SNV SMART DEVELOPMENT WORKS

SNV/KENYA, NETHERLANDS DEVELOPMENT ORGANISATION

KENYA MARKET-LED DAIRY PROGRAMME (KMDP)

HANDBOOK

DESIGNING AND PLANNING MODULAR DAIRY COW HOUSE (KENYA)

the Friesian dairy development company

VETVICE happy cows, happy farmers

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

°C	Degrees Celsius
BC	Building Company
BCS	Body Condition Score
BLV	Bovine Leukaemia Virus
BOQ	Bill of Quantities
BVD	Bovine Virus Diarrhoea
CBE	Milk Collection and Bulking Enterprise
CC	Coliform Count
CFP	Commercial Fodder Producer
Cfu	Colony Forming Unit
CIP	Cleaning In-Place
DTI	Dairy Training Institute
EIA	Environmental Impact Assessment
EUR	Euro
FMD	Foot and Mouth Disease
Ha	Hectare
IBR	Infectious Bovine Rhinotracheitis
KES	Kenyan Shilling
KMDP	Kenyan Market-led Dairy Programme
kW	Kilowatt
LPD	Litres per Day
Lt	Litre
MCP	Milk Collection Point
MSF	Medium Scale Farmer
Neg.	Negative
NEMA	National Environment Management Authority
Pos.	Positive
QA	Quality Assurance
QC	Quality Control
Qnt	Quantity
RVF	Rift Valley Fever
SCC	Somatic Cell Count
SNV	Netherlands Development Organisation
SOP	Standard Operating Procedure
SS	Stainless Steel
t.b.d.	To be decided
Tn	Tonnes (weight)
TPC	Total Plate Count
UHT	Ultra High Temperature (treated milk)
USD	United States Dollars

PREAMBLE

This Handbook has been prepared for the Kenya Market-led Dairy Programme (KMDP) by Vetvice (www.vetvice.com) and The Friesian Dairy Development Company (www.thefriesian.nl). Both companies are based in the Netherlands and operate worldwide as consultants and trainers in cow house design and dairy management. In Kenya they were assisted by Perfometer Consultants from Nairobi and Eldosirikwa Consultants from Eldoret.

KMDP is a 4.5 year programme funded by the Embassy of the Kingdom of the Netherlands in Nairobi. The programme started 1st of July 2012 and is implemented by SNV/Kenya, Netherlands Development Organisation, in collaboration with stakeholders in the Kenyan dairy industry.
SNV is an international not-for-profit development organisation founded in the Netherlands nearly 50 years ago. SNV has offices and programmes in 36 countries in Asia, Africa and Latin America (see for more information at www.snvworld.org).

KMDP (KMDP Kenya) stimulates best practices and facilitates transfer of knowledge and skills, for enhanced competitiveness of the dairy industry in Kenya. The overall goal of KMDP is to contribute to the development of a vibrant growth-oriented and private sector-driven dairy industry, with beneficiaries across the value chain. It works around two pillars or strategic intervention levels:

I. Smallholder dairy value chain
KMDP works with 4 processors and 16 dairy societies across Kenya's major milk sheds, who are willing to invest in farmers' training & extension, milk quality, enhanced input and service provision and improved governance and business management.

II. Dairy sector systemic issues
Under this pillar KMDP facilitates innovations, transfer of technology, knowledge & skills, and (international) investments that help spur transitioning the dairy sector structure, including the infrastructure for services and training. Here KMDP works with medium and large scale commercial dairy farms (MSF Model), commercial fodder producers and supply chains (CFP Model), and processors willing to pilot a quality based milk payment system. In addition to this, KMDP supports initiatives for commercialisation of training for practical skills development, through its engagement with DTI Naivasha and Practical Dairy Training Farms or Centres located close to the farmer. Finally KMDP stimulates and facilitates business-to-business linkages and partnerships between stake-holders in the Kenyan dairy industry and Dutch (and other international) input suppliers, service providers, knowledge institutes and investors.

The activities under Level II are geared towards dairy sector transitioning and KMDP has singled out the steady growing group of emerging Medium Scale commercial dairy Farmers (MSFs), as a special target group for support. This segment of farmers is viewed by KMDP as crucial for sector transformation and food security in the long term, due to their interest and ability - in terms of land and capital - to invest and innovate in professional dairy farming.
Besides, it is assumed that if these MSFs are capacitated to grow and to improve their dairy farming practices, this will have important positive spill-over to the smallholder supply chain; for example as regards to fast-tracking the development of an effective dairy service infrastructure.

KMDP support is focused on organisation of MSFs in platforms and study groups and training on Total Farm Management, incl. fodder management, cow house design and farm record keeping.

KMDP is implementing a special demonstration project on farm record keeping with 10 demo farmers in North Rift, Central and Eastern. This Handbook is concerned with cow house design.

The Handbook is developed especially for MSFs who intend to invest in the establishment of a new dairy farm enterprise, or who wish to upgrade or expand their existing dairy production facilities. In particular this Handbook will be of use to Dairy Consultants and Architects in advising and guiding MSFs on farm planning and cow house design.

The main objective of the Handbook is therefore to guide farmers/investors – and their advisors - on professional and cost effective methods of developing their dairy farm, by following a structured and planned approach. In the Handbook emphasis is on the design of the cow house or cattle barn and on all other important support functions and structures that are part of a commercial dairy unit.
The Handbook follows a modular approach and shows examples of 4 different cow house modules, starting with 20 cows and moving to 40, 60 and up to 80 cows. For each module the design and the layout is illustrated by technical drawings and a description is given about usage and management. Also a 3D presentation is made available. The designs and technical drawings are premised on international best practice dairy management translated to the Kenyan context.

Nairobi/Leeuwarden, February 2015

www.snvworld.org
www.thefriesian.nl
www.vetvice.com

www.modulardairyfarm.com

CHAPTER 1: INTRODUCTION

This Handbook presents an investment plan(s) and technical drawings (including a 3D presentation in Google SketchUP), for the construction of a modern cow house with utility buildings. The design and the costings are adjusted to Kenyan conditions, but the principles of the design are based on international best practice and standards. The Handbook follows a modular approach and shows 4 stages of development of the dairy farm with modules for 20-40-60-80 lactating cows plus dry cows and young stock for replacement. The target group for this Handbook consists of dairy investors, medium and large scale dairy farmers, dairy consultants and architects.

Chapters 1 to 5 of this Handbook contain explanations and clarifications as regards to the modular design and good dairy management practices. The technical drawings and cost calculations (BOQs) are provided in a number of separate Annexes.
Although focus is on the design and costs of the cow house itself, the Handbook also pays attention to support functions at the dairy farm, and the physical structures and systems that need to be put in place to make the dairy farm operational. This includes amongst others reliable access to electricity and water, land for fodder production, farm mechanisation, buildings and other structures for storage of feed, fodder and fertilizers, sheds for farm machinery and fencing of the farm.

The modular concept shows two major challenges - at the same time objectives. The first is to achieve a high level of cow comfort and efficient work processes (e.g. short animal and milk transportation routes). The second is to design a physical structure (cow house) that can be easily expanded at low cost to allow growth of the farm/herd, whilst maintaining the efficiency of the work processes.

In Chapters 2 and 3 the lay out and functions of the modular cow house with utilities are described, and other farm support structures and facilities are mentioned. The stables are designed to accommodate the dairy cattle in-doors in a free walking setting all year round. There is also an outdoor free walking area and, depending on the farm setting, there is a possibility to include exits for cattle to enter the grazing fields. In the free walking design concept, animals have access to clean drinking water, a central feed alley and cubicles where they can lay down and rest.

Chapter 4 presents a summary of the investment plan for the modular cow house and the utilities. More detailed cost calculations per module – including Bills of Quantity – are provided in the Annexes. This chapter also gives a short overview and explanation of other investments that need to be made on the farm, e.g. in the dairy herd, fodder production, silage pits, hay barn, feed stores and in farm machinery. These investments are to an important extent elastic and will increase with the modular design.

In Chapter 5, the planning process for the implementation of the modular cow house concept is presented. This is a guideline or checklist for the project owner and his advisors, on how best to manage the dairy project step-by-step. Chapter 5 recommends that the investor engages timely with government authorities such as local authorities, and involves a professional architect and contractor to assure, amongst others, compliance with County governments' land use planning/zoning, attainment of building licenses and permits, an optimal farm layout configuration, and proper technical specifications of materials and prices.

CHAPTER 2: STRUCTURES, CONSIDERATIONS AND IMPLICATIONS

Before establishing a dairy farm, consideration must be given to all core and support facilities such as the cattle barn or the cow house with the milking parlour and other utilities, feed storage, manure storage, farm machinery and so on and so forth. Also the demands of a dairy farm operation in terms of water and energy use and fodder production and pastures must be well understood.
There is a major difference in factors to consider when an existing barn is being expanded or modified, or in case a new cow house is to be built from scratch. In this Handbook the establishment of a new dairy farm operation is described, as this covers the whole range of action points to be considered for best practice cow house design and planning.
The sections below describe the minimum considerations and principles to be adhered to – from a view of international best practice. Although the Kenyan situation will differ and every farm and farm site has its unique features – as will be the case for the investment capacity and vision of the dairy investor/entrepreneur – these principles are not compromised in this Handbook to suit the "investor" or "common practice". Rather these principles give guidelines and benchmarks based on scientific and practical proven concepts for optimization of dairy production and profitability worldwide. It is up to the reader of this Handbook to pick from them and to see what is attainable and achievable at the short and the long run in his or her specific situation.

2.1 Access to Public Utilities

A commercial dairy farm needs good access to roads, electricity and water, for the following reasons:

a. Road network: Good road access to the farm site is an important issue to consider, as road construction costs are significant and it is essential for the dispatch of fresh milk and supply of feed. Good access to the main road network and proper logistics on the farm have important impact on milk quality and transportation costs. This is important especially for long term planning, so that when volumes of feed and milk grow the infrastructure will accommodate the growth.

b. Electricity supply: A connection to the national grid is preferred as electricity is required on the farm for certain farm operations, such as automated milking, cooling and feed milling/chopping. Special attention must be given to a high voltage (3-phase) power connection, which may be a requirement for milking and cooling processes. A high voltage power connection is a considerable investment and will usually increase with the distance between the farm site and the nearest high voltage power distribution point.

c. Water supply and drainage: The availability of sufficient clean water is important for animals, farm processes and humans alike. Rain water catchment may help to create (seasonal) storage for drinking water for a limited herd size. However for commercial dairy farming a continuous supply of fresh water must be guaranteed to avoid shortages of drinking water. Besides, clean water is needed for cleaning farm equipment such as the milking machines and the milk cooling tank, but also for cleaning of floors in the milking parlour and milk room. In the event that a piped water connection to the national grid is not possible or feasible, the installation of a deep well or borehole needs to be considered. Also the issue of water drainage must be given attention. Especially in the event of heavy rainfall, excess water must be channelled away from the farm site to existing water reservoirs, drainage canals or the local sewage system.

2.2 Dairy Farm Lay-out Principles

The optimal lay-out of a dairy farm takes into account the following principles:

Principles

a. One central entry and exit point
b. One central square
c. Central view on the farm/central square
d. Straight and short lines for all traffic (people and vehicles)
e. The premises are fenced
f. The route to pasture and arable land is separate from the central entry and exit point.

Explanations

a. One central entry and exit point
   This enables the farm to check vehicles and persons coming in and going out. Facilities for disinfection of vehicles and persons entering the farm can be placed here. One central gate allows for strict control and monitoring of vehicles and persons coming in and going out. The amount of space needed for drive ways is minimized

b. One central square
   All on-farm traffic movements and work processes should start from here. The buildings and the main working areas are ideally located as close as possible to the central square. Entries and exits of all buildings are situated at the square-side in the most logical place. This lay-out gives a very good overview over most processes that are happening on the farm and short walking distances. People are close together and this supports easy supervision and communication.

c. Central view
   The farm house or the office should be placed in such a way that the farmer or farm manager has a good view on the central gate and the central square. Windows at the place where people sit (office, kitchen and canteen) should be facing the central gate and the central square. In this manner farm workers can be continuously supervised and visitors are immediately detected.

d. Straight and short lines for all traffic movements: people and vehicles
   Cows, people, and moveable machinery should move in straight lines on the farm. This makes it easy to drive around with farm machinery (time saving, less accidents) and the space needed for drive and walk ways is minimized. Regarding buildings: designing the farm in straight lines makes it easy to expand buildings.

e. The premises are fenced and can be enclosed with a gate
   It is advisable to fence the farm and put one main entrance, possibly with an additional gate at the cow house area. This will enhance safety and prevent other animals to enter the farm and bring in contagious diseases. At the central gate hygienic measures for vehicles and humans can be executed.

f. Separate route to pasture and arable land
   The arable land and pastures should be fenced and need to accessible through a separate route rather than through the main gate. This allows for separation of vehicles and animals from outside and inside the farm (bio-security, safety).

2.3 Dairy Cow House Design

An efficient and effective dairy barn or cow house design is based on the following principles[1]:

a) Cow comfort
b) Labour efficiency, safety and comfort
c) Simple, robust, flexible and expandable
d) Durable, cheap
e) Straight lines
f) Concentration of labour
g) Optimizing and separating flows:
   - ✓ Cow flow (over the day, over the year)
   - ✓ Feed flow
   - ✓ Manure flow
   - ✓ People flow/work flow
   - ✓ Materials flow
   - ✓ Information flow

In view of good animal health care practises, the preferred stable is designed in such a way that it can accommodate animals of all age groups separately in a free walking area all year round.
At the same time it must facilitate labour processes – e.g. milking, feeding and manure collection – in a safe and efficient manner. It also must provide high cow comfort for optimal milk production and good ventilation and protection against unfavourable weather conditions (e.g. heat, rain, wind).

Free stall system (cubicle housing)
There are different systems to accommodate dairy cattle, of which free stall, loose housing and the tie stall are the most common ones. In this Handbook the free stall system is selected as the most appropriate design for the Kenyan situation. The free stall gives a higher level of cow comfort. Cows are cleaner and there is a lower incidence of teat/udder injury. Compared to loose housing the investment is comparable or slightly lower, due to the facts that in the same surface in a free stall barn a higher number of animals can be kept, but construction costs per square meter are higher. Loose housing also requires more use of bedding material and labour to handle manure. The tie stall design provides the least cow comfort of the 3 systems because animals are restrained and cannot exercise at will.

The three most common dairy cow house types:

Freestalls

Loose housing

Tiestalls

[1] From: Building for the cow. Jan Hulsen. Roodbont Publishers; 2008.

In this modular free stall design, cattle can use a (fenced) free walking area (dry lot) outside the barn structure. This area can be closed in periods with much rainfall. And it can be taken out the design i.e. when cows have access to pasture. Access to pasture is anticipated for in the design.

The most important parameters for the design of the cattle barn are as follows:

a. Cows in lactation
b. Dry cows (Far off/Close up)
c. Maternity (calving area)
d. Calf rearing (age 0 – 3 months) in calf boxes and group housing *
e. Female young stock (age 4 -7 months)
f. Female young stock (age 8 – 11 months)
g. Heifers (age 12 – 15 months)
h. Pregnant heifers (age 16 – 19 months)
i. Pregnant heifers (age 20 months – delivery)
j. Breeding bull(s) *

(Note: In this Handbook it is assumed that bull calves are not kept for rearing and leave the farm within two weeks after calving. However, 1 or 2 bulls may be selected for the purpose of breeding (natural mating) for cows that are difficult to conceive through AI.*

In addition to the list above, the following functions in the cow house design also need consideration:

a. Cow handling and treatment area
   This area is usually closely located to the milking parlour. It is used to single-out cows from the herd for purposes of individual attention, for example hoof-trimming, artificial insemination or veterinary treatments. In this area, an individual treatment box can be located in which individual animals can be confined for treatment. At farms that have a dairy herd of more than 60 cows a separate "attention area" is recommended, where animals are housed temporarily during a period of time outside their normally allocated barn space, for the purpose of individual monitoring or treatment (e.g. animals with lameness, mastitis or any other conditions that would call for regular attention).

b. Milking parlour
   A milking parlour is the location at the farm where cows are generally milked twice a day. The reason to milk cows at the same location is because this place can be equipped with stationary milking machinery and a safe and hygienic working environment can be created with sufficient light and ventilation. From an ergonomics point of view a milking parlour provides a good position for milkers to work safely and keep a good view at udder level.

c. Milk- and machine room
   This is a dedicated area for the reception, cooling and the storage of milk. This is the place where the dispatch of fresh milk takes place. It is also used to manage the cleaning of milking equipment, utensils and milk cans. Where applicable this is also the place where the milk testing equipment is stored. Situated adjacent to the milk room is the machine or equipment room in which compressors and vacuum equipment are placed. The heat radiating equipment is physically separated from the cooling equipment. The cooling equipment is instead located in the milk-room to avoid inconsistent flows of (heated) air and contamination by oils and lubricants.

d. Office and sanitation room
An office is an absolute necessity for proper management and administration. Some of the management aspects include farm recording, herd fertility and AI, animal health and veterinary care. Also the (cold) storage of veterinary medicines, artificial insemination utilities (including bull semen) and spare parts of the milking equipment are kept in the office room. It is recommended that a sanitation unit be included in close vicinity of the office which houses the toilet with the washing area and the changing room.

2.4 Example Layout of Modular Dairy Cow House

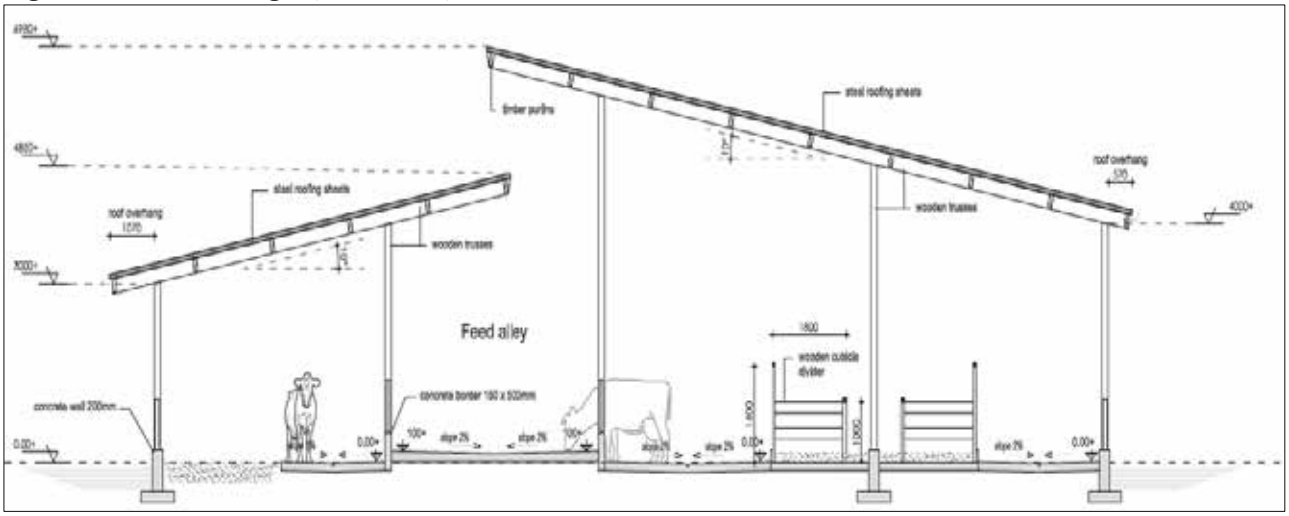
Figures 1 and 2 show the basic layout of the modular cow house design as explained in this Handbook. The example below is for the 40 cow module 2 cow house unit. The principles of this unit are the same for the other modules (1: 20 cows; 3: 60 cows and 4: 80 cows). Detailed technical drawings of all modules are provided in the Annexes. See also Figure 15.

It should be noted that the reference to 20-40-60-80 cows as per the module titles, is based and determined by the number of lactating cows in each module. Thus in module 2: "40 cows" barn, means 40 lactating cows, and so on for the other modules. This implies however that the total herd per module is larger as it includes also dry cows and young stock (the latter for replacement). This applies to all modules.

Equally and in line with this, the housing capacity for each module is determined by the total herd, which includes cows in lactation, dry cows and young stock. For illustration purposes reference is made to Table 11 in Chapter 4, which gives a breakdown of the total herd for the 4 modules (for 2 scenarios). All four cow house modules in this Handbook are designed to accommodate this total herd.

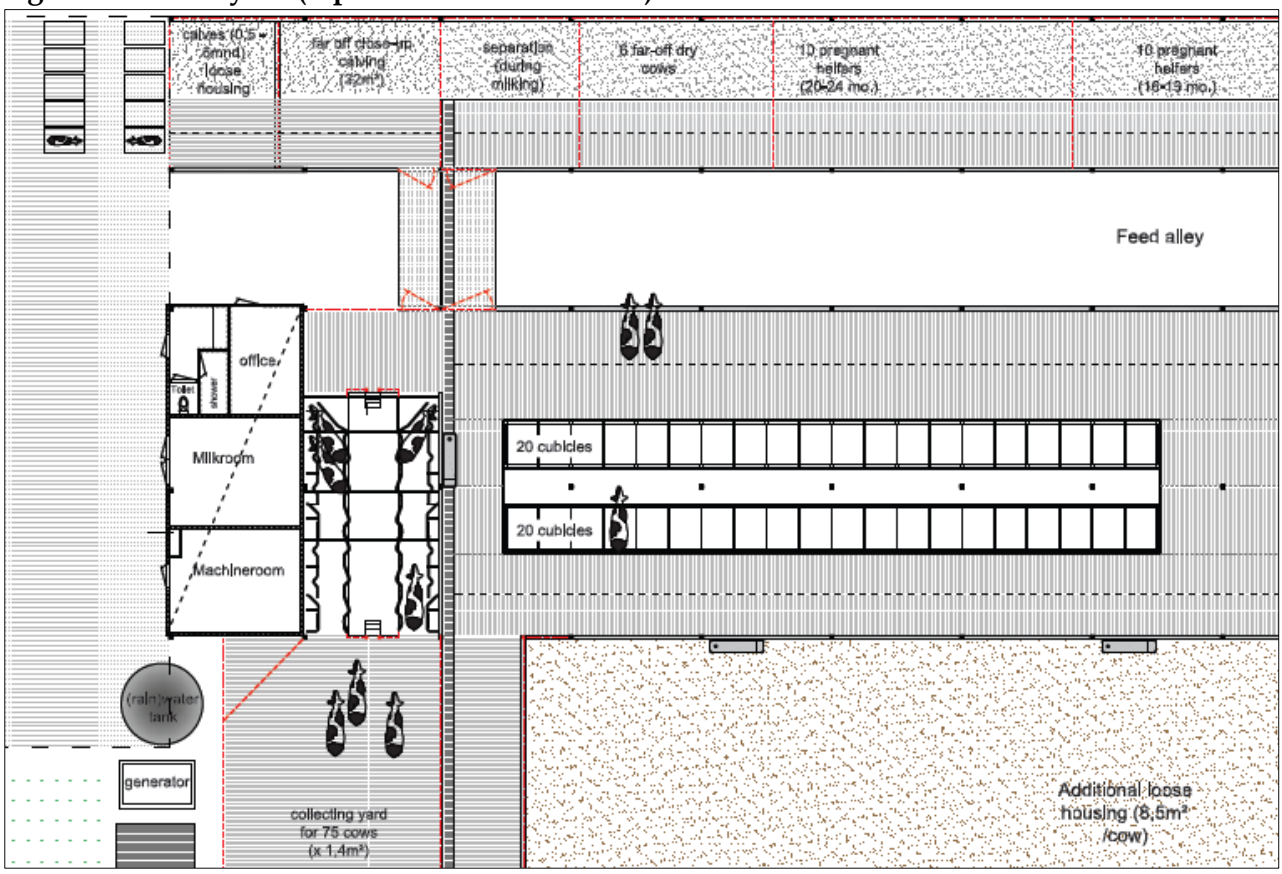
Thus the design in figure 2 below encompasses both the accommodation for cows in lactation (40), dry cows and young stock. The lactating cows are housed in a free stall system. Young stock and dry cows are housed in a loose housing system (in group boxes), which are located opposite the lactating cows. The required materials - including an estimated cost - are shown in the Bill of Quantities in Annex 4 (BOQ) and summarized in Chapter 4. The BOQ makes a distinction between an option that uses wooden frames and an option that applies steel beams.

Figure 1. Barn design (side view)



For more details see technical drawing: Annex – 3.f TD 20 cows module

Figure 2. Barn layout (top view 40 cows module)



For more details see technical drawing: Annex – 3.e TD Farm layout

2.5 Support Functions and Physical Structures

Next to the cow house and utility buildings, the dairy farm has a number of other buildings and structures of which the most common are:

a. Feed storage/handling area: sufficient space must be allocated for structures to store dairy feed such as:
   - Hay and straw, located near the cattle barns in an open structure that could have the roof only.
   - Silage bunker silo (maize, grass, sorghum, etc.) located in close vicinity to the cattle barns, preferably made of reinforced concrete to allow access of tractors and heavy loads during the silage making operations.
   - Dairy feed concentrates (mixed and as raw materials) are preferably stored in a separate building. Milling and mixing of concentrate rations takes place at this location.

   In selecting the best location on the farm for these feed storage structures, due attention must be given to easy access of farm machinery – e.g. tractors, maize harvesters, feed trailers - and to prevent interference with waste or manure storages/processing lines.

b. Cattle dip/spray area: Frequent spraying (or dipping) of all cattle is necessary to protect them against external parasites and tick borne diseases, when they have access to pasture. A spray race or dipping pit can be located in the vicinity of the cattle barns and can be reached preferably through a fenced gateway.

c. Agriculture utility or inputs store: This building is required to store agriculture tools, fertilizers, seeds, herbicides and pesticides. It is recommended that this building is lockable. Chemicals must be stored in a separate cupboard for safety reasons.

d. Farm machinery storage or go-down: This building protects major farm machinery and implements against unfavourable weather conditions. It is designed with an open front to allow easy access for large machinery such as a tractor, plough, sowing machine, maize harvester and chopper and so on and so forth. The building may also include a small workshop to allow for minor repairs, such as tyre repairs, lubrication and servicing of machinery. Spare parts of farm equipment can be stored here.

e. Drinking water storage tanks: A guaranteed supply of good quality water is important to provide cattle with their daily water requirement and for cleaning. Rain water catchment may be used to provide part of this, but will not be sufficient to guarantee sufficient volumes year round. It is advised that the farm be connected to the national piped water supply system, or sinks a deep-well or borehole.
Water storage tanks with sufficient storage capacity need to be present in the event that the water supply gets temporally disrupted. As a rule of thumb the water storage capacity should be equal to a minimum of two-day water requirement of the cows plus water needed for cleaning.

f. Electricity supply and power back-up unit: Where an electrical power generator is installed on the farm premises, it is recommended that the generator be placed in a separate building away from the main farm buildings. Safety considerations (particularly in relation to fire protection) must be borne in mind when assigning the location of fuel supply and storage facilities. In case fuel (e.g. diesel) is stored in an external storage tank, it is recommended that the storage tank be located outside the power back-up building for safety reasons. At the same time this storage tank may be used to store fuel for the farm machinery as well (tractors). The fuel tank needs a concrete slab that will hold any leakages or spoilage from the tank to prevent contamination of the soil.

g. Manure collection and storage bunker/pit: The handling of cow manure is a very important operation of a dairy farm and requires much attention. Manure must be collected daily and put in a concrete storage facility or bunker whose design depends on the volume, usage and destination of the manure. The most common ways of using manure in rural Kenya are:

- Organic fertiliser: Manure is stored over a longer period of time in a concrete pit or bunker, from where it is distributed periodically to agricultural land as an organic fertiliser. This is the recommended practice for integrated dairy farms with sufficient land to grow their own fodder. Use is best made of a manure spreader. The frequency of manuring the land depends on the soil fertility, demand per crop and availability of land. The duration of cropping season and rainfall patterns also determine how much manure needs to be stored over a certain period of time. In Kenyan this period would be between 3 and 6 months.

- Bio-gas: Livestock manure and other organic waste from the farm (e.g. maize stovers) is ideal feedstock for methane gas production in so-called biogas digesters. In Kenya there are several low-cost solutions in the market for such "farm-based" bio digesters ranging from KES 50,000 to 150,000, depending on size and materials used. The use of these biogas digesters is widespread in dairy farming systems across the country and the size ranges from 6-20 m3. The biogas is used for domestic and farm purposes, such as lighting, cooking

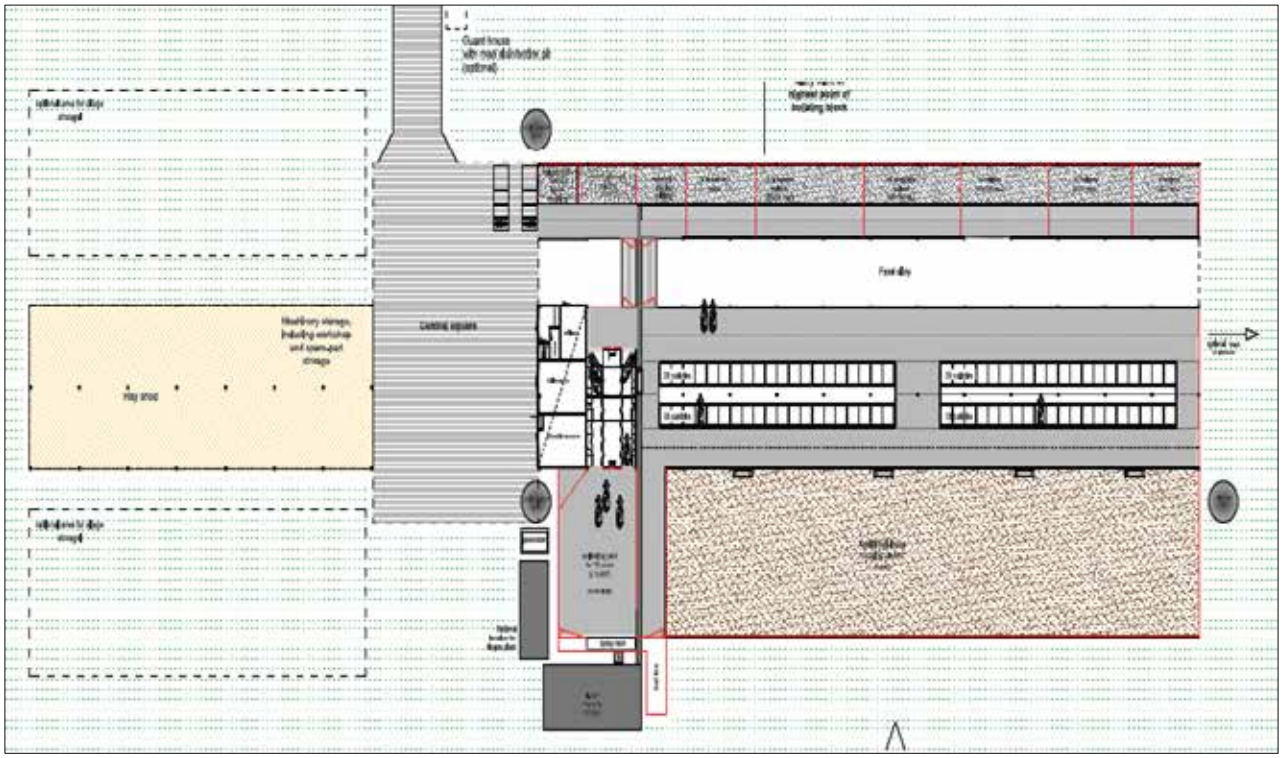
and heating water for cleaning of the milk tank and the milking machine. It can also be used to generate electricity, although this requires a considerable extra investment. The slurry that is accumulated in the biogas digester can be used as an organic fertilizer for soil improvement and enrichment.
The different options and requirements concerning biogas digesters and their use are briefly mentioned in Annex 3. For construction of the biogas digester it is recommended that the farmer contacts a certified biogas contractor (http://africabiogas.org/).

2.6 Typical Farm Layout and Fencing

Figure 3 shows a typical farm lay out with one central entrance gate, the central square in the middle and the cow house with utility building on the right. (Modular) expansion of the cow house is preferably in this direction. On the left there is space for other structures including silage pits and a hay stack. The detailed technical drawing of Figure 3 is presented in Annex – 3.e TD Farm layout.

It is advised to fence the farm for security and bio safety. Fencing is recommended to avoid movement of cattle from neighbouring areas into the farm and entering of wild animals. These movements may spread contagious cattle diseases. Prevention of theft is another reason for fencing the farm and applying additional security measures.

Figure 3. General farm layout



Reference Annex – 3.e TD Farm layout

CHAPTER 3: CATTLE BARN MODULAR APPROACH AND OPERATIONS

The basic principles concerning the lay-out and design of the cow house and the support functions have been summarized in the previous chapter, i.e. cow comfort, labour efficiency, robust, durable, straight lines, separation of flows.
This Chapter pays attention to topics that need special attention and care when moving the dairy farm through a "modular" design to the next level, thereby increasing the herd size. It therefore looks more at management of the dairy herd and the functions as per the modular design.

3.1 Modular Farm Development

Dairy farms develop over time by increasing the number of cows. If properly planned and implemented, this expansion can bring down the costs per kilo of milk produced at the farm, thus maintaining a profitable situation and allowing for the benefits of economies of scale. This is of particular importance when the cost price of milk increases more rapidly than the sales price. Scaling up the dairy herd size and specialisation of farm operations, offer the potential to realize economies of scales and cost price reduction per unit (cow, litre of milk), thereby increasing profits. It also usually leads to improved quality of raw milk.

A well-planned cattle barn and dairy farm are designed in such way that future expansion becomes easy and cost-effective. Dairy farm growth, in terms of expanding farm structures and facilities, is usually planned in steps to accommodate the growth of the herd over time.
Designing a dairy barn and dairy farm is however always a tailor-made process. Very few investors/dairy farmers have the same vision and/or options for developing their dairy farm and some of the parameters that vary case by case include:

a) <u>The amount of investment capital available</u>
Little investment capital is often a reason for investors to decide to use cheap(er) materials and very simple type of construction methods. As a result of this, a cow barn is created that will wear out faster and is often more labour intensive and less comfortable to work in. It may also compromise on cow comfort which will negatively affect milk production and profitability. During the upgrading/expansion of the dairy unit, the (sub-standard) buildings that are in place may need to be fully replaced with new ones, that suit the demands of managing a larger dairy herd. "Full replacement of buildings" increases the costs of expanding a dairy farm considerably. Some examples of areas of basic decision-making between cheaper and more durable solutions include:
   - To opt for a milking-parlour with stands versus an integrated milk-parlour with a pit.
   - Using wooden fences and other low-cost construction materials versus more durable materials such as galvanized steel and concrete.
   - Economize on the size of the cubicles and the height of the cow house at the cost of cow comfort and ventilation.

b) <u>The size and properties of the area on which the buildings are constructed</u>
The site characteristics, e.g. slopes, size, existing buildings, access to water etc., will to a large extent determine the farm and the barn design. It may lead to decisions that compromise the basic principles described in this Handbook, for example the principle of straight lines, one entrance/exit, and even own fodder production versus purchase from outside.

c) The farmer's vision on use of labour versus mechanisation
If labour is cheap and abundant it is tempting to opt for (unskilled) labour-intensive solutions rather than mechanisation. This however may compromise basic principles of good dairy husbandry, cow house design and fodder production. In the modular cow house design labour efficiency is an important factor. This is e.g. visible in the design of the milking parlour. A high capacity of the milk parlour (higher number of milk clusters) reduces the milking time. As a rule of thumb, the number of cows milked per hour is equal to half the number of clusters. When milk production increases, milking time also increases.

d) The time frame for development of the dairy farm
Investments that are not yet fully utilized – e.g. overcapacity of the milking parlour – contribute to higher fixed or overhead costs. However, with a short time frame between development steps and a well-planned growth strategy based on a modular approach, "overdesign" at the start (module one) will reduce total investment costs at later stages in the growth model. In the absence of a modular approach, every expansion of the farm will be a project on its own with the risk of duplication or replacement of existing structures.

e) Market access of farm products
Efficient management of sales and purchases of farm products (milk, breeding stock) and farm inputs (e.g. fertilizers, feed) respectively, may reduce the need for storage facilities.

3.2 Management of Modular Farm Development Plan

The development strategy for the dairy farm – also in a modular design or approach – is partly based on the personal choices and preferences of the investor or farmer, his ability to invest as well as the specific conditions and circumstances on-site. This has been briefly referred to in the previous section.
As a general guideline, the following elements of cow house design are however important to consider timely and adequately across the board, to allow for easy expansion and effective use of resources. For example when moving from 20-80 cows (plus young stock) in a stepwise manner:

a. Capacity of the milking parlour
b. Manure storage/waste water storage
c. Waiting area before milking
d. Treatment and handling of cows
e. Milk storage
f. Cows: milk production and dimensions
g. Special needs cows
h. Grouping of young stock

3.2.1. Capacity of the Milking Parlour

The design of the required milking parlour capacity is based on the assumption that total milking time (milking + cleaning of the milking parlour, milking equipment and holding pen) should not take more time than two hours, and the last cow that is milked should not have been standing waiting longer than 60 minutes (2x per day milking), or 45 minutes (3x per day milking). It is furthermore assumed that the first cows immediately enter the parlour and the last cow enters the parlour exactly 60 minutes later, at the latest.

During the modular stages 3 and 4 (60 and 80 cows), the dairy herd can be separated into two groups. In this situation only half the milk parlour capacity is needed.
In the modular stages 1 and 2 (20 and 40 cows), the cows have to wait between the stalls and the outside wall of the barn, before they can be milked. In this situation, some of the cows can lay down while waiting. This slightly reduces the need for milking all cows within one hour and fifteen minutes as long as the stalls are available for the cows that are waiting.

Table 1. Number of clusters needed to milk all cows in 1 hour and 15 minutes:

	Average milk production/day	
Dairy herd:	**15-20 Lt**	**20-30 Lt**
20 cows	3 clusters	4 clusters
40 cows	3 swing over, or 6 (2 x 3)	8 (2 x 4)
60 cows	5 swing over, or 10 (2 x 5)	12 (2 x 6)
80 cows	6 swing over, or 12 (2 x 6)	16 (2 x 8)

Table 1 above shows the growth steps of the milk parlour. The farmer can start milking on one side of the parlour in modular stage 1: 20 cows. And then switch to milking on two sides in modular stage 2: 40 cows. In a herd with a milk production of up to 20 litres per day per cow (+/-), a swing-over system can be used with limited disadvantages. In a swing over system, a cluster hanging in the centre of the parlour is used for milking the cows on both sides. As cows with higher production need more time to be milked out, in herds with higher productions a swing over system is far less optimal as cows have to wait long before the cluster can be attached.

3.2.2. Manure Storage/Waste Water Storage

Until the outside waiting area is constructed (module 3: 60 cows), the manure is collected in an open storage basin. Manure is collected by scraping it off the floor manually. The outside waiting area can be constructed on top of the open manure storage, by building two small walls and making a concrete floor on top. The manure storage can also be used as waste water storage. An overflow construction must be put into place, enabling the waste water to flow to a designated place in case the manure storage basin or pit is full. From this moment on, the manure is scraped and directed into a channel and flows by gravitation into the newly constructed manure storage, next to the holding pen.

Example of poor manure handling: do not let manure run off. Manure is a valuable fertilizer for both food and fodder crops. Proper storage and application on the cropping area is crucial.

3.2.3. Waiting Area (Holding Pen)

In the 20 and 40 cows modules (1 and 2), the alley between the stalls and the outside wall is used as the waiting area. After milking, the cows move into the alley between the stalls and the feed fence. At this moment the feed trough must be filled.
When dealing with more than 60 cows, there is need to construct an outside waiting area or holding pen. The cows must enter this area at the far end of the cow house, away from the milking parlour and most certainly not at the front close to the parlour. A separate alley to this waiting area can be created, enabling the herd to be milked in two groups. In this approach, each group changes pen with each milking.

3.2.4. Treatment/Handling of Cows

In small herds of up to 40 cows, animal handling for health checks, treatments and inseminations are mostly done on individual cows one at a time. Therefore, these treatments can be done with the cow standing in a stall or in another place where she can be tied up. Cows in small herds usually are easy to catch and position. In bigger herds, animal handling, checks and treatments are more often done in groups, with more cows at a time. Spotting, catching and positioning a cow requires more time. This makes a self-locking feed fence a good place to organize and create a facility for cow inspections and treatments and to safe time catching cows.
In the design, a self-locking feed fence is installed when the dairy farm reaches the 3rd modular stage (60 cows). The farmer may also decide to install it in an earlier stage of course.

3.2.5. Milk Storage

When milk volumes grow to volumes of 500-1,000 litres per day and above, an investment in a milk chilling tank is a logical and necessary step. This also may depend on the logistical arrangements in place as regards to milk collection and sales. Some farmers may be able to transport and sell their raw milk immediately after each milking, or store the milk for half a day in milk-cans. The latter is only acceptable if the milk can be kept in a cooled/chilled environment. However with higher volumes being produced and stored at the farm – at some point - a chilled milk tank becomes a requirement for proper raw milk handling and storage, in order to assure micro biological quality.
Milk cooling tanks can vary in size from 500 – 10,000 litres. The advantage of the smallest size cooling tanks is that they can operate on a 2-phase electricity system. The larger sizes need 3-phase, however solutions can be found by fitting 2 compressors on 2-phase rather than one big compressor on 3-phase. A milk tank requires sufficient amount of space. Table 2 shows the estimated milk production in two (2) days for the 4 modules, thus showing the minimal storage capacity required when the milk is collected once every two (2) days. See also Chapter 4.3 for more information about milk storage.

Table 2. Milk production per day as input to decide milk tank capacity

	Average milk production (Lt)/day			
No. cows	**15**	**20**	**25**	**30**
20	600	800	1,000	1,200
40	1,200	1,600	2,000	2,400
60	1,800	2,400	3,000	3,600
80	2,400	3,200	4,000	4,800

3.2.6. Cows: Milk Production and Dimensions

Improved dairy management, in particular feeding and breeding, has an impact on cow characteristics and needs. This in turn has implications on the cow house design, labour needs, management skills and other factors that relate to cow comfort and management. The table below gives an overview on the dynamics at play in the herd and on the farm.

Table 3. Attention list cow characteristics

Cow characteristic:	Change over time:	Impact:
Dimensions	Will increase due to genetics and better young stock rearing.	The sizes of milk parlour entries and stands, stalls and the feed fence will need to be adjusted accordingly.
Feed intake	Increase of milk production comes from an increase in feed intake.	Bigger loads of feed will need to be put in the feeding troughs, which results in more work. Feed requirements increase (production, purchase, storage).
Manure production	Higher milk production = higher feed intake = higher manure production	More manure storage is needed. Alleys might need to be scraped more often. Manure will be less dry and hence different handling requirements.
Need for comfort	Higher milk production puts pressure on the cow's physical systems: she works very hard. Cows have less buffer capacity and are more vulnerable.	Prevention of hoof problems becomes more important: comfortable stalls, dry and flat flooring, no more than 2.5 hours forced standing per day. Susceptibility for heat stress becomes higher.
Heat production	Fermentation, digestion and milk production produce a lot of heat. When milk production increases, heat production also increases.	Prevention and management of heat stress becomes more important. Providing shade and installing fans.
Moisture exhaustion	Higher milk production comes with higher exhalation of moisture via the respiration	Ventilation of the cows' direct environment becomes more important.
In-heat period/ Heat detection	Higher milk production reduces the length of visible in-heat period.	Heat detection requires a higher level of accuracy, more awareness and more accuracy.
Eating/lactating	Cows with a genetically high potential for milk production, have a high feed intake (almost implying that cows produce milk until they drop down) Young stock will more easily get too fat (too high bcs).	Cows need to be very well managed and fed 24/7. Nutrition and care of young stock requires a higher level of management skills and practice.
Metabolic changes during transition	The transition from dry period to lactation contains a bigger change in metabolism. Transition cows become more vulnerable.	Management of transition cows needs more accuracy, skills and knowledge. Transition cows require more comfort and better care.

3.2.7. Special Needs Cows

In Annex 2 (average number of animals present per module in pdf) the average number of special-needs-cows on a weekly basis is shown, i.e. transition cows, calving cows, fresh cows, sick cows. The need for separate facilities for special-needs-cows largely depends on the level of cow comfort in the cow house. The modular design contains a high level of cow comfort and thus requires few facilities for special-needs-cows. A calving-pen or a sick cow-pen will be sufficient for 95% of the time.

3.2.8. Grouping of Young Stock

Grouping of young stock in herds up to 40 cows largely depends on coincidence. In a herd with 40 cow lactating, on average 1 heifer calve is born every 20 days. In a herd with 80 lactating cows, on average 1 heifer calf is born every 10 days. When the farmer strives for a maximum of 4 weeks age difference in a group, on a farm with 80 cows there are groups of maximum of 3 calves. Coincidence has a big effect on these numbers, as in some periods there will be more calves born compared to another. Or there will be more bull calves than heifer calves or vice versa (unless sexed semen is used). When 5 heifer calves in a row are born, this has little impact on a farm with 200 cows. On a farm with 40 cows it has major impact. And the probabilities for this to happen are the same on both farms!
The issues to address and to solve are: the dimensions of free stalls and feed fence, bullying of small calves by dominant larger calves, and inseminations. Practically, the barn design needs to be very flexible regarding dimensions of calves. This is achieved with loose housing and a Swedish feed fence. See Figures 17 and 18 in Annex 1.

Since in the design there is much feeding space available, the risk of older calves bullying away younger/smaller calves can be controlled easily by good feed management. Prevention of feed selection is the main target and providing enough feed is the second target.
Insemination and heat detection with these numbers of young stock is always aimed at individual young stock. The farm management should identify the animals that need to be bred (use a cow-calendar, measure girth circumference with a rope), mark them (colour mark, halter, chalk board, etc.) or remember them, and inseminate them when they are in heat.

3.2.9. Water Supply

The mode of water supply is to be decided for each farm individually as access to piped water, surface water, rainwater and a deep well or a borehole will vary from place to place. In designing a system for rain water harvesting one shall take into consideration the rain fall pattern/seasonality, the daily water use and the rain water storage. In case of extreme rainfall the water collection and storage system will overflow and the design should allow for proper discharge of excess water, in such a way that it does not cause any problems to the day-to-day farm operations.

Table 4. Rain water collection and usage

Module	Number of cows	Width metre	Length metre	Total surface m^2 (1)	Rain water tanks(2)	Water usage cows: Lt/day(3)
20	22	23	25	575	2	3,300
40	40	23	39	897	t.b.d.	6,000
60	60	23	67	1,541	t.b.d.	9,000
80	80	23	78	1,794	t.b.d.	12,000

1 = the amount of rainwater collected in litres equals the millimetres rainfall x the total surface. 2 = total number of rainwater tanks is per case to be decided (t.b.d.) and depends on rainfall, water usage and tank volumes. 3 = the water usage of the cows is a rough estimate

Table 5. Example of rain water collected (Litres)

10 mm rain	after 24hr	20 mm rain	after 24hr	30 mm rain	after 24hr
5,750	2,450	11,500	8,200	17,250	13,950
8,970	2,970	17,940	11,940	26,910	20,910
15,410	6,410	30,820	21,820	46,230	37,230
17,940	5,940	35,880	23,880	53,820	41,820

3.2.10. Essential Points to Consider for each Module

Module 1: 20 cows

- The milking parlour should be made suitable for extension with 2 milking places when constructing module 3 (60 cows).
- The manure transport canal should be constructed in anticipation of moving to module 3 in the near future. Or the design should be such that the manure transport canal can be easily dug in the existing floor when constructing module 3 (60 cows).
- To save costs, the office and machine room do not necessarily need to be constructed in this module. The space for erecting these structures in a later stage/module should however be marked and claimed.

Module 2: 40 cows

- The cross alley at the far end can be constructed without a roof over it, or it can be covered with simple temporary roof.

Module 3/4: 60/80 cows

- The manure storage is removed and replaced by the holding pen.
- The manure transport canal is extended to the new manure storage behind the holding pen (and optional spray race).
- The milking parlour is extended with 2 milking places, towards the outside of the barn and toward the new holding pen.
- A walk alley is constructed next to the new holding pen.

3.2.11. Management to Increase Number of Cows

The dairy farm intends to increase the herd by at least 20 more cows shortly after the completion of a module. The income from the extra milk production is used to pay off the investments.
Buying pregnant heifers (close to calving) is the fastest and easiest way to increase the number of cows. One should be aware that with the higher number of cows, also the number of replacement heifers increases. Bringing in animals from outside the herd and the farm carries the risk of introducing infectious diseases such as:

- Bacteria (digital dermatitis, salmonellosis, mycoplasma)
- Viruses (IBR, BVD, BLV, FMD, RVF, etc.)
- Parasites (mange, lice, intestinal parasites, etc.)

Hence, there should be a programme for selection of healthy animals (certified-free of specific infections) and placement in a four week quarantine period in an isolated area on the farm, or in another (isolated) place outside the farm. During this quarantine period, specific treatments and tests can be executed according to a herd biosecurity plan.
The young stock facilities have space for more animals than just the number of animals needed for replacement. This requires use of the dry lot area outside the barn and more bedding material to keep the loose housing resting-area dry.
The same goes for the cows' area. The dry lot enables the farm staff to overstock relatively to the number of cubicles for a period of time, before the next growth step. In all modules it is possible to create more space to keep higher numbers of animals through the following approaches:

- Construct the area for the cows as designed in the next module. This creates 20 extra cubicles that can be used to house dry cows and pregnant heifers. The area that becomes available in the dry cow/young stock part of the barn can be used to raise more young stock (or bulls).
- Construct the area for young stock as designed in the next module.
- Construct the next module and use the extra space for raising young stock and perhaps bulls to get extra income.

3.3 Design of Floors and Cubicles

Considerations
a.) Flooring
Stalls should be comfortable enough for high lactating cows to lay down at least 12 hours per day in zero-grazing systems. The most important aspect of a stall is the flooring; this should be soft and dry. It should also be non-skid to avoid slipping and falling when the cow lies down or gets up.
The barn plan has deep bedded free stalls. There are stalls without a concrete floor that are filled up with bedding.
By far the best bedding material is sand. Second best, close to sand, are deep bedding materials such as saw dust, (chopped) straw, rice hulls, dried manure solids and other dry materials that do not lead to formation of hard lumps when used in the cubicles.
All in all, mattresses and mats are highly inferior to deep bedding materials because they are expensive, wear off and become harder over time. Rubber mats are usually close to being just as hard as uncovered concrete. And mattresses and mats need a concrete surface underneath. Both mattresses and mats need good daily maintenance including use of drying materials such as saw dust. Research shows that 5 cm of saw dust should be used on mattresses and at least 10 cm on mats or concrete.

- Bring a high risk for the development of bruises, swellings and lesions on hocks and front knees of the cows. These cause pain, infections and lead to foot problems, stress and reduced milk production.
- They provide little grip and a hard lying surface, and therefore hardly contribute to cow comfort.
- They also demand the use of large amounts of bedding.
- They require higher investments (concrete, rubber/mattress).

More information on floor design and construction is presented in Annex 1.

b.) Headspace

The second most important aspect is to create sufficient head space for the cow to swing her head when she lies down or gets up. The stall or cubicle needs a width of minimal 115 cm for a 135 cm high cow. Bigger cows need wider stalls. Optimal dimensions for modern HF cows (700 kg adult weight): 122 cm wide, 255 cm long, open head space, neck rail and brisket locator adjustable in position, distance neck rail and bedding minimal 1.30 cm. (confirm this dimension)

c.) Design

Deep bedding, 115 cm wide, 250 cm long. Neck-rail is adjustable. The Brisket locator is max. 5 cm above bedding level and rounded, position adjustable. If the size of the cows increases, because of genetics, feeding or increased milk production, the size of the barn should be adapted as well. In this barn, this can be done by putting the neck rail and the brisket locator in a different position.

d.) Matching cow sizes with stall dimensions

Cows in the herd and in groups can get bigger, smaller, longer and shorter over time. Variation in dimensions of animals within a group can have big impact on the use of stalls. When barns are too small, the large cows will not lay down enough and may lay with their hind parts outside the stalls. Diagonally laying down is a clear signal that the resting area is too short, that there is not enough head space at the front, or that the neck rail is too far backwards. When stalls are too big, the smaller animals are likely to deposit manure and urine in the stalls.
Therefore, once a year and when indicated, there should be an assessment whether the cows still fit well in the stalls and whether the stalls are still comfortable enough. Use the checklists in the Cow Signals Checkbook for this. When there is much variation in cow size within a group, one can divide the group into a large-cow and a small-cow group, and to suit the stall dimensions for each group.

Use

- Deep bedding: sand, rice hulls, chopped straw, manure solids.
- Fill stalls weekly or minimal once every 14 days.
- Keep level of bedding above curb level.
- Inspect the stalls minimal 3x a day: remove wet bedding and manure, flatten the surface.

Checkpoints

- All cows should be able to stand straight with four feet down in a stall. If not, move the neck rail forward. When there is much variation in cow size in a herd causing dirty stalls, split the herd in a small-cow group and a large-cow group. Adjust stall dimensions accordingly.
- All cows should be able to lie down straight in a stall. When too many cows lie diagonally, move brisket locator forward.
- Clean out manure and wet bedding from the stall 3-4 times per day.
- Ensure that the top 2-3 cm of the last meter of the stall bedding is dry.
- Level of bedding should not be lower than the curb. If so, the bedding should be flattened. When there is not enough bedding for this, bedding should be added.

Good practice: examples of well-dimensioned and comfortable free stalls with deep bedding.

Poor practice: Cows have problems lying down on hard surfaces. This brings stress and health problems and as a result a reduced milk production.

Mattresses are expensive and do not create a comfortable resting surface. Deep bedding that is maintained well on a daily base, is far better for the cows, and will bring more milk and more health

Poor practice: Because of the wall, the cow that wants to stand up cannot lunge her head forward and has problems getting up. The standing cow has problems lying down because of the same reason. The wall also blocks ventilation.

Poor practice: When the stalls are not comfortable the cows will more often ly down elsewhere to rest. Resting in dirty places brings stress, less milk and higher risks for mastitis and wounds.

.

Further reading on free stall (cubicles, beds) constructions

Books: Cow Signals the Basics, Cow Signals Building for the Cow, Cow Signals Checkbook, Cow Signals Hoof Signals.

Websites: Extension America's Research-based Learning Network and Cow Comfort and health

3.4 Feed Fence

Considerations
The feed fence stops cows from stepping into the feed. A self-locking feed fence is used to catch cows and to fixate them for treatments. The feed fence includes a neck rail (post-and-rail barrier). Feed fences should be adapted to the dimensions of the cows. If not, the cows will develop bumps (acquisite bursae) and wounds. A self-locking feed fence is a good investment on farms with 40 or more cows, as it reduces time to catch cows and it facilitates handling of groups of cows. On farms with fewer cows the benefits are less. From an economical point of view, farmers with less than 40 cows can choose not to install self-locking feed fences. The only argument, besides price, against putting in place a self-locking feed fence, is that cows can be too big for a certain size feed fence.

Design
A Swedish feed fence never touches the neck of the cow, but stops the animals at the shoulder. This feed fence matches with cows of almost all sizes. The only issue is with young calves that might step through it. Neck rails almost always give rise to the development of shoulder bumps. See an example of a Swedish feed fence in figure 17 and 18, in annex 1.

Management
Cows should be locked in a feed fence for as short as possible because forced standing creates excessive pressure on the hooves, and thus stress and pain.

Poor practice: Wrongly designed or constructed feed troughs and feed fences force the animals to perform unwanted behaviour, like standing in the feed and contaminating it with manure.

More information on feed fence design and construction is presented in Annex 1.

Further reading
Books: Cow Signals the Basics, Cow Signals Building for the Cow, Cow Signals Feeding Signals.
Website: www.roodbont.com

3.4.1. Breeding Bull(s)

Considerations
Some farmers want to have a breeding bull. In most cases this bull will serve only some of the cows in oestrus, while the majority of the cows are artificially inseminated. Housing bulls on solid floors and in free stalls creates a lot of work as regards to providing them with dry resting places. When their resting places are too wet, the bulls will build up dirt crusts on their sides that can give rise to skin infections. It is very dangerous to house a bull together with the cows!

Housing a bull or bulls

Options for housing a single breeding bull:

- In a separated pen next to the dry cows.
- In a pen located at the far end from the milking parlour or in a pen created in the dairy cow barn.
- In a special pen built on the side of the dry lot, or created by segregating a part of the dirt lot. Feeding this bull requires bringing feed to him.

Mating plan

Option 1: Next to the dry cows

The cow in oestrus can be tied in the separation pen and the bull can be brought to this cow led by a person. The best and most safe option for this is when the bull has a nose ring. The second best option is a halter. When the bull has served the cow he is led back to his pen.

Option 2: Mating in the dirt lot

Best option is to make a temporary pen in the dirt lot, in which the cow in oestrus is put. Then the bull is released in, both cow and bull can be loose. Ensure they cannot go into the barn.
After a certain time, separate the cow from the bull by chasing the bull into the barn and leaving the cow in the dirt lot. Lead the cow back into the herd.

Option 3: Special pen in the dirt lot

In this situation a special self-locking feed fence for a bull should be put in place. Here the bull is locked before the cow is put in, and after he has mated with the cow.

Letting cows being mated by the bull in the dirt-lot requires a specific gating plan that is required to safely and easily separate the bull and the cow. As a bull can be very aggressive when a person wants to separate him from a cow, special attention must be given concerning gate positions and possible exit/escape routes before entering the dirt-lot. The head and neck of mature bulls can be too big for a self-locking feed fence sized for dairy cows. In this case, a special self-locking feed fence for a bull is needed and highly recommended.
Putting bull and cow loose in a pen with a solid floor can easily lead to slipping, falling and trauma of both bull and cow. Cleaning the pen and/or stalls can best be done when the bull is locked in the feed fence, away for mating or tied up.

3.4.2. Schedule for Barn Inspection Rounds

Considerations

Barn rounds serve for daily management of the stables and cow checks. The person doing the barn inspection rounds goes in between the animals. These rounds are standardized, to ensure that every worker follows the same routine operational procedure in which nothing is forgotten.
Four barn rounds are performed every day, two (2) big rounds and two (2) small rounds. The barn rounds always start on the same point and at the same time. The rounds end where they started. The material (stall cleaner, bedding material) is stored here.
Because the person doing the barn round goes in between the cows and gets his boots dirty with manure, at the end point he must be able to clean boots and/or to change boots.
The barn rounds can very well be combined with pushing-up feed towards the feed fence. Almost always it is most logical to first push-up the feed and then do the barn round. The feed push-up will stimulate cows to stand up and go to the feed fence. As a result more stalls will be empty which offers a good moment to observe cow behaviour (oestrus detection, cows not active/not eating well).

Table 6. Barn inspection round schedule

Barn round	Chore	Remarks
1. Major: Before or immediately after milking	• Complete treatment of stalls • Clean floor in cross alleys and other indicated places • Check all cows for oestrus (dry cows: calving) • Check each cow for behaviour, health, feed intake, issues • Tasks that come on specific days: - clean water troughs two times per week	Cleaning of cross alleys must be done shortly before the alleys are scraped
2. Minor: Before or after lunch	• Clean stalls • Check cows for oestrus (dry cows: calving) • Scan cows for behaviour, health, issues	
3. Major: End of the afternoon	• Treatment of stalls • Clean floor in cross alleys and other indicated places • Check all cows for oestrus (dry cows: calving) • Check cows for behaviour, health, feed intake, etc.	
4. Minor: Evening (last round)	• Clean stalls • Check cows for oestrus (dry cows: calving) • Scan cows for behaviour, health, issues.	Combined with feed push up

Further reading
Books: Cow Signals Robotic Milking, Cow Signals Dry cows, special needs and treatments, Cow Signals Building for the Cow. Website: www.roodbont.com

3.4.3. Week-planning

Considerations
A strict planning structure of the work helps to ensure that prevention and maintenance chores are actually performed, like foot bathing, vaccination, cleaning, replacing oil, ordering supplies, etc. It also reduces the possibilities that work is forgotten, like drying-off of a cow on the correct date.

Essential building stones for effective planning and follow up

a) Agenda and white board
In the office the following should be in place:
- The week planning printed and attached to the wall for all employees to be visible.
- A calendar or agenda with ample space for making notes.
- A white board, on which the events and actions that are not in the normal week planning are written down.

b) A fixed work schedule
For dairy herds of approximately sixty cows and more, it is essential to apply a fixed and disciplined work planning. Routine activities should be planned on the same days of each week. With smaller numbers of cows on the farm a routine work schedule is of less importance, due to the fact that less numbers of people are involved and activities may vary more from week to week (some weeks there will be no cows calving, no cows to be dried off, etc.). To establish a structured work schedule it is recommended to apply a Week-Planner and White Board. See an example in Figure 4 below.

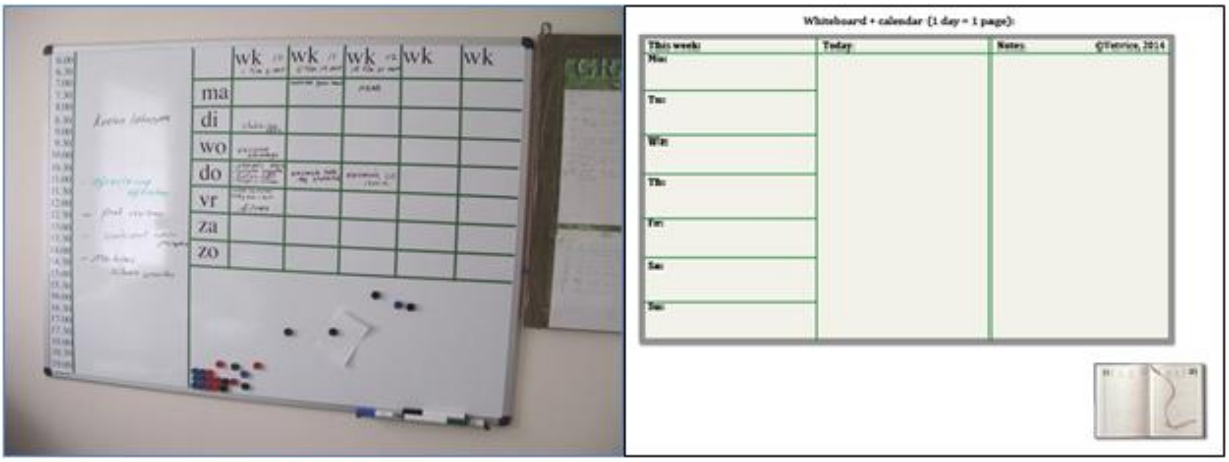


Figure 4. Week Calendar and White Board

3.5 Hygiene and Biosecurity

Considerations

Hygiene at the farm is of utmost importance in all operations. Hygiene covers amongst others the following aspects of dairy farming:

a) Personal hygiene

The design makes the milk room the logical and only entry to the dairy barn. Here boots, overalls and cleaning facilities for hands, materials and boots can be placed. There is a fully equipped toilet including a washing basin.

b) Environmental hygiene

This concerns cleaning and tidying of the grounds and drainage. The organized structure of the design makes it easy to mow grass and offers very few places where people want to put unused or rarely used materials and equipment, and junk. Manure should not leak or run off outside designated areas. All building structures must be equipped with floor drains in order to drain water from floors, washing basins, CIP, toilets etc. Drainage water must be separated from toilets (human excrements and CIP water including lye and acid).

c) Bio-security

- Prevention of infections entering the herd
  The modular design has one entrance to the farm, with the option of a separate entrance for the cows to the pasture (if present). Having only one entrance enables good control and overview over trucks, cars and persons entering the farm. Nobody from outside the farm should be able to have contact with the animals, unless after proper hygienic measures, i.e. washing of hands or wearing gloves and wearing farm clothing (boots, overalls). Preferable the farm is surrounded with a fence that prevents people and animals coming in.
- Reduction and prevention of the spread of infections within the herd
  This aspect of biosecurity has many dimensions:
  - ✓ Early detection, isolation and effective treatment of cases of possibly infectious diseases.
  - ✓ Segregation of groups of animals. This is difficult to achieve on farms with less than 100 cows, although a good attempt is made with the calves that drink milk. These are first housed individually in pens, and thereafter in groups separated from the older animals.
  - ✓ Vaccination and eradication of infectious diseases.

d) Milking hygiene

This concerns hygienic milking procedures and hygienic handling and storage of milk.

- Milking parlour: The milking parlour offers an infrastructure in which best practices are supported:
  - ✓ 1 cloth for every cow
  - ✓ Teat dipping after milking
  - ✓ Cleaning of the stand underneath the udder
  - ✓ Good view on the udder, good light
  - ✓ Comfort for the cow

- General barn design:
  - ✓ Placement of lights
  - ✓ Hygienic properties of the floor underneath the udder: it should be possible to rinse or swipe manure, milk and water away
  - ✓ Enough space, no potentially harmful constructions for the cow

- Milk room: The milk room offers all facilities for cleaning of milking equipment, milk cans and other milk storage equipment.

Table 7. Milk-room facilities and requirements

		20 Cows module	**40 Cows module**	**60 Cows module**	**80 Cows module**
Daily milk production (Lt):		**400**	**800**	**1,200**	**1,600**
	Requirements:				
A.	Aluminium milk-cans (Cap. 50 Lt)	10	20	-	-
B.	Milk cooling tank (Cap. 2 Tonnes) Incl. CIP / Milk dispatch pump)	-	-	1	1
C.	Machine-room (condenser/vac) o (high) voltage electric power	-	-	1	1
D.	Hot water boiler	1	1	1	1
E.	Washing basin for milk-cans: o Pre-rinse (cold) o Washing (hot) o After rinse (cold) o Dry-rack (milk-cans)	1	1	1	-
F.	Utilities: o Desk w/cabinet (small tools) o Scale (milk-cans) o Strainer with sieve	1	1	1	1
G.	Floor Drainage of water	1	1	1	1

Critical control points as regards to the above table are:

a) Washing basins section

In this room the following equipment/facilities are located or available:

- Washing basins to clean aluminium milk-cans (pre-rinse cold/hot cleaning/cold post-rinse)
- Dry rack holder (for milk-cans)
- Availability of hot and cold water

b) Milk-room
In this room the following equipment is located:
- Milk cooling tank
- CIP/milk-dispatch pump
- Milk cleaning system/basins
- Hot and cold water (taps)

c) Machine room
In this room the following equipment is located:
- Electric power back-up (separate fuel storage outside building)
- Vacuum pumps milking machine
- Condenser unit (milk-tank)
- Hot water boiler
- Electrical switch board
- Storage cabinet (oil and spare parts)

d) Office
In this room the following equipment is located:
- Desk set with storage facilities for parts, medicines (refrigeration)
- Fridge (milk samples)
- Small spare parts storage

e) Toilets
In this room the following equipment is located:
- Toilets including washing basin

Table 8. Separate (room) structures typical measurements (indicative m²)

	Structure	m²
1	Washing basin (milk-cans)	12
2	Milk-room	18
3	Machine room	16
4	Office	9
5	Toilets w/washing closet	4

Essential building stones for hygiene/biosecurity
- Only one single entry to the farm for people, trucks, cars, etc. A gate around the farm, that keeps persons and animals out.
- When cows have access to pasture, the pasture should also be fenced-off for persons and cattle of all ages. Also dogs and wild animals should be stopped to get in.
- Planned set up of the farm buildings and driveways, so mowing of grass is easy and there are no places where junk or unused materials and equipment is stored.
- Treatment of animals must be an easy and safe job, under circumstances that make good quality of work possible. For herds up to 80 cows all treatments can be well organized and performed in cubicles or in the feed fence, including vaccinations and hoof trimming. Udder treatments are best performed in the milking parlour.
- Calves up to 4-6 months of age should be housed separately and not mixed with older animals. Young calves suffering from diarrhoea should be separated from other young calves, which can be achieved by solitary housing.
- The barn(s) with animals should have one logical entry. Before entering the barn there should be a space for washing hands, disinfecting booths and with overalls for visitors and staff.

- The milk room must be equipped with necessary facilities for cleaning of milking equipment, milk collection materials and with facilities for correct storage of milk. It should be a functional, safe and comfortable place to work. Cleaning must be very easy (smooth floors). There should be no places for entry and staying for mice and rats.
- The milking parlour should be a safe and comfortable working environment (light, temperature, noise, constructions, space) both for people and for cows.

Management
The actual level of hygiene highly depends on management, maintenance, awareness and routines. The planning should have fixed events for:
- Cleaning
- Managing supplies
- Maintenance of equipment and facilities
- Training and instruction, including consultancy
- Monitoring of hygiene, diseases and infection risks.

Further reading
Books: Cow Signals the Basics, Cow Signals Building for the Cow, Cow Signals Dry cows, special needs cows and treatments, Cow Signals Udder Health Large Herd Edition.
Websites: www.roodbont.com and google on "bio-security dairy cows".

3.6 Treatment and Handling Dairy Cattle

Considerations
On several occasions and for various reasons cows need to receive medical treatment. When the facilities and procedures are good, cow handling and treating is a safe job that can be performed in a well-controlled manner, leading to the following two objectives:
- Treat a cow as soon as possible after diagnosis of the nature and cause of an illness.
- Give preventive treatments according to the planning.

Essential building stones for treatments and handling of cows
Cows must be well positioned in good facilities for treatment. What is considered good depends partly on the treatment that needs to be given. The treatment process must ensure minimal (dis-) stress for the cow. This depends partly on the treatment facilities and partly on the way the animals are put in the facility, handled and herded (herdmanship).

Management
- For cow barns that are designed for a capacity to house up to approximately 100 cows, a self-locking feed fence is the best facility for many treatments, for example: vaccinating, fertility checks and inseminating. An important issue that requires attention when using a self-locking feed gate, is that cows should not be left standing locked-in for periods longer than 45 minutes.
- In a barn that is designed to house over 40 cows a separation pen is created, in which a self-locking feed fence is installed and used to fixate a cow.
- In barns designed to house up to 40 cows, the farm staff can work well by catching cows in the free stalls, and/or by using halters to fixate them.
- Hoof trimming requires the most specific treatment facility or structure.

The following activities can be organized in a free-stall at the different sections/locations:

- Dry cow treatment: Cows can be separated after being milked in the parlour. Immediately after milking time, they are herded back into the parlour where they are given dry cow treatment.
- Hoof trimming (individual cows): In the wooden free-stalls a rope is used to tilt up the hind legs or the front legs. In the iron free-stalls, one free-stall can be equipped with a hoof trimming construction. Or a special mobile hoof trimming chute can be used.
- Hoof trimming (group treatments): In farms with up to 40 cows, it is advised not to hoof-trim the whole herd at one day, but to do the hoof trimming based on a plan (strategic trimming):
  - ✓ Every cow at drying off
  - ✓ Every cow at 80-100 days in milk
  - ✓ Every cow that shows signs of hoof problems
- When specialized hoof trimming services are available through a trained external service provider, group trimming will be the best approach. The person who offers this service will bring his own hoof trimming chute. In herds over 40 cows, the farmer can choose between either strategic trimming or group trimming. Group trimming needs a free-stranding hoof trimming chute.
- Vaccinations: When a self-locking feed fence is available, one should vaccinate cows when all are locked in. If a self-locking feed fence is not in place, the cows can be locked very closely together in the barn for vaccination. In herds over 40 cows, the track going to the holding pen can be used to vaccinate cows.
- Clipping cows*:* Tie up the cow with a halter, or lock her up in the self-locking feed gate.
- Intra-mammary treatments*:* In the milk parlour, during milking.
- Intra-uterine treatments: In the self-locking feed gates or in a free-stall. In the self-locking gates, it is most helpful to lock-in cows next to the cow that is treated. These cows block the sideways movements of the cow that needs treatment.
- Clinical investigation, operations and treatments by a vet*:* Best place and setting is chosen by the vet. This will either be in the lactating herd, in the calving pen or outside the pen.
- Calving help*:* This is done in the calving pen.

CHAPTER 4: COST CALCULATIONS FOR THE MODULAR BARN DESIGN

This chapter gives a summary of the cost of construction of the modular cow house design (4.1). In addition to that, it presents data and forecasts on herd development (per age group), expected milk production, feed requirements and manure production for each module. These data are indicative and merely serve as example to stress the importance of the need for forward planning.

Forward planning is essential in a situation where the farmer has a clear growth strategy. The information will assist in timely investments to assure sufficient capacity as regards to animal housing, milk storage/chilling and transport, manure management, feed storage and fodder production. The latter requires a fodder cultivation plan that includes type of fodder crops grown and numbers of acres required based on herd size and anticipated expansion one year down the line.

4.1 Cow House Construction Costs

The design drawings for the modular cow house are presented in Annex 3. The local consultants who were engaged in the compilation of this Handbook, prepared BOQs and costings for the construction of the modules 1-4, at Kenyan prices and locally available building materials. Detailed BOQs and construction cost calculations are presented in Annex 4 for each module. A detailed BOQ and cost calculation for a biogas digester is presented in Annex 5. The tables below give a summary of the construction costs for the cow house modules and a biogas digester.

4.1.1. Construction Costs Cow House Modules 1-4

Table 9 gives the construction costs for each module in KES. The figures are indicative as prices of building materials may differ per region, depending on availability and source of origin. For each module a price is given for "wood" and for "steel" to allow for different choice in building materials Timber is cheaper but less durable. Steel on the other hand needs good care to protect it against corrosion (especially caused by manure).

Table 9. Approximate cow house construction costs in Kenyan Shillings (KES)

Material	Timber		Steel	
	Total	Per cow	Total	Per cow
Phase 1: 20 cows	4,866,000	243,300	6,450,000	322,500
Phase 2: 40 cows	7,841,750	196,044	10,224,750	255,619
Phase 3: 60 cows	10,627,000	177,117	13,815,000	230,250
Phase 4: 80 cows	13,032,750	162,909	16,989,750	212,372

See detailed construction costs in Annex 4

Figure 5 on the next page shows the lay-out of the 4-modular cow house design for illustration purposes. Other design drawings and a 3D presentation are provided in Annex 3.

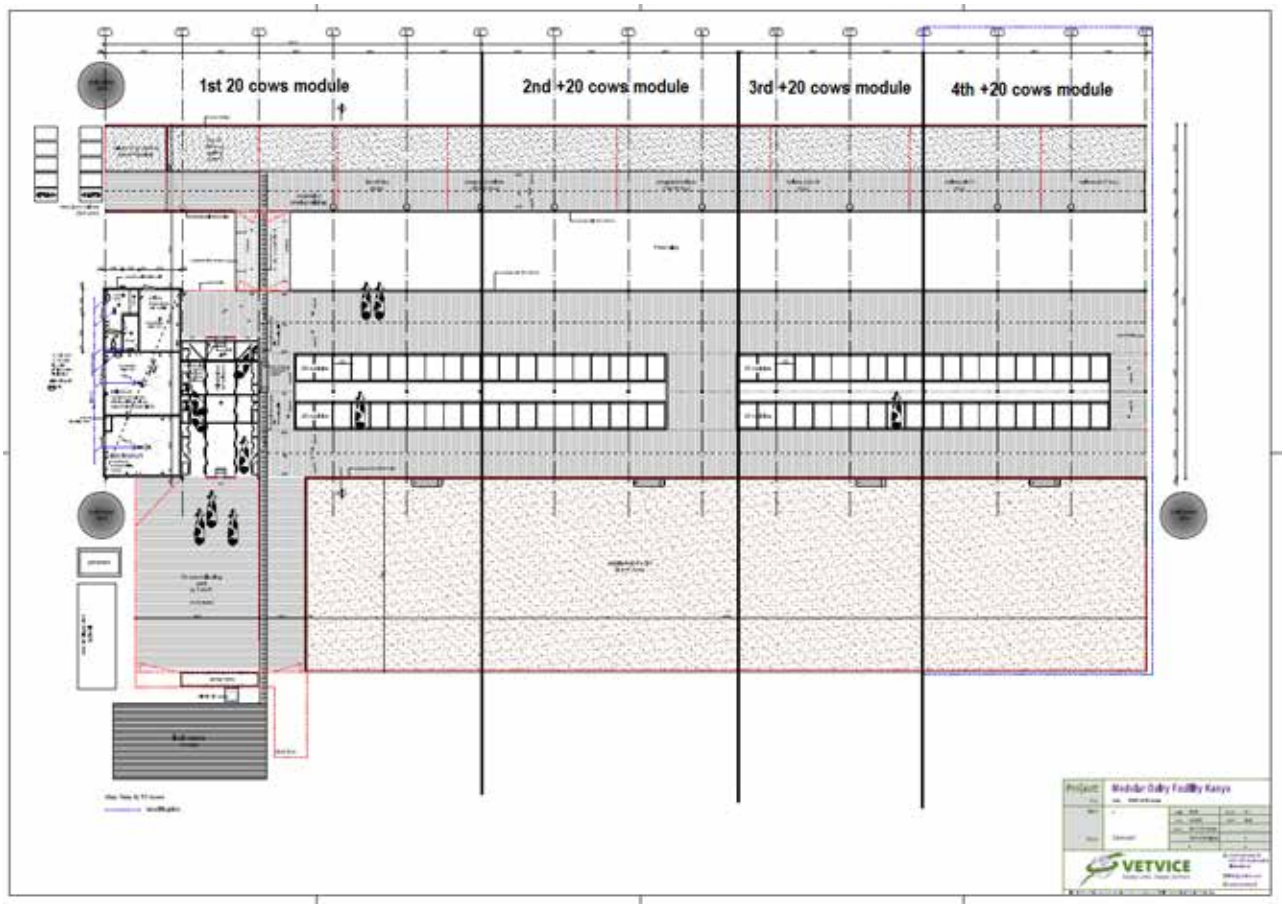


Figure 5. Cow house modular design with 20 cows per module

4.1.2. Biogas Digester

In the event a biogas unit is considered, a typical design and BOQ of the construction materials – including indicative pricelist - are shown in Annex 5. The design drawings show four different capacities, viz. 4, 6, 9 and 13 m^3. The estimated construction costs are shown in the table below.

Table 10. Biogas estimated construction cost

Capacity	4m^3	6m^3	9m^3	13m^3
Building materials	30,485	46,443	55,962	66,756
Biogas materials	2,730	1,560	1,560	2,460
Company fees	11,028	14,568	16,644	19,140
Totals	**44,243**	**62,571**	**74,166**	**88,356**

4.2 Herd Development

As mentioned in the introduction of this chapter, in case a farmer wishes to expand his dairy farm and has a clear growth strategy, he needs to do forward planning. Expansion of the herd has various implications in terms of housing and feeding requirements, but – of course - also as regards to milk production and storage. As for cow housing, the number of animals per different age groups have different housing requirements, including measurements. This has its impact on the design of the stable interior and the layout of the cow house. The table below illustrates – in a typical example - what happens to the herd size and composition when moving from module 1 to module 4. The young stock that is part of the herd in the example below is only replacement stock.

Table 11. Herd development (established situation)

Scenario	20 cows		40 cows		60 cows		80 cows	
	Pos.*	Neg.	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.
Cows in lactation	20	20	40	40	60	60	80	80
Cows dry	2	2	4	4	6	6	9	8
Pregnant heifers **	0	0	1	1	1	1	1	1
Total lactating + Dry	**22**	**22**	**45**	**45**	**67**	**67**	**90**	**89**
Calves	1	1	3	4	3	3	4	4
Weaned – 6 months	1	1	3	3	4	4	6	6
7 – 12 months	2	2	5	5	7	7	9	10
13 – introduction	4	9	9	18	13	27	17	37
Pregnant heifers	3	3	5	5	8	8	10	10
Total young stock	**11**	**16**	**25**	**35**	**35**	**49**	**46**	**67**
Total head	**34**	**39**	**73**	**84**	**105**	**119**	**140**	**160**

** Pos. = scenario: age at first calving 24 months, calving interval: 420 days and replacement 20%.*
** Neg. = scenario: age at first calving 36 months, calving interval: 460 days and replacement 20%.*
*** Pregnant heifers 6 weeks before calving.*

The herd development table presents two scenarios: viz. a scenario reflecting the number of animals in the desired situation (subscript "Pos") and a second less desirable scenario (subscript "Neg"). See for more detailed information Annex. 2 Dairy Herd Number Calc Tables. The Annex includes an example of reports that can be generated by Vetvice showing treatments in relation to herd size.

4.3 Milk Production and Milk Storage

Forecasting milk production is not only required from a financial point of view (sales and income) but also for logistical reasons, in terms of milk storage and milk transportation. Table 12 shows annual and daily production for the 4 modules and for 2 average production levels (with Pos/Neg. scenario).

Table 12. Milk Production (indicative)

Scenario	20 cows		40 cows		60 cows		80 cows	
	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.	Pos.	Neg.
Based on average production of 7,000 litres milk/cow/year:								
Annual milk production (Lt)	133,833	122,196	273,750	249,946	407,583	372,141	547,500	494,337
Average per day (Lt)	367	335	750	685	1,117	1,020	1,500	1,354
Based on average production of 4,000 litres milk/cow/year:								
Annual milk production (Lt)	76,476	69,826	156,429	142,826	232,905	212,652	312,857	282,478
Average per day (Lt)	210	191	429	391	638	583	875	774

The forecast of milk volumes is of particular importance to timely invest in the required storage and capacity and transport of raw milk. Use of aluminium milk-cans (cap. 50 Lt.) may be an economical way of collecting and storing the fresh milk up to 1,000 litres per day. In this case the raw milk should be dispatched twice daily to a receiving party that is equipped with a chilling tank (e.g. a processor). It is not advisable to store milk overnight at the farm without chilling!
The installation of a milk cooling tank may be considered once milk volumes reach in excess of 1 ton per day (replacing the aluminium milk cans). While determining the required milk storage capacity of a milk chilling tank, consideration must also be given to the duration that milk can be stored at the farm. For example if milk is stored for 2 days, the milk storage capacity must equal 2 x 1,600 Lt = 3,200 Lt for scenario 80 cows (Pos.*).

4.4 Feed and Feed Storage Requirements

Feed requirements and storage capacity also increase when a farmer expands the herd and moves from module 1 to 4.

a.) Feed ration

The required storage capacity for forages - e.g. silage and hay – is largely determined by the feed ration and the herd size. The feed ration gives insight in the different types of forages that are used on the farm and whether these concern fresh or preserved fodder (such as maize/grass silage or hay). An important parameter in this respect is the total daily dry matter (DM) intake or requirement for each different group of animals categorized by age or type (e.g. lactating cows, dry cows, pregnant heifers, calves etc.), and the actual dry matter content of the different feeds (including forages) used in the ration.

In order to achieve an optimum milk production, the feed ration must be determined in consultation with an animal feed nutritionist. Based on the available feed ingredients, feed prices and nutritional values of the different feed ingredients, an optimum feed ration can be calculated pegged on an estimated/desired level of milk production. In the table below an example is shown of such a dairy feed ration, based on an average milk production of 7,400 kg/dairy cow.

Table 13. Typical example of a feed ration

	Kilogramme Dry Matter (DM) ration						
Feed name	**Cows lactating**	**Cows dry**	**0 – 3mth calves**	**4 – 6mth calves**	**7 – 12mth Calves**	**13–15mth heifers**	**Pregnant heifers**
Lucerne	1.95			0.40	1.00	1.00	1.00
Maize silage	7.80	3.40		1.00	1.00	1.00	2.10
Rhodes grass hay	1.95	1.70	1.00	0.40	1.00	1.00	1.00
Napier grass hay	-	5.00					
Oats straw	0.50						
Total forages	**12.20**	**10.10**	**1.00**	**1.80**	**3.00**	**3.00**	**4.10**
Maize grain	3.40		0.75	1.00	1.00	1.50	1.00
Wheat bran	1.70	1.70			1.00	1.00	1.00
Wheat pollard							
Soy bean meal	1.70		0.75	1.00	1.00	0.50	
Sunflower cake	0.90					0.50	1.00
Lupine seed meal	0.90	1.70					
Limestone	0.06						
Sodium Bicarbo	0.12						
Mineral mix	0.19	0.20		0.03	0.03	0.05	0.07
Total concentrate	**8.07**	**3.60**	**1.50**	**2.03**	**3.03**	**3.55**	**3.07**
DM intake/head	**21.17**	**13.70**	**2.50**	**3.83**	**6.03**	**6.55**	**7.17**

The feed ration can also be based on the whether the farmer targets a maximum or an optimum milk production. The maximum milk production level attainable with the breed on the farm, may not lead to the highest profitably or "margin" for the farmer. This is e.g. the case when aiming at maximum production may disproportionally increase the cost of feeding as a share of the total cost of milk production. The optimum milk production may be well below the maximum or potential milk production of the cow however profitability of the dairy enterprise may be higher.

b.) Total feed requirement

Based on the expected herd development (see Table 11) and the feed ration-in-place (see Table 13), the total (annual) feed requirement can be calculated. Care must be given to cater for harvest, feed and storage losses.

An example of the annual feed requirement of an 80 cows farm module (module 4) is presented in Annex 6. For each feed ingredient or forage in the feed ration, the total storage capacity is derived from taking the figures for the total weight in dry matter (DM) and the average weight per cubic meter. Reference is made to Tables 14 and 15 for the required storage capacity for maize silage and lucerne hay respectively for module 4 (80 cows).

- Silage storage

Silage is stored in a bunker preferably made of concrete (floor and walls). The measurements (length, width, height) of the bunker depend on the amount of silage that needs to be kept over a certain period of time and the feeding needs or feeding speed per day. As a rule of thumb every day about 2 meters should be fed out of the silage bunker to prevent quality losses.
In the example presented in Annex 6, a total of 269 tonnes dry matter of maize silage is required per annum (868 tons x 31% DM = 269 tons). In order to calculate the required size of the silage bunker(s) it is necessary to know the reference standard of product DM kg/m^3 in relation to different bunker sizes (width and height).
As per the example of the above mentioned annual feed requirement (maize silage, Annex 6) a sample calculation of the required maize silage bunker space is presented in the table below.

Table 14. Maize silage bunker measurements (without soil cover)

Side height	**Kg. Dry Matter per metre length bunker with width of:**					
metres	**8 metre**	**9 metre**	**10 metre**	**DM kg/m^3**	**-5% ***	**Net DM kg/m^3**
1.5	3,530	3,970	4,410	245	12.3	233
1.8		4,740	5,250	250	12.5	238
2.0		5,280	5,865	255	12.8	242

Maize silage harvest		
269 tonnes DM (see Annex 6) ……	269,035	total kgs of DM annually (80 cows + young stock)
Divided by Net DM kg/m^3 (233) ….....	1,156	m^3 silage bunker capacity required (269,035 / by 233)
Total length of ……..…...	96	metres silage bunker
	3	number of silage bunkers
Practical length +/- 30 – 40 mtr …….	32	metres length per silage bunker
	1	additional length (silage bunker ends)
	99	metres total length required (in metres)

(*) = correction is made to silage density in Kenyan situation of -5%.

- Hay storage

Hay is stored in a hay shed or barn, which usually is a simple open structure with a roof. The measurements of the hay shed depend on the amount of hay that needs to be kept over a certain period of time. In the example of Annex 6 a total of 156 tonnes of dry matter of Lucerne and Rhodes grass hay is required per annum (respectively Lucerne 88 ton x 85% = 75 ton DM and Rhodes grass 96 ton x 85% DM = 81 ton DM, total 156 ton DM).
In order to calculate the required measurements of the hay shed one needs to know the average weight in dry matter per cubic metre of hay. In this example this is put at 180 kg of DM per m3.
Based on this, the required measurement of the hay shed for Lucerne and Rhodes grass for the 80 cow module/feed ration presented in Annex 6, is shown in the Table 15.

Table 15. Hay storage capacity

	Tn DM	Tn Product	Kg/m³	Totals			
Annual production:							
- Lucerne hay	75	88	180	488	m³		
- Rhodes grass hay	81	96	180	531	m³		
				1,019	m³		
Number of hay sheds:				1	X		
Capacity per hay shed:				1,019	m³		
					metres		
				m³	*w*	*l*	*h*
Storage capacity and measurements per hay shed:				1,100	10	22	5

4.5 Manure Production and Storage

Manure production

In order to calculate the required manure storage capacity, the manure production of each different animal per age-group must be known and the level of milk production per dairy cow.
In Table 16 an example is given of the average annual manure production (m3) per animal age-group with an average milk production of 7,500 kg/lactation.
It should be noted that total manure production and storage capacity depend on the farming system that is in place. For example free grazing or semi-zero-grazing versus full zero-grazing makes a huge difference. In the given example it is assumed that all animals are housed in the stable all year round. However, an allowance of minus-25% in the total annual manure collection is applied, due to the fact that the lactating herd has access to a free walking area. Furthermore, it is assumed that the manure of calves (age 0–3 months) is collected separately and does not enter the main manure collection/storage facility.

Table 16. Manure production per annum

Animal type / age group	m³*	loss**	loss	total	Avg. animals present Scenario 20	40	60	80	Production m³ Scenario 20	40	60	80
Mature cows	18	25%	4.5	13.5	22	45	67	89	300	601	901	1,202
0 – 3 months***	0	25%	-	-	1	2	3	4	-	-	-	-
4 – 6 months	3.2	25%	0.8	2.4	2	3	5	6	4	7	11	14
7 – 12 months	8	25%	2.0	6.0	2	5	7	9	14	27	41	54
13 – 15 months	11	25%	2.8	8.3	4	9	13	17	35	70	105	140
Pregnant heifers	11	25%	2.8	8.3	3	5	8	10	21	41	62	83
38.4					**Total per year (m³)**				**373**	**746**	**1,119**	**1,493**
					Loss (m³)			3%	11	22	34	83
					Collected per year (m³)				**362**	**724**	**1,086**	**1,448**
					Avg. collected per day (m³)				**1.0**	**2.0**	**3.0**	**4.0**

* = *based on an average 7,000 kg/milk/cow and 100% summer feeding.*
** = *loss due to free walking in sand or soil yards.*
*** = *manure from calves (age 0 – 3 months) is handled separately (as solids).*

Manure storage capacity

The farmer not only needs to know the daily/monthly volumes of manure produced by the herd in the cow barn, he also needs to plan for sufficient storage capacity. This not only depends on the volume produced by the cows, but also on the use of the manure. For example whether this is to be applied on the land where forage or other crops are grown, it is fed into a biogas digester, or gets sold to third parties. The latter is not uncommon in Kenya, especially for farmers in peri-urban areas with little land.
The intended use of the manure has implications for choices and investments as regards to the structures and facilities needed for storage and management. In the example provided in Table 17

the assumption is that the manure is used to fertilize the arable land of the dairy farm. Since manure cannot be distributed on the land all year round due to cropping- and rainy-seasons, it is essential to know the period that manure must be stored. In the example given below a period of 180 days is taken.

Table 17. Manure storage (used as fertiliser)

Required collection & storage capacity		**Scenario**		**20**	**40**	**60**	**80**
Mixing tank	3	days	m^3	3	6	9	12
Total production	183	days (0.5 year)	m^3	181	362	543	724
Storage buffer capacity	20	%	m^3	36	72	109	145
Required total storage capacity			**m^3**	**217**	**434**	**652**	**869**

Tank measurement required	**w**	**l**	**h**	**m3**			
Mixing tank:	2.0	3.0	1.0	6	6	6	6
1. Storage tank **20** cows:	10.0	9.0	2.5	**225**			
2. Storage tank **40** cows:	10.0	17.0	2.5		**425**		
3. Storage tank **60** cows:	10.0	17.0	2.5			**638**	
4. Storage tank **80** cows:	10.0	23.0	2.5				**863**

4.6 Other Farm Buildings and Storages

In Chapter 2.4 a number of other farm structures and buildings have been mentioned, which are essential for a professional commercial dairy farm.
This includes for example a feed store where dairy concentrates, minerals and other feed ingredients are stored, either in bulk or in bags. Here also usually milling (if applicable) and mixing of the different feed ingredients take place. It is important to avail sufficient space for this feed store and for storage of the dairy meals produced (or purchased) to complement the forages in the feed ration. This feeds store needs a robust weather proof design, should be lockable and well insured (including the goods stored inside).
Other farm structures that need to be considered in the farm plan are buildings for storing of agricultural inputs like fertilisers, seeds and chemicals and small tools. In addition to that, a shed for parking and safe-keeping of farm machinery - and a workshop for maintenance and repairs and storage of spare parts and lubricants - needs to be present on the farm.

4.7 Summary Farm Structure Measurements

The table on the next page gives a summary is of the main farm structures and recommended measurements as presented in this Handbook for each module.

Table 18. Farm structures measurements (summary) indicative in metres

		Scenario			
Name farm structure		**20**	**40**	**60**	**80**
Silage bunker[1]:	l	25	50	74	99
	w	2	4	6	8
	h	1.5	1.5	1.5	1.5
	m^3	298	596	894	1192
Hay shed:	l	6	11	17	22
	w	10	10	10	10
	h	5	5	5	5
	m^3	275	550	825	1100
Manure storage:	l	9	17	17	23
(with storage capacity 0.5 year)	w	10	10	15	15
	h	2.5	2.5	2.5	2.5
	m^3	225	425	638	863
Farm machinery store and workshop:	l	10	10	20	20
	w	10	10	10	10
	h	4.0	4.0	4.0	4.0
Agriculture store:	l	5	5	10	10
(seeds/fertiliser/chemicals)	w	8	8	8	8
	h	4	4	4	4.0
Feed storage and handling area:	l	7.5	7.5	15	15
(concentrates)	w	10.0	10.0	10.0	10
	h	4.0	4.0	4.0	4.0

[1]: The face of the silage should move forward with a minimum speed of 2 meters per week.

CHAPTER 5: PLANNING AND IMPLEMENTATION

Setting-up a new - or expanding an existing - dairy farm is a heavy investment, not only as regards to the cow house and the herd, but also in connection to the support functions referred to in the former chapters. Timely planning and a well-considered step-by-step approach are therefore critical to avoid mistakes and failure. For example production of fodder needs to start one year before the new stock arrives.
Especially in dairy farming long term planning is essential. Typically it takes three (3) years of planning and preparation before a calf starts to produce its first milk! Where a new dairy farm is to be established, it is recommended that a comprehensive planning cycle is made and followed. This planning cycle has 5 steps or phases:

a) Concept plan
b) Business planning and financial feasibility
c) Preparation and planning
d) Implementation (construction)
e) Training and management.

In the concept stage, the project idea is borne and appraised as a viable and interesting business opportunity – pending validation of assumptions as regards to investments, costs and turnover.

Thereafter a business plan is prepared. Particularly this plan gives detailed information on the level of required investments, operational costs, sales and incomes, and the expected profit margin or IRR.

Once the project is sanctioned by the owner, the building plans and time schedules, bills of quantities, contracts with contractors and suppliers are prepared, and the licenses and permits are acquired.

The implementation stage is the beginning of the actual construction (ground breaking ceremony). During this phase – or even before - timely attention must be given to ensure that sufficient feed is grown, key staff is trained/employed and other support functions are in place.

Although the complexities concerned with building a 20 cow modular cow house and a 80 cow module are quite different, the principles and the importance of a well-planned phased approach, remain basically the same.

5.1 Concept Plan

At this stage, and in order to make some fundamental decisions about the projected business enterprise in relation to its scale, scope and products, the project owner must obtain good knowledge and understanding of the local dairy industry. Some fundamental issues that need to be considered and decided upon before preparing the farm business plan may include:

- The market dynamics and trend as regards to the demand and sales of raw and processed milk (buyers, price, government policy).
- The potential and profitability of processing raw milk on the farm (cheese, yoghurt).
- Whether the dairy farm shall produce its own fodder (ref. land requirement, investments in farm machinery, stores).

- Whether there exists a lucrative or potential market for fattened bull calves (cow house design)?
- To keep female young stock – next to herd replacement – for rearing and breeding pregnant heifers.

In addition, attention must be given to many other practical issues, ranging from the outlook of the dairy industry and government policies, access to public utilities, the location of the farm and the siting of the cow house and other buildings, the preferred breed of dairy cattle, the amount of land needed for fodder production, and so on and so forth. A brief description is given below of some of the main areas of concern.

a. Dairy sector landscape and government policies
In order to prepare a good business plan, an overview must be obtained about the national landscape of the dairy industry (demand, prices, processors and other buyers, etc.) and the national policies in place. The latter is important e.g. as regards to the regulations on the sales of raw milk, prevailing tax incentives such as exemptions on dairy and farm equipment, and VAT policies. In addition government may have – or is developing – hygiene and animal welfare standards for commercial dairy farms, and investors are likely to acquire permits and building licenses.

b. Roads, electricity and water
The farm needs to have easy access to all-weather roads, (preferably 3 phase) electricity and clean water. Long distances and travel times have much impact on the operational costs of the farming enterprise and the quality of milk delivered to the market.

c. Water drainage
To have good drainage on the farm attention must be given to sufficient slope in order to properly discharge excess rain water. A slightly sloped landscape also facilitates the handling of manure, which requires gravity to transport it from collection gutters to a holding area (and/or bio-gas processing). For this reason the stables are preferably positioned at the highest point of the projected project site.

d. Availability of suitable land for dairy farm structures
In the event an entire new farm needs to be developed and the farming location has yet to be selected, it is most important to consider some critical selection-criteria in order to identify the most suitable location where farm stables and other farm structures can be established. These are related to access of roads, electricity supply, water (drainage), conducive climatological conditions such as temperature and rainfall, and the presence of good and abundant arable land for fodder crop production. Fields for fodder production should be close to the cow stable to avoid long distances in bringing the forages to the cows (and manure on the land). If a farm is feeding fresh grass in a cut-and-carry system the grass fields are to be situated immediately adjacent to the cow house. Preserved feeds in silage bunkers and hay barns need to be at arm's reach to the cow house.

e. Preferred breed of the herd
At this stage also attention must be given to the cattle breed that suits the business plan best. Basic decisions need to be made on whether to select a typical dairy breed, such as Holstein Friesian or Jersey, or a dual purpose cow (e.g. Fleckvieh). The latter produces less milk compared to a typical dairy breed, but has better milk-meat value ratio. The choice of breed also has implications to the design of the stables, as each breed requires different stable measurements and size of cubicles.

f. Size of land in relation to feed/forage requirements

With regards to the required amount of land some basic decisions need to be made, depending first of all on the availability of dairy feed and whether land is needed to cultivate forages.
The cost of feed may be as high as 60-65% of the total cost price of milk. It is therefore important to understand the cost drivers of feed and ideally the production of forages on-the-farm is part of the business plan. Although the investment is considerable - in land, machinery, manpower – it is the best guarantee to secure sufficient and timely supply at affordable prices or costs. Supply of forages by third parties, may be considered, although it exposes the farmer to extra risks and disadvantages- particularly in regard to seasonality in prices, timely supply of sufficient quantities and quality.

Sufficient area must also be reserved for the storage of silage and hay in pits respectively barns. Other structures to consider if growing forages on-site are the farm machinery shed and an agricultural input store (fertiliser, seeds, chemicals etc.). With regards to the siting of these structures on the farm, considerations must be given to security, safety and efficiency. Hay stacks or barns are for example preferably located at some distance from other structures as a result of the risk of fire.

Planning for herd development and forage production usually go hand in hand, as the growing herd requires more fodder. In Kenya dairy farming is rain-fed with usually one long and one short rainy season, of which it is not uncommon that one fails. This requires forward planning and large storage capacity of forages, notably maize silage that can cover a period of at least 18 months. For this reason it is also advisable to include extra land in the initial business planning, which enables expansion of forage crop production, next to the land space required for expansion of stables and utilities (NB: as a simple guideline a herd of 20 cows and young stock needs approximately 40 acres of land for fodder maize for silage to cover a period of 18 months).

g. Time planning

It is recommended that a time schedule or plan is prepared as part of the concept stage. The time schedule addresses the major timelines as regards to actions to be taken and deliverables. Briefly these can be categorised as follows:

- Planning and preparation (hardware supply, contracts, permits and licenses etc.)
- Construction
- Cultivation of forages (harvested and stored before the arrival of cattle)
- Sourcing of cattle
- Training/employing farm manager/workers
- Start farming operations.

Although this Handbook provides exhaustive information about the stable design, it is nevertheless advisable to involve an architect in the preparation and planning phase of the project. An architect may assist in obtaining permits and licenses and could provide other services during the construction (including supervision). The architect – possibly in consultation with a dairy consultant - will also be able to advice as regards to any diversions from the plan.

Well in advance of the arrival of cattle, feed sources and supply must be organised. Reliance on on-farm forage production requires planning at least one year ahead in terms of land preparation, cultivation, harvesting and fodder preservation. Ideally the feed storage facilities are fully stacked at the moment cattle arrive at the farm.

The arrival of cattle is a critical deadline in the project planning and therefore, a major reference point to the whole project planning. In this regard also possible quarantine periods and/or veterinary health requirements need consideration (transportation of livestock).

5.2 Business Planning and Financial Feasibility

Once the concept plan is accepted and validated, a business plan is developed. The business plan shows the financial or commercial feasibility of the proposed project. Irrespective of the project size, the business plan should include a description of the business operations, the required investments, the operational costs including salaries and staff qualifications, sales & incomes and a timeline.
If so required or desired, the business plan could be divided in two parts: one business plan for only the dairy farming operations and one business plan for forage production. In this case the dairy unit would purchase fodder from the forage unit at market conform prices/costs.

The financial section of the business plan includes a balance sheet. The business plan may be essential in case external funding is required in order to finance the project (e.g. banks, investors). In such cases it is recommended that the business plan gets prepared in a bankable format. As regards to the financial paragraph of the business plan the major topics to be addressed are listed below:

a. Initial investments
- Land cost (if hired it is an operational cost)
- Livestock purchases
- Construction costs of physical structures (including design costs, permit fees etc.)
- Other hardware such as equipment, machinery, implements, furniture, tools etc.
- Public utilities (water, roads, electricity connection or generator)

b. Operating costs
- Land lease
- Salaries and wages
- Feed costs
- Machinery consumables (fuel) and insurances
- Machinery repair and maintenance
- Operating costs per hectare (incl. irrigation)
- Consumables, supplies
- Vet/AI (medicines, services)
- Interest paid on loans and insurances
- Others (preparation cost etc.).

c. Production and revenues:
- Fresh milk (or processed if any)
- Livestock sales
- Manure sales
- Forage sales
- Others

d. Cash flow

e. Depreciation

e. Taxes and funding

f. Profit and loss (IRR)

g. Design drawings

In order to capture the project construction cost as accurate as possible, design drawings can be done. Although this is at a considerable cost, it provides a clearer view of all the costs that are involved in the project. These drawings are also helpful in understanding the final business plan and financial section, which may be of particular importance in the event the project seeks external funding.

Usually the design drawings are done by an architect, who will also generate a Bill of Quantities (BOQ). The BOQ lists all the required materials needed, including the material specification, the quantities and a cost indication for each item. The set of drawings and BOQ provide a good indication of the project construction cost and is also used in the next planning stage (5.3) as reference to select the best offer in case the project gets tendered.

This Handbook includes in Annex 3 design drawings and the BOQ – including an indicative pricelist – of the modular cow house design for 20-40-60-80 cows. The cow house design includes the milking parlour, the office room, the milk annex machine room, an ablution block and dressing room and the manure pit. For the business plan of a new dairy farm – or in case replacement or expansion of other buildings is needed at an existing farm - it is recommended to also have design drawings and BOQs prepared by the architect. This also applies to the technical drawings for other structures, such as the agriculture store, hay and silage storage and the machinery/workshop shed. In the project site layout these structures are also shown.

5.3 Preparation and Planning for Implementation

In case the business plan shows that the proposed project is feasible from both a financial and technical point of view, the project is ready to start. This phase requires that sufficient funds are made available for the purchase of building materials, equipment/machinery and dairy cows, and payment of the contractor and other advisors. There is need to prepare and plan for implementation very well and numerous activities need to be addressed during this planning stage. These may vary from one project to another and therefore below only the main activities are summarised. They can be grouped as follows:

a) Construction-related activities
b) Procurement of equipment, machinery and livestock
c) Contractual arrangements (e.g. dispatch of fresh milk and supply of feed)

a.1) Construction works

Regarding the preparation of the construction works, it is recommended to engage an architect with a proven track record in agriculture related projects. Experience in this field is required so as to have full understanding of the specific issues that (may) arise in an agricultural project, such as cow comfort and animal health related issues.

The architect will prepare the design drawings, the BOQ with a price list and a site plan. He may also be asked to arrange for tendering of the project usually this is done by asking for a proposal or quotation from a minimum of 3 contractors. As for the site plan, the optimal location of the structures is determined by the straight line concept and other principles referred to under

Chapter 2.2. However the landscape on-site, the available space and the presence of existing buildings may cause need to divert from these principles. Special attention may go to:

- Manure handling- and storage- area
- Storage area of silage and hay,
- Dairy feed handling- and storage area,
- Utility buildings, such as the agriculture store.

a.2) Arranging the required licences and permits

The architects may also provide additional services to facilitate the project, such as dealing with local authorities in order to ensure the project objectives are made in accordance to law and regulations in force, such as:

- Spatial planning and zoning (rural/urban planning)
- Construction permit (County Government)
- Environmental license or permit (EIA/NEMA)
- Connection to national grids for electricity and piped-water supply
- Permits for a deep-well, borehole, dam and use of surface water (water permits).
- Permits to import cattle (if applicable) from DVS/State Department of Livestock
- Others regulatory standards

In Kenya, an Environmental Impact Analysis is administered by The National Environment Management Authority (NEMA) as per Environmental Management and Coordination Act (EMCA) (1999) and the Environmental Impact Assessment and Audit Regulations (2003). Reference is made to Annex 7 for more detailed information concerning government regulations in relation to building construction projects.

a.3) Supervision of the construction activities

In the event the architect supervises the construction works (which is recommended!), he can review the contractor's shop drawings and other submittals, prepare and issue site inspections and instructions, and provide construction contract administration and certificates for payment.

b) Procurement of equipment, machinery and livestock

The hardware that needs to be procured is listed in the business plan and the BOQ. Careful attention must be given to the planning and timing of the procurement of machinery and equipment, as some need to be installed during the construction works. Equally important is the moment of procuring livestock, which can only arrive at the farm when construction works are completed, enough clean water, feed and forages are available, and a trained workforce is present. Although most is straight forward there are a few priorities in the procurement process, which are:

- Procure agricultural equipment first (land preparation, irrigation, planting, harvesting)
- Pay attention to equipment that needs to be imported because of longed delivery times
- Pay special attention to equipment that needs to be installed during the construction works (milking parlour, milk cooling equipment, stable interior and the like)

In the event dairy cattle will have to be procured from outside the local proximity, attention must be given to veterinary protocols e.g. vaccinations, quarantine period and transportation regulations.

c) Contractual arrangements

In order to secure the dispatch and sales of farm products (fresh milk) it is advisable to arrange a contractual agreement with a dairy processor or a dairy cooperative (fresh milk delivery contract). Of similar importance is the security of reliable supply of dairy feed, such as dairy concentrates and ground materials.

5.4 Implementation of Construction Works

The implementation stage normally starts with a ground breaking ceremony. As emphasised in the previous chapter, important during the implementation stage are (a) the involvement of the architect for supervision of the works, and (b) the procurement of hardware.
The project manager/owner needs to be alert that equipment that requires specific testing (such as milking parlour equipment, milk cooling equipment, irrigation installations), is tested directly after installation. This kind of equipment needs certificates that state and validate performance in accordance with the technical specifications and warrantees from the manufacturer. It usually involves preparation and submittal of test reports by a qualified and accredited technician, stating the testing procedures, the performance standards and the test results.

Concerning the construction works it is advisable that the architect issues certificates of completion for each phase of the work, and for completion of the works. These will state that the construction works have been completed in accordance with the terms and conditions laid down in the construction contract (and e.g. in the tender documents) and according to professional standards. The certificates are used to approve and release payments to the contractor for the phase completed.

5.5 Farm Management and Training

Depending on the ability and availability of the farm owner/investor to take lead in farm operations, the farm workers and the manager (if present/required) require the proper skills and knowledge to manage the farm efficiently and effectively.
In case of a new dairy farm enterprise, every worker should either have proven experience or received adequate training in the specific field of operations. One of the key issues in farm management is herd management, which includes feeding, herd health and fertility, milk production and rearing. Nowadays computerised dairy herd management and/or farm recording programmes exist and may be considered to be included in the farm plan. In addition it is advised to organise for sufficient consultancy/training and support services (Vet/AI services, fodder production, bookkeeping) to backstop the farm manager/owner and his staff.

Kenya Market-led Dairy Program is funded by:
The Embassy of the Kingdom of the Netherlands
Nairobi, Kenya

SNV SMART DEVELOPMENT WORKS

SNV Netherlands Development Organisation - Kenya
Ngong Lane, off Ngong Road
P.O. Box 30776 - 00100
Nairobi, Kenya
T + 254 20 3873656
F + 254 20 3873650
E kenya@snvworld.org
www.snvworld.org