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MINISTRY OF AGRICULTURE

Food and Agriculture Organization of the United Nations

Ministry of Agriculture

Quarantine Import Export Inspection and Certification Directorate

Feedlot Construction Guidelines

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Table of Contents

Acronyms

ECTAD: Emergency Centre for Transboundary Animal Diseases

FAO: Food and Agriculture Organization of the United Nations

m: Meter

cm: Centimeter

mm: Millimeter

m^2: Square meter

L: Liter

Kg: Kilogram

TDS: Total dissolved salts

Mg: Milligrams

Km: Kilometer

SPS: Sanitary and phytosanitary

Acknowledgements

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Foreword

This technical document entitled “Feedlot Construction Guidelines” is one of the documents in a series of Guidelines and Standard Operating Procedures that were developed from 2008 to 2010 by the then Ministry of Agriculture and Rural Development in collaboration with the Ethiopian Sanitary and Phytosanitary and Livestock and Meat Marketing Program.

This Guidelines and Standard Operating Procedures document is at present reviewed and updated by the Ministry of Agriculture in collaboration with the FAO-ECTAD Ethiopia, Improving Sanitary Capacity and Facilitating Export of Livestock and Livestock Products from Ethiopia Project. The main goal of project is to increase exports of meat and livestock to benefit Ethiopian livestock producers and exporters and to promote national economic development.

This guidelines document is intended to provide guidance for quarantine import export inspection and certification directorate inspectors and live feedlot operators with broad principles and minimum standards required to be licensed as operator of livestock feedlot facilities that finish livestock primarily for export. The guidelines include criteria for site selection, layout and design, construction as well as other general and specific requirements for establishing and operating livestock feedlot facilities in Ethiopia.

At this point, the Quarantine Import Export Inspection and Certification Directorate of the Ministry of Agriculture would like to thank the FAO-ECTAD Ethiopia, Improving Sanitary Capacity and Facilitating Export of Livestock and Livestock Products from Ethiopia Project, for providing the necessary technical and financial support required for reviewing, updating and publishing this guidelines document.

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1. Introduction

Livestock feedlot is a confined area with watering and feeding facilities where animals are held and completely hand or mechanically fed for the purpose of production. This includes any adjoining or nearby area where such livestock are, tended, loaded and unloaded; the animal wastes from the feedlot are accumulated or treated pending removal or disposal, facilities for feeding and animals are maintained, facilities in which the feed is stored, handled or prepared.

A feedlot is an extremely sensitive production system which runs up considerable costs for animal purchase, feed, personnel, etc. The economic success of a feedlot operation is dependent upon whether or not the daily gains of the animals cover their maintenance costs per day, and above all whether or not a profit can be returned. Success therefore heavily depends on excellent management, a favorable economic climate, and relative freedom from unfortunate events such as disease epidemics.

Therefore, the main prerequisite for the successful running of such an operation is that the animals gain weight from the day they arrive, and that there is neither stagnation nor any loss of weight because of disease or poor management practices. Apart from this, the value of individual animals is so high that total losses must be excluded. For this reason, the animal health service is responsible for not allowing diseases which reduce daily weight gains or cause mortalities in animals. Outbreaks of disease with high morbidity and a high mortality rate must not occur under any circumstances.

The production principle of an intensive fattening operation is therefore optimizing of production factors and minimizing costs. The economic viability of feedlot is therefore significantly dependent on the presence or absence of diseases which affect productivity.

International trade in livestock and livestock products continues to be seriously hindered by presence of trans-boundary animal diseases as these diseases are transmitted rapidly and have substantial socioeconomic impacts and human health implications in recipient countries. To ensure safe livestock and livestock products trade and meet international animal health and welfare standards, animal health measures must be applied along the different stages of the feedlot operations.

One of the basic requirements required for running a successful feedlot business operation is to know where and how to establish the feedlot facility. Feedlot operators that want to finish their

animas for the purpose of export trade need to know, understand and be committed to comply with the regulatory requirements set for constructing a feedlot facility.

1.1 Objective

The objective of this guidelines document is to outline the basic feedlot facility construction requirements that may be used as a reference document both by the regulatory authority and private individuals or companies that may be interested in establishing livestock feedlot operations within the country.

1.2 **Scope**

The guidelines apply to all feedlot facilities to be established in Ethiopia for finishing cattle, sheep, goats and camel for the purpose of export trade.

2. **Definition of terms**

Holding ground: is a facility owned and managed by a private individual or company where animals purchased from nearby markets are assembled for a short period of time to enable the clients and the traders to complete the consignment

Biosecurity*:* means a set of management and physical measures designed to reduce the risk of introduction, establishment and spread of animal diseases, infections or infestations to, from and within an animal population.

Stocking density: the average facility pen area in square meters allocated to each animal.

Animal welfare: means the physical and mental state of an animal in relation to the conditions in which it lives and dies.

Feedlot: is a confined yard area with watering and feeding facilities where livestock are held and completely hand or mechanically fed for the purpose of production

Masonry wall (fence): is an outdoor wall or fence made with blocks or bricks of materials such as cement or natural stone that can be used as one of the alternative perimeter fences for feedlots.

Trans-boundary animal diseases: are those **epidemic diseases** which are highly contagious or transmissible and have the potential for very rapid spread, irrespective of national borders, causing serious socio-economic and possibly public health consequences

Importing country: is a country that is the final destination to which commodities are sent.

Quarantine station: *a facility under the control of the federal regulatory authority where a group of animals is maintained in isolation, with no direct or indirect contact with other animals, to be observed for a specified length of time and, if appropriate, testing and treatment.*

Community amenity: means any public benefit, improvement or contribution that can enhance the quality of life for a community that includes public spaces, land and facilities which meet a range of social, environmental, cultural, recreational and infrastructure needs of the community

3. Feedlot overview

Feedlots are well managed finishing and health management facilities under strict bio-security and management systems for livestock. These facilities will be managed primarily by the owners of the feedlots with support and supervision of the public veterinary service in charge of overseeing overall feedlot health management practices.

In this regard, feedlots can be considered as part of the live animal export quarantine system in which animals managed at feedlot facilities may be sent directly to the export quarantine station for final inspection and export certification.

Establishment and management of feedlot facilities requires, among other things, the following:

- Correct siting of feedlot to meet the needs of the confined animals for proper shelter from the weather, a well-drained, hard standing surface and a constant supply of suitable and sufficient feed and water.
- Construction and maintenance of standard facilities
- Employment of full time, well trained and sufficient personnel.
- Employment of veterinarian experienced with feedlot animals whose instructions regarding the maintenance of animal health and welfare must be followed.
- Constant monitoring of feed quality, palatability, and disease processes.
- Quick identification and isolation of sick animals in proper facilities with appropriate treatment instituted.

4. Construction requirements

4.1 Site selection

Many factors must be considered when selecting a site for establishing feedlot facilities that manage live animals for export. Where possible, the site should be selected so that the need for costly engineering works and environmental protection measures are avoided and community amenity is not adversely affected.

Issues to be considered include:

- Bio-security considerations to prevent disease transmission and spread.
- Economic viability issues, such as proximity to feed and livestock supplies.
- Infrastructure support issues such as access to roads and water sources.
- Suitability of climate for easy operation of facilities without the provision of expensive protection measures.
- Site features such as suitable topography and availability of suitable construction materials.
- Environmental impact issues such as the protection of water quality and protection of community amenity.
- Distance between the site and human habitation, non-compatible industries, etc.
- Available land resources (on and/or off site) capable of utilizing the effluent and manure from the facilities.
- Animal welfare issues such as minimization of heat stress in livestock.

4.2. Site selection criteria

4.2.1. Geographic location

To be economically viable, feedlot facilities must be located close to supplies of feed resources, slaughter animals, labour, abattoirs and all-weather access roads.

4.2.2. Climate

- Climatic conditions have an impact on the environment, performance of animals and their welfare. Most environmental problems are associated with wet conditions. For this reason, sites with a high annual moisture deficit are desirable.
- Design and management changes can be adopted for sites with high rainfall. Facilities established in these areas often require the construction of higher capacity drains, sedimentation systems and holding ponds. Larger effluent utilization areas are also often

required. Higher standards of pen foundation construction may be required to ensure durability in these wetter climates.

- Livestock can be finished in a wide range of climates. However, productivity decreases as the environmental temperature increases. If sites are selected where high temperatures persist for prolonged periods, the provision of shade should be considered.

4.2.3. Topography

It is desirable that the feed yard area has a natural slope of 2% to 6%. For sites with fewer slopes, earthworks can be undertaken to create slope in the yards. Yard slopes greater than 6% are undesirable due to the excessive manure movement from the yards during rainfall and possible erosion of the manure-soil interface. Similarly, yard slopes less than 2% are also undesirable due to the slow drying of manure and little drainage from yards during and after rainfall.

It is generally undesirable for facilities to be established on hillsides above residences or towns due to the potential for odour nuisance. This is particularly an issue if the down-hill air movement can be concentrated or confined by valley walls. As a general rule, offensive odours are less likely to be detected at residences situated at a higher elevation than the facility.

4.2.4 Risk of disease transmission

The risk factors for infectious diseases are mainly related to the environment that puts them into contact with the disease agent. As a result, feedlot facilities should be established away from high livestock density areas, human habitations, game reserves, livestock trekking routes and markets.

4.2.5 Pens

A soil with 25 percent or more clay is preferred to sand or fractured rock structures. It is desirable to locate the pen area on a compacted, smooth, well-drained site. Hence, the following areas are not suitable:

- Rocky areas.
- Areas where natural springs occur.
- Areas with light sandy soils.
- Areas with highly expansive heavy clays overlying shallow groundwater aquifers.

4.2.6 Sedimentation systems, holding ponds, drains, manure stockpile and composting areas

A site must be available where sedimentation systems and holding ponds can be economically constructed and will fill by natural drainage from the facility yard area. The soils underlying the ponds, drains, manure stockpile and composting areas should have a sufficient clay content to ensure that they are not permeable. If the available soil types are not suitable, imported clay may be used.

4.2.7 Effluent utilization area

Productive agricultural soils are required for the long-term application of water, nutrients, salts and organic loads in the effluent. The best agricultural soils should be set aside for this purpose. The soils should preferably be deep, free draining and should not be overloaded with nutrients or salts. Ideally, the effluent application area should be close to the holding ponds. The availability of clean irrigation water for effluent dilution and supplementary irrigation enhances the productivity of effluent irrigation schemes. The lack of good soil for effluent irrigation cannot be overcome by engineering works or the importation of material.

4.2.8 Manure utilization area

Manure can be economically spread over a much wider area than the liquid effluent. Nevertheless, manure spreading area must not be too far from the facility premise. Most soils will benefit from the well managed application of manure. The actual application rate should be determined after analyses of both the soil and the manure, in light of the proposed cropping program. The addition of inorganic fertilizers to balance nutrients is often required. Most soils suitable for cropping or pasture production will be suitable for manure spreading, provided sufficient area is available.

4.2.9 Land requirements

When selecting a site for feedlot facilities, it is essential to ensure that there is sufficient land available. The availability of adequate land for all present and future facility activities is an essential part of site selection. Land is required for feed yards, feed handling and storage facilities, animal handling yards, isolation pens, water storage and tanks, manure stockpiles, ponds, effluent and manure utilization areas, roadways, animal lanes and drains, carcass disposal areas and buffer zones.

Buffer zones include, double fences, tree belts and windbreaks around the facility yards, screens or tree belts to visually screen them from the public and buffer strips between land utilization areas and water courses.

The total area required will depend on animal numbers and size, methods of waste utilization, local climate, soil types and topography, cropping programs and availability of existing buffer zones. The area required for waste utilization will depend on whether the material is to be used on or off site, the soil type and cropping program. It is generally necessary to have sufficient land area available on the facility property to utilize the liquid effluent produced by the facilities. In the case of manure, it is desirable for facilities to have some productive dry land or irrigated cropping or pastures areas available for application.

When establishing a feedlot, attention must be given to future expansion plans. Future expansion should be considered in the development application for new feedlots with thought being given to the availability of suitable land for separation distances as they would be required for the future expansion options. Where practical this land should be owned by the developer as future change of land use within the separation distance may reduce the opportunity to expand.

In general, a reasonable feedlot area estimate should be at least three times the pen area, which is the maximum number of livestock multiplied by the stocking density. Hence, a 5000 head cattle feedlot at 15 m^2 /head requires 7.5 hectares of pens. The total feedlot area would therefore require about 22.5 hectares of land. Additional land will almost certainly be needed for effluent irrigation and some solid manure disposal, along with a buffer zone between the development and nearby sensitive receptors. It is desirable to plan for 100 hectares of land per 1000 heads of cattle for manure and effluent utilization on productive cropping land.

4.2.10 Water supply

Feedlots require a continuous supply of good quality water for uses such as drinking water, dilution of effluent water for irrigation, dust control, fire control and feed preparation. Water for feedlots can be obtained from surface water, groundwater or municipal supplies or a combination of all three. When planning a feedlot, the reliability of the water supply must be assessed to ensure that the intended water source(s) are sufficient to meet both the average feedlot water requirements throughout the year, as well as the peak demand days and times of the day.

Wherever possible, feedlots should have more than one water supply source (e.g. river plus bore or bore plus dam). If one source fails, the feedlot can change to the other. The volume of water required will depend on animal numbers and weights, local climate, irrigation requirements and feed preparation requirements. Hence, an individual estimate is required for each site.

When assessing the suitability of a water supply, it is necessary to determine total annual requirements, peak short-term flow rates and emergency reserves in case of supply breakdowns. Bores provide a constant source of water provided that the quality is suitable.

4.2.11 Surface waters

Flooding: Pens, manure stockpiles, effluent irrigation areas, sedimentation basins and holding ponds should not be located in flood prone areas unless adequate safeguards are incorporated. Consideration should also be given to vehicle access to the site during periods of prolonged flooding.

Protection of surface water quality: The facilities should be sited, designed and managed so that the quality of surface waters in the vicinity are not degraded by runoff, leaching or seepage from the facility yards, ponds or waste utilization areas. To achieve this, a reasonable buffer should be provided between the facility complex (including waste utilization areas) and streams, rivers and other watercourses. The separation distance chosen should be a function of the intervening topography, vegetation, natural gradient, management practices employed by the facility operation and other site-specific factors.

Protection of ground water quality: Feedlot facilities should be sited, designed and managed so that the quality of groundwater is not degraded by the movement of pollutants or pathogens into the water resource. To achieve this, facilities should not be sited above ground water recharge areas or above ground water resources that are deemed to be vulnerable, unless those resources can be demonstrably protected. Such protection may be provided by one or more impervious geological strata and/or because the water is at considerable depth.

Waste utilization areas should be sited away from bores and wells. Effluent or manure should not be applied within 25 m of a bore or well which is used for domestic consumption.

4.2.12 Infrastructure and staff

Access: The site must be selected so that there is suitable access. Consideration should be given to the preferred routes for vehicles entering and leaving the facility. Permanent all-weather access is required and should not be limited by flooding or other similar occurrences.

Staff: While it is necessary to locate feedlot facilities away from residential areas so as to maintain community amenity and bio-security, it is also undesirable to locate them in an extremely remote area. In such instances, availability of manpower may be a problem.

4.2.13 Community amenity

The environmental impacts of a feedlot such as water quality degradation, dust and odours can be controlled firstly by good feedlot design and management practices and secondly by restricting livestock numbers and maintaining suitable separation between feedlots and impact areas. All activities which are likely to cause the increased emission of odours, such as manure spreading or effluent irrigation, should be performed when the prevailing weather conditions and the time of day will cause the least odour emission and impact on sensitive receptors.

To protect community amenity, facilities should be established at an appropriate separation distance from sensitive community receptors. The desirable separation distance between the point of generation of the odour and each sensitive receptor will be a function of the source and intensity of the odour, the prevailing meteorological conditions at the site, and the nature of the intervening terrain and vegetation. Wherever possible, it is desirable to utilize existing topography and vegetation to screen new facility developments from roads, towns and nearby residences. The value of these natural features as buffers against odour, dust and noise should be utilized wherever possible.

Fixed separation distances shall be the least horizontal distance between the boundary of the feedlot complex and each of the relevant features as shown under table 1 below.

Table 1: Separation distances of physical features from feedlot

Physical feature	**Separation distance from feedlot in meters**
Public road - except as below	200
Public road - unsealed with less than 50 vehicles per day excluding feedlot traffic	50
Major watercourse	200
Property boundary	20

4.2.14 Community consultation

Community consultation in the decision-making process is important in the management of odour. The proponent, as part of the planning process, should recognize and address the public's perceptions and concerns associated with the emitted odours and other environmental concerns. It is usually appropriate to meet with the neighboring residents and discuss the proposal before a development application is submitted to the relevant authority.

5. Layout and design

The following general principles should be followed when considering the layout and design of feedlot facilities:

- Receiving, induction, dispatch and isolation yards, manure stockpile and feed storage and processing areas should be included in the facilities-controlled drainage area. Runoff from this area should be treated and collected in the sedimentation and retention pond system.
- The size of the controlled drainage area should be kept to a minimum by diverting any runoff from areas that have not been affected by manure, away from the site. This will minimize the required pond sizes and effluent utilization areas.
- Pen rows should run parallel with the contour of the site to minimize pen to pen drainage. The maximum acceptable pen to pen drainage occurs when the cross slope is equal to the slope down the pen
- Staged development/future expansion should be considered
- Any existing topographic features or vegetated areas should be utilized wherever possible to screen the facilities from the public and/or neighboring landholders.
- The layout for feedlot facilities should be shown with an explanation.

- ❖ Landscaping and grading of these facilities should consist of general site grading and detailed grading in the pens and road areas in order to direct water toward the runoff retention area.
    - o The overall area of these facilities should be graded at a minimum 0.5% slope toward the runoff retention area.
    - o Pens where required should be graded at a 2% slope toward the rear of the pen and subsequently into the drain alley.
    - o Livestock alleys should be sloped at 2% toward the drain alley.
    - o The drain alley center line should be sloped at 0.5% toward the runoff retention area.
    - o Feed and inspector alleys should be constructed with a negative crown of 2% to the middle of the alley.
    - o The center line of the feed alleys should be sloped at 0.5% toward the runoff retention area.
    - o There should be a perimeter interceptor ditch around the facilities, sloped at 0.5% toward the retention area.

6. Blue prints (plans and specifications)

- ❖ Drawings must be scaled to not less than 1:100, except for the "Site Plan".
- ❖ Drawings must have a title block providing the legal address of the establishment, date, designing company name, the scale, and the compass North point.
- ❖ The "Site Plan" shall show the entire premises. It must include:
    - o The boundaries of the plant property,
    - o Location of all section and location of the plant in respect to other structures in the surrounding,
    - o Loading and unloading areas,
    - o Receiving pens,
    - o Inspection crush,
    - o Pens with their partitioning,
    - o Alleys,
    - o Locations of foot baths,
    - o Feed and water troughs,
    - o Shades,
    - o Feed store,

- Offices,
- Sick pen,
- Recovery pens,
- Emergency slaughter,
- Gates and doors,
- Fences, fence types, internal and external and their distances,
- Potable water sources (wells, dams, rivers, lakes, reservoirs, etc),
- The route of water and sewer lines and drainage systems,
- Surfacing materials e.g. packed earth etc.
- Roads,
- Effluent treatment sites,
- Neighboring businesses,
- Power lines
- Relationship of all the different levels of the establishment e.g. receiving, pens, effluent, etc,
- The limits of the official premises.

❖ A floor plan showing:

- The purpose for which each area is going to be used,
- Holding capacities of facility/pens,
- Location and size of floor drains,
- Gutters and slope of floor towards drains,
- Location of fences, partitions, gates, posts,
- The elevations of the fences,
- Flow of animals,
- Employee traffic in the facility.

❖ A cross section of the facilities showing fence, shade, office ceiling, walls, feed and water troughs, crushes, loading and unloading ramps and feed store heights,

❖ Plumbing plan(s) shall show:

- The location of all sewage lines (including their sizes), hand wash facilities, toilets, floor drains (including their size and connections),
- Gutters, slope of floors towards drains,

- Water storage tanks (including location, size and construction material).

7. General requirements

7.1. Feed supply

The animal feeder must formulate feeds based on the species, sex, age, weight gain desired and the moisture content of available roughage and feeds. The feed ration should be adjusted to the requirements for fattening livestock based on the availability of feed materials in the locality.

7.2. Water supply

- Animals must have access to an adequate supply of clean and suitable quality drinking water.
- As a guide to drinking water requirements, a 400 kg cattle requires about 35 L/day in cold weather and 70 L/day in hot weather. The daily water requirement of water for camel, goats and sheep is 30-40L/head, 10L/head and 6L/head respectively.
- In addition, where water is required for dust control, an additional application of 5 liters plus 2 liters per day may be required per square meter of pen floor. In very dry conditions, 15 liters per square meter is recommended every 10 days.
- Daily requirements for water can also be calculated for each other species of animals to be kept in the feedlot by considering their daily requirement/head as 30-40L/head/day for camel; 10 L/head/day for goat and 6 L/head/day for sheep.
- The daily water requirement for each species required should be delivered to the pens over an 8-hour period.
- Cattle are reasonably tolerant to water with high levels of salts but the recommended maximum for growth is 5,000 mg/l TDS. Goats may adapt to high salt levels but generally prefer saline levels less than 2000 mg per litre while sheep prefer saline levels less than 4000 mg per litre.

7.3. Drains

- Adequate drainage must be available throughout the establishments.
- Drains should be located outside main drive alleys, chutes and crowd pens.
- The floor of pens should be made in such a manner that effluent including manure runs off at the lowest point down the stock lanes between the pens and channeled into broad drains and ultimately into anaerobic ponds or evaporation ponds.

- Drains must be lined with material of sufficiently low permeability to minimize the potential for leaching of contaminants into the soil or underground water resources.
- They must have sufficient flow capacity to avoid overtopping.
- They must be free flowing to avoid excessive sediment build up.
- They must be easy to maintain them in a clean weed free condition.
- They must have sufficient bed gradient to effectively convey suspended sediments to the sedimentation system without excessive scouring of the drain bed. Flow velocities will be affected by the drain cross section profile, dimensions, slope and drain bed material.

7.4. Floors

The adoption of a suitable floor slope is essential for ensuring good drainage. By ensuring that the floors dry out rapidly after rainfall, odor generation is minimized and animals are not subjected to muddy conditions, which could adversely affect their health, welfare and performance in the facilities.

- Slopes are often described as percentages, for example a 3% slope is a uniform fall (or rise) of 3 meters over a horizontal distance of 100 meters.
- The pen slope may utilize the natural slope of the site, or the slope may be artificially constructed.
- The flooring of feedlot facilities should be graded and can include compacted soil, limestone outcrops or ridges or a compressed rubble base.
- The floor slope should be in the range of 2 to 6% with 3% considered optimal in order to facilitate drainage and minimize erosion.

7.5 Stocking density

The stocking density is generally defined as the average facility pen area allocated to each animal. It can influence the performances of animals in addition to their general health and welfare. Furthermore, it has important implications for the environmental management of the facilities, as it affects the moisture content of the pad and therefore its potential to produce odor and dust.

- Stocking densities should take into account the local climate and the size of livestock in the feedlot.

- There needs to be a compromise between the higher odor generation potential at heavier stocking densities and the higher incidence of dust problems at lighter densities.
- In general, a range of 12 to 25 m^2 /head is recommended for cattle, 1.0 -1.3 m^2 /head for sheep, and 4.6 - 5 m^2 /head for goat.
- The space requirement for camels is 100 m^2 for one camel plus 50 m^2 for each additional camel with a minimum width of 6m.

8. Specific requirements

8.1 Receival and dispatch facilities

All livestock arriving at a feedlot must undergo a process of 'induction' soon after arrival before being allocated to the production or feeding pens. Animals that have travelled a long distance or that are stressed are first allowed to get overnight rest with feed and drinking water to allow them to settle. All newly arrived animals are observed for injury or impending disease, key details are recorded and treatments given, along with identification (for those not identified earlier) and are then moved to their respective feeding pens.

Receival and dispatch facilities include various associated components including holding pens, races, loading ramps and vehicle maneuvering areas. Receival and dispatch facilities should:

- be able to accommodate varying types of livestock transport vehicles expected
- be able to accommodate the type and number of livestock to be handled
- provide access to holding pens and processing facilities
- prevent injuries to and minimize stress on livestock
- prevent injuries to operators
- provide feed and water for unloaded animals
- provide water for livestock to be loaded
- have lockable slide gates to prevent accidental escapes, illegal/unauthorized livestock delivery or removal
- provide drainage
- provide non-slip surfaces
- consider access for truck drivers

- position ramp so that the truck driver may back in with a good view from the driver's side of the vehicle.
- consider the direction of sun in morning and evening; avoid walking livestock directly towards bright light (artificial or sun)

Moreover;

- The location of the receival and dispatch facilities within the overall site layout should provide good access for trucks and trailers and appropriate traffic flow of livestock transport vehicles.
- If night time loading or unloading is likely, the area should have appropriate lighting. Lighting should cover all areas including the holding pens and personnel access areas, with a number of lights to prevent shadows
- If receiving or dispatching a large number of animals requires a number of trucks, a suitable stationing or parking area should be available for the waiting trucks.
- Adequate space required for turning and reversing, depending on the size of the trucks and the number of trailers should be available.

8.1.1 Loading & unloading ramp

Well designed and constructed loading facilities result in quicker, safer loading with less stress on livestock carriers, stock and owners.

- ❖ The reception and dispatch areas should have offloading and loading platforms, respectively.
- ❖ Docks of different heights or adjustable ramps should be provided to accommodate vehicles of varying heights.
- ❖ The unloading and loading facilities shall be so constructed that unloading and loading can be carried out without having a gap between the vehicle and the dock or ramp.
- ❖ The sides of any ramps or dock should be high enough to prevent the escape or injury of animals.
- ❖ The loading and unloading dock area should be leveled and non-slippery.
- ❖ Stock will generally flow well with a gentle stepped ramp of around six meters in length to reach the standard 1.1 - 1.2meter loading height.

- ❖ The loading and unloading ramp should have a slope of no more than 20 degrees with a floor of concrete, steel or timber;
- ❖ Ramp floors should give good grip, be easy to walk on, not flexible and bouncy, and should not resonate or create undue noise
- ❖ Unloading ramp should have a horizontal docking area approximately 1.5m long to prevent livestock from slipping as they step out of the transporter.
- ❖ Loading height will vary slightly with the type of livestock transport vehicle to be used, but is generally 1.1–1.2 meters for most body trucks and semi-trailers.
- ❖ At the top of the ramp, a level platform of about 2–3 m long will allow livestock to balance and gain more confidence to move onto the different flooring material of the trailer.
- ❖ Sheeting the sides of the lead-up race and the loading and unloading ramp should be done to make animals focus on the exit, eliminates baulking from visual distractions and thus improves flow.

8.1.2 Receiving (holding) pen

- The receiving pens hold livestock for a relatively short time before processing
- The holding pen size is typically for a single deck of livestock, which is generally an easier quantity to process at a time. This capacity will need to be able to fill the race for feeding into the crush.
- Space requirement for holding pens is 1.8 - 2 m^2 for cattle; 2 m^2 for camel and 0.5 square meter for sheep and goats.
- The holding pens should have direct access to the crush.

8.1.3 Race

A race is a narrow lane to single file livestock for further processing, batch treatment or visual inspection. It can be used in conjunction with crushes, weigh boxes, loading ramps. Livestock are forced into single file to direct them towards the crush or weigh box, and to overcome their natural instinct to return to where they came from. The aim is to maintain a constant and continuous flow without involving many workers in the process. The feedlot race should fulfil the following:

- A race should be located before a crush.
- Races may be parallel-sided, V-shaped or with adjustable width.

- Races are can be curved but can be straight. However, the race needs to be straight for at least 3.5 - 4 m lengths at the start, as an immediate curve would look like a dead end to the lead animal.
- The height should be 1.8 m for cattle and camel, 1.2 m for sheep and 1.4 to 1.5m for goat
- The race length will depend on the number of livestock being handled – about 1.6–2.4 m per head is required for cattle.
- The width of the race shall not be greater than 90 cm for cattle and 35 cm for sheep and goats (should not allow the direction reversal of animals).
- The outer panel of the race needs to be sheeted to aid good livestock flow by overcoming external visual distractions that will frighten them

8.1.4 Inspection crush

In order to precisely inspect and differentiate diseased and injured animals, it is important that each and every animal pass through crushes at the gate of the facilities.

- ❖ Each feedlot needs to have inspection crushes next to receiving pens along the entry into the pens and also at the end of the alley which leads to the loading ramp.
- ❖ The crush needs to be well designed so that it has pre-inspection collection pen and also detaining pen for rejected animals.
- ❖ The length of the crush is determined by the number of animals that must stand in the crush simultaneously. The recommended length is 2 m per animal.
- ❖ The width of the crush requires careful consideration as a crush that is too wide, will allow animals to turn around. The inner dimension should be around 0.68 to 0.75m for cattle but for a V shaped crush, the inside width at the base of the squeeze should be 0.28 to 0.4m for cattle.
- ❖ For sheep and goats, where V-shaped crushes are used, a base width of 0.2 to 0.3m and a top width of 0.45 to 0.68m is recommended.
- ❖ The height of a crush should be 1.6 to 1.8m for cattle, 1.8m for camel, 1.2 m for sheep and 1.4-1.5 m for goats.
- ❖ There should be no sharply contrasting shadows or bright patches that may baulk animals.
- ❖ There should be no distractions to forward movement as animals should be able to see well ahead.

- ❖ Crushes must be well maintained and kept free of loose objects.
- ❖ Must be so constructed to render the floors and drain covers non-slippery.
- ❖ To encourage entry, livestock should be able to see at least 6 m of unobstructed space beyond the crush.
- ❖ Animals are more willing to enter a crush if the sides are covered, thereby preventing sight of the handler alongside. The use of solid sides also reduces the risk of an animal's leg becoming trapped between the crush supports.

8.1.5 Weigh box

- A dedicated single-animal weigh box may be integrated into a processing facility to speed up processing or for accurate weighing of individual animals.
- Weigh boxes are walk-through design, typically 2.8 m long and 66 to 76 cm wide inside.
- They are usually located immediately before the crush.

8.2 Pens

The production pens are the main animal housing unit for a livestock feedlot. Sound design will ensure optimum animal performance, good animal welfare and high standards of environmental performance.

The design objectives for a feedlot production pen are to:

- ❖ Provide an environment for livestock where production performance and animal welfare are maximized
- ❖ Promote safe access for livestock to and from the pen
- ❖ Minimize environmental impacts such as odour and dust
- ❖ Promote drainage to provide a comfortable environment for livestock and minimize environmental impact
- ❖ Optimize the management and removal of manure from the pens
- ❖ Minimize ongoing maintenance costs
- ❖ Provide a safe working environment for feedlot personnel.

For this, feedlot pens must fulfil the following requirements:

- Must be so constructed and maintained to avoid injury of animals.

- Feedlot pen fences should be 1.6 to 1.8 m high for cattle; 1.8m for camel; 1.2 m for sheep and 1.4-1.5 m for goats.
- Pens should have compact floors that are curbed and drained and non-slippery.
- Should be fitted with gates which have a minimum width of 0.8 m for sheep and goats; 1.8m for cattle and camel.
- Must have well drained manure blocks for manure prior to removal
- Isolation area for suspect animals must have solid walls and gate and must not drain across other pens or pose any other contamination risk.
- Pen rows should run parallel with the contour of the site to minimize pen to pen drainage.
- A smooth, consistent pen slope is very important in promoting the runoff of storm water.
- Pens should not be constructed with slopes of less than 2% as the drainage of rainfall will be ineffective. The ideal is considered to be 2 – 6%.

8.2.1. Pen size

It is convenient to size pens to match multiples of deck sizes of livestock transport vehicles. Pen sizes generally vary according to the facility preferred management practices.

- ❖ Pen sizes in commercial feedlots commonly range from 50 to 300 head in capacity for cattle, and not more than 500 for sheep and goats.
- ❖ However, a range of available pen sizes can be useful where different sized consignments are commonly received.
- ❖ Pen depth should be restricted to a maximum of 65 m to limit the distance to feed facilities.
- ❖ Pen depth should be decreased for steeper pen slopes to reduce the potential for erosion of the pen surface, e.g. 50 m maximum depth recommended for 6% pen slope.
- ❖ Pen width should allow sufficient room for ease of operation and cleaning.
- ❖ If livestock are to be fed from open feed troughs, the pen width must be adequate to provide the required trough length for the number and size of animals being fed in the pen.

8.2.2 Pen orientation

- Adverse climatic effects can sometimes be alleviated by studying the local climate, e.g. prevailing winds, and taking advantage of the local topography.
- A northerly aspect is generally desirable for maximizing exposure to the sun.

- For shades to be installed at the facilities a north-south orientation of rows of pens can generally make provision of shade structures easier.

8.2.3 Pen floor construction

Well-constructed and managed pen floors, in conjunction with good pen cleaning practices, increase animal productivity. The pen floor must not break down during rainy season. The following general specification for pen floor construction is the minimum preparation for feedlots:

- ❖ The area should be cleared of trees, scrub, and stumps.
- ❖ Tree roots should be grubbed to 300 mm below natural ground surface.
- ❖ Topsoil should be stripped from the area and stockpiled for later reclamation work.
- ❖ All holes should be back-filled with suitable clay or gravel
- ❖ If the exposed material is of a suitable quality for pen floor foundations ie clays having low, intermediate and high plasticity, clayey sands and clayey gravels, the area should be ripped, brought to optimum moisture level for compaction, and compacted to 95% of standard maximum laboratory dry density with a suitable roller.
- ❖ Cut, fill and grade the foundation to a smooth 3 – 6% slope away from the feeding areas.
- ❖ The top 300 mm surface fill should consist of a suitable gravely clay to provide a sufficiently durable pen surface. This should be laid in even layers having a maximum thickness of 200 mm prior to compaction, brought to optimum moisture level for compaction, and compacted to 95% of standard maximum laboratory dry density with a suitable roller.

For feedlots built on sandy soils the following method is suggested for the construction of the pen floor foundation:

- ❖ The area should be cleared of trees, scrub, and stumps. Tree roots should be grubbed to 300 mm below natural ground surface.
- ❖ All holes should be back-filled with coarse sand.
- ❖ The sand base should be graded, watered and compacted to form a smooth 3 – 6% slope away from the feeding area
- ❖ The top 450 mm surface fill should consist of a suitable gravely clay to provide a sufficiently durable pen surface. This should be laid in even layers having a maximum thickness of 200

mm prior to compaction, brought to optimum moisture level for compaction, and compacted to 95% of standard maximum laboratory dry density with a suitable roller.

8.2.4 Pen signage

All pens should have a small sign with the pen number. This sign should be at the top end of the pen along the feed bunk so that feed truck operators can locate the correct pen when delivering feed. It is also useful to be able to identify the pen number from the livestock lane with another sign on the entrance gate from the stock lane to the pen.

8.3 Feed troughs

Feed troughs should be designed to allow sufficient space for all livestock to eat without competition.

For cattle, the following points should be considered:

- Feed troughs should always be located along the fence line, never within the pen.
- They should be located along the higher end of the pen with drainage away from the trough on both the feed road and pen sides. This minimizes boggy conditions on the pen side of the trough and keeps the feed road firm and accessible.
- Open troughs should incorporate 2.5 to 3.0 m wide reinforced concrete aprons sloping away from the feed source.
- Feed troughs should be constructed of durable material which is not easily damaged and cannot be moved by animals.
- They should have an internal profile which can be easily cleaned, and the external sides should meet the ground at right angles.
- To prevent manure and spilt feed accumulating beneath the trough and to improve the ease of cleaning, troughs should have vertical external sides.
- The bed of the trough should be 17.5 cm above the level of the apron to facilitate a natural feeding stance, particularly after a layer of manure builds up on the apron.
- The ends should be open, and long runs of troughs should include drainage points to allow drainage after rainfall.
- The inside surfaces of feed troughs should be smooth with well-rounded corners to facilitate easy cleaning.

- To prevent livestock from entering the feed trough and possibly escaping, cables should be strung out over the feed trough.
- The cross-sectional area of the trough determines the amount of feed that can fit into the trough per unit length. If the cross-sectional area is too small frequent filling will be necessary. If the feed trough is too wide, feed pushed to the back of the trough is less accessible and animals are tempted to step into the trough to try to reach it.
- Feed troughs should allow rainwater to drain, preferably by having drain holes or slots at intervals along the length of the trough. These drainage points need to be large enough that they do not get blocked.
- Feed trough length will depend on the number of livestock to be fed within the pen. Cattle of 600 kg live-weight require a minimum of 30 cm of trough space/head when fed once daily. More frequent feeding will allow the trough space per head to be reduced. An average market size bull with a weight of 250-395 kg may require a minimum of 18 cm trough space and a younger cattle of less than 250 kg body weight may require 15 cm trough space.

Table. 2. Sample feed trough dimensions for cattle

Description	Dimension
The height of the back wall above the feed apron.	500 mm
The height of the front wall above the feed road.	700-750 mm
The height of the livestock restraint rail above the apron	1000–1150 mm
The width of the feed storage area of the trough	715 mm
The thicknesses of the front walls	135 mm
The thicknesses of the back walls	120 mm
The cross-sectional area of feed per metre length of trough	0.196 m2
The cross-sectional area of concrete for the trough per metre length of trough	0.219 m2

- Trough space for camels should be managed on the same basis as for cattle.
- For sheep and goat, the following should be done:
    - Troughs can be designed so that sheep and goats have access to one or both sides – it is important that the correct feed space is provided to reduce shy feeding.

- For double-sided access to feed troughs length of 20cm per adult sheep or goat and 15cm trough length for a kid or lamb of less than one-year of age.
- For single sided access to a trough, 30cm per lamb or kid and 40cm per adult sheep or goat of trough space should be allowed.
- Troughs should be raised off the ground to reduce fouling. Lift the top edge up to 40–45cm for lambs and kids and 50–55cm for adults.

Fig 1. Sample cattle feed trough

Fig. 2 Sample sheep and goat feed trough.

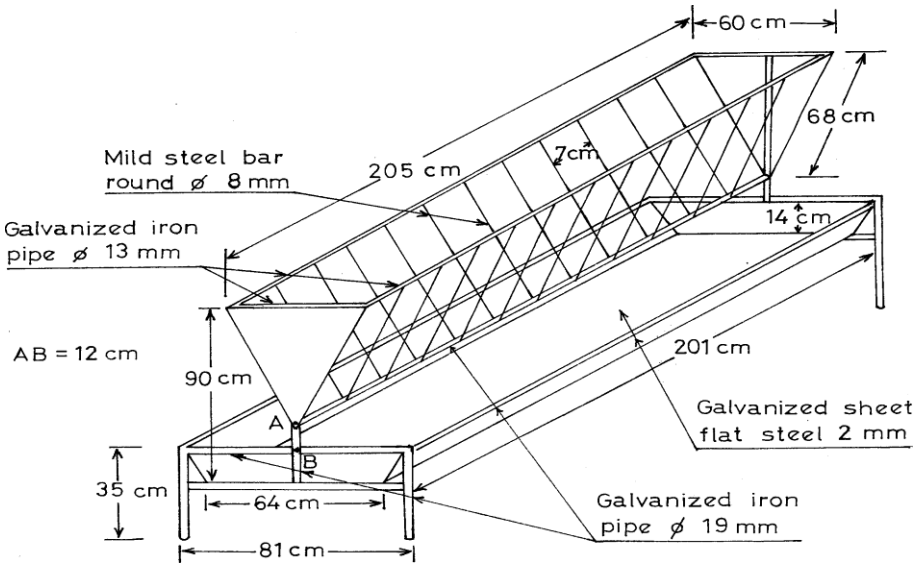

Figure 3 – Sample sheep and goat grain and hay feeder. Hay is placed on the top.

8.4 Water troughs

- Access to an adequate supply of good quality water is essential for the survival, welfare and performance of animals in feedlot facilities.
- Water troughs should be large enough and designed in such a way that the all livestock have easy access.
- Each pen should preferably have access to two water troughs so that livestock can have access to water if one trough blocks
- Animals must be prevented from stepping or falling into water troughs by sides extended high enough from the ground and an exclusion bar (steel or timber frames) over the surface of the trough.
- Low volume shallow troughs are preferred to reduce the flushing volume generated during regular cleaning operations. A good quick supply of water is essential for low volume troughs.
- Water troughs should be in the lower half of the pens, with provision for any spillage and water discharged during cleaning to drain directly to the drainage system to avoid creating wet spots.
- Water troughs should have vertical external sides which meet the ground at right angles to prevent manure accumulating beneath the trough.
- Troughs should not be shared between pens to avoid disease transmission.

- The water source should not be close to the feed source, to avoid more feed is deposited in the water trough or vice versa.
- Water troughs should incorporate at least 3.0 m wide reinforced concrete aprons all around the trough sloping away from the trough at 2 to 3%.
- Water troughs may incorporate shade structure as hot water reduces intake. The size of the trough shade structure should be limited to the need to protect the water trough from direct sunlight but not to provide shade for animals standing underneath.
- Water troughs should have a height of 0.9 m for cattle and camel, 0.3 m for sheep and goats.
- A minimum of 25-30 cm of water trough length per head is required for cattle and 30 cm/head for camel;
- For sheep and goat, at least 30cm of trough for the first animal and 1.5cm for each additional animal is recommended. For example, a trough length of 7.6m is the minimum requirement for a size of 500 sheep or goat.

8.5 Feedlot shade

Shade is a thermal radiation shield that reduces heat load on the animal. Shade does not readily affect air temperature but can reduce exposure to solar radiation and also enhance minimal air movement for cooling. The design of shade structures should ensure that ventilation beneath the structure is maximized and where possible, air temperatures are kept below body temperature of animals.

8.5.1 Orientation of shade structures

- ❖ The optimal alignment of shade structures is north-south. This allows the shade to move across the pen throughout the day and assist the drying of the pen floor beneath the structure.
- ❖ A slope of 15^{o} rising to the east provides two extra benefits – the shade roof will create its own passive air movement as air heated beneath the roof rises, and the slope will allow a larger area to be shaded during the mid to late afternoon when the day temperature is usually highest.

8.5.2 Size of shade structures

- ❖ The minimum requirement is that the area of shade be sufficient to cover all animals.

- Recommended shade areas per head range from 1.9 square meters to 6.0 square meters for cattle and camel, 0.55 -1 m^2 for sheep and goat.
- Higher shade structures provide more cool air for the livestock, and allow the shade to move across the pen faster.
- Minimum suggested height is 5.0 meters on the western side rising at a slope of 15^o towards the eastern side to the maximum height of 8.1 meters.
- Most shade structures are 12 meters wide.

8.5.3 Positioning of shade structures

- Shade structures should be erected towards the center of the pen so that animals can follow the shaded area as it moves across the pen during the day.
- Shade positioning should take advantage of the morning sun for drying while maximizing the shaded area in the afternoon summer sun.
- Shade should not be positioned over water or feed troughs

8.5.4 Shade materials

The most common shade materials are galvanized sheeting or shade cloth due to availability and relatively low cost. Shade cloth has the advantage of allowing air to pass through the material, but shade cloth can be affected by degradation of the material, bird damage, and vermin damage if furled during the rainy season. Galvanized sheets have a longer service life and can allow free flow of air if spaces are left between the sheets. They are generally heavier than shade cloth to erect and support, requiring more substantial structures.

8.5.5 Structural design of shade structures

Shade structures need to be designed carefully with attention paid to the loads that the structure must bear. Wind blowing against the structure results in directional loads. Side loading is caused by wind action against walls and posts, while wind action on a sloping roof can cause the roof to act either as a wing or an aerofoil depending on wind direction.

These forces must be taken into account when designing the structure. The mass of material supported by the structure is called the “dead load”. The dead load of galvanized sheeting is higher than for shade cloth, so the support structures need to be more substantial. The dynamic load of the shade structure is a load that varies in character. It typically results from movement of

a structural member or other variable or oscillating force. It is recommended that engineering advice be sought in the design and placement of feedlot shade structures.

8.6 Feed storage

Should be constructed on the opposite side of the area where the isolation and recovery pens are located. Animal feed store must be vermin proof.

8.7 Fences, gates & lanes

By providing careful thought to the design and arrangement of fences, gates and lanes, ongoing livestock handling labor costs and injury of animals and/or facility staff can be minimized. Fences, gates and lanes should be designed to enable efficient movement of livestock and cleaning machinery. No single fence type appears better than others and this decision is left to the producer and availability of local materials. Access into the pens may require 1 or 2 gates. Consideration should be given to moving livestock, cleaning of pens and removal of manure.

8.7.1 Perimeter fence

The external fence should be fenced with 5 cm diameter wire mesh, woven wire or using masonry walls as may be considered appropriate. The type of fencing needed for livestock confinement depends on several factors including animal species, age, breed, and production system. Factors for selecting fencing type include affordability, maintenance, durability, and effectiveness of containing livestock.

A. Mesh wire fence

Mesh wire fences are strong and provide great safety to animals. Mesh wire fencing is made in 11, 12 ½, 14 and 16 gauges, and fences are available in diamond-mesh and square knot designs. The square knot wire design is formed from single line wires spaced 10 cm apart and stay wires spaced 5 cm apart. The joints are held by a piece of short wire formed into a knot.

The diamond-mesh wire design uses two smooth wires spaced 10 cm apart, which are twisted together for all line wires. Stay wires consist of single smooth wires the same size as the line wires. These stay wires are wrapped around adjacent line wires to form a triangle with a 5 cm base. The diamond shape is formed when two of these triangle bases are fitted together. Both mesh fence designs are strong and highly safe for animals.

Fig.4 Sample wire mesh fence

- ❖ The metal or wooden stands or poles need to be interconnected by tensile barbed wire strands which may be reinforced with plain wire meshes.
- ❖ The fencing for cattle and camel should be built with metal poles standing at intervals of about 10-15m with wooden poles in between.
- ❖ The spacing of posts for sheep and goats should be 3.7 to 6m apart.
- ❖ The height of the fence may be 1.4 - 1.5 m for cattle (which may be 1.6-1.8 for cattle not accustomed to handling); 1.2 m for sheep; 1.4 – 1.5 m for goats and 1.8 m for camel.

B. **Woven wire fences**

Woven wire fences consist of a number of horizontal lines of smooth wire held apart by vertical wires called stays.

B.1 Cattle

- Barbed and woven wire fences have traditionally been used for cattle. However, barbed wire fences require higher maintenance and have shorter lifespans than woven wire fences.
- 5-strand woven wire fences with one or more strands of barbed wire above the fence are excellent for cattle.
- Fence height should be at least 1.4 - 1.5 m for cattle (which may be 1.6-1.8m for cattle not accustomed to handling) and 1.8 m for camel. Though the initial cost of woven wire fence is

higher than the cost of a 5-strand barbed wire fence, woven wire fences require less maintenance and last longer that barbed wire fences.

- Standard galvanized woven wire with the top and bottom strands of number 12 1/2 gauge or larger are recommended.
- Vertical stay wires shall be 14 ½ gauge or larger and spaced not more than 30 cm apart.
- One or more strands of barb wire spaced approximately 10 – 15 cm apart shall be added at the top.
- Posts spacing should be not more than 4.8m for standard galvanized woven wire.
- Fences for camel can be made with similar materials and specifications with that of cattle by considering the specific height requirement of 1.8 m.

B.2 Sheep and goat

- Several options currently are available that include barbed wire, cable, woven wire, net wire. Factors for selecting a fencing type include affordability, maintenance, durability and effectiveness of containing livestock.
- Woven wire fencing is said to be good for sheep and goats.
- Depending on the breed types to be confined, fence height should be at least 1.2 m for sheep; 1.4 – 1.5 m for goats high.
- Woven wire fencing consists of smooth horizontal (line) wires held apart by vertical (stay) wires.
- Spacing between line wires may vary from 4 cm at the bottom to 20 cm at the top. Wire spacing generally increases with fence height.
- Stay wires should be spaced 15 cm to 30 cm apart depending the size of the animals.
- Woven wire fencing is excellent for predator control. The fence bottom should be placed on the ground to allow for the use of snares where predators dig under the fence.

Fig.5 Sample woven wire perimeter fence for sheep and goat

8.7.2 Pen fence

Pen fence must be economical to build and maintain; they must contain stock but not hinder pen drainage or cleaning.

A. Cattle

- The height of the fence may be 1.4 to 1.5 m for cattle (which may be 1.6 to 1.8 for cattle not accustomed to handling) and 1.8 m for camel.
- Pen fence posts are generally made from either steel or timber. Wooden posts should be at least 25 cm in diameter with corner and gate posts 30 to35 cm in diameter.
- The posts may be of steel or timber, and should be set into the ground at least 90 cm, and at least 4.5 to 9m for cattle and camel;
- If timber posts are to be concreted into position, the post should protrude below the bottom of the concrete to allow water to drain out and prevent the post from rotting.
- Steel posts need to be set in concrete 90 cm below ground level with the concrete finishing about 20 cm above ground level
- Pen fences constructed with cables are stronger than wire fences.
- Fences should include five rows of cables and rails to allow under-fence cleaning while preventing animals escaping by rolling under the cable.
- Cables should be attached to, or directed through, fence posts so that no sharp edge can deteriorate the cable as it moves constantly back and forth under pressure from the animals.

- ❖ Cables can be run through holes in wooden posts; steel posts require hollow sleeves or external eyelets
- ❖ The bottom cable or wire should be 40 cm above the pen surface to enable under fence cleaning with a push bar.
- ❖ Top rails and belly rails are required to add strength to a fence.
- ❖ Top rails and belly rails and posts can be either wood or steel. Wooden rails should be at least 150 mm in diameter and steel rails at least 100 mm in diameter
- ❖ The parameters indicated above can be adapted to camel by giving consideration the relative height differences

B. Sheep and goats

- Woven wire fencing is the most reliable form of sheep and goat fencing because it provides a strong but flexible barrier.
- Individual knots are tied to the horizontal and vertical wire intersections, creating a mesh that holds tight and won't slip. The knots create a springy texture, so the fence will flex when challenged, rather than snap the way welded wire can.
- Wire fence spacing should be no more than 10 cm high and 10 cm wide to keep goats from breaking free.
- The height of the fence may be 1.2 m for sheep and 1.4 to 1.5 m for goats
- Install H-braces at each corner of the pen and at gate entrances to bolster their strength.
- Brace and corner posts should be made of 15-20 cm diameter treated lumber and set in the ground a minimum of 100 cm to prevent movement.
- Line posts hold the fence in place between the corners and gates and are typically wood (10 cm treated lumber), steel t-posts, or a combination of these.
- Steel t-posts are a good alternative to wooden posts and make for easier installation. Various weights are available to meet different needs for strength and durability.
- Recommended spacing of line posts is between 2.5 - 3.65 m depending on the material that the posts are supporting and the anticipated amount of pressure on the fence.

- To assure stability, line posts should be set at least 60 to 75 cm deep, and tall enough to accommodate a top-line wire if desired.
- Install posts on the outside of the fence line so that pressure from animals pressing against the material is supported.
- The bottom wire of the fence should be as close to the ground as possible. Stake it securely to prevent goat and sheep from trying to go under the fence.
- Woven wire fences consist of smooth horizontal (line) wires held apart by vertical (stay) wires. Spacing between line wires may vary from 4 cm at the bottom to 20 cm at the top. Wire spacing generally increases with fence height.
- It's important to keep the crimps intact on the horizontal line wires. This allows the fence to expand and contract during fluctuating weather conditions. Avoid using too much muscle when stretching the fence.

Fig.6 Sample woven wire pen fence for sheep and goats

8.7.3 Gates

- ❖ The size and location of gates are important; they must provide good, safe access to the pens for both pen cleaning equipment and stock
- ❖ Feedlots require a gate at the rear of pens for movement of stock and pen cleaning equipment, and another across the feed trough apron for easy cleaning of aprons
- ❖ Stock movement gates are usually located at the bottom of the pens
- ❖ Gates should be lightweight but strong

- Gates should not have any sharp protrusions such as badly positioned hinges and latches that livestock can bump into and be bruised by as they move in and out of the pen.
- All gates should lay flat against the fence line when open and should be long enough to block the livestock laneway when open.
- Gateways should be set at an angle so that tight turns into pens are avoided.

8.7.4 Laneways

- A good lane system will promote efficient movement of livestock and pen cleaning equipment
- Lane widths of between 4 and 5 meters are generally suitable for moving livestock and machinery into and out of pens.
- Laneway fences should be constructed with cable or plain wire.
- The use of barbed wire should be avoided.

8.8 Isolation pens (sick & recovery)

Early detection and treatment of ill or injured animals will optimize welfare and productivity and minimize mortalities. Returning treated animals straight back to production pens may increase the risk of cross infection.

- Sick animals should be separated from their congeners and held in special pens.
- Isolation pens should be sited and constructed in such a way that waste and effluent from them cannot contaminate adjacent pens in the facility or passageways.
- Isolation pens should have separate drainage systems.
- Isolation pens should be away from the main passageways used by people and animals.
- The pens should have separate facilities such as water and feed troughs.
- The distance between an isolation pen and the rest of the facility shall be at least 60 meters.
- Sick and recovery pens can be constructed adjacent to each other for an easy transfer of convalescent animals.
- The sick pens should have a minimum space allowance of 14 m^2 per head for cattle; 1.0-1.3m^2 for sheep; 4.6 – 5m^2 for goats and 100 m^2 for 1 camel plus 50 m^2 for each additional camel with a minimum width of 6m.

8.9 Emergency slaughter pen

- ❖ All feedlot facilities should have well separated areas to slaughter accidentally injured or severely sick animals.
- ❖ The cattle and camel unit would be equipped with floor pulling ring, hoist and rail system, cradles and equipment sterilizer and hand washing facilities.
- ❖ The sheep and goat unit would be the same except that it would not have a pulling hoist or rail system.
- ❖ The units should be equipped with stainless steel table, drain hole, pressurized cold and hot water supply.

8.10 Foot bath

Each feedlot facilities should have 0.5 x 1.5 m foot bath made of 10 cm thick mass concrete along the following alleys.

- At the gate of the entry into the facility compound, offices and feed stores.
- At the end of the crush after animals are received.
- Along the exit alley from the recovery pen.

8.11 Effluent management system

- ❖ There should be a sedimentation system where the base should be constructed from compacted gravel to enable cleaning operations to proceed under wet conditions.
- ❖ Basin embankments and beds should be impermeable to prevent seepage of effluent into ground or surface water resources.
- ❖ Holding ponds should be constructed so as to ensure impermeability.
- ❖ A cut-off trench and compacted clay core are generally required beneath and within the embankment respectively.
- ❖ The embankment crest width should be at least 3 m.
- ❖ The upstream and downstream batters should be no steeper than 1 in 3.5 and 1 in 2.5, respectively, if clay construction materials are used.
- ❖ A by-wash should be provided to ensure that the embankment is not overtopped following extreme rainfall events.

8.12 Manure management system

- Manure stockpile areas should incorporate a stable compacted base to enable manure handling operations to proceed under wet weather conditions.
- Manure stockpile areas should be established within the facilities along the controlled drainage area and with a regular 1-3% slope.
- The foundation of the area should be prepared to the same specifications as the facility pen foundation, and the surface should be finished with a layer of compacted stones to ensure all weather access.
- The manure stockpiles should be constructed up and down the slope of the area, not across the slope as this will assist drainage.

8.13 Office

Feedlots should have adequate offices accommodations. Suitable rooms for storage of veterinary drugs, vaccines and equipment need to be constructed.

8.14 Water storage

Feedlots should have an onsite water storage to overcome differences in supply and demand and to also provide an emergency storage for temporary supply failures. Emergency water storages can be constructed from almost any material as long as they safely store water at a reasonable cost. Most emergency water storages are either steel or concrete above-ground tanks or earthen embankment storages.

Ideally, the emergency water storage should be part of the normal feedlot water supply system, so that it can cater for diurnal variations in supply and demand and at the same time remain relatively full in the event of an unexpected supply failure.

Earthen embankment storages: Earthen embankment storages are filled by pumping water from some other source. The ring tank is in the shape of a ring (or square or rectangle) bounded by a compacted earthen embankment and usually located on relatively flat ground. The material required for the embankment is excavated from inside the embankment, hence water can be stored above and below the natural ground level.

As all water is stored above natural surface level it can be gravity fed to the point(s) of usage. Each earthen embankment storage is unique in size, shape, capacity, location, soil and environmental characteristics and hence has to be designed individually.

Above-ground tanks: Above-ground tanks are an alternative to earthen embankment storages. They can be constructed from various materials (e.g. concrete, polyethylene, corrugated iron), are available in various sizes and generally have an enclosed roof. Most steel or concrete tanks can be supplied with a cover. When located on a stand or high point above the feedlot pens, gravity assists flow of water to the off-take points. The cost per volume of storage of these tanks is much higher than from earthen storages.

Temporary supply: Trucking emergency water is expensive and requires intensive management. It should be considered only as a temporary solution or in extreme emergencies.

Storage size: Emergency or back-up water sources sufficient to meet the basic water requirements of livestock during peak demand days and the anticipated emergency period must be incorporated in the design and planning process. This supply or storage should be of sufficient capacity to supply water to livestock under emergency conditions until breakdowns can be repaired.

Emergency supply should be capable of supplying basic water requirements for at least 48 hours. Where some infrastructure (e.g. deep artesian bores) may take much longer than 48 hours to repair, a secondary water supply source or large temporary supply is essential.

The number of days of storage required depends on the anticipated time needed for pumping systems to come back online. The following formula can be used to determine the emergency storage volume.

Storage Volume (L) = Peak drinking water (L/head/day) × Pen capacity × No. of supply days. For example, a feedlot with 1000 head of cattle on feed needs a two-day emergency supply volume of = 40 L/head/day × 1000 head-on-feed × 2 = 80,000 L.

The same formula can be used to calculate water requirements for other species of livestock by considering the daily water requirement for camel = 30-40L/head/day; for sheep = 6L/head/day; for goats =10L/head/day.

8.15 Incinerator

- The incinerator should be built on the leeward of the feedlot.
- The incinerator could be built either from metal or bricks.
- Its size should be enough to incinerate whole carcass of cattle or camel at a time and should be at least 50 m away from the livestock pen and service facilities

8.16 Energy production unit

- ❖ Packaged boiler, refrigeration units and an electric generator or connections to the public supply should be housed in separate rooms.
- ❖ Hot water heaters or heat exchangers for the feedlot supply shall be located in a central boiler room.
- ❖ The diesel engine room should be built separately on the leeward of the feedlot facility.

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