5

Physical features on large-scale farms

This chapter presents an understanding of the important physical resources necessary for large-scale tropical dairy systems to be viable.

The following physical features are set out below for a large-scale dairy farmer milking a herd say of 100 or more dairy cows, as well as rearing their own heifer replacements. If the ultimate plan for the farmer is to milk more (say 1000 cows) or fewer (say 80 cows) stock, then the size of the physical features need to be adjusted in proportion to the number of total dairy stock. This chapter is similar in layout and detail to Chapter 4, because the principles for the design and layout of the dairy farm are not dissimilar for both smallholder and large-scale farms. This chapter should then be read in conjunction with Chapter 4, particularly as it will not duplicate the following sections:

- other facilities in cowsheds (4.3.3)
- cooling cows (4.3.4)
- other farm buildings (4.3.5)
- feed storage (4.4)
- checklist for planning dairy sheds (4.5).

5.1 Land

5.1.1 Location

See Section 4.1.1 for discussions for smallholder farms.

5.1.2 Forage production area

The key principles are outlined in Section 4.1.2 for smallholder farms. The following refers specifically to the layout of larger-scale farms.

Area of forage grown

For a 500-cow farm where all the stock's forages are to be produced on-farm, the farmer should aim to utilise a total of 60 to 80 ha land for forage production. This recommendation is for a farmer in the humid tropics growing Napier grass as the primary forage source. This will obviously vary with the location and preferred forage species, but because of its relatively high yield, the required area is likely to be larger in regions where forage species other than Napier grass are grown.

Area available for grazing stock

The optimal stocking capacities in Section 4.1.2 are all based on the forage being mechanically harvested and fed to dairy stock housed in sheds. Additional land can be developed for grazing for some classes of stock, such as growing heifers or dry cows. However, combining grazing with 'cut and carry' forage feeding systems in the tropics requires an additional set of skills, namely grazing high yielding cows in the humid tropics. If land is available, grazing should be preferentially offered to growing heifers and dry cows, as they do not require twice daily attention as do milking cows and milk-fed calves.

In some areas, milking cows may be provided with large areas of pastures for grazing as well as indoor feeding facilities. The indoor feeding facilities are then called feedpads or feedpad sheds. If the feed offered indoors is mixed and delivered using a mixer wagon, it would then be called a partial mixed ration (PMR), rather than a total mixed ration (TMR) that is fed to stock living inside sheds.

Other aspects of forage production and utilisation

Fresh forages fed to large milking herds are usually harvested mechanically, although they may be harvested by hand using large teams of farm staff. The forages are then transported to the cowshed, either by vehicle if distant, or by hand or hand-pushed trailer if close by. They may be wilted before being fed out to reduce moisture content, in which case a series of wilting racks needs to be constructed close to the cowshed. Finally, they should be chopped, either by hand or machine, before feeding out.

Large-scale harvesting of forages is best undertaken using a forage harvester that chops the forage before directing it into a large wagon for transport to the feed shed.

5.1.3 Effluent storage and management

From Section 4.1.3, a 500-cow (plus replacements) farm thus produces 16 to 18 t fresh manure and 7000 to 10 000 L urine each day and this would amount to a total volume of 15 to 20 m^3/d, excluding any rainfall run-off.

Any farm with more than say 100 milking cows is too big to rely entirely on physical labour to collect and distribute the shed effluent. Therefore, to minimise labour, such a farm would require a large storage pond plus manure pump and distribution system. The size of the storage pond would depend on the annual rainfall, the ability to divert run-off water to other disposal systems, the daily input from the dairy shed and the frequency of applying the effluent to the forage production area. However, it would have to have a capacity of at least 50 m^3 to provide for several days' storage.

The depth to groundwater under the soil surface is important as this will limit the pond depth and so increase its required surface area. The base of the pond should be at least 1 m above the highest seasonal watertable. With large dairy farms, the permeability of the soil is particularly important, as this will influence any seepage to groundwater supplies.

Effluent solids removal is also an option, with the solids being spread on grass or forage, or being sold and the liquid used for irrigation. Large-scale bio digestion and electricity production is also an option worth considering with solid waste used as fertiliser.

5.1.4 Water supplies

It is essential that cows are provided with adequate supplies of good quality drinking water. If this is not readily available year-round, then it can be supplemented with a system for collecting the rainwater during the rainy season for storage until required. Throughout the humid tropics, greater attention needs to be given to ensuring all sheds and houses have gutters and downpipes to facilitate the collection and storage of rainwater for stock drinking purposes.

Lactating dairy cows in the tropics require 60 to 70 L of water each day for maintenance, plus an extra 4 to 5 L for each litre of milk produced. Water requirements rise with air temperature and an increase of 4°C will increase water requirements by 6 to 7 L/day per L milk produced. High yielding milking cows can drink 100 to 150 L water/day during the hot season, so a 500-cow herd would require up to 75 000 L/d to ensure limited water intakes do not restrict appetite. In areas with lengthy dry seasons, very deep underground bores may be the only reliable source of stock water. The high cost of accessing this water often leads to shortages in drinking water, which can reduce feed intakes, accentuating the problems of reduced milk yields arising from depressed nutrient intakes.

5.2 Buildings

Cowsheds need to be sited to ensure a balance between dairy production, livestock health, environmental protection and long-term farm sustainability, and at the same time have minimal impact on neighbours.

There are many issues that must be considered when selecting a site for cowsheds on large farm. These include:

- access to the milking shed, feed supplies and farm laneways for stock movement
- access for employees and vehicles
- access to a breeze to cool cattle
- being of a suitable size, height and distance apart to allow breeze for ventilation and cooling
- being suitably placed for maximum biosecurity
- highland areas, because the air temperature decreases 6.5°C for every 1000 m increase in altitude above sea level
- being close to areas potentially destined for large-scale industrial development, because this can change the microclimate of the farm over several years
- expansion opportunities and staged development programs
- access to sufficient water of acceptable quality
- slopes and other topography features
- visibility from milking shed or farm residences
- any existing site services, such as channels, drains, electricity
- existing vegetation, particularly native vegetation
- proximity to waterways, dams and streams
- existing buildings, particularly farm residences
- prominence in the landscape, views into the site and general aesthetics and amenities
- provision of shade in the absence of trees on the farm
- boundaries and easements
- flooding impacts
- groundwater impacts and consequences
- uncontaminated stormwater control or diversion
- ease of harvest of manure and reuse of wastewater and nutrients
- prevailing winds in relation to odours and farm and neighbouring residences
- potential conflicts with future development of urban areas, residences, land zoning
- proximity to archaeological or heritage sites
- proximity to threatened or endangered species or ecological communities
- proximity to underground telecommunications, water reticulation or electrical or gas transmission conduits.

5.2.1 Topography

The natural drainage regime of the area must be considered to facilitate the diversion of uncontaminated storm run-off, the removal and transfer of wastewater to an effluent storage, the reuse of wastewater and the drainage of contaminated run-off from the feed storage area.

Slope creation on a cowshed site relies on having sufficient soil depth to accommodate the cut and fill requirements necessary for undertaking earthworks. This applies particularly to areas where holding ponds are required.

The sheds should be formed well above the natural surface level to promote drainage, increase air movement to decrease odours and to discourage insects. The cost of sourcing and moving sufficient suitable soil needs to be taken into account. Buildings and works should not be located on steep slopes, greater than 20%.

5.2.2 Flooding

Before determining a potential shed site, a property floodplain overlay should be obtained from relevant local or state government agencies to clearly identify potential flood-prone areas. This should avoid any adverse impacts during significant rainfall events and periods of prolonged rainfall.

The sheds should be located above the 1-in-100-year flood level and all earthworks should be designed to avoid offsite impact of floodwater discharge either through funnelling or backwater effects. The tops of any farm dams should also be above this flood level, but not necessarily any irrigation recycling sumps used to shandy effluent.

The natural drainage regime of the area must be considered so that uncontaminated rainfall run-off can be easily diverted away from the effluent storage. Gutters and downpipes leading to drains or water storages will allow more effective control of such rainwater.

5.2.3 Groundwater impacts

Groundwater investigations are also important when designing sheds and determining potential sites for their construction. It is often advisable to dig check wells at various localities and monitor them over a 24 hr period to see if they fill with water.

Cowsheds and associated areas, such as cattle loafing and silage bunkers, have the potential to generate high levels of nutrients which in turn pose significant risks to both surface and groundwater supplies through surface run-off and leaching. These risks need to be identified and managed during the development phases of the farm.

5.2.4 Shed slope

A fundamental design aspect of any large shed site is ensuring the floor slope is adequately determined and constructed to optimise the proposed site's natural topography. This will also avoid unnecessary soil importation, which will add significant cost to the construction.

The overall slope of the floors and associated loafing areas is important to:

- effectively remove effluent, fibrous material and sand from alleyways by optimising flood washing systems performance
- enable sufficient drainage from the site to remove water quickly following heavy rainfall events

- prevent unnecessary pooling of water creating odour and boggy areas
- enhance cattle flow and prevent potential flat slippery areas
- utilise the site's topography and natural drainage features
- eliminate tractor and mixer wagon slip when feeding out
- allow sufficient turning space for vehicles.

5.2.5 Soils

Soils need to be evaluated to assess their suitability for constructing the sheds and effluent storages. The engineered earth must be strong enough to carry the heavy loads of machinery, building foundations and, of course, stock. Clay dominant soils will be required and sandy soils avoided. Soil investigations and permeability tests should be undertaken to avoid costly mistakes and risk to the surrounding environments.

During shed construction, better compaction can be achieved by removing and stockpiling the topsoil to use later for landscaping or covering exposed soils (with a minimum layer of 100 mm to protect against erosion).

Insufficient soil investigations for shed sites can lead to:

- constant maintenance and repairs of high traffic areas
- surface cracking
- groundwater pollution from nutrient leaching
- seepage into effluent storages.

5.2.6 Access for stock and vehicles

The sheds should be in a central location to minimise vehicle movement and provide for orderly stock management and effluent collection. A tyre wash should be considered for all vehicles entering the farm as part of the biosecurity system.

The physical dimensions of the laneways, races, gates, entrances and exits should be designed for ease of stock access and movement. Vehicles require a minimum of 3.7 m width for easy access. A compromise is usually necessary between very wide laneways, which occupy land and reduce stock control, and narrow laneways with a funnelling effect that can contribute to problems with lameness. Factors to consider include:

- structures should take advantage of the social behaviour and natural movement of cows
- fences and gate should have no protrusions to hinder stock movement
- laneways should be a minimum of 4 m wide which should be increased to 5.5 m for herds of more than 120 cows. Laneways 8–10 m wide are now commonly used on farms with herds in excess of 1000 cows. Very wide laneways can reduce control of stock movement
- allow stock to enter the sheds without having to change direction by more than 90°. Use rubber matting on high traffic and turning areas to reduce hoof erosion
- all laneways, access and stocked areas should be well drained with the run-off directed to drains leading to the shed effluent system.

The shed design should also allow for all-weather access of vehicles with:

- minimum width for laneways of 4 m
- feed lanes should be 4.5 to 6 m wide to allow for easy tractor and feed-out wagon access
- entry and exit points, as well as turning areas for cleaning and feeding out, should be wide enough (8–10 m) to allow free flow of stock and vehicles
- room for distribution of feed on the feeding area
- room for cleaning operations
- movement of trucks to deliver feed on site
- access from a main or secondary road
- sufficient room for large trucks requiring high clearance
- adequate area for collection and stockpiling of solid wastes and residues from effluent storages and solids traps.

5.2.7 Constructing and maintaining external laneways

Routes for laneways should permit easy cow flow and, if necessary, allow for herd expansion. Grass and topsoil should be removed and the prepared area well compacted, above the watertable and free from pugging. Additional materials, such as pit or river gravel, may be necessary to elevate or stabilise the surface in preparation for track construction. This layer should also be well compacted.

First, construct a sound base that can support the top surface without moving, wetting or breaking up:

- using coarse material with a clay content of 15–30%. Do not use soft clay
- applying the material in 150 mm layers and compact well between layers with a roller at slow speed. Use a power grader with an experienced driver, or alternatively, a tractor mounted blade and a pneumatic-tyred roller or loaded vehicle with high-pressure tyres
- developing a camber or slope across the track that will shed water and be comfortable for cows, using a slope of say 1 in 10.

Second, construct the top (wearing) surface suitable for cows to walk on, ensuring:

- it has a minimum depth of 50 mm, with 100 to 150 mm preferred
- it does not contain stones which can cut hooves, or free uneven material that can cause bruising
- if coarse gravel is used, it is well rounded gravel of less than 25 mm diameter, with 15–30% clay content to allow adequate compaction, binding, wear resistance and smoothness
- large stones are avoided as these get kicked out of the track, leaving the site susceptible to water ponding and hoof damage
- the surface is sealed and the camber finished to prevent moisture draining into the base. The addition of 3% cement before compaction assists sealing
- compaction is essential as cows are not able to compact tracks adequately.

When maintaining laneways:

- seek out sections that are breaking up to identify and rectify any underlying causes
- drainage may need to be improved or the top surface may require additional compaction
- repair sections closest to the dairy first, as these are ones most frequently used
- remove stones from these sections and make sure they are well compacted, appropriately crowned and well drained. Cows cannot adequately compact these wearing surfaces
- if problems exist with cow flow, that section of the track may need drainage, repairing, crowning, maybe widening or even rerouting.

It is important to avoid right-angle bends in laneways as cows tend to bunch up, slowing down movement and increasing effluent dropped. Manure in laneways is less likely to enter the effluent system to be redistributed around the farm, thus losing its potential as a useful soil nutrient. Good cow flow minimises the time cows spend on laneways, hence the lost effluent. Allowing cows to move at their own pace will also reduce lameness and fouling of laneways.

5.2.8 Height and orientation

The height of any shed should be accessible to machinery used for cleaning and feeding, with a minimum recommended ridge height being 9 m and eave height of 5 m with central roof ventilation. It should also promote sufficient ventilation and penetration of sunlight. As the positioning of eaves and roof canopies will affect shading and sunlight, orientation is important. Winter sunlight provides additional warmth for the stock, helps to dry the feedpad surface and reduces the incidence of diseases. Summer shade reduces heat stress.

The sheds can be orientated to either maximise or minimise exposure to climatic elements such as prevailing winds, sunlight and rainfall. Extreme weather conditions can affect all feedpad operations from time to time, regardless of geographic orientation. Orienting the feedpad perpendicular to the summer and autumn prevailing winds assists in cooling the cattle. For a covered or shaded shed, a north–south orientation promotes drying because the shade moves across the pad during the day. Dry shed conditions are important as wet areas can predispose the stock to mastitis. However, since a north–south roof or shade orientation does not provide any less area under shade compared to an east–west one, covered free stall sheds should be orientated east–west.

5.2.9 Drainage

Effective drainage is important for all weather access, collection of contaminated run-off and diversion of uncontaminated stormwater. Raised floors will promote natural drainage. The drainage system should be designed to handle shed run-off from a 1-in-20-year 24 h storm event. Additional water from all surfaces, as well as washing systems and trough spillages, should be included in any storage volume calculations.

The drainage system should incorporate:

- drains or diversion banks
- sedimentation basin to remove solids from liquid effluent
- catch drains to carry storm run-off and effluent, with minimum slope of 0.5%.

It is important to minimise the necessary capacity of effluent storage requirements. Rainfall contaminated by faeces, urine or residue feed should obviously be directed into effluent systems. However, uncontaminated rainfall run-off (from clean surfaces such as roofs) should be diverted to the natural drainage system.

Run-off from livestock areas contains relatively high levels of nutrients, salts, chemicals, debris, pathogens and oxygen demanding organic matter so must be directed to effluent re-use systems (see Figure 5.1a to d). Wherever changes are made to cow flow, provision should be made for the diversion of contaminated run-off to effluent systems.

5.3 Specific details of buildings

5.3.1 Free stall cubicles and sheds

A free stall shed is essentially a feedpad with the addition of specific bedding areas where the stock can lie down. It is generally a covered shed and may include a loafing area for cattle to also be loose housed where they can stand, ruminate or idle. When well-designed and managed, free stalls provide the ideal system for intensively managing dairy cows off-pasture as each animal is provided with a specific place to rest, their management (feeding, cleaning and relaxing) is potentially optimised and the system can operate efficiently with minimal labour. However, they are expensive to construct and can become very unprofitable if stock suffer from poor welfare, animal health and milk quality due to poor feeding, cow comfort and herd management.

Free stalls are individual cow bedding cubicles where partitions orientate stock for comfort and sanitation, providing each cow with a dry and comfortable place to lie down and rest and ruminate. Free stall sheds should have one stall for each lactating cow. Some farmers provide additional stalls to allow for herd growth and to provide areas for subordinate animals to move away from more aggressive herd mates.

Stalls must allow enough room for the largest cow to freely enter the stall, lie down, rest comfortably and easily get to her feet to exit the stall. To do this, stalls should take into account the cow's normal desire to rest facing uphill slightly and

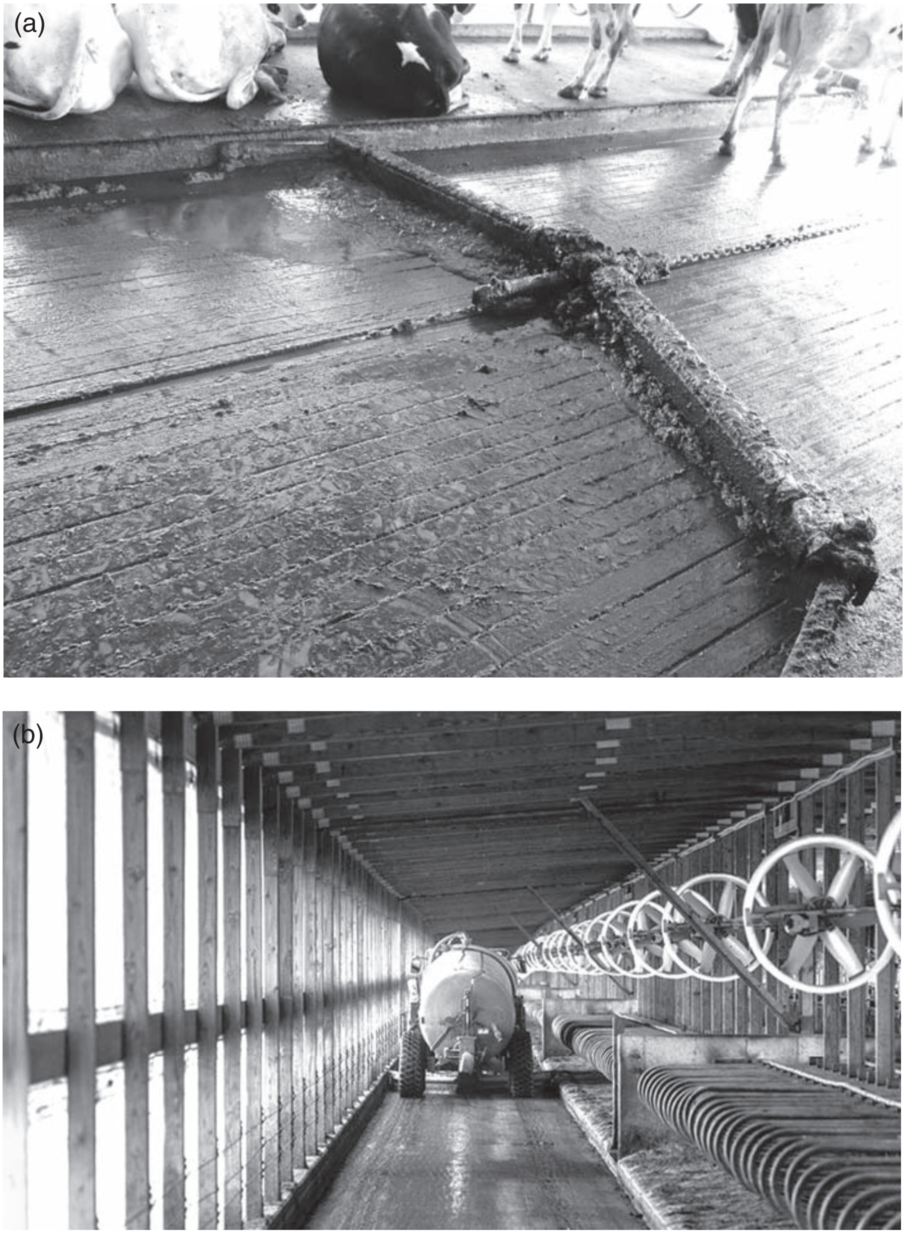

Figure 5.1: Managing cow effluent is a major issue on any large dairy feedlot farm. This series of pictures shows various ways it can be addressed. (a) The floor scraper is a chain driven device that operates 24/7. It is the most popular system to remove shed effluent even though it cannot completely clean the cow walkways. The shed effluent is directed towards a 'solids separator' facility to reduce the liquid content sufficiently for it to be handled by machinery to transport and spread it on the forage-producing areas of the farm or to nearby contract forage-producing farms. (b) This effluent tank is towed down the cow walkways while the cows are at milking

(c)

(d)

Figure 5.1: (Continued)

or otherwise locked out of the free stall shed. It sucks up the effluent for further processing before distribution on the forage-producing paddocks. It would produce a cleaner walkway surface than the floor scraper system. (c) The flushing system provides the best and most efficient cleaning system but there has to be a series of drainage pits to reduce the water content to allow the handling of the solids. Either that or the entire effluent solution is applied by flood irrigation. (d) The water flushing system requires large volumes of fast-moving water, hence the water towers shown in this picture. It is obviously better suited to high rainfall areas.

change resting positions or stretch while lying down. In addition, there needs to be sufficient room at the front of the stall as cows need to lunge forward to lift their hindquarters first when rising.

The shed layout should provide a flight route for submissive cows. In pens with rows of free stalls, there should be at least two cross-alleys, even in small groups of eight cows. Per 20 cows, there should be at least one cross-alley as a cow should never have to walk past more than 10 stalls to reach a cross-alley.

Cubicles or stalls can be arranged in a single row or in more than one row with a central feeding alley or with feeding alleys along the sidewalls. The cubicles can be arranged with cows facing one another (head-to-head) or the other way around (tail-to-tail). With the tail-to-tail arrangement, a central cow alley, 2.2 m wide between the cubicles is needed. If the cubicles are head-to-head, two cow alleys behind each row are necessary. Usually one of these alleys is combined with the feed alley. Free stalls are usually laid out in modules with crossovers providing access to the feeding alley. These can provide multiple routes between cubicles and feeding area and so minimise the adverse effects that dominant stock can have on the eating behaviour of submissive stock. Some free stall sheds have self-catching lockable feeding headstalls along the feed bunk to allow animals to be caught for veterinary attention, insemination or even locked away from the feed.

The latest information in relation to stall dimensions must be checked before any construction beginning. The following is a guide only.

Stall dimensions should be based on the largest 25% of the herd to allow for increase in cow size through improved feeding and genetics over time. They should also provide for adequate lying down as well as necessary forward and sideways lunging to stand. Typical Friesians require ~240 cm long × 120 cm wide lying space with a further 60 cm forward lunging to allow for normal standing behaviour. Forward lunging space can be shared where two rows of stalls face head to head.

The size of the cubicles depends on cow size. For cows:

- weighing 400–500 kg, they should be 104–109 cm wide and 198–208 cm long
- weighing 500–590 kg, they should be 109–114 cm wide and 208–218 cm long
- weighing 590–680 kg, they should be 114–122 cm wide and 229–244 cm long.

Stalls that are too long or wide allow the animal to move forward or at an angle, in which case faeces and urine can be deposited within the stall and not in the alleyway. To further prevent cows from soiling the cubicles, shoulder, breast and neck rails are needed to force cows backwards when they stand up. The distance of the adjustable shoulder rail to the back of the cubicle, measured diagonally, should be ~1.8 m, and the height to the cubicle floor may vary between 0.9 and 1.05 m.

The stall kerb separates the stall area from manure in the walkway. It should be high enough to prevent manure from entering the stalls, but low enough to allow cows to enter and exit the stalls easily. Recommended maximum curb heights are 20 cm or, if a mattress or mat is used, 30 cm.

The ideal lying surface is soft, absorbs moisture and does not promote the growth of bacteria. When cows are forced to lie on hard surfaces, they do not lie down for long, are more unsettled and may develop knee and hock lesions and swelling, acidosis or laminitis. The stall base is usually made of concrete or compacted fill, which is then covered with bedding, or even a mattress filled with recycled rubber (or crumb, foam, gel or water). Alternatively, rubber mats can be used with bedding. All base types need loose bedding material on top for further cushioning, moisture absorption and to reduce friction. If the stall base provides good cushioning, less bedding is needed on top.

The simplest and most effective bedding is concrete with a deep layer of sand, but it needs care to maintain the surface. Cows often push sand around, but a cement base, compared to an earthen base, can reduce this. Sand bedding can cause problems with mechanical or liquid manure handling systems because it fills up storage tanks and is very abrasive, damaging equipment such as manure pumps.

A concrete foundation with a disposable bedding of chopped straw, sawdust, wood shavings or crushed corncobs is more common in Europe, as rice hulls are not readily available. Rice hulls makes ideal bedding for free stalls. Hard surfaces should have a slope of at least 1% so that urine will drain into the cow alleys.

Hard rubber mats provide little cushioning, particularly if very thin, and they may be slippery. Soft rubber mats provide similar features as mattresses. Attachment methods, surface texture and compaction of the mat or mattress material are all issues to consider when selecting and installing mats or mattresses. Bedding is required on top of mattresses and mats to help to maintain clean dry conditions.

Manure and wet bedding should be removed and replaced with dry bedding material at least once per day. Cleaning should be frequent enough to keep the back of the stall clean because this is where the cow's udder and teats are in contact with the bedding when she lies down. Organic bedding (sawdust, straw, hay, composted manure, rice hulls) should be added daily, especially on mattresses and rubber mats, as it is hard to keep bedding on these surfaces.

Dirty cow alleys will result in dirty beds and udders, weakened hoof horn and potential mastitis. Cow and feed alleys should be kept clean by manual scraping, automatic scrapers or flood washing. Although cows can still be in their stalls, it is better to time flood washing when they are away from the shed.

Mechanical scrapers are probably the most common floor-cleaning equipment in free stall sheds but they still leave a film of cow manure on the floor, thus continually exposing stock to pathogens. One operator in Vietnam commented that in such a shed, lameness and mastitis levels increased each summer, when sprinkler systems were in common use to cool the cows, because the additional water on the floor (from the sprinklers) increased the degree of exposure to these pathogens. Therefore, ideally the floors in sheds that use mechanical scrapers should also be hosed down every day to reduce this pathogen load.

The free stall environment should be made safe for the stock through ensuring they cannot put their heads through gates and fences or get stuck under stall divisions and barriers. There should be no projections, such as broken boards or rails or rough, sharp edges on the concrete. Rails should be strong enough not to break when cows lean on them. Walking surfaces should be grooved to minimise slips and falls and so encourage normal oestrous activity. Cattle crushes and head gates should be well designed to ensure that stock can be examined without fear of injury.

The free stall facility should be designed to ensure smooth and quiet cow flow. There should be no sudden changes from light to dark, reflections or drains across the cow alleys. Cows will move more smoothly along curved races, up a slight incline and where they have 'sure' footing. Gates can be muffled by attaching rubber strips to prevent excessive noise when closing. Yards must be designed for easy drafting of targeted cows. Stock should only be moved around using 'flappers' (leather strips attached to a cane) rather than using wooden or metal pickets or pipes. Excessive twisting of an animal's tail is unacceptable and electric prods should only be used in emergencies.

Monitoring free stall use

The cow is the final inspector of free stalls and if cows are not successfully and regularly using them, or they are dirty and show signs of injury, action is required. There are a variety of ways to monitor the cows' use of free stalls and free stall sheds, such as:

- Do cows appear comfortable when standing or lying? If not, stall dimensions and bedding may need attention.
- Do cows have to push, bang and/or bump against stall components to lie down, get up or change positions?
- Do cows lie backwards or sideways in the stalls or in the alleys?
- Do cows stand half-in or half-out of the stalls? This is called 'perching'. This can occur when the stalls are too short, the neck rail is too far back or when the stalls are otherwise uncomfortable.
- Do cows stand in the stalls at an angle? This indicates the stalls are too wide.
- Are all stalls used equally? If not, there would be a reason why some are not chosen by the cows.
- When cows normally rest (between 10 p.m. and 4 a.m.) are more than 20 to 30% of the herd standing in the stalls? If so, stall comfort may be questionable.
- Cows should lie down for at least 11 to 12 hr each day.
- Are cows' udders, tails or hindquarters dirty? This could indicate dirty bedding but may also be due to low fibre diets and very loose manure.
- Are there patches of rubbed-off hair or visible injuries to hocks and knees? These are signs that cows rub excessively on stall floors, partitions or neck rails when rising or lying down.

- Are cows walking very slowly, or timidly, with rear feet spread wide? This could be a sign of poor traction or laminitis.
- Are some cows slipping and falling in the shed? This could also be a sign of poor traction.
- Do more than 20% of the cows defecate in the milking parlour? This could indicate discomfort or uneasiness in the free stall shed.
- Are cows bellowing excessively or exhibiting abnormal behaviour?
- The comfort of the stall bedding can be assessed by the:
  - wet knee test, which involves kneeling in the stall for 10 s and if the knee is wet, the stall bedding is not dry enough
  - drop knee test, which involves crouching and then dropping to your knees in the stall. Any pain reaction in your knees will quickly tell you how truly comfortable the stalls are.

5.3.2 Facilities and equipment for additional health care

To ensure good health care, sufficient health facilities are needed and cowsheds should include additional stalls for such purposes. These and other stock handling aids are included in the following list.

- *Treatment area*, for confining animals on heat, artificial insemination, routine health checks, pregnancy diagnosis, lameness and examining sick cows. As animals are usually separated when they leave the milking parlour, it should be located close by. The width of this treatment area should be at least 0.7 m per cow and the length 3 m. Farmers usually find it convenient to store equipment in a specific veterinary drug box in this treatment area for treating hoof problems, for trimming hooves, taking blood samples etc. There should be one treatment stall for every 20 cow stalls with a minimum of two.
- *Separation area or hospital pens*, to treat sick cows properly and prevent the spread of disease. It should be located close to the milking parlour. Drinking water should be available, with concrete floor and gutters to allow for frequent cleaning and sanitising. There should be one hospital stall per 50 stalls with a minimum of two. With tie stalls, there is little need for a special separation area.
- *Calving area,* to permit proper attention at this critical time. With loose housing, cows may need to be tied up in stalls and should calve down away from the milking herd and close to the calf pens. As with the separation area, ease and thoroughness of cleaning and sanitation are key features. There should be one calving stall per 30–50 stalls with a minimum of two.
- *Separate bull and mating pen*. Although farmers generally use AI to mate their cows, herd bulls are often kept to mate heifers or cows that have been unsuccessfully inseminated several times. Bulls should be kept separate from

the adult cow herd except when used for mating. A mating yard will allow for cows on heat to be separated from other stock for better control of the bull's activities. It is preferable to bring the cow on heat, once identified, to the bull and so provide room for mating activities in the bull pen rather than let the bull mate in the laneway or a free stall.

- *Cattle race, crush and/or head bales* or other ways of immobilising stock are important both for the stock (to reduce stress) and the staff (to reduce injury). A cattle race allows stock to be separated out and immobilised when requiring additional attention such as insemination, veterinary treatment or foot trimming. It is important that stock can be handled safely when individually separated from the herd. The farm should have a set of cattle yards that includes a race for AI, a crush for close veterinary attention and treatment and, if desired, a set of scales to routinely weigh stock. Special hoof-trimming crushes are available in which each foot can be lifted up separately and secured to aid trimming of the hooves. Cattle crushes and head gates should be well designed to ensure that stock can be examined without fear of injury. Head bales should be made of steel with sufficient robustness to hold a large unsettled animal.
- *Footbaths* should be available for routine hoof treatment, at least 2 to 3 m in length and 0.15 m deep. The width should be the same as the passage to prevent cows from bypassing the bath without using it. Double footbaths are better because they allow dirt to be washed off before treatment. The first bath tends to activate the dunking reflex that allows the solution in the second footbath to stay effective for longer. A solid platform of 3 m between footbaths will help shed off some of the wash solution from the first footbath. Emptying and refilling them should be quick and easy. Hulsen (2013) recommends that footbaths should contain 4% formalin or 38% commercial formaldehyde solution, although formalin is a human health risk. Copper sulphate can also be used in the second footbath. Each cow should walk through them once each week. The frequency should vary depending on hoof cleanliness and dryness and how much they show evidence of horn erosion or digital dermatitis. Placing footbaths in the raceway from the milking shed will ensure a more thorough foot treatment protocol.
- *Electric cow trainers.* These consist of wires positioned above stalls that carry electricity and are used to teach cows to step backwards when their back is arched before defecation and urination. The cows then alter their behaviour, which keeps them and their stalls cleaner. Electric cow trainers are, however, risk factors for silent heats, clinical mastitis, ketosis and culling, with herds not using cow trainers having less of these issues. In some poorly designed stalls, cows prefer to stand and experience the pain associated with lying and rising. When they are moved to better-designed stalls, the cows learn to use these trainers. Many farmers do not use them as they are more likely to unsettle temperamental animals.

- *Storage of veterinary drugs and other dairy equipment.* Veterinary drugs should be stored in a dark cupboard, and if required, inside a refrigerator. For security purposes, it should be lockable. Other dairy equipment, such as detergents and sanitisers for cleaning milking machines and equipment for trimming feet or dehorning calves, should also be stored in a specific location. Milk-harvesting equipment, such as buckets, sieves and milk cans, should be stored off the ground. Farmers should hang this equipment upside down to aid drying.
- *Farm office and staff quarters.* This is an essential part of any large dairy farm. This area would house the administration team and their equipment, such as office files and computers, and also provide a centralised meeting place for senior management and farm staff. It would seem logical that microwave ovens, for routinely monitoring the DM of TMRs and their ingredients, microscopes for monitoring semen quality and other laboratory equipment also be located in this area. Closed circuit TV (CCTV) cameras would be worth considering to provide for 24/7 observations of stock (in sheds for milking cows, calves and heifers) to monitor stock behaviour and their wellbeing. Suitable chairs and tables should be included for business meetings with service providers and other farm-related visitors. The farm staff should be provided with space to eat and relax when off duty. This could include a shower and toilet, food preparation area and storage for their work clothes.
- *Cooling cows.* The air temperature decreases 6.5°C for every 1000 m increase in altitude above sea level. Cooling cows is discussed in Chapter 4, Section 4.3.4 and also in Sections 5.3.4 and 5.5 below.

5.3.3 Housing for other stock

In addition to milking cows, farms have to house dry cows, milk-fed calves and weaned growing heifers and herd bulls. Some farms also rear non-dairy (dairy beef) stock such as heifers, bulls and steers that may or may not have originated from the milking herd.

The area needed to house young stock depends on:

- their number
- type of housing
- calving pattern of milking herd
- replacement percentages of milking herd
- division of herd into age groups.

A good management practice is to divide replacement heifers into the following four age groups:

1. 0–1 month-old milk-fed calves,
2. 1–5 month-old milk-fed and weaned calves,

3. 5–22 month-old weaned heifers and yearlings,
4. 22 months and older pregnant heifers.

Young milk-fed calves should be housed in clean and disinfected individual pens (0.6 × 1.3 m), separated from the cows. The pen partitions should be solid and smooth, 1.5 m in height. The raised floor could consist of wooden or metal slats 20 mm apart or the calves could be penned on a free draining deep litter system. Containing each milk-fed calf in a raised metal, individual cage provides the best housing as they are isolated from each other, live in a well-ventilated and clean pen, are easier to feed and water (as the farmer does not have to bend down to feed them) and, of most importance, it allows for much easier individual surveillance. Some farmers are concerned that young calves need to be kept in groups so they can learn to socialise, but this can happen post-weaning without any detrimental consequences.

Older calves can be housed in tie stalls (0.7 × 1.5 m) or preferably in group pens. Weaned heifers can be housed in tie stalls (0.8 to 1.0 m wide × 1.7 to 2.1 m long, depending on live weight) or preferably group pens or free stalls. Pregnant heifers can be housed with dry cows, although they will have different feed requirements.

If outside grazing areas are available, weaned calves and older heifers could be grazed as long as they can be provided with troughs for supplementary feeding when individual parasite treatment and shelter is required.

5.3.4 Other equipment

Such items will improve cow comfort and can become important factors beneficially influencing herd contentment in large sheds where there is likely to be increased competition between cows. There are considerably more antagonistic interactions within a herd of several hundred dairy cows than within a SHD herd, so having these sorts of equipment can reduce negative interactions.

- *Rotating cow brushes* are sometimes provided to allow cows to groom and scratch themselves. It may also reduce frustration or stress due to boredom. (Generally, cows need little behavioural enrichment because feeding, ruminating and resting occupy most of their time and they can rely on other cows for social stimulation.) Cows can be very vigorous in their use of brushes so this equipment needs to be quite robust. Some brushes automatically start rotating when an approaching cow is detected. As cows mostly use brushes to scratch their backs rather than their heads, they should be positioned accordingly.
- *Self-locking headstalls* are designed to restrain cows as they put their head down to eat from the feed bunk. Some free stall sheds have self-catching lockable feeding headstalls along the feed line to allow animals to be caught for veterinary

attention, insemination or even locked away from the feed. These then constrain the cow to facilitate closer observation or individual management. For example, some herd synchrony programs use coloured crayons to mark each potentially cycling cow (if she stands to be mated by another cow, the hair around the crayon is ruffled and easy to note) and these cows can be easily identified during feeding with the stock restricted in self-locking gates. In addition, they reduce aggressive interactions and displacement of socially subordinate cows while eating. These self-locking headstalls are not preferred by cows when they have an option. Despite this, when forced to use them, they have little impact on daily feed intakes, milk yields, levels of mastitis and signs of stress.

If heifers have never been exposed to these headstalls before entry onto the feedlot, some headstalls should be removed from the feeding area so the stock will readily consume the TMR, then reintroduced slowly over a few days or weeks so the stock will adapt to eating through them.

- *Cow showers* are designed to be activated either manually or automatically. In the latter, the showering and interval cycles are triggered only when the dual motion sensors detect an animal is present and the air temperature is above a specified threshold. As air temperatures increase, the interval time automatically decreases, thus giving animals more frequent shower and fan cycles to reduce heat stress. By using a high capacity, coarse droplet shower nozzle, enough water can be applied to fully wet the cows to the hide. Mist and fogging nozzles work by cooling the air around the cows and the disadvantage is that the mist can increase humidity and be easily blown away under windy conditions, or when used with fans. If a mist or fog builds up on the cow's hair coat, it can also trap a layer of air between the skin and the water, which holds in body heat. In comparison, soaker nozzles produce a coarse droplet spray, which penetrates the hair and wets the cow's hide.

  There should be a continuous flow of air over the backs of the cattle any time the cooling system is in operation. This causes the water to be evaporated, which takes the heat away from the cattle in the process. Fans can be controlled separately from the cooling system, and are set to operate continuously above a set temperature. It is worthwhile aiming some fans directly onto stock lying in the free stalls as well as having other fans directing air over their backs when they are eating.

  Normal recommendations are to shower the animals for a short period of time, 0.5 to 3 min, to soak the hide. After the shower shuts off, the water is evaporated from the cattle by fans blowing across their backs for 5 to 15 min, before repeating the shower cycle. Common locations for installing a shower cooling system are in the holding pen area, where cows are crowded together tightly, and at the feed bunk, but not so water will spray onto the feed or into the stall area.

5.4 Water and feeding management

5.4.1 Water supplies

Stock must be provided with sufficient drinking water at all times and the system should be able to supply at least 20 L/cow/hr to meet likely peak demand. The optimum temperature for drinking water is 15–17°C. Peak demand often coincides with feeding times. The pipe diameter needs to be at least 75 mm with an operating head of at least 10 m. A tank could be used for short-term supply in the event of a power failure. A backup water supply should be available to hold at least two days' peak requirements, in case of a breakdown or loss of normal water supply.

Upgrading the facilities can involve increasing the rate at which troughs fill or providing greater trough capacity. Cows can consume up to 20 L/min. Options involve upgrading pumps and water pipe diameters or increasing the number of watering points, particularly those close to the feeding area. Cows often drink a third of their daily water intake in the hour after morning milking on a hot day.

When depending on dams, water quality can become an issue because as dam levels drop, salt contents, bacterial loads and algal outbreaks all tend to increase. Grazing cows can tolerate reasonably high levels of salt in their drinking water, but tolerance levels drop as they are offered less pasture. Problems that limit water intake also limit feed intake, hence cow performance.

Water troughs should be well separated (but within 15 m) from feed troughs with the same water trough servicing adjacent pens. Provision should be made for water spillages, or leakages, to directly enter the drainage system and also for drainage control in the event of burst mains or a jammed float valve. Troughs should be located at the high point of a water line to reduce sediment and to facilitate purging air from the pipeline. Trough design should allow for regular, easy cleaning with a removable bung for complete drainage. In free stall sheds, they should be located at crossovers to reduce the incidence of stock blocking each other in alleys.

Each cow should be provided with 75 mm of linear watering space in free stall sheds while for circular water tanks, one watering space (60 cm of tank perimeter) should be available for every 15 to 20 cows. A water depth of 15 to 20 cm helps keep water cooler, fresh and easier to clean because less debris accumulates. The optimal trough height is 60–90 cm, from ground to the top of the trough. Watering points should be cleaned out at least weekly to remove any feed and other contaminants.

The passage around the drinkers should be at least 4 m wide, so when a cow is drinking other cows can easily pass by. At least 10% of the cows should be able to drink at the same time, but when the air temperature exceeds 30°C, 20% of the cows should be able to drink at the same time.

Access to a reliable supply of water of acceptable drinking quality is imperative. Watering systems may also be required for dust suppression and for sprinklers to cool cows. Although such run-off may be minimal, it should be directed into the effluent system.

If cows are tethered, it is possible to install individual cattle drinkers, with two animals sharing one drinker. To ensure water is freely provided, troughs need to have float valves rather than depend on a hose whenever the farmer decides to refill it. A single watering trough system can control water levels in up to 10 small troughs just by one float valve in a central reservoir with syphon pipes leading to all the troughs, although flow rates can be relatively slow.

5.4.2 Feed troughs and feeding strips/bunks

It is important that all stock can eat comfortably with minimal competition. Whether feeding into troughs or onto cement feeding strips, 70 cm feeding space should be allocated per mature cow. For a feeding strip or trough when cows eat from both sides of the strip, hence face each other to eat, this equates to a total feeding strip allocation of 35 cm/cow. Trough space can be reduced to 45 cm/head for 6 month-old cattle, or to 55–60 cm/head for stock 18 months old. Competition between animals is much less severe when complete rations are fed *ad lib* throughout the day, so trough lengths can be reduced, even down to 30 cm/head.

Ideally, troughs should be covered with a grate that directs the cow's head downwards and precludes the lifting of the head above the trough; however, this feature must be considered alongside the ease of filling the trough with feed. Self-locking head bales will reduce the incidence of cows throwing feed around as they lift their head, hence will reduce wastage. In the latest feedpad designs in the US, concrete feeding strips are covered with epoxy resin to reduce corrosion of concrete. Feeding strips should be positioned 75–150 mm above cow feet level with a nib wall to protect the feed from the effluent, 400–550 mm above the feeding strip. Trough width should be related to the reach of the animals which is up to 80 cm for mature dairy cows eating from the base of a trough 30 cm above ground level. Feed barrier walls wider than 15 cm can restrict how far stock can reach into troughs or onto feed strips.

Feed troughs and strips should be situated on the high side of the pen, running parallel with the contour to minimise pad drainage. They should also have smooth surfaces, as those without grooves or holes that can trap feed are easier to clean and help reduce build-up of waste feed, mould growth and unpleasant odours. The base of the trough should then be raised 10 to 30 cm, with the front 50 cm above this. If too much room is allowed, wastage can increase as the objective is to allow the stock to feed and then move back.

The height of any wall constructed to retain feed should accommodate the chute of the feeder wagon which should be higher than 60 cm, although it is wise to check this with the particular machine. In addition, there should be no uprights that might interfere with discharge from the feeding wagon.

5.4.3 Keeping cows out of the feed

The term 'feedbunk' is traditionally used in the US for feeding strips, but the practices listed below also apply to trough feeding.

- To maximise feed intakes and milk production in lofted stock, feedbunks should not be left empty for more than 2 or 3 h/d.
- When feeding time is limited to less than 8 hr/d, milk production can be reduced by 5–7% in mid lactation cows, and to an even greater extent in high producing cows, which are at or near peak lactation.
- Push up the feed regularly to encourage feeding and minimise sorting of ingredients.
- The feed barrier should not restrict cows' reach.
- It is important to provide sufficient feedbunk space so competition does not adversely affect feed intakes but not too much space so stock can throw feed around as they eat.
- As first-calf heifers tend to eat smaller meals more often than do older cows, separating them out in large herds might reduce competition and improve their performance.
- Feed surface is ideally 100 mm above feet level.
- Feed area should be under cover to prevent rain decreasing feed intakes.
- Remove residue fed and use for other groups, such as heifers or dry cows.
- Cattle consume most of their feed during the comfortable period of the day, that is in late evening in hot weather and during the middle of the day in cold weather. That is the time they should be offered the most.
- Cows are animals of habit that like routine. Once a schedule has been developed, stick to it and if changes are necessary, allow time for the cows to adapt and monitor feed intakes to decide if it was worthwhile.
- Ideally, feed residues should be restricted to 3% or less without impacting on milk production or cow health.

There is no easy answer to the problem of keeping cows out of the feed troughs, as it depends on the feeding system. Some ideas are shown below.

- To reduce bullying, cows can be separated into smaller groups, ensuring there is sufficient room at the feeding face.
- The trough length should be no more than 70 cm/cow if they are all feeding at once or 30 cm/cow if they are fed *ad lib*.
- Ensure the inside floor of the trough is 10 to 15 cm higher than the feedpad surface to provide easier access to the feed.
- Install an electric fence down the centre of the trough.

- Install pipe head bales. Although expensive, they prevent cows from climbing into or being pushed into troughs and also prevent them from lifting their heads out of the troughs, hence able to throw feed around.

5.5 Tunnel or assisted ventilation barns

The high relative humidity and high internal heat production, particularly in high yielding milking cows, create enormous problems with keeping cows cool enough so they maintain sufficient appetite for the high fibrous forages frequently offered them. Ideally in the humid tropics, large-scale dairy farms should be located in highland areas where air temperatures are lower, hence cows are less heat stressed. Evaporative cooling systems, where water droplets reduce air temperatures are often ineffective in the humid tropics because the air already contains too much moisture (as humidity). Thus cooling shed air has limitations in humid environments due to the lack of additional moisture holding capacity of nearly saturated air. As long as the cow's skin is so wet that applied water runs off the coat and there is sufficient air movement, her cutaneous evaporative system can cool the cow up to a point. Computer-controlled systems that spray large water droplets then utilise fans to promote air movement are in occasional use in many large-scale dairy farms in Asia's humid tropics.

Relatively new cooling systems for large sheds are ventilation barns housing 200 or more milking cows. These are often called tunnel barns and are designed to rapidly increase air movement over the stock to effectively cool them without the need to apply additional water to reduce air temperature. The principles are twofold, namely increasing air velocity to cool the stock, while at the same time improving air exchange to reduce the build-up of manure gases, dust and pathogens. The rapid air movement also discourages flies and birds in these sheds. The keys to success of this system are an adequate number of properly sized and located axial-flow fans together with a shed layout that will maximise the entrance of fresh air then its unhindered flow, at cow height, throughout the shed. Many different types of assisted ventilation systems are available as tunnel ventilation sheds are becoming popular throughout the humid tropics.

The back of these sheds holds a batch of very large fans (150 cm in diameter) which blow air out of the shed. Sometimes the front of these sheds have a second batch of large fans sucking air into the shed. This negative pressure then sucks air longitudinally throughout the shed's entire length. As well as promoting rapid air movement over the cows, it exchanges barn air uniformly with fresh outside air.

The shed design is completely different to the more normal free stall sheds, in that the layout facilitates the movement along the shed with a low roof and enclosed sides incorporating large plastic curtains. The fans can be retrofitted into existing sheds but they require extreme internal modifications so as to encourage unhindered air movement over the stock. Because the fans are not usually operating 24/7, shed designs should promote sufficient natural air movement to remove the airborne pathogens and gases when they are not operating. Curtain sidewalls must then be provided to act as air inlets and outlets. They can be closed during fan operations to form the 'tunnel'. In addition, horizontal air baffles along the roof are necessary to redirect the moving air back towards cow level. If there are no fans at the front of the shed, it should be as open as possible so as to maximise air movement into the shed.

The computerised controller would monitor air temperature, wind speed and direction to decide on which mode of ventilation is most desirable. If switching from natural to tunnel ventilation, the fans could be activated with adjustments made to curtain sidewalls and baffled air stacks. Such computer-controlled banks of tunnel fans should be programmed to initially be activated say at 21°C air temperature then become fully operational at say 27°C. These operating threshold temperatures will obviously vary with humidity and targeted cow milk yields.

Standby power generators are normally needed on dairy farms to ensure uninterrupted electrical service to milk-harvesting and cooling equipment during power outages. This must also include backup power to the tunnel fans and their control systems. Alarm systems are also needed to alert farm staff if an electrical service is interrupted to the tunnel fans, together with an evacuation plan to remove cows from the shed if needed. At the very minimum, automatic curtain drops need to be in place in the event of mechanical power failure.

The net return on investment is a function of how well cows maintain milk production for an adequate number of days in a tunnel-ventilated shed each summer as compared to a naturally ventilated shelter. The additional cost of purchasing, installing, operating and maintaining the tunnel system must be offset by the sustained milk production in order for this investment to deliver a return. In addition to lost milk production, reduced conception rates, compromised growth rates of unborn calves and sub-optimal cow health should also be assessed when performing a complete economic analysis of the system. A large-scale dairy feedlot has recently installed a tunnel ventilation shed in the highlands of East Java in Indonesia (1200 m above seal level) and the operators have calculated, for cows producing 30 L/day, the milk response was an additional 3 L/day of milk.

To date, complete design systems for tunnel ventilation are not available (however, see Figure 5.2 for an example from North Vietnam). Pertinent questions that remain unanswered include:

- What is the practical length of a shed that can be tunnel ventilated?
- How can uniform air velocity in the shed be best maintained?
- What are the optimal settings for automatic controls?
- What is the cost/benefit ratio for tunnel ventilated barns?

Figure 5.2: The tunnel ventilation shed would be considered an essential for any large-scale dairy feedlot in the humid tropics. It comprises a batch of large fans, as in this North Vietnam dairy feedlot. This shed has a second batch of fans at the other end of the shed, with one batch blowing and the second batch sucking, to produce a rapid air movement over the stock inside. In the dry tropics, 'water curtains' (or rubber strips over the fan outlets with water dripping off them) can be used to reduce air temperature but this system is ineffective in the humid tropics. The performance of high yielding cows in the lowland humid tropics will always be constrained for many months of the year by suppressed appetites which will reduce milk yields and increase the number of inseminations per conception. No matter what they cost, the tunnel ventilation shed must be considered a good investment. It is possible to modify non-ventilated sheds through a series of curtains along the sidewalls and baffles to direct the moving air over the cows.

5.6 Milking parlour and automatic data recording

5.6.1 Milking parlour

A separate milking area has many advantages. It can be centrally located requiring only one supply of hot water (for cleaning animals and equipment). Daily hose down and weekly disinfecting will minimise environmental constraints to good milk quality. Furthermore, if farmers eventually decide to invest in machines for milking, one milking area minimises problems with low vacuum pressures in long air-lines. In addition, if a decision is made that cows are allowed outside to cool down at night, it seems logical to plan their movements around milking times.

Cows can be milked in a variety of ways. Hand milking is very common with smallholder farmers throughout Asia while bucket milking can be used for cows in tie stalls. Loose-housed cows are usually milked in a separate milking area that can be specifically designed for ease of cleaning and occasionally sterilising. Hot water is essential for thorough, twice daily cleaning of all milk-harvesting equipment. Ideally, milk-cooling equipment should be installed, unless there is close access to a milk collection centre.

Bucket milking is the simplest and least expensive system to install, but the milk must be carried to the cooler. This type of system is usually used in small herds and where cows are milked on a level floor of the shed or milking area. A separate vacuum line can be built around the entire shed if the cows are to be milked while in tie stalls. The labour of carrying milk to the cooler can be avoided by installing a transfer system, which consists of a small receiving tank (say 30 L), including a built-in filter, mounted on wheels so it can be moved around the shed. Pipeline milkers transport the milk directly from the cow's udder to the milk cooler and are usually installed in milking parlours where the milker stands below the level of the cows. Although they are expensive, they save backbreaking labour and are usually designed to be cleaned in place, a feature that not only saves labour but helps to ensure good sanitation.

Designs of milking parlours

Any type of parlour should have a high quality concrete floor and metal rails for durability and ease of cleaning. Walls are not required, but if included they should be at least plastered masonry walls. The pit where the milker stands should have a floor level 90 cm below that of the cows for the most comfortable working position. The number of stands is determined by the milking herd size and the allowable milking time of the herd, taking into account the time taken for the cows to eat the concentrate rations often fed in the milking parlour. Parlours can be of the following types:

- *Abreast parlour.* The milker and the cows share the same floor space. Cows can enter and leave individually. The stands should be 1 to 1.1 m wide when a bucket milker is used or when the cows are hand milked, while 0.7 to 0.8 m is adequate when a pipeline milking system is used. The width for the milker should be 0.6 to 0.8 m. The main drawback is the relatively long distance to walk between milking points, and the cows obstructing the milker.
- *Tandem parlour.* This allows for individual care of the cows but has larger space requirements.
- *Walk through parlour.* Cows enter and leave in batches. Their narrower width can be an advantage if fitted into an existing building.
- *Herringbone parlour.* This provides a compact working area and allows feeders to be fixed to the side walls. Three or four stands on each side should suffice for up to 80 milking cows. Its popularity is due to its simplicity and high capacity

(measured as cows milked per man hour). However, the risk of cows kicking the milker is greater than in parlours where the milker stands beside the cow. The large ones are generally equipped with rapid exit gates in which the entire side of the milking area opens up once milking is finished.

- *Rotary parlour.* These are expensive to install, hence are better suited to very large milking herds.
- *Robotic milking.* This will not be discussed in this book.

If in-parlour feeding is required, it is best to equip milking parlours with grain feeders that allow each cow to be fed in ratio of her milk production. If cows expect to be fed while being milked, they will enter the parlour more readily, thus saving some labour. Each cow can be manually fed her ration using a measuring scoop or an electronically controlled concentrate dispenser. Alternatively, all cows can be fed the same quantity from an automatic concentrate dispenser. Cows can also be trained to enter the parlour willingly with no in-parlour feeding, and this requires very good cow handling and management expertise.

An entrance to a milking parlour that is straight, with no turns will ensure a smooth and convenient operation. Once trained, stock will walk readily into the parlour. A single step 1 cm high will help keep manure from being carried into the parlour. An exit leading to an uncrowded area will facilitate cow flow. It should be narrow (70 to 80 cm depending on cow size) to keep the cows from turning around.

Milking hygiene is generally very poorly managed in many countries, particularly those where farmers are not adequately rewarded or penalised for their milk quality. However, it will become increasingly important as the milk processors invest in the industry and when farmers consider value-adding with other dairy products, such as cheese, that require very good quality raw milk.

Milk room and cooler

Sanitation is the primary consideration in handling milk, whether from a hand or machine-milked cow. Adequate supplies of potable water are essential for cleaning the milking equipment immediately after use. Hot water (85°C) mixed with a chemical detergent is required for effective cleaning and cold water used for rinsing. Milk should be handled in a separate area that can easily be cleaned and is free of insects, birds, rodents and dust.

With machine milking, the vacuum pump and the engine that powers it should be housed in a separate room.

The milk room should be well ventilated with a concrete floor sloped 20 mm/m to a drain and with masonry walls having a smooth, water resistant surface that can be easily and thoroughly cleaned. On dairy farms of sufficient size, the milk is cooled by chilled water circulated between an evaporative water cooler and a milk cooler (plate heat exchange), through which the milk is passed until it is adequately cooled.

Where milk is transported in cans, cooling can be accomplished through a coil, which is immersed in the can. The larger-scale farmer, having a pipeline milking system, and milk collection by a tanker will require a refrigerated cooler and holding tank.

5.6.2 Electronic cow monitoring systems

In most modern large-scale dairy feedlots, each cow is provided with an electronic eartag which is an integral part of the farm's complete cow milking, feeding, breeding and veterinary recording system. Historical data on individual cows, together with graphical user interface, allow staff to monitor lactation curves, milk fat and protein contents. In addition, individual historical records of ailments, treatments and culling allow farm staff to evaluate their management practices.

The individual cow's milk yield can be automatically recorded. Sudden changes in daily milk yields are one of the fastest detectors of animal health problems in newly calved cows, with the first 3 or 4 weeks of lactation containing the majority of all health issues.

Cows can be grouped according to their milking time for more effective use of the parlour capacity as well as identifying, for isolation, those cows requiring special attention or treatment. Any animal requiring special attention can be separated via an automatic sorting gate.

As part of the electronic recording system, activity meters continuously collect and transmit activity data on each cow which provides valuable information, in addition to field observations, on cows' reproductive cycles hence the herd's breeding program. Low activity can also be monitored which may be due to disease. Following input of cow group feed intake data, feed costs and unit milk returns, computer printouts can provide business data on milk income less feed costs (MIFC) or Feeding Profits.

The rapid evolution of electronic monitoring equipment and computer systems will no doubt lead to many new objective assessments of cow productivity, herd performance and farm profits which, with further developments, will become more cost effective. One such example are mini-microphones attached to cow collars that can monitor rumination patterns throughout the day and night which provide valuable insights into individual animal reactions to changing heat stress and feeding management. An automatic accurate recording of cow respiration rates would be a very useful tool for the humid tropics.

5.7 Summarising considerations for shed designs

These elements have been summarised in Table 5.1 for concrete floored, feedpad sheds and in Table 5.2 specifically for free stall sheds. As previously mentioned, feedpads are concrete feeding areas for cows that also spend considerable time in between grazing pastures. The same equipment is required for feedpads as well as for any indoor stock feeding system, such as forage conservation, effluent handling and feed mixing and feeding out.

Various cowshed plans are presented in the Appendices, namely:

- Appendix 4; A dairy shed to hold 50 milking cows, 40 calves, 10 dry cows and 40 young replacement heifers or dairy beef animals and 3 herd bulls.
- Appendix 5; A free stall shed.
- Appendix 6; Cooling systems for a free stall shed.

Table 5.1. Elements to consider when designing feedpad sheds.

Elements	Considerations
Cow and feed alley surfaces (concrete)	Grooved (parallel to alley length) and broomed to provide maximum traction Provides good hoof support; flat surface with no irregularities Minimum hoof injury; no sharp edges or protruding aggregate Typical grooving is 12–25 mm deep, 20–25 mm wide and spaced at 100–125 mm intervals Edge of groove has no ridges Newer patterns have small grooves between larger grooves, to provide more traction Durable pad surface to withstand wear from feet, manure and water Rubber matting on turning area
Loafing area	Located adjacent to shed Run-off factored into effluent disposal design
Roof and wall type	Steel construction Gable style roof Removable wall panels, sliding doors or curtains to aid ventilation
Roof design	Lower roof pitch for slow air movement (1:4) Steeper roof pitch for faster air movement in warmer climates (1:3) Provide continuous open ridge to promote air movement, for convective heat dissipation Minimum eave height of 5 m at roof pitch 9 m In open side sheds, provide eave overhang of at least 1.5 m
Ventilation	Provide clean dry air to cows using passive or mechanical ventilation Passive ventilation is most economical Cross-ventilation provides air more readily to entire building
Machinery access	Minimum of 3.6 m clearance for entry and exit Minimum of 7 m for internal ridge height, for working machinery Minimum of 15–18 m turn around areas for tractors and machinery; check with manufacturers

Table 5.2. Elements to consider when designing free stall sheds.

Elements	Considerations
System design	Allow for easy cow movements around the shed Stalls should be comfortable, dry and clean Should allow for regular manure removal Provide easy access for machinery to feed out and clean Allow for multiple routes from stalls to feeding area, to overcome dominance within herd Feeding space and free stalls should be proportional Stalls, feeding and watering spaces should be arranged in modules
Modular design	No more than 60 stalls per module Modules can be manipulated to match site constraints
Stall sizing	Dependent on cow size (weight and body dimensions) Size based on largest 25% of cows in group Provide for adequate lying down as well as necessary forward and sideways lunging to stand
Stall slope	4% slope from front to rear 3% lateral slope, so cows lie in same direction facing down slope, to minimise teat injuries
Stall curb	Minimum of 200 mm above alleyway
Stall design	See text
Alley width	3–3.6 m wide avoiding sharp turns
Crossovers	Locate every 20–25 stalls, that is every 24–30 m 4.5–4.8 m wide, so 1 cow can drink and 2 cows pass behind Elevate floor slightly above stall curb, allow crossover to drain into alley
Bedding material	Inorganic (sand, rubber) Organic (sawdust, straw, hay, composted manure, rice hulls) At least 100 mm thickness of rice hulls, sawdust shavings or sand Consider hygiene, degree of compression when cow lies down, performance over time, how it will interact with effluent disposal system