect on productivity especially
during the dry season, during late pregnancy, for the young stock/weaners and where the animals are stall fed. However, they must be fed as supplements to roughage since feeding high amounts of concentrates with too little roughage will result in the rumen not functioning well. Before buying concentrates for the dairy animal it is important to make sure that the expense is necessary and can be justified economically. The best practice is to feed concentrates when it is absolutely necessary and at critical physiological stages. The main concentrate fed to dairy animals is dairy meal.

a) **Home-Made Dairy Feed**

These are formulations by the farmer on the farm using locally available raw materials as well as external ingredients.

**Note: The formulation is guided by an expert (see example table xx-below):**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize germ</td>
<td>43</td>
</tr>
<tr>
<td>Wheat pollard</td>
<td>16</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>26</td>
</tr>
<tr>
<td>Sunflower meal</td>
<td>5.5</td>
</tr>
<tr>
<td>Cotton meal</td>
<td>6.75</td>
</tr>
<tr>
<td>Lime</td>
<td>0.5</td>
</tr>
<tr>
<td>DCP</td>
<td>1</td>
</tr>
<tr>
<td>Magadi</td>
<td>1</td>
</tr>
<tr>
<td>Premix</td>
<td>0.25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**Note: KEBS specifications for 10.5 ME/Kg (Energy), CP=14-16%, Cal = 0.7% & P=0.5%**

**Figure 22: Feed formulation**
Agro-industrial by-products

Industrial by-products consist of the residues left over at the end of food processing. Although they may be difficult to obtain, it is worth the effort, as these feeds are often very nutritious. They are broadly divided into those rich in protein such as cotton seed cake (38% CP), sunflower seed cake (21 % CP), coconut cake (32 % CP), and soya bean cakes (42 % CP). The energy rich by-products include: Maize germ/meal, wheat pollard, molasses, brewers’ spent grains (machicha), rice-bran, wheat bran, etc. These are all important protein- and energy-rich. Broken grains are also very nutritious especially after a heavy harvest. A small amount of these combined with locally available feed of moderate quality can greatly improve the quality and digestibility of the ration as a whole. These feeds can be fed to dairy animals as supplements to bulk forages or could be used as ingredients for on farm feed rations.

d) Mineral supplements

Although most of the forages and concentrates contain naturally occurring minerals, it is important to supplement them. A number of minerals are essential and are classified into 2 groups - macro and micro elements. The macro minerals include: calcium, chlorine, phosphorous, potassium, magnesium, sodium and sulphur. The micro elements which are required in much smaller quantities are: cobalt, copper, fluorine, iodine, manganese, molybdenum, selenium and zinc. There may also be a need for other trace minerals such as barium, bromine, cadmium, chromium, nickel, selenium, silicon, strontium and tin.

As a rule of thumb, mature dairy animals should be given free access to commercially processed mineral lick. These could be fed more appropriately as mineral licks but could also be provided in the mixed feed.

e) Water

Dairy herd should have access to adequate clean water at all times. This water is required for the normal bodily functioning and for those in lactation it is required for milk production. Although some water is obtained from the natural moisture in their food, this will rarely be enough. This is especially so during the dry season when the feed is very dry. During hot weather, the dairy animal will drink more water. Dry grass or straw only contains 10 - 15 % water. If the animals don’t find enough water, they will eat less food and their production will drop.

Feed and nutrient requirements (Energy, proteins, minerals & vitamins)

The amount of feed needed by dairy animals depends on their size and stage of development. As a general rule of thumb, a dairy animal will need 3-3.5 % of its body weight daily in the form of dry matter (DM) in feed to satisfy its requirement. Most fresh forage on average contains about 33 % dry matter.

Feeding Strategies

Supplementary Farmers’ practice: where farmers feed fresh/cut Napier, then offer/supplement, while milking, with unlimited amount of concentrates not based on the animal’s performance. This
approach does not assist at all on milk yield and cost. What matters is for the farmers to accustom the animal to milking without any feed but ensure it has consumed its proportion of concentrates mixed with roughage.

**Recommended practice [Total Mixed Ration (TMR)]**

TMR feeding system is a practice of weighing and blending all feed stuffs into a complete ration. In this system cows are fed based on production for the milking herd and growth rate required for young stock, growth rate and fat deposition for the beef animals. It has several advantages over the ad lib non planned feeding system; among these are:

- Minimizes wastage, enhances voluntary feed intake
- All feeds roughage and concentrate are mixed together allowing no selection,
- Feeding done with an aim of meeting specific needs
- Grain mixture can be liberally fed without fear of grain overload
- Its’ easy to access the genetic merit of each cow
- Its’ cheap in relation to feeding labour cost
- It’s possible to estimate the feeds requirement etc.
- Minimizes production cost/liter.

**Table 8 - An example of a TMR formulation based a standard cow whose live body weight (LBW) =500kg, milk yield (MY) = 25lts/day, butterfat =3.6% at 1st calving**

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Amount (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Napier fresh (18%DM)</td>
<td>20</td>
</tr>
<tr>
<td>Rhodes hay</td>
<td>5</td>
</tr>
<tr>
<td>Cotton Seed Meal</td>
<td>2</td>
</tr>
<tr>
<td>Maize germ</td>
<td>2.5</td>
</tr>
<tr>
<td>Pollard</td>
<td>2.5</td>
</tr>
<tr>
<td>Molasses</td>
<td>1</td>
</tr>
<tr>
<td>Urea</td>
<td>0.15</td>
</tr>
<tr>
<td>Mineral Lick</td>
<td>0.1</td>
</tr>
<tr>
<td>High-yield dairy Meal</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total fresh weight</strong></td>
<td><strong>38.25</strong></td>
</tr>
<tr>
<td><strong>Total DM</strong></td>
<td><strong>18.65</strong></td>
</tr>
</tbody>
</table>

**(vi) Routine Management**

This will entail feeding of the dairy herd as well as control and management of the herd health. It involves availing quality and adequate feeds to the dairy animal. Mineral salts and clean
water are supplied throughout. Control and management of the herd health will be done through: Proper housing, Proper feeding, Breeding management, Culling sick and/or unproductive animals, Deworming, Vaccinations, Tick control, Hygiene management and Treatment of common diseases

Figure 23: Administering Drug to a Dairy Cow

General management Practices
1) Castration
Male calves are castrated to prevent unwanted mating where male and female cattle are reared together in one herd. In addition, castrated males are easier to handle and they produce better quality meat. There are various methods of castrations as follows;

**Knife castration:** is the only completely safe method to sterilize male animals and can be done at any age by a qualified veterinarian.

**Elastrator rings:** The rubber ring is applied around the neck of the scrotal sack using the elastrator. To minimize pain when using the rubber ring method of castration, they must be applied within three days of birth.
Fig. 24: Elastrator method of castration: A strong rubber ring is placed around the top of the testicles thus cutting off blood supply. The testicles die off slowly.

The burdizzo: This is an instrument used to cut off the blood supply to the testicles, causing cell death of the testicular tissues resulting in degeneration of the testicles. It is best done at 3-4 weeks after birth when the spermatic cords can be felt.

Fig. 25: Burdizzo method of castration: The equipment is used to clamp and crush the top of the testicles

Dehorning

Horned cows are not only dangerous to people working with them, but cause a great deal of damage to hides. Dehorning also improves the animal’s appearance. Dehorning can be done by
several methods as follows;

Fig. 26: Hot iron dehorning

![Image of Hot iron dehorning]

**Hot iron:** Electric, gas or fire-heated iron is the most common in calves (4 to 6 weeks). Hot iron dehorning can be done with ease up to 3 months of age (while the dehorning iron still fits over the bud comfortably), thereafter horn growth is fairly rapid, making surgical removal necessary.

Figure 27: Dehorning a calf

![Image of Dehorning a calf]

**Surgical method:** uses saw or cutting wire. In older animals, surgical procedures must be used, especially if horns have grown to a length of 2 cm or more.

II) Identification
Identification of calves should be done immediately after birth to allow efficient and proper recording. Identification can be through various methods as shown below:

**Branding**
Hot iron-brand placed for a short time on the legs so as not to spoil skin. This is permanent but not common in dairy cattle.

**Earmarking** can be done through ear notching, ear tattooing, ear tagging.
Figure 28: Three types of calf identification

Electronic identification devices can be used for identifying dairy cattle. These include devices that can be inserted in the rumen as boli, under the skin, attached on the animal or fitted with a collar. These devices are normally linked to remote computers or satellites for purpose of data capturing and storage.

Note: The dairy farmer should keep physical and financial records to guide in management of the enterprise.

(vii) Clean Milk Production

Factors to consider to produce clean milk

- Clean and proper milking and handling of milk not only gives consumers hygienic milk but also reduces other economic losses like mastitis, tainted milk, reduced quantities or loss of cows.

- Milk from sick cows can be harmful when consumed. A sick cow can contaminate milk with pathogens either from direct introduction of the pathogen in the udder or by heavy faecal contamination of the milking environment causing secondary contamination of milk.

- One should have regular screening for mastitis, tuberculosis, brucellosis and other diseases that can be transmitted to humans through consumption of milk. Sick cows should be milked last and the milk destroyed or discarded.
• There is need to provide a clean milking parlour away from manure and other contaminating agents to avoid the milk being contaminated. This means therefore, that while constructing a dairy cattle structure, one should consider putting it up at the right place.

• Feeds with strong odours such as silage and some agro industrial waste should not be fed to the cows immediately before milking as milk will quickly absorb odours and bad smell and lead to spoilage and rejection by consumers. Avoid feeding aromatic forage during and around milking time.

• Farmer should try and establish a routine milking time so that the cow does not have to stand waiting to be milked for long periods. Milking 1-2 times is good enough depending on the amount of milk produced.

• Milk from animals under treatment should not be used for consumption and processing. Recommended drug withdrawal periods should be observed as advised by a veterinary or the drug manufacturer.

Procedure for clean milk production

• Take the cow to the milking place (milking platform placed in a clean and well ventilated place)
• All containers used for milking should be washed with detergent and rinsed with clean water
• Wash your hands with soap before milking
• Wash the udder with clean water which has disinfectant
• Use clean damp cloth to wipe the udder/teats clean
• Check the milk for mastitis by pre-milking into a separate container (a black one is the best to see clots)
• Milk into a clean container immediately after preparing the udder and teats
• After milking cover the container and remove the milk from the milking place
• In case the cow has a suckling calf, let the calf suckle to empty the udder, otherwise you can withdraw the last milk by stroking the udder with your hand, which stimulates the milk flow into the teats

Hand milking technique

Good hand milking is done by the squeezing method which involves using the whole hand. The procedure is as follows;

• Start by massaging the udder to encourage milk let down
• Grasp the teat between thumb and forefinger with the hand as much as possible against the udder
Close the teat cavity at the top with your thumb and forefinger
Then close your other fingers one by one so that the milk is squeezed out of the teat
Then you open your hand so that the teat cavity fills up again with milk
Milk firmly and rhythmically until the udder is empty.

Milk handling and equipment

In order to produce hygienic milk, proper milking procedures should be followed as described above. Maintaining high standards of raw milk quality is important because it increases storage time and guarantees quality products. The following important points should be considered while handling milk:

- Milk should be filtered to remove dirt particles and put into a clean container with a lid
- If the milk is for home consumption, it should be boiled immediately to kill harmful microorganisms. This makes the milk safe for drinking and prolongs storage time
- Where farmers have excess milk and are far away from the market or processor, they should chill the milk to inhibit multiplication of microorganisms that can spoil milk. This prolongs storage time before the milk gets to the market
- For longer storage, milk can be processed into other products like cheese, yogurt and butter milk.

(viii) Pests and Disease Management

The three categories of disease presenting challenges to improving productivity of the dairy herd are trans-boundary diseases, tick borne diseases and diseases of intensification, mainly metabolic and mastitis disease incidences.

Common diseases of intensification are metabolic, mastitis and lameness, which are of greatest importance in high yielding animals. Metabolic diseases of importance are milk fever, which frequently occur the time of parturition and lactating animal. The prevalence of this disease is less than 1% but cases may rise if mineral feeding supplements are inadequate. Lameness in dairy animals is a condition associated with dirty stalls and wet muddy or stony floors, which may predominate with heavy rains experienced with the changing climate. Increased incidences have been noticed with feeding lactating cows with high energy concentrates in the absence of regular mineral supplementation. Though cattle are predisposed to lameness and foot lesions due to confinement in the zero-grazing housing conditions, the incidence of lameness is less than 2% per month in a herd. Cattle diseases are generally caused by micro-organisms such as viruses, bacteria and fungi. Here are some common diseases that affect cattle:

Foot and Mouth
This disease is caused by viruses. It makes the animal weak and feverish. It affects the tongue, lips, cheeks, feet, teats and udder with sores appearing on these parts.
Control
- Practice improved sanitation and vaccination.
- Frequent occurrence of the disease makes it difficult to stop. Thus, it’s better to kill affected animals.

Tuberculosis
This is a chronic bacterial disease. The disease is very dangerous because man can also contact it from cattle through infected milk and milk products.
Control
- Take quarantine measures and regular tuberculin testing.
- Infected animals should be quarantined or slaughtered
- Disinfect pens regularly.

Lung Plague (Pleuropneumonia)
This viral disease makes the animal cough even as it weakens the animal before finally leading to death. It can be controlled by isolating the infected animal.

Rinderpest (Cattle Plague)
This viral disease is destructive and symptoms include stomach disorder that leads to diarrhea; high fever, blood-stained faeces and general weakness in animals. It can be treated by use of preventive vaccines and isolating infected animal.

Worms
These include flukes, tapeworms and round worms. Symptoms include lack of appetite, emaciation and excessive salivation.
Control
- Constant Deworming
- Good sanitation
- Rotational Grazing

Sleeping Sickness (Trypanosomiasis)
This disease is caused by the tsetse fly. The parasite destroys the red blood cells. Symptoms include general body weakness and high fever. Prevention can be carried out by eradicating tsetse fly and by vaccination. It can be controlled by isolating affected animal and slaughtering it.

Parasites
These are disease transferring tiny but dangerous organisms like ticks, mites, flies and lice. Tick is the commonest and transmits diseases like the tick fever. Three (3) ways to control parasites
1. Maintain clean environment
2. Dipping animals in chemical solution
3. Regular fumigation
Milk is highly perishable and easily contracts diseases. It has a high protein content making it a suitable medium for bacteria growth. For these reasons clean milk production practices are inevitable.

The following are the main preventive measures every dairy farmer should consider:
- Proper feeding and prevention of starvation
- Preventive health care such as regular tick control
- Prevention of management diseases
- Vaccination of animals according to veterinary recommendations for the area
- Good housing/milking facilities, where proper hygiene can be managed
- Good supervision to ensure incidental diseases are dealt with in a timely and appropriate manner

4. AGGREGATION AND VALUE ADDITION
Milk aggregation is the collection of milk from various producers for ease of processing and/or marketing. It is done by individual traders, self help groups, cooperatives and processors. Value addition includes grading, cooling, pasteurization, packaging and transportation. In order to increase the value and shelf life of the Milk it is processed into value added products such as: butter, cheese, yogurt, Mala, ice cream, powder milk, long life etc.

Processed milk and milk products in Kenya constitute between 20 and 30% (0.395 billion litres) of the total marketed milk and dairy products an indication that there is a high preference for unprocessed milk. Some reasons for high preference for unprocessed milk compared to processed are: relatively cheaper, tastier, higher butter content, in flexible diverse quantity to customer needs, widely accessible or more within proximity of the consumers and conservative consumers with high preference for unprocessed milk.

Major milk processors are the New KCC, Brookside dairy, Limuru Co-operative Dairy, Githunguri Dairy Co-operative Society and Meru Central Dairy Co-operative Union. In total there are 54 registered milk processors with 34 operational, all combined handling 1.5 million litres per day but their installed processing capacity is 3 million litres. Therefore 50% of the processing capacity is unutilized. Installed capacity for Ultra Heat Treated (UHT) milk processing is 1.2 million litres per day with more than half of this capacity being new investments by the private sector.

Milk Value Added Products
The products include butter, cream, cheese, yogurt and ghee. Long life milk dried whole milk and skim milk powders have ready export market but are produced in limited quantities because of low processing capacity. Cost of equipments is high and only New KCC has invested in drying plant facility for processing milk powder. Local consumption of these high value dairy products is low in the domestic market.
Figure 29: Milk Value Added Products

5. MARKETING

Generally, informal milk outlets absorb most of the milk from smallholder farmers accounting for over 86% of the total milk sold, while formal market handle 14% of all the total milk produced. Brokers, traders/hawkers, transporters, co-operatives and farmer groups are the most important participants at the rural markets. Cooperatives remain the main channel for collecting milk destined to the formal market.

Trading blocks for milk and milk products include regional markets (EAC, COMESA), EU-African-Caribbean-Pacific/Lome Convention and the African Growth & Opportunity Act (AGOA).

Kenya has potential to export dairy products, having the largest and well-developed dairy herd in Sub-Saharan Africa. Kenyan dairy products are currently being exported to Zambia, Tanzania, Uganda, Democratic Republic of Congo, Rwanda, Burundi and Saudi Arabia among other countries.

Dairy cooperatives have played an important role in the development of the Kenyan dairy sector as markets have become competitive and farmers have to be efficient in order to access markets for their dairy products.

Marketing and Pricing of Milk and Milk Products

The price of a product in the market is an important factor influencing consumer demand and to be marketable, a dairy product must be competitively priced. This implies that the costs involved in raw material procurement, processing, packaging, storage, marketing and distribution must be kept as low as possible. Generally, the price of a dairy product will involve:

a. Cost of raw milk  
b. Cost of collection and transportation  
c. Cost of processing  
d. Cost of packaging  
e. Cost of marketing and distribution
f. Taxes and tariffs

g. Profit margins at each stage of the marketing channel (Collection, Processing and marketing margins)

In order to arrive at a realistic costing of a product, all those elements involved at each stage must be carefully calculated on a unit basis through a method known as Cost Accounting.

The table below shows some of the essential cost elements:

**Table 9: Elements Essential in Costing Milk**

<table>
<thead>
<tr>
<th>Market function</th>
<th>Cost element</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Raw milk procurement</td>
<td>Cost of raw milk; labour; materials etc.; collection margin</td>
</tr>
<tr>
<td>2. Transportation</td>
<td>Transport cost; labour; materials and equipment; transport margin</td>
</tr>
<tr>
<td>3. Processing</td>
<td>Raw materials; machinery and equipment; labour; packaging; energy; taxes; marketing and distribution; processing margin</td>
</tr>
<tr>
<td>4. Marketing and distribution</td>
<td>Transport; labour; materials; rent; retail margin</td>
</tr>
</tbody>
</table>

The cost can be broadly categorized as fixed costs and variable costs. Fixed costs include things like depreciation of equipment and buildings while variable cost includes direct expenses such as raw material; marketing expenses; overhead costs [labour and personnel expenses It is important that all the cost elements are included in the calculation of the market value of the product. Overpricing can lead to uncompetitiveness of the product while under pricing can cause financial loss and eventual collapse of the business.

The demand and supply projections indicate that the current milk production will rise from the current 5.2 billion litres (2014) to a high of 12 billion litres by the year 2030 while the consumption will rise from 4 billion litres to 11 billion litres during the same period.

### 6. POLICIES

The dairy development policy provides direction on the growth and development of the dairy sector. The policy acknowledges the role of informal milk markets in the development of the sector and will help to legitimize small-scale milk traders, subject to them being trained and certified in milk hygiene.

An elaborate legal and regulatory framework supports the dairy industry in Kenya. The main regulatory body in the dairy industry is the Kenya Dairy Board (KDB) and has the responsibility of developing, promoting and regulating the dairy industry. The Kenya Bureau of Standards is
the statutory body charged with enforcement of standards and certification of quality standards of all products and services in the country.

List of the policies that affect Dairy sector in Kenya

- National Livestock Policy
- Agriculture Act 1955
- Veterinary Surgeons and Veterinary Paraprofessionals Act
- Food, Drugs and Chemical Substances 1965
- Agricultural Produce (Export) 1921
- Dairy Policy
- Animal Diseases Act, 1965
- National Animal Breeding Policy (Draft)
- Dairy Act 336

7. SERVICE PROVIDERS

Service providers are organizations that offer services for the growth and development of the dairy industry. The various service providers are expected to ensure efficient delivery of demand driven research, extension, finance and market information services by Public, Private and NGOs to value chain operators.

Table 10: List of Service Providers

<table>
<thead>
<tr>
<th>Institution/Organization</th>
<th>Services Provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of Industrialization and Enterprise Development</td>
<td>Provides technical advisory services in good management practices, accounting standards, legal and regulatory matters</td>
</tr>
<tr>
<td>State Department of Agriculture</td>
<td>Provides technical advisory services in terms of good agricultural practices</td>
</tr>
<tr>
<td>State Department of Livestock</td>
<td>Provides technical advisory services in terms of good animal husbandry, disease control and regulatory issues on livestock and livestock products</td>
</tr>
<tr>
<td>State Department of Fisheries</td>
<td>Provides technical advisory services in terms of fish rearing, marketing and related regulations</td>
</tr>
<tr>
<td>Development Partners</td>
<td>Provides development funds for the various agricultural sectors</td>
</tr>
<tr>
<td>Business Development Service Providers</td>
<td>Provide technical skills to entrepreneurs in the agricultural sector through training</td>
</tr>
<tr>
<td>County Government</td>
<td>Provide conducive business environment and necessary resources for programme and project implementation</td>
</tr>
<tr>
<td>Input Suppliers</td>
<td>Provide good quality inputs at the right time and reasonable cost</td>
</tr>
<tr>
<td>Institution/Organization</td>
<td>Services Provided</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Manufacturers {Feeds, Equipment}</td>
<td>Manufacture feeds and equipment of high quality for the production, storage and processing of milk and dairy products</td>
</tr>
<tr>
<td>NGOs [Public Benefits Organization]</td>
<td>Provides technical advise</td>
</tr>
<tr>
<td>Financiers</td>
<td>Provide capital for investment in the dairy industry and insurance against risk</td>
</tr>
<tr>
<td>Kenya Bureau of Standards</td>
<td>Certification of dairy products</td>
</tr>
<tr>
<td>Kenya Dairy Board</td>
<td>Enforcement of standards of dairy products</td>
</tr>
<tr>
<td>Kenya Agricultural and Livestock Research Organization (KALRO)</td>
<td>Provides Research findings/Technologies on Livestock</td>
</tr>
<tr>
<td>Milk Processors</td>
<td>Provides extension services, bulking, processing and training of value chain operators</td>
</tr>
<tr>
<td>Artificial Insemination Service Providers</td>
<td>Inseminate the animals</td>
</tr>
</tbody>
</table>