



REVIEW ARTICLE

Addressing the Key Constraints to Increasing Milk Production from Small Holder Dairy Farms in Tropical Asia

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ABSTRACT

The dairy industries of tropical Asia have failed to keep pace with the speed of dairy development in Western countries over recent decades. Granted, the tropical environment is not ideal for dairy cows as high temperatures and humidities and seasonality of rainfall reduce both the nutritive value of available forages and the level of cow comfort, hence the production potential of the stock. In addition, many of the farmers, usually small holders with less than 10 milking cows, have not been able to develop the skills of efficient milk production. This has primarily been due to poor extension services more so than lack of technical knowledge on tropical dairy farming. The constraints to profitable dairy farming in tropical Asia are many and varied and can be categorised into institutional, government, socio-economic, technical and post-farm gate. This review lists 35 key on farm constraints to milk production technology, based on their position in the dairy production chain, together with a range of possible solution to overcome each one. The future for small holder dairy farming in tropical Asia is optimistic so long as the industry can rectify many of these constraints to improving domestic production of raw milk, particularly those at the farm level.

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INTRODUCTION

As a result of applied dairy research, development and extension over the last 20 years, Western countries have produced quite sophisticated dairy production systems (Little, 2012). Herd sizes have grown, efficient feeding systems have evolved and many farmers routinely monitor test results on their cows for milk production, composition and quality and for mastitis. They then use this information for making decisions on culling milking cows and for breeding genetically improved stock. High labour costs have led to much mechanisation, such as machine milking and forage conservation, while grazing cows can harvest their own forages far more efficiently than can farmers. Low population pressures, hence relatively cheap land, have allowed these farms to expand in both size and cow numbers. Unfortunately the dairy industries of tropical Asia have failed to keep pace with the speed of such dairy development in Western countries (Devendra, 2001).

There are many reasons for the productivity and efficiency of small holder dairy (SHD) farming has not greatly improved over the last two decades. Numbers of

cows have greatly increased in most Asian countries, largely through government support for social welfare and rural development programs. The increased demand for milk (accentuated through school milk programs) and the concept of national food security are the driving forces behind many dairy development initiatives. However in terms of milk production per cow and feed inputs per kg of milk produced, improvements have been slow (Falvey and Chantalakhana, 1999)

Granted, the tropical environment is not ideal for dairy cows as high temperatures and humidities and seasonality of rainfall reduce both the nutritive value of available forages and the level of cow comfort, hence the production potential of the stock (Moran, 2005). In addition, many of the farmers, usually small holders with less than 10 milking cows, have not been able to develop the skills of efficient milk production. This has primarily been due to poor extension services more so than lack of technical knowledge on tropical dairy farming.

SHD farmers, with socio-economic and agro-economic conditions vastly different to those in Western dairy industries, cannot readily adopt the science and technology available in developed countries. Even the

most appropriate technology is rarely transferred to small holders due to a lack of effective services. It is essential that any production technology being transferred is relevant to the needs of small holders as well as being feasible, given their local support networks of dairy cooperatives, advisers (government and agribusiness), creditors and milk handling and processing infrastructures (Devendra, 2001).

Chantalakhana (1999) categorised the factors limiting SHD production into

- Institutional factors, such as dairy cooperatives, suppliers of credit, training, extension services
- Government policies, such as development programs, milk promotion, dairy boards
- Socio-economic factors, such as farmer education, off-farm jobs, traditional beliefs
- Technical factors, which can be further categorised into feeding, breeding, health
- Post-farm gate factors, such as milk processing, marketing and consumption

For SHD farmers to expand and intensify there must be:

- Adequate infrastructure and marketing opportunities
- Access to reliable markets
- Promotion of dairy development through government policy
- Availability of credit for purchasing of livestock and planting pastures
- Available productive and adapted forage species
- Ready access to information
- Farm management systems which ensure adequate year-round feed supplies
- Management of animal wastes
- Disease control measures
- Adequate hygiene for milk collection

Swot on small holder dairy farming

Prior to assessing the constraints to dairy production technology, it is worthwhile summarising a recent industry study of SHD farming in the tropics. The SWOT analyses provide a strategic planning tool to evaluate the industry's strengths and weaknesses. It is undertaken in four parts, assessing the business or industry's strengths (S), weaknesses (W), opportunities (O) and threats (T). Although Table 1 was undertaken specifically for Indonesia's SHD industry by Anon (2005), it is applicable to any SHD industry in tropical Asia.

Anon (2005) then concluded that SHD farming in Indonesia, as in other tropical Asian countries:

- improves the food security of milk producing households
- creates employment opportunities throughout the entire dairy chain (for both producers and processors)
- is a powerful tool for reducing poverty and creating wealth in rural areas
- can incur relatively low production costs

Regional constraints to milk production in Indonesia

In the early 2000's a series of strategic planning workshops were conducted in Indonesia, in East and West Java, to identify and prioritise the key constraints for milk production and to develop action plans. Burrell and Moran (2004) summarised these as follows:

Constraints in East Java

The following were the priority industry issues in East Java, together with some of the action plans for industry development:

1. **Low cow productivity:** improve management of feeding, reproductive management and milk harvesting
2. **Low milk price:** reduce costs of production, improve milk quality, mediate on milk pricing, find alternative markets
3. **Poor milk quality:** improve milking hygiene at both farm and post-farm gate, improve milk composition through better feeding management
4. **Poor feed quality and availability:** identify better forage species (e.g. legumes), appoint quality control teams for concentrate supplies, utilise marginal land for forages
5. **Co-operative management:** reduce management structure and merge small co-operatives, improve post-harvest technology, improve calf and heifer rearing practices

There were other industrial issues raised but not discussed in detail. These included the need to promote fresh and manufactured dairy products, improve technology transfer, stimulate farmer motivation, work towards autonomy of co-operatives and improve collaboration between government agencies and training organisations.

Constraints in West Java

A similar list of priority industry issues was developed independently for West Java, with some of the action plans for industry development summarised as follows:

1. **Human resources:** improve knowledge, skills and attitudes of farmers and support staff
2. **Poor feed quality and availability:** increase area of land for growing forages, overcome seasonality of forage supplies, reduce variability of concentrate quality
3. **Low capital investments in industry:** invest in infrastructure for post-farm gate industry support
4. **Small scale of farming:** increase herd sizes, overcome shortage of breeding stock
5. **Insufficient technology:** increase supply of breeding bulls, improve feed supplies, diversify farming systems, value add milk in farming areas to help overcome farmers' low cash flows
6. **Institutions:** improve co-ordination amongst service providers, introduce better control over milk quality, improve efficiency of administration in institutions

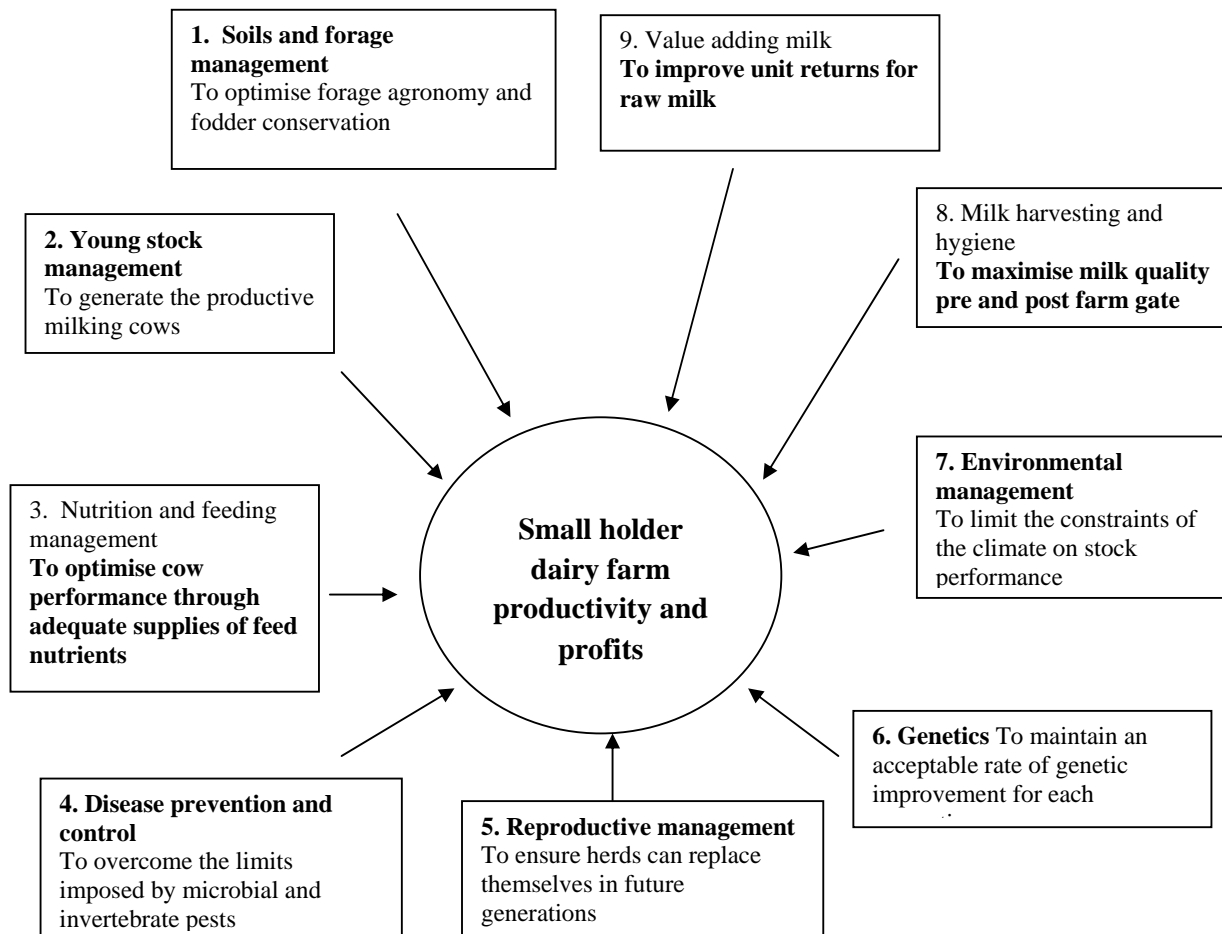
There were other industry issues raised but not discussed in detail. These included the need to promote fresh drinking milk, facilitate and support milk marketing and develop post-farm gate technology in milk processing.

The nine key activities of dairy farming

Although there are constraints throughout the entire dairy supply chain, this review will deal mainly with those on-farms, namely the constraints in dairy production technology. Many years ago, a manager once said to me "do not come to me with a list of problems without their

Table 1: Findings of a SWOT analysis of Indonesia's SHD industry (Anon. 2005)

Components of SWOT	Findings
Strengths	Low production costs High farm income margins Low liabilities Relative resilience to rising feed prices SHD farmers are then cost competitive and resilient to market fluctuations They thus provide a competitive source of milk supply to imported dairy products
Weaknesses	Lack of knowledge and technical skills Poor access to support services Low capital reserves and limited access to credit Low labour productivity (small herd sizes and low output per cow) Poor milk quality
Opportunities	SHD farmers are often unable to take advantage of existing market opportunities Growing demand for dairy products in developing countries Likelihood of increased milk returns Major potential to increase labour productivity Great potential to increase milk yields Employment generation Significant opportunities to improve the demand (quality and milk price) Significant opportunities to improve the supply (improving production technology)
Threats	Policy support in developed countries Exposure from competitive business forces Underinvestment in dairy chain infrastructure Unsuitable dairy development plans Environmental concerns such as a high carbon footprint Increasing consumer demand for food safety Succession of dairy farms Increasing local wage SHD rarely meets its full potential because of many threats, particularly the last four

**Fig. 1:** The nine steps in the supply chain of profitable dairy farming

possible solutions". In the light of this worldly statement, as well as listing the key constraints, this review highlights some approaches to address each constraint. This provides an extensive, but not exhaustive, list of management practices to rectify each constraint.

On any dairy farm, no matter its size or location, the dairy production technology can be broken down into 9 key activities, which can be considered as steps in the supply chain of profitable dairy farming (Moran, 2009a). Just as any chain is only as strong as its weakest link; each step in this supply chain must be properly managed. Weakening any one link through poor decision making can have severe ramifications on overall farm performance and hence profits. In chronological order of their role in ensuring a profitable dairy enterprise, the "links" are presented in Figure 1.

Addressing the on farm constraints to dairy farming

The on farm constraints to SHD dairy production technology in tropical Asia are many and varied. Thirty five of the key ones are listed in Table 2. They are categorised using the nine key activities from Figure 1 and complemented with a range of possible solutions to overcome each one. An extra category "Other on farm constraints" is included in this table to take into account those covering farm business skills.

Cow colonies: potential benefits and problems

In many tropical Asian countries, considerable attention has been given to large scale investments in "cow colonies". These consist of large dairy sheds, holding 50 or more cows that are owned by a number of SHD farmers, and presumably nearby development of large areas of forage production. Although small holders still own and manage their own herds in these large sheds, the perceived benefits of cow colonies lie in the magnitude of size of the total herd management. Such an approach can overcome many constraints to production but may introduce others as listed below:

Potential benefits of cow colonies

- Greater investment potential since cooperatives have more borrowing power than individual farmers
- Use mechanical forage choppers and milking machines
- Employ contract labour to rear young stock
- Grow large areas for forages, such as maize, for livestock feeding
- Less wastage in recycling manure to forage production area, through building effluent ponds to minimise volatilisation of nitrogen from urine
- Bulk handling of conserved forages using large scale silage bunkers

Table 2: Key constraints to improved milk production on tropical Asian small holder dairy farms and possible approaches to solutions

Key activity	Key constraints	Approaches to solutions
1. Soils and forage management	a. Low yields of forage	Use inorganic fertilisers as well as manure Reduce nitrogen volatilisation of shed effluent by directing it into water storage Optimise forage agronomy (soil preparation, weed control)
	b. Poor forage quality	Use inorganic fertilisers as well as manure Use most appropriate forage species for region Consider other forages such as tree legumes Reduce harvest intervals
	c. Shortage of dry season forages	Consider silage making of wet season forages Plan year round forage supplies
2. Young stock management	a. High calf mortality	Better parturition management to minimise likelihood of infecting new born calf Ensure use of semen or bulls with low calf birth weights Improve colostrum feeding program (Quantity, Quality, Quickly) Pay greater attention to navel dipping with iodine Better shed hygiene Develop skills in identifying potentially sick calves Better health management Identify causes of death or sickness and change management accordingly Improve calf housing Minimise stress in calf shed Consider feeding less milk to encourage concentrate intakes Be more aware of fluid replacers v antibiotics for treating calf scours
	b. Poor post weaning growth rates	Feed adequate amounts of concentrates Ensure calf concentrates have 18% protein Feed less forages to stimulate concentrate intakes Better health management Ensure routine Clostridial vaccination program Monitor post weaning growth rates
	c. High wastage rates (from birth to conceiving in 2 nd lactation)	Dairy cooperatives could consider heifer farms
3. Nutrition and feeding	a. Low quality of by-products and formulated concentrates	Routine laboratory testing of ingredients and formulation Quality control during formulation

management	b. Poor performance of cows during early lactation (poor peak and daily milk yields, delayed cycling)	<p>Use coop system to bulk purchase quality by-products</p> <p>Ensure best forages for cows in early lactation, never rice straw Ensure enough forages are fed (30 to 50 kg fresh grass per cow per day) Monitor total dry matter intakes and increase if insufficient Consider wilting fresh forages to stimulate intake Ensure at least 16% protein in total ration Ensure all feeds are palatable Ensure adequate clean drinking water Provide Ca & P supplements in formulation Check if sufficient rumen buffers in concentrates Do not make concentrates and water into a slurry Chop forages to reduce selection and wastage Address any heat stress issues</p>
	c. Cows (particularly high genetic merit cows) do not cycle for many weeks after calving	<p>Ensure sufficient forages and concentrates are fed Check to see if rapid loss in weight or body condition Ensure at least 16% protein in total ration Consider vet checking for ovarian or uterine health</p>
	d. Seasonality of milk production	<p>Plan year round sourcing (growing or purchasing) of quality forages Ensure year round supplies of by-products and formulated concentrates Ensure adequate supplies of drinking (and washing) water throughout the dry season Ensure adequate cow comfort throughout the year</p>
	e. Little profits in milking cows	<p>Check Milk Income less Feed Costs (MIFC) Be aware of marginal milk responses if feeding too much Set realistic target milk yields and feed to achieve them Ensure ration is balanced for nutrient contents Maybe feeding too many cows for available feed supplies Feed fewer cows better</p>
4. Disease prevention and management	a. Problems with lameness	<p>Check floors for ease of walking on them Consider foot bath for all stock Check ration if too much concentrates causing laminitis Undertake locomotion test and treat affected cows</p>
	b. Problems with mastitis	<p>Identify subclinical cases with California Mastitis Test Ensure one towel to wash only one cow policy Treat every infected cow with antibiotics ensuring withdrawal period is followed Milk infected cows last Initiate routine dry cow antibiotic therapy Consider culling chronically infected cows</p>
	c. High calf and heifer morbidity and mortality	<p>Follow procedures as in Young stock management</p>
	d. General animal health problems	<p>Develop skills in identifying potentially sick stock Routinely inspect stock for external parasites Isolate sick stock Improve routine use of vaccinations Routinely use quality and viable pharmaceuticals Reduce the degree of exposure by improving shed hygiene Consider testing for internal parasite egg counts Reduce any overuse of antibiotics Find better trained and more practical veterinarian</p>
5. Reproductive management	a. High age at first calving	<p>Follow procedures for poor post weaning growth rates in Young stock management</p>
	b. Low 100 day in calf rate (pregnant within 100 days from calving) or high 200 not in calf rate (not pregnant within 200 days of calving)	<p>Better feeding management during early lactation Check AI techniques Can veterinarian confidently undertake pregnancy diagnosis? Pay closer attention to heat detection</p>
	c. High number of services per conception	<p>Improve AI techniques or check that technician is sufficiently skilled Pay closer attention to heat detection Consider vet checking for ovarian or uterine health</p>
	d. Low % mature cows are	<p>This is a simpler measure of poor reproductive performance so follow</p>

	milking	procedures above
6. Genetics	e. Increasing the proportion of heifer calves	There may well be a role for sexed semen in well managed dairy farms
	a. Poor milking cow quality	This generally is not an issue because the genetic merit of imported dairy heifers is likely to be better than any cow on the farm. It is quite likely that the performance of most milking cows will be limited by environment (feeding, disease, heat stress etc.) rather than genetic merit. Be aware of the genotype by environment interaction which means that high genetic merit stock require better levels of feeding and farm management to express their higher potential performance
	b. Most suitable genotype for the system	Some countries will not allow Jersey crossbreds to be imported hence the imported Friesians limit the dairy production to the highlands If Jerseys are allowed to be imported, they may well prove the more profitable breed in lowland regions
7. Environmental management	c. Difficulty of collecting robust data from genetic improvement programs	More emphasis on permanent identification of heifers Pay greater attention to maintaining cows in milking herds for relatively lengthy periods
	a. High incidence of heat stress during the 24 hour period	Count respiration rates to quantify degree of heat stress Pay closer attention to heat dissipation -Check shed design for ventilation -Consider artificial cooling (sprinklers and fans) Feed cows during the evening, when cooler Consider outside area for night time cooling and heat (cycling) observations Feed better quality forages to reduce internal heat production
	b. High incidence of animal health problems due to poor shed hygiene	Improve shed hygiene Remove manure more frequently Isolate sick stock
8. Milk harvesting management	c. Reduced forage quality due to high temperatures and rainfall	Unfortunately it is not easy since tropical forages are more fibrous than temperate forages. Soil testing can assist with overcoming monitoring leaching due to high rainfall
	a. Poor milk composition (fat and protein contents)	Address any limiting feed nutrient deficiencies Ensure sufficient forage intake to maintain milk fat content Maximise cow comfort so cows will maintain their appetite
	b. Poor milk quality (bacterial contamination)	Improve milking hygiene (hot water, detergent, sanitiser) Ensure machine milkers are operating effectively (short milking times, correct pulsation rate) Ensure rubber liners are correctly replaced Address any mastitis problems Ensure rapid milk cooling Could be a post farm gate issue hence outside farmer's control
9. Value adding milk	a. Poor milk returns	Consider value adding to improve unit milk returns
10. Other on-farm constraints	a. The small farm size restricts development potential	Dairy cooperatives could develop cow colonies (see next section)
	b. Poor profitability of dairy farming	Quantify profitability over 6 to 12 month period Quantify milk returns and overall farm income (actual and potential) Quantify Cost of Production (COP) Be aware that increased profitability can result from decreased COP as well as increased farm income Dilute fixed costs with higher farm cash throughput
	c. Low capital resources for investing in farm infrastructure	Seek alternative low interest loans
	d. Poor dairy farming skills	Institutional support to improve farmer training
	e. Underdeveloped entrepreneurial skills in dairy farmers	Work closely with potentially successful farmers to help develop these skills
	f. Poor farmer-management dairy coop relationships	Provide training in farm business management and developing farmer business skills Become more vocal to improve them

- Easier communication between advisers and farmers and between farmers themselves
- Easier to implement training programs involving practical skills as well as technical theory
- Easier to monitor post training application of new skills
- Better motivation of farmers to improve management practices
- Easier monitoring of individual farmer's milking hygiene practices and hence individual remuneration for better quality milk
- The concentration of farmers in the one place provides an ideal opportunity to introduce other motivation techniques such as regular awards for best management practices
- Better coordination of forage production, cow feeding, insemination, animal health, milk handling etc.
- Training of farmers in specialist skills such as machine milking or calf rearing
- The installation of cooling units on site
- More rapid cooling of milk and greater availability of hot water for more effective cleaning and sanitising equipment
- Increased likelihood of sufficient milk production to justify small value adding operations to benefit small dairy cooperatives
- Greater potential returns to the local dairy cooperative, hence the farmers themselves

Unfortunately such impressive facilities go hand in hand with high profile projects such as stocking them with imported pregnant Friesian heifers. The high mortality rates so far experienced in countries such as Indonesia, suggest that the current colony feeding and herd management has yet to be improved to benefit from these high genetic merit animals.

Potential problems with cow colonies

- The sheds are constructed and filled with cows before the forage production area has been developed, leading to many poorly fed cows
- Insufficient attention placed on growing out non-revenue generating, young stock
- Poorly planned forage production areas, e.g. with minimal water for irrigation during the dry season
- Insufficient land allocated to forage production, partly because of provision of insufficient daily forage allocations to achieve target milk yields
- Incorrect perception that rice straw, sugar cane tops and over mature maize stover are suitable forage sources for milking cows, particularly when target milk yields are 15 L/cow/day or more
- Lack of understanding of the potential of forage and tree legumes as important forage sources for high yielding cows
- Potential spread of disease because of variable management between individual farmers, e.g. during calf rearing, mastitis if using milking machines
- Poor concept of the need for more sophisticated milking hygiene when using milking machines, e.g. regular replacing of milk liners and testing of machine performance
- Continual breakdown of machinery, choppers and milking machines

- Need for highly trained and well skilled labour for year round supply of quality forages
- Need for senior managers to develop both short term and long term views on development program
- Difficulties of regularly sourcing finances for completion of these large scale capital development projects, such as provision of milking equipment, durable forage choppers
- Inherent problems of passing over responsibility to individuals within small management teams. The larger the operation the more essential that skilled individuals be given more responsibility in specialist areas, such as forage production, animal health, milk quality
- Management teams for large scale cow colonies should not be expected to oversee that of any nearby small holder farms
- Need for senior managers to find and keep quality staff with capabilities of solving both day to day small management problems as well as contribute to large scale development. This problem could be addressed by employing bright young animal science graduates who would be prepared to live as well as work in villages near cow colonies.
- With the penalties imposed by milk processors, returns on these large capital investments are markedly reduced because of the low unit milk returns through poor quality milk. Small investments, such as steam cleaners, small hot water units become even more effective in light of the large capital costs of sheds, silage bunkers etc.
- As with all small holder ventures, it is more profitable to "feed fewer cows better"

Poorly resourced SHD farmers, whose businesses are often in "survival mode", can become very individualistic and take time to develop the cooperative, sharing nature required for successful cow colonies (Falvey and Chantalakhana, 1999). This has been given as a common reason for their poor success rate in countries with relatively new SHD industries such as Indonesia.

Using current cow milk yields to assess adequacy of the current farm management

The dynamic nature of dairy farming makes it difficult to develop a simple set of criteria with which to assess current management skills. The term Key Performance Indicators (KPI) has been derived to describe a series of measures of dairy farm performance with which to provide realistic targets following improvements in feeding, herd and farm management. Such a set of KPI for SHD farming have recently been published by Moran (2009b). All these KPI can be quantified to provide guidelines as to which ones require priority in any dairy farm improvement program. Although some are relatively easy to quantify, others are quite difficult. Probably the simplest, most commonly used, single measure of SHD farm performance is the average milk yield of the milking cows. The correct term for this figure is "rolling herd average" as it is the average milk yield of all the milking cows, which on any one day will be at various stages in their lactation cycle.

Table 3: Interpreting the adequacy of dairy farm management from cow milk yields. Range in average herd milk yields on tropical Asian dairy farms

Herd milk yield (kg/cow/day)	Adequacy of dairy farm management practices
5	Very poor feeding and herd management and low genetic merit cows (or milking buffalo)
7	
9	Typical of many SE Asian smallholder farms, even with high grade Friesians
11	Gradual response with grade and crossbred Friesian cows to improved feeding, herd, young stock and shed management.
13	
15	Milk yields of 15 kg/day are considered acceptable by many government dairy advisers.
17	
19	
20	Potential level in lowland humid tropics following improved management of body condition throughout lactation
25	High genetic merit cows in tropical highlands or lowland dry tropics with excellent farm management
30	Typical peak milk yields in herds with 25 kg/cow/day rolling herd averages
35	Unrealistic in SE Asia except where all major constraints to milk production have been overcome

This single value provides a summation of all the important aspects of SHD farm management, so any interpretation must take into account a diversity of feeding, herd and farm factors (Moran, 2012). Accordingly, many dairy specialists may query its usefulness as a single measure of dairy farm performance. However, it is routinely used by farmers to describe their farm's performance in relation to their neighbour's farm and also in relation to production targets provided by many government advisers. In addition, it is often quoted by government officials when summarising the stage of development of their national dairy industries. Table 3 describes the adequacy of the farm's dairy farm management practices using the rolling herd average.

There are other factors and KPI to consider when interpreting such data, as follows:

- It is important to differentiate between rolling herd averages and peak milk yields
- Should also consider milk composition as indicators of feeding management, for example:
 - low milk fat can indicate possible subclinical rumen acidosis
 - high milk protein can indicate good dietary energy intake
 - however milk lactose levels are fairly constant
- Excessive body condition is indicative of low protein diets, due to:
 - inability of cow to partition nutrients from body reserves to milk synthesis
 - poor fertility as cows cannot easily cycle hence conceive
- Very poor body condition is indicative of low energy intake as:
 - High genetic merit cows preferentially partition body reserves to milk synthesis
 - Cows will not cycle due to excessive weight loss
- Herd dynamics can also indicate adequacy of dairy farm management
 - Excessive number of dry non-pregnant cows can indicate very poor farm management
 - Low percentage of lactating adult cows can indicate poor farm management

Conclusions

After several decades of dairy development in many Asian countries, typical milk yields per cow per day still

range between 8 to 10 kg as compared to average yields of 20 to 30 kg in developed countries. In addition, the average calving interval of dairy cows on SHD farms is commonly as long as 16 to 20 months, when it could be reduced to 14 to 15 months. With regards to young stock management, heifer ages at first calving are more commonly 30 to 36 months rather than the 24 to 28 months commonly found in temperate, more developed dairy industries. These clearly show the low levels of farm productivity in tropical Asia. Many technical solutions are available (as in Table 2) but they must be carefully selected so they will be suitable for small farmers and their socio-economic conditions. This means that scientists and extension worker must be able to understand factors influencing the acceptance when transferring such technology to farmers. Scientific knowledge alone cannot solve small scale farm problems (Falvey and Chantalakhana, 1999).

Policy makers should also resist the all too common assumption that development efforts should move from small holders towards supporting larger scale, "more efficient" milk producers to meet growing consumer demand. Instead, growing demand should be used as a stimulus to help continue and sustain SHD enterprises particularly when they face increasing barriers to participate in value chain markets (Ahuja *et al.*, 2012).

If well organised, SHD can compete with large scale, capital intensive "high tech" dairy farming systems as practiced in both developed and developing countries. However SHD development plans must include strategies to increase competitiveness in all segments of the dairy industry chain, namely input supply, milk production, processing, distribution and retailing (APHCA, 2008; Otto *et al.*, 2012). The future for SHD farming in tropical Asia is optimistic so long as the industry can rectify many of the constraints to improving domestic production of raw milk, particularly those at the farm level.

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