2

The diversity of dairy farming systems in tropical Asia

This chapter presents an overview of the different types of dairy farming systems and development strategies in tropical Asia, to sustainably increase milk supply.

2.1 Definitions of dairy farming systems

Dairy farming in Asia can be broadly classified into three major types of production systems (Moran 2017) as follows:

1. *Mixed farming*, in which milk production only contributes a relatively small proportion of total farm income. Many of these farms have evolved from essentially cropping enterprises to those where livestock production becomes more important. Milking herd sizes are generally quite small on these farms, ranging from fewer than five to no more than say, 20 cows.
2. *Essentially smallholder dairy farms,* where milk production has increased over recent years to become a major contributor to farm income. In many cases, construction of the dairy facilities and available land has evolved and may not be sufficient for future expansion. Milking herd sizes are very small, generally no more than five to 10 cows.
3. *Larger specialist dairy farms,* which were established primarily to produce raw milk. Dairy facilities on these farms have been better planned to satisfy the requirements for a predetermined number of milking cows. In most cases,

land would have been allocated to produce the required fodder for the planned herd size, although in certain cases agreements would have been made with surrounding farmers to provide the necessary forage base. Milking herd sizes on these farms would range from 20 to 100+ cows. Large-scale intensive dairy feedlots would also be included in this category that can have up to 1000+ milking cows.

The contribution of these various farming systems to the total milk produced in each country varies with population pressures and the demands for alternative land use, other than providing livestock fodder. However, Systems 1 and 2 contribute the bulk of the raw milk produced. The majority of dairy farmers are smallholders, with average herd sizes often as small as one to five milking cows. In fact, smallholder dairy (SHD) farmers produce over 80% of the developing world's milk, making a significant contribution to the annual world production. Despite their high profile in their dairy industry, there are relatively few large dairy feedlots in any one Asian country.

2.1.1 Supporting smallholder dairy farmers

National governments, international aid agencies or benevolent governments or agencies from developed countries have devoted, and are still devoting, a lot of resources to improving the productivity and profitability, hence sustainability of the SHD industries throughout tropical Asia. The focus is on sustainable intensification of SHD farming. The term 'intensification' requires clarification. In general terms, intensification is understood to be increases in efficiency for a unit of a given resource. For advisers and researchers of crop–livestock or pasture-based livestock production, the term is often interpreted as increasing productivity per unit of land, usually associated with an increase in stocking rate.

The national dairy development (5- or 10-year) programs in most Asian countries concentrate much of their efforts towards the System 2 farmers mentioned earlier i.e. smallholder dairy farms. In other words, they are trying to phase out 'part-time' dairy farmers (in System 1) and encourage 'full-time' dairy farmers. National dairy plans provide government support, which often includes the establishment of dairy cooperatives or even just installation of new milk cooling units in areas where dairy farming is being encouraged.

System 3 farmers (larger, specialist dairy farms) are usually less reliant on public support as their establishment is often financed by private investors. Furthermore, in many cases the farm and stock are not actually owned by individuals, but by a group of investors. However, in recent years there has been considerable interest (and investments) in larger-scale, feedlot dairies. This is occurring because governments have struggled to overcome the inefficiencies of current SHD systems, such as low milk yields, poor milk quality, poor cow fertility and high young stock mortality rates which drastically limit their ability to achieve self-sufficiency in dairy production.

Smallholder farms generally yield low outputs of milk per animal. However, on a cost–benefit basis, the use of by-products or other waste as feed, and multiple outputs such as calves and meat production, the continued efficiency of smallholder systems can outweigh the apparent efficiencies of dairying monocultures. Application of current technologies will allow increases in the production and efficiency of milk production by better understanding the nutrient requirements for milk production, in addition to those for growth and meat production.

As stated earlier, many resources from international aid agencies, benevolent governments or national governments have been allocated to improve the sustainability of the SHD industries throughout tropical Asia by improving the productivity and profitability of this sector. This support is ongoing. The success rate of such programs is very variable when assessing the achievements against their long-term objectives. However, SHD farming is still 'the backbone' of milk production throughout tropical Asia.

2.1.2 Types of dairy development

Simplistically, Staal *et al.* (2008) separated dairy development into two types, traditional smallholder and commercial large-scale industrial. These categories were developed for the convenience of global dairy policymakers and readers of this book would rightly argue that there are many 'in between' dairy development programs.

1. **Traditional smallholder systems** reflect small-scale farm household systems often associated with informal milk marketing systems that predominate in many developing countries. These are frequently based on mixed farming with cash crops and have small dairy herds with low levels of farm inputs and outputs. There are frequently nutrient deficits both on the farm and in the farm household. The farms are generally located close to the markets and consumers. Their milk marketing is diffuse with many small-scale market agents, based on labour intensive handling and transportation. The farm outputs are destined for mostly low return liquid products that are limited in diversity and with little emphasis on milk quality and food safety. In addition, there is great diversity in market behaviour and the farmers have limited input into dairy policymaking.
2. **Commercial large-scale industrial systems** represent large-scale 'industrialised' production systems and the integrated marketing observed in most developed countries. These systems are usually single enterprise with large herds and high levels of farm inputs and outputs. With high capital inputs, their production systems are based on economies of scale. They often have nutrient surpluses both on the farm and in the farm household. There is a high dependency on infrastructure (roads, water, electricity) and labour, as well as long market chains. Milk marketing is generally concentrated, consisting of few large-scale,

vertically integrated marketing agents and industrial processors based on capital intensive technologies with diverse products destined for value-added products, many non liquid. In addition, there is little diversity in market enterprise types with a larger input into domestic and international dairy policymaking.

As with all generalisations, there are invariably exceptions. Indonesia for example, is rather unusual in that its dairy production sector is based on traditional smallholder farmers but most of the milk is destined for industrial processing. Most of the farms are located in the highlands of Java whereas the milk is transported long distances to the coastal cities where the processing plants have been established, strategically located near the ports to more easily source imported milk powder.

Because it is much easier to 'showcase' large-scale dairies, they are popular with governments when planning high-profile regional dairy development schemes. However, they require a much higher level of well-managed technical input than do smallholders and once they become more heavily mechanised, 'more things can go wrong'. Hooten (2008) even goes so far to argue that in developing dairy industries, the growth and opportunity profile of such investments will eventually become stagnant compared to schemes more directed towards the poor, informal, smallholder dairy farmer.

2.1.3 Dairy herd sizes in Indonesia and India

Government statistics on dairy herd sizes generally only report the average number of milking cows on any one farm. The total number of dairy stock will be greater than this because farmers usually rear their milk-fed calves and weaned heifers on their farm. How many more animals constitute the total dairy herd varies but assumptions are that it is likely to be at least 50% more than the number of adult cows either being milked or non-lactating.

The following tables present data on the ranges in herd size in two of SE Asia's large dairy industries. Table 2.1 presents 2011 data for Indonesia (Morey 2011) while Table 2.2 presents 2015 data for India (Chamberlain *et al*. 2015).

Table 2.1. The number of farms with different herd sizes in Indonesia.

Herd size (cows per farm)	Average herd size	% farms	Number of farms	Number of cows
1–3	2.7	88	123 200	332 600
4–6	5.8	8	11 200	64 900
7–10	9	2	2800	25 200
10–20	17	1.5	2100	35 700
20–100	35	0.05	70	2450
100–1000	600	0.01	14	8400
Total	**–**	**100**	**139 384**	**469 250**

Table 2.2. The number of farms with different herd sizes in India and their annual milk yields.

Herd size (cows per farm)	% farms	Number of farms (million)	Number of cattle (million)	Average cow milk yield (L/year)	Milk production (mill MT)	% milk production
2	97	73	146	700	102	72
8	3	2	16	1100	18	12
18	0.4	0.3	5	1500	8	6
50	0.07	0.05	3	2500	6	4
100	0.03	0.05	2	4000	8	6
Total	100	75	172	2365	142	100

Nearly 90% of the farms in Indonesia have three or fewer milking cows (71% of the total cows) while 97% of the farms in India have only two cows (85% of the total cows). Furthermore, fewer than 1% of the farms in Indonesia and 0.5% of the farms in India have more than 18 to 20 cows.

2.2 Strategies to increase domestic milk production

National levels of milk production can be increased in various ways. These include:

1. Placing the highest priority on increasing the number of dairy farmers in the country, without greatly changing their average milk outputs per cow or per farm.
2. Placing more emphasis on increasing per cow milk yields in association with increasing the population of dairy farmers.
3. Increasing the number of cows (that is the average size of each milking herd) on any one farm, without greatly changing the number of dairy farms or yields of their milking cows.
4. Combinations of increasing the number of farms, the size of the milking herds and per cow production.
5. Changing the type of dairy farm, from the smallholder, but maybe part-time, dairy farms (say with one to five cows) to larger farms which are still privately owned (say with 20 to 100 cows) to a ‘mega farm’ that is owned by investors or other well-resourced individuals or commercial enterprises (say with 500 to 1000 cows).
6. Another approach is to reduce the wastage between the farm gate and the consumer’s kitchen.

The first option requires sourcing new areas for dairy farm development, a task that is often difficult because of competition for existing land use and the current high density of dairy farms in dairying regions. One such example would be sourcing new land for dairy farming on the island of Java in Indonesia, where 97% of the dairy industry is already based. Developing new regions for dairy farming, for example outside Java, is a slow process as it requires:

- finding suitable highland areas and providing alternative locations for current landholders
- building milk-processing facilities near these new dairying regions
- sourcing adequate farm services such as water, electricity or gas
- sourcing suitable dairy animals to populate these new farms
- sourcing areas of fertile land to grow the required forages
- sourcing ample supplies of suitable by-products to provide the ingredients of concentrates for the dairy herd
- establishing a population of skilled workers who understand and can carry out the relatively sophisticated farm practices of successful smallholder dairy farming.

This last point is very important because increasing per cow daily milk yields from the current levels of say 8 to 10 kg/cow/day, to a potential 14 to 16 kg/cow/day (with existing genetic quality of most SHD milking herds) requires a set of skills rarely found in most SHD farming populations.

Mention of cow milk yields in Asia averaging 30 or more kg/cow/day in high genetic merit herds is simply unrealistic because of the many production constraints in the humid tropical climate (Moran 2013), even in the highland areas. Dairy cows only produce milk to their genetic potential when these constraints are essentially overcome. In Asia we have taken a temperate species of animal, the dairy cow, and expected it to be easily translocated to the foreign environments generally with high temperatures and humidities, often infertile leached soils and relatively constant day lengths.

Furthermore, low per cow milk yields are energetically highly inefficient because of low nutrient outputs produced each day in raw milk relative to the high nutrient input requirements for maintenance in milking cows (and growth of replacement stock), hence the inability to dilute these high energy requirements with copious yields of high energy raw milk. Therefore, depending mainly on increasing per cow milk yields to satisfy the high national demands for raw milk is a very slow and unreliable process.

The most obvious way to more rapidly increasing domestic milk supplies is through sourcing more dairy stock suited to the environment, assuming the land, feed supplies and skilled labour force are also available or can be developed. Natural increases of dairy cow populations cannot be relied upon to increase national cow numbers because of the high mortality rates of young stock and the poor reproductive performance of mature cows on most SHD farms in the tropics (Moran 2005). Some countries may develop national breeding centres to address these issues. However, the only reliable way to increase dairy cow populations in Asian countries is through importation of breeding heifers, either unjoined or in early pregnancy. This is certainly occurring in many countries in the region. These stock are available from developed dairy industries such as those in Australia, New Zealand and the US and Europe. Some Asian countries, for example Thailand, also have stock available to import into other Asian countries.

These animals are usually exotic heifers, either unbred or up to 5 months pregnant, in that they originate from temperate dairy industries where they have been reared on pasture in a largely climatically comfortable environment. Upon arrival, they then have to adapt to all the constraints of tropical SHD farming, such as high temperatures and humidities, limited quantities of poor to moderate quality feed and the vastly different rearing environment of a low investment system with limited to no grazing and a small cowshed. Changes in animal behaviour clearly indicate that this adaptation period can be quite traumatic and lengthy, up to 6 months according to experienced SHD farmers. This is exacerbated by the often different standards of acceptable practices of stock welfare on their new home farm.

To find the most suitable animals, tropically adapted stock – or at least stock with some degree of *Bos indicus* (Zebu) breeding – are required or the temperate adapted heifers must be destined for highland regions where there are fewer constraints to profitable milk production. Even when imported into tropical highlands, they will be more susceptible to environmental and farm management constraints than the indigenous dairy stock. In addition, because the imported heifers will be invariably be of higher genetic merit than the local dairy stock, they require a higher quality of post-arrival feeding and herd management than would the local dairy heifers. Therefore, the higher level of skills necessary for satisfactorily managing these imported heifers means that the farmers, to which these animals are destined, need to be chosen and/or trained in such herd management skills.

2.2.1 The range in size of the milking herd on dairy farms

As already mentioned, most dairy farms in Asian countries only have relatively few milking cows. In addition to actual milking cows, the farms would also contain a few replacement dairy stock such as milk-fed calves or weaned heifers. Such farms often have other farming pursuits, hence dairy farming would not be a full-time activity for these farming families. The definition of a SHD farmer may include farms with milking herd sizes up to 10 or even 20 cows. In countries such as Indonesia, these farms may not have additional land on which to grow forages so the farmers would need to source the herd's forage requirements from grasses and other herbage from the roadsides, rice paddies or other areas (such as state forests or under cultivated cash crops) – generally freely available during the rainy season. Another source of forage for the 'landless' farmers would be from forage crops grown under the supervision of dairy cooperatives: in these cases they would not be free. Oil palm plantations are another source of forages recently used for grazing stock (generally beef cattle or young dairy heifers), say between 3 and 7 years after the palms are planted. If grazed any younger than 3 years, the young palm plants themselves are likely to be stripped of their leaves, while if the plantation is 7 years or older, there would be little sunlight reaching the ground, hence there would be negligible forage regrowth.

Other dairy farms range in herd size from 20 to 50 to 100 milking cows, and would still be privately owned. However, there is increasing interest in developing much larger dairy farms, containing 200 to 500 to over 1000 milking cows. Such farms could be considered as corporate farms, with ownership of land, facilities and stock by investors or other well-resourced individuals or commercial enterprises. These 'mega dairies' are constructed for, and generally achieve, increased per cow production of high quality milk. However, they are often criticised because their emphasis is more on the yields and economics of domestic milk supplies rather than the social and economic development of the country or region in which they are based. However, employing many farm workers on large farms will be of direct benefit to the local economy. In the long run, it is up to the particular Asian country to decide which is the higher priority, producing more and cheaper quality milk or facilitating the social development of the region.

2.3 The pros and cons of large-scale dairy farms

Large-scale corporate type dairy farming is not new in the developed world and is becoming more refined with increasing technical and commercial knowledge and experiences. Many of these current management practices can easily be transferred to the tropical, developing dairy industries, provided the local management is made more fully aware of the constraints to high levels of per cow milk production, cow comfort and fertility in such hot, humid environments with tropical animal health issues. These are certainly harder to manage in the tropics than in the temperate, developed dairying countries. Nevertheless, there is growing interest in establishing such 'mega dairy' farms in virtually every SE Asian country. Therefore, the design, construction and day-to-day management of such ventures justify closer investigation.

There are many 'pros and cons' associated with increasing milking herd sizes from 20 to 500 to 1000+ cows. A total of 15 pros and 19 cons, originally highlighted by Moran and Morey (2015), are presented below, together with a series of additional considerations.

2.3.1 Pros

1. Allows for mechanisation, hence reduced human error in everything from growing and sourcing forages to feeding, herd and effluent management to milk harvesting.
2. Provides enough cash flow for appointing experienced farm managers and other professional on-site staff.

3. Provides enough cash flow to justify routinely testing all feeds for their nutritive values.
4. Provides large volumes of shed effluent that can either be sold as fertiliser or used to supply many of the essential nutrients for soils to grow quality forages on-farm.
5. Potentially provides large numbers of bulls or steers for local dairy beef farming either by the dairy farm itself or by local smallholder beef farmers.
6. Supplies large volumes of high quality milk (or processed dairy product) which provide better bargaining and marketing opportunities.
7. Allows for more consistency with forage crop agronomy, hence more consistent forage quality.
8. Allows for bulk purchasing (hence cheaper) suitable by-products to provide the ingredients of concentrates for the dairy herd.
9. Requires investment in large numbers of livestock, which would have higher genetic merit and be more consistent than when sourcing local stock.
10. Mechanisation of milk harvesting reduces variation in milk quality.
11. Provides for opportunity for on-site milk processing to value-add the raw milk.
12. Provides raw products of better consistent quality more suitable for milk processing.
13. Provides employment opportunities for locals as farm workers.
14. Provides opportunity for local beef farmers or for dairy farmers to redirect their efforts from milking a small herd of dairy cows to become specialists in growing out the large number of replacement heifers required by the newly established farm. This may not eventuate because large-scale intensive dairy farms generally want to have direct lifetime control of their stock.
15. Provides opportunity to outsource other activities (such as contract growing of forages) and developing closer commercial and social relationships with the local farming population.

2.3.2 Cons

1. Requires access to large cash reserves to construct facilities and purchase farm equipment (such as for milk harvesting and preparing total mixed rations or TMR).
2. Requires access to large cash reserves to purchase livestock, generally in large numbers.
3. Requires specialist skills in land preparation, planting, maybe irrigating, harvesting and processing large quantities of forages.
4. Requires skills in design and construction of large sheds and other farm facilities.
5. Requires skills in ration formulation and other aspects of feeding management.
6. Requires skills in reproduction and other aspects of herd management.

7. Requires skills in addressing mastitis and lameness and other specific animal health issues.
8. Requires skills in animal health issues arising from heavy concentration of stock in one place.
9. Must improve local infrastructures (roads) to handle extra heavy traffic.
10. With poor effluent management, it could increase local pollution loads.
11. Needs access to large quantities of suitable by-products to provide the ingredients of concentrates for the dairy herd.
12. Ideally requires access to year-round supplies of quality forages.
13. May require additional skills and infrastructure for forage conservation, specifically silage making.
14. Requires skills in information and communications technology (ICT) for capturing data from many sources (stock, feed reserves, HR management) on the farm.
15. Requires ensuring all staff develop animal welfare friendly herd management practices.
16. With such large numbers of stock, any small mistake in farm management can have large-scale and expensive ramifications.
17. Biosecurity is of high priority for all equipment, livestock and staff.
18. Personality interactions between management, farm and administrative staff require close monitoring and if required, early intervention.
19. Integrity of management staff is paramount, to set best examples to farm and administrative staff.

2.3.3 Additional considerations

- There is likely to be a lack of firsthand experience in veterinary support for animal health, e.g. disease diagnosis, surgery (if required), recuperation and management. Animal health issues more specific to intensive management e.g. left displaced abomasum (LDA).
- Higher yielding cows have a greater susceptibility to heat stress, exposure to pathogens, poor feeding and herd management, hence they have a need for greater protection against such constraints.
- The importance of strict routines/protocols in feeding and herd management cannot be overemphasised, hence the need for more consistent support mechanisms such as maintenance and backup of forage choppers, feed mixers and feed-out machinery, as well as regular farm staff in service capacity building programs.
- The more rapid milk cooling and delivery of raw milk to processing plants will ensure better integrity of value-added dairy products.
- There is also a need to eventually develop public relations programs to counteract the propaganda disseminated by the animal liberation lobby and other anti ‘industrial farming’ social pressure groups.

- There is a complete lack of experience in the logistics of large-scale intensive dairy farming in contrast to more in the traditional dairy production systems.
- There is an obvious need to find investors who are prepared to wait several years before they can achieve positive cash flows and maybe even longer for eventual profits.
- There is a lack of consultants with experience in initiating and operating intensive dairy systems in the humid tropics, which is very different to temperate dairy feedlotting.
- There seems to be a lack of evolution of dairy genotypes adapted to the humid tropics yet can still achieve high feed intakes, hence levels of cow performance in less constrained environments.
- The most important objective of tropical dairy feedlotting is counteracting the deleterious effects of high temperature/humidity together with high internal heat production arising from high feed intakes (see Figure 2.1). Tunnel ventilation and fans/sprinkler systems are still ineffective at achieving thermo-neutrality.

Figure 2.1: No matter what the milk production system in the tropics, there is a need for additional ventilation to reduce the adverse effects of heat stress during summer. This picture is of a large free stall shed in North Vietnam with fans directing air into the free stalls as well along the feeding face of the shed.

- Year-round quality forage supplies normally arise through developing forage-cropping systems together with forage conservation (usually as silage).
- It is essential to install systems to cope with large amounts of shed effluent and its recycling to forage production areas.
- There is a need to invest and maintain reliable machinery to overcome constraints arising from variability in farm staff skills. Labour is cheap but often unreliable.
- There is a need to invest in equipment and materials and develop skills in sophisticated tasks associated with large-scale dairy systems, e.g. oestrous synchronisation to produce batch calving to overcome problems of poor conception rates in summer, embryo transplants to more rapidly increase herd genetic merit, routine feed dry matter (DM) testing to aid ration formulation, microscopes for assessing semen quality, Brix spectrophotometers to assess colostrum quality, feed additives with specific purposes (such as Betaine) to address heat stress.

2.3.4 Other aspects of large farm management

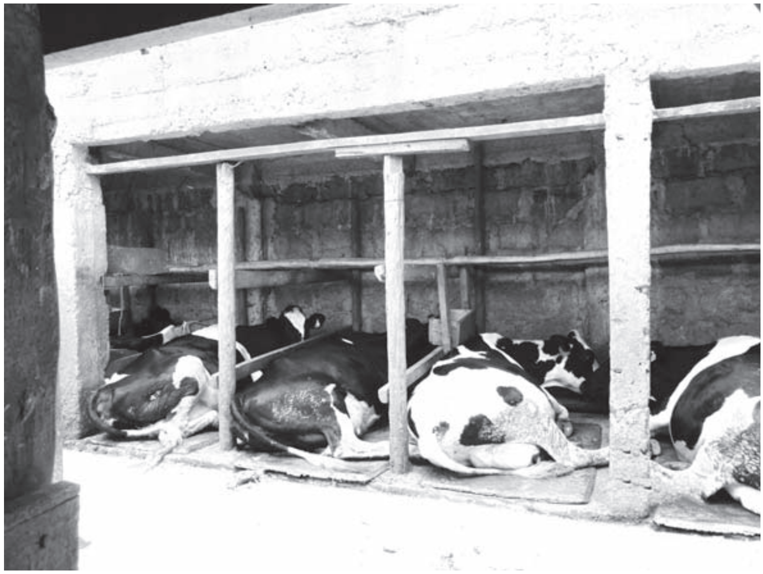
It is more desirable to gradually increase herd (hence farm) size over a period of years to allow for the staff to become more familiar with the principles and practices of large herd management. This will also provide better opportunities to observe and address any unforeseen key issues in such a large-scale intensive dairy enterprise.

Achieving the Key Performance Indicators (KPI) for cow performance (such as weight and age at first calving, milk yields at different stages of lactation, herd fertility, mastitis and lameness problems) and others listed in Section 7.4 of Chapter 7 are essential to achieve the required KPIs for farm and business performance (such as cost of production, gross profit, return on assets) within predetermined, realistic time frames.

As in all countries, there are likely to be government (national, provincial or local) regulations and incentives related to developing a large-scale dairy enterprise. It is then essential, to seek such information at an early stage of farm development.

It must be emphasised that large-scale dairy farming requires large amounts of readily available liquidity (or cash). Cash flows are likely to remain negative for several years. If sourcing dairy heifers to populate the farm, they will also take several years to reach maturity and attain adult levels of cow performance. For example, when developing a budget and projected cash flow on a farm with optimum feeding and herd management, it is best to gradually increase the predicted milk yields, even of high grade Friesians, over the first few years of farm operation from say 4000 to 5000 to 6000 to 7000 kg/cow/year consecutively for

(a)



(b)

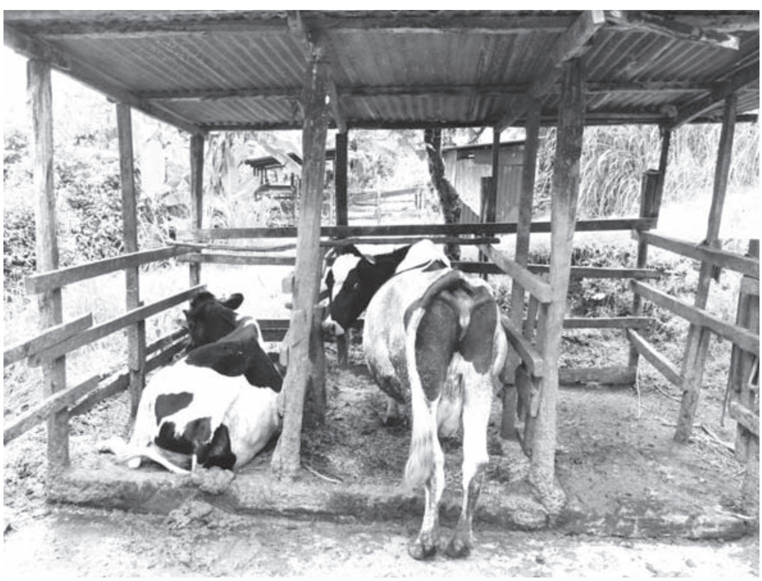


Figure 2.2: Even on smallholder farms, there is a wide range in milk production per cow. These pictures were taken in Kenya on two free stall adjoining farms, highlighting the results of their variation of feeding management and cow comfort. (a) These Friesian cows were averaging 14.4 L milk/cow/day with each cow provided with a thick sponge rubber mat on which to lie. (b) These Friesian cows were only averaging 5 L milk/cow/day with no soft bedding. Note the difference in cow size and body condition between the two farms.

their first four lactations; this approach is discussed in Section 11.4.1 in Chapter 11. Furthermore, it is always better to err on the pessimistic side of projected cash flows until you are certain that all the anticipated (including some of the unforeseen) constraints to cow and farm performance have been identified and addressed. Intensive large-scale dairy farming is a long-term program so profits will arise in the near not the immediate future.

Dairy farming in the humid tropics is fraught with problems. However, once they are addressed, good profits can be made (see Figure 2.2). For example, Seruni *et al*. (2015) compared the financial performance of a large-scale (with 1467 head) operation and a small, well-managed farm (with 52 head) in the Chiang Mai highland region of northern Thailand, finding on both farms, positive profit levels. Although the capital costs were 65% higher per cow on the large farm, profits expressed as the income less costs as a percentage of costs, were 63% on the large farm versus 55% on the small farm. On the large-scale farm, daily income was US$7.49/cow, daily costs (both variable and fixed) were US$4.59/cow thus providing a daily profit of US$2.70/cow.