

BUSINESS MANAGEMENT FOR TROPICAL DAIRY FARMERS



JOHN MORAN

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Foreword

John Moran is a master of dairy farm management and he has written a masterly book about managing dairy farming in the tropics. The strength of the book is the mix of disciplinary knowledge he brings to the task. This book, *Business management for tropical dairy farmers*, is a valuable addition to the literature about agriculture in the tropics.

This text encapsulates the whole farm approach to farm decision analysis and planning. The approach to decisions is built firmly on a sound technical foundation, with the important human, economic and beyond farm elements fully considered.

Sound measurement of the major components of the system and the key relationships between inputs and outputs establishes the basis for proper understanding of what is happening in the farm system, and is the basis for good farm management.

The whole farm approach, as presented in this book, is the only logical approach to farm decision analysis and farm planning and decision making.

Dairy farmers, their advisers, students, suppliers of farm inputs including farm financiers, and processors of farm output, who master the concepts and approach explained in John Moran's book, could not fail to find ways to increase the productivity and profitability of dairy farming in the tropics.

Prof Bill Malcolm
Professor of Farm Management Economics
University of Melbourne, Parkville, Victoria
Australia

About the author

Dr John Moran is an Australian senior research and advisory scientist from Victoria's Department of Primary Industries, located at Kyabram in northern Victoria. He spends half his time advising farmers in southern Australia and half his time working with dairy farmers and advisers in South and East Asia. His specialist fields include dairy production, ruminant nutrition, calf and heifer rearing, forage conservation and whole farm business management.

John graduated in 1967 with a Rural Science honours degree from New England University at Armidale in NSW, followed by a Masters degree in 1969. In 1976, he obtained a Doctorate of Philosophy in beef production from University of London, Wye College in England.

During the 1980s, John lived in Indonesia for three years, working in beef cattle and buffalo research. Since 1999, he has initiated and conducted training programs on smallholder dairy production to farmers, advisers and policy makers in Indonesia, Malaysia, Thailand, Vietnam, China, Pakistan, Sri Lanka and East Timor. In so doing, he has built a team of Australian dairy extension specialists in forage production, silage making, nutrition and ration formulation, extension methodology, milking hygiene and reproductive management.

As a result of his Asian programs, in 2005 John wrote the book *Tropical dairy farming – Feeding management for small holder dairy farmers in the humid tropics*. As well as hard copy, the book was published on the internet, making it freely available to dairy stakeholders throughout the world. By July 2008, the book had received over 42 000 'hits' on the internet, indicating its relevance, particularly to tertiary teaching institutes and to government livestock departments.

Over the last three years, John worked with an extension team to prepare an extension and training program on Farm Business Management for the Victorian dairy industry. Based on his South and East Asian experiences, using the same basic principles of farm management, he has modified the recommended practices specifically for smallholder dairy farmers in the tropics.

John has published more than 200 research papers and advisory articles. He has also written several farmer manuals on dairy and beef cattle nutrition, veal production, calf and heifer rearing and on silage production. The first edition of *Calf rearing: A guide to rearing calves in Australia*, published in 1993, sold more than 10 000 copies. The second edition, published in 2002, is now selling widely throughout Australia. He also published a companion book on young stock management, *Heifer rearing: A guide to rearing dairy*

replacement heifers in Australia. His book, *Forage conservation: Making quality silage and hay in Australia*, published in 1996, is now a set text for undergraduate study in several Australian universities.

His initial training in a systems approach to livestock science, together with his many years working closely with dairy industries in Australia and South and East Asia stands him in great stead to write this book, a companion book to *Tropical dairy farming*. *Business management for tropical dairy farmers* is both a training manual of farm business management plus a series of observations on how successful and profitable smallholder farmers manage their day-to-day farming practices.

Other books and technical manuals by the author

Books

- Calf rearing – A guide to rearing calves in Australia* (1993)
Forage conservation – Making quality silage and hay in Australia (1996)
Heifer rearing – A guide to rearing dairy replacement heifers in Australia (with Douglas McLean) (2001)
Calf rearing – A practical guide (2002)
Tropical dairy farming – Feeding management for small holder dairy farmers in the humid tropics (2005)

Technical manuals

- Maize for fodder – A guide to growing, conserving and feeding irrigated maize in northern Victoria* (with Ken Pritchard) (1987)
Growing calves for pink veal – A guide to rearing, feeding and managing calves for pink veal in Australia (1990)
Growing quality forages for small holder dairy farms in Indonesia (2001)
Managing dairy farm costs – Strategies for dairy farmers in irrigated northern Victoria (2002)
Feeding management for small holder dairy farmers in Thailand (2002)
Improving milk composition through better feeding management (2003)
The key drivers of good reproductive performance on Indonesian dairy farms (2006)
Value adding Indonesia's dairy industry: Developing cottage industries in East Java (2006)
Improving business skills of small holder dairy farmers in Thailand (2007)
Dairy production in Malaysia with particular reference to milk quality (2007)
Dairy production in Indonesia with particular reference to milk quality (2007)
Developing a post-arrival herd management protocol for imported Australian dairy heifers (2007)
Managing heat stress and housing for Pakistani dairy cows and buffaloes (2007)
Dairy production from smallholder farmers in Asia – Synopses of workshops from 2000 to 2007 (2008)
Dairy production in Sri Lanka: Current situation and future prospects (2008)
Improving business skills in Vietnam's small holder dairy industry (2008)
Guide to good dairy herd management: A manual for farmers, dairy advisers, technical staff and other dairy specialists (2009)

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During the last three to four decades, governments throughout Asia have established smallholder dairy farming as part of their social welfare and rural development schemes, to provide a regular cash flow for poorly resourced and often landless farmers. Now these are becoming accepted rural industries thus requiring a more business-minded approach to management decisions on each farm. Dairy farmers across the world milk cows to make money, even the smallholder mixed farmer with only one or two cows. As the dairy value chain becomes more liberalised, and farmers become more exposed to the pressures of global markets, their daily farming decisions must become based on changes to their farm profitability.

This manual uses an approach originally finetuned for Victoria's dairy industry over the last five years (Gibb *et al.* 2006). It has been extensively modified to ensure its relevance to smallholder farmers in Asia. I would like to acknowledge my colleagues in northern Victoria, in particular Ian Gibb (Farmanco, Kyabram) and Phil Shannon (DPIV, Cobram). This manual has also made good use of another Victorian government initiative, the Milk MAP (Target 10, 2004), a program to better understand and document the process of Farm Business Management for dairy farmers. For his informative discussions, I would like to thank Mike Weise (then at DPIV, Warrnambool) and his Milk MAP development team.

Following the successful publication of my book, *Tropical dairy farming*, in December 2005, which by mid 2008 had received over 42 000 hits on the internet, CSIRO Publishing asked me to write another manual on Asian dairy production. As with my first book, my gratitude goes out to ATSE Crawford Fund, who provided generous financial support, and to Ted Hamilton and the publishing team at CSIRO Publishing who very professionally converted my laptop computer writings to both a 'hard copy' book and a collection of PDF files.

I also acknowledge the teams that helped produce a glossy brochure on smallholder dairy farming in Indonesia, those both in Java (Tetra Pak, De Laval and the Indonesian Association of Dairy Cooperatives) and Australia (Victorian and Queensland governments). Finally, this book was written while I was working full time as a dairy adviser at DPIV's Dairy Extension Centre, and I thank the management team for supporting my endeavours.

Other colleagues whom I would like to acknowledge for their advice and guidance over the years are:

- Prof Bill McClymont (now deceased) from New England University in Armidale, Australia, who first instilled me with enthusiasm about livestock production and feeding while I was an undergraduate.
- Dr Devendra from Kuala Lumpur, Malaysia, who keeps trying to help me ‘fit into the farmer’s shoes’ to more fully understand the problems of the smallholder dairy farmer in SE Asia. Or as my Thai colleague, Prof Charan Chantalakhana, expresses it, seeing the world as a farmer.
- Prof Bill Malcolm, Professor of Farm Management, University of Melbourne, Parkville, a valuable colleague in discussion and with his comments of early drafts of this manual.

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Chemical warning

The registration and directions for use of chemicals can change over time. Before using a chemical or following any chemical recommendations, the user should ALWAYS check the uses prescribed on the label of the product to be used. If the product has not been recently produced, users should contact the place of purchase, or their local reseller, to check that the product and its uses are still registered. Users should note that the currently registered label should ALWAYS be used.

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1

Introduction

This chapter presents an outline of the book and its role in developing training programs in tropical Farm Business Management (FBM).

The main points in this chapter

- This book is a companion to *Tropical dairy farming*, which discusses the management of the farm's biological and natural resources to produce quality milk.
- This book concentrates more on the human side of smallholder farming, focusing on the farming family and their support structures.
- The thrust of this book is smallholder dairy farming of both dairy cattle and buffalo in South and East Asia.
- The book is multipurpose in that it forms the basis for various structured training programs in Farm Business Management.
- One of the key benefits of developing an understanding of FBM is the calculation of a realistic on-farm cost of production for raw milk.

This book is a companion to *Tropical dairy farming* (Moran 2005) which details the production technology of smallholder dairy farming. This second book discusses the farm business management (FBM) skills required to ensure such systems can remain financially sustainable.

The first book addresses the management of the farm's natural and biological resources to produce quality milk, these being the climatic environment, soils, forages, concentrates, the livestock. This second book concentrates more on the human side of smallholder dairy farming, that is, the farming family and their support structures. These include the village communities, cooperatives, marketing and government agencies and other service providers, and importantly, the consumers. The aim is to ensure such farming systems remain profitable and sustainable into the future.

During the last three to four decades, governments throughout Asia have established smallholder dairy farming as part of their social welfare and rural development schemes, to provide a regular cash flow for poorly resourced and often landless farmers. Now these have become accepted rural industries. The need is for a more business-minded



Figure 1.1 Farmer participants at a FBM training course in Binh Duong province, Vietnam

approach to management decisions on each farm. Dairy farmers across the world, including the Asian smallholder mixed farmer with only one or two cows, milk cows to make money. As the dairy value chain becomes more liberalised, and farmers become more exposed to the pressures of global markets, their daily farming decisions must become based on changes to their farm profitability.

Dairy farmers are business managers, irrespective of the size of their milking herd. A successful business is based on a good understanding of the technology underlying the production of the end product, in this case raw milk, and the ability of the manager to run the day-to-day operations at a profit and to make astute decisions regarding investments in its sustainable future. The scale of operation is generally limited by personal asset worth, but even smallholder farmers can make good financial returns on their dairy enterprise.

Every day we intuitively manage our personal assets when we make household business decisions at the shops, schools and in the wider community. It is the same with the smallholder dairy farmer when deciding on today's livestock feeding program, next week's crop agronomy program or the optimal herd size for next year's likely farm gate milk price. Such decisions are based on the elementary frameworks of farm business management.

Most farmers intuitively think about farm costs and returns. However, greater use should be made of ways to make them become aware of the relative importance of all their financial inputs, in terms of their contribution to the cost of production (COP) per kilogram of milk produced on the farm. In addition, when contemplating changes in their routine farm practices, such as those discussed in detail by Moran (2005), proposed changes should be appropriately costed to allow farmers to make more meaningful and timely decisions.

The performance and sustainability of any dairy value chain in the tropics depends on the continued supply of raw milk from the smallholder farmers. Economic pressures,

such as those experienced by dairy industries throughout South and East Asia, require each farmer to be more aware of their individual COP. Without such skills, farmers cannot prioritise their management decisions to address the high cost items of their production systems.

In addition, better knowledge of farm business management allows support organisations to more clearly define the key drivers of profit on smallholder farms. This information can be used to develop regional and national strategies for government departments and national dairy organisations, such as those overseeing the producer-driven dairy cooperatives, to routinely evaluate and update their industry policies.

1.1 Aims of the manual

This manual assists smallholder (and large-scale) dairy farmers to identify the most important physical, financial and human issues affecting their business and it looks at ways of ensuring sustainable profitability. It allows farmers to understand where their business is currently positioned, what opportunities exist for them to move forward and improve its performance.

When used as part of the reviewing process, together with their dairy cooperative, government or milk processor adviser, the regular FBM sessions can engage farmers in discussion, assessment and recognition of their current situation and future options. It provides a framework to structure discussions with trusted, credible advisers who have a solid understanding of farm management and local dairy industry issues. Following through such discussions can help farmers to more quickly and easily identify their weaknesses or opportunities using agreed physical and financial indices. These may even be previously unidentified features of the dairy enterprise that place the operation at risk.

This book does not provide detailed guidelines on how to develop farm cash books or farm financial records although examples of such statements are presented in Appendix 6. It concentrates on developing an understanding of what exactly farm costs and income are on a smallholder dairy farm in the tropics and how they can influence ‘the bottom line’, namely farm profit.

This book provides a framework for farmers to develop new skills to become more astute business managers. Many smallholder dairy farmers have mixed enterprises, such as cash cropping and various types of livestock of which dairying may be just one. Mixed farmers must be able to separate out the inputs and outputs from their dairy enterprise, to be able to manage that enterprise within their whole farm business. They should be able to budget their cash inputs to match their cash outflows during different seasons of the year, and also invest wisely in improving their herd size, cattle housing and other farm infrastructure and of most importance, their feed management systems.

1.1.1 Some key points about this book

- Dairy farmers, whether they run five or 100 cows, milk cows to make money.
- Farmers’ concepts of costs, returns and hence profit, vary considerably and this can have a dramatic effect on their long-term viability.
- Ideally, farmers should make farm management decisions based on their profitability.

- In many cases they do not take all the costs of dairy farming into account, for example imputed costs such as family labour or depreciation.
- Family labour is not free, particularly if it can generate income off the farm. In other words, family labour should be considered as an opportunity cost of dairying.
- Profit can be categorised into three types; cash, efficiency (of utilisation of existing resources) and wealth (creation).
- The relative importance of these three types of profit will vary with the type of dairy industry existing in that country.
- This book presents a framework to determine COP.
- This book also presents concise summaries of various key aspects of production technology, such as feed and herd management, which could be considered the 'raw materials' of FBM.

1.2 Outline of the manual

This book is written primarily for the stakeholders of smallholder dairy production in the tropics. Smallholders are the major suppliers of milk in the tropics. However, many larger farms with up to one thousand milking cows, using intensive feedlot or less intensive grazing systems, have been established throughout South and East Asia in recent years, to satisfy the increasing demand for fresh milk. These farmers and their advisers will also gain much from this manual. In addition, the book provides relevant key information to research scientists on aspects of tropical dairy production and business management, such



Figure 1.2 Smallholder farmers waiting to deliver their milk at the Milk Collection Centre (East Java, Indonesia)

as forage production, herd and feeding management. Policy makers and senior managerial personnel would also benefit from reading selected chapters.

Most tropical countries have pro-active programs to increase local supplies of milk, which require increasing numbers of well trained workers to service the dairy industry. Consequently, educators from agricultural schools, universities and technical colleges need to be kept abreast of the latest technical developments and applications in dairy farming. This manual also serves this purpose. Table 1.1 on page 9 presents suggested structured training programs that can be developed from the manual.

Geographers categorise the humid (or rainy) tropics as areas with at most one or two dry months and no winter, with the coolest month above 18°C mean temperature. Other tropical zones are:

- Wet and dry tropics, having a well developed dry season, with one or two rainy seasons
- Semi arid tropics, with light rainfall and high evaporation
- Hot arid tropics, with negligible rainfall and high evaporation.

My first book, *Tropical dairy farming* (Moran 2005) limited its scope to the humid tropics of South-East (SE) Asia. This book extends its scope to all the above zones within tropical Asia, although dairying is more likely to be restricted to just the humid and the wet and dry tropics. In addition, it covers both South and East Asia, not just South-East Asia as in *Tropical dairy farming*. Tropical Africa and Central America are not discussed in any great detail.

The book also extends its scope to cover milk production for all large ruminants, namely dairy cattle and milking buffalo. To differentiate between the two species, the term ‘cow’ is used specifically for dairy cattle, even though this descriptive word often covers milking buffalo as well.

These principles of improved farm and business management can be profitably incorporated into dairying anywhere in the tropics, although successful examples in this book will be mainly those from South and East Asia. Its thrust is on smallholder dairy farming. Since most of the relevant principles of FBM currently available in the world literature cover larger-scale operations, these have had to be adapted for readers of this manual.

With the cows generally located in close proximity to the home, dairying offers opportunities for women to become more closely involved in the day-to-day management than with other farming pursuits. This is important in the village life of South and East Asia, where women have traditionally been the homemakers and family rearers. The cultural and religious bonds limiting their contribution to managing the family budget are becoming loosened in many smallholder dairying communities. For the sake of brevity, when referring to managers, this book assumes them to be men, although in many situations the description could apply equally to the farming women who make key management decisions.

Chapter 2 addresses the question, ‘What is Farm Business Management?’ Chapter 3 provides an insight into the role of smallholder dairying in Asia and how dairying has developed in various South and East Asian countries.

Chapters 4, 5 and 6 cover the production technology of smallholder dairy farming, namely feed production (Chapter 4), herd management (Chapter 5) and milk harvesting and marketing (Chapter 6). Some key aspects of this technology can also be found in *Tropical dairy farming* (Moran 2005), but these have been duplicated because they are essential to profitable dairy farming and need to be well understood by business minded dairy farm operators. These chapters also include more recent aspects of dairy production technology cited following the publication of my first book.

The major profit driver on smallholder farms is the base price of raw milk and this is discussed in Chapter 7. Chapters 8, 9, 10 and 11 address the basic principles of FBM. The outcome of any FBM decision depends on sourcing accurate farm records, either production or financial (Chapter 8), using these records to quantify actual farm costs and farm revenue (Chapter 9) then with the tools of business analyses (Chapter 10), calculating the various measures of farm profit (Chapter 11).

It is relatively easy to quantify profit through monitoring feed costs, so Chapter 12 discusses the mechanics of formulating profitable dairy rations while Chapter 13 discusses how profit is influenced by feeding management, the greatest contributor to farm costs.

The next three chapters are important to the farm business manager in that they provide insights into key business decisions. Firstly, there are certain farm measures, called key performance indicators (KPI), which can quickly provide a guide as to 'how the farm is travelling', in a financial sense. These can provide a quick assessment of farm profitability (Chapter 14). It is one thing to know the farm's current financial performance, but it is also important to be able to predict how it will respond to changes in farm practice. Chapter 15 discusses this in terms of marginal responses and partial budgets. All farm decisions are based on coping with risk, the topic of Chapter 16.

The best way to understand the process of farm business decision making is to undertake case studies, several of which are presented in Chapter 17. Chapter 18 provides an insight into running a two- or three-day workshop on FBM for farm technical and financial advisers or for the farmers themselves.

Chapter 19 looks towards the future for production technology and business management of smallholder tropical dairy farming. It addresses such questions as, 'How appropriate is high technology, dairy farming to the smallholder farmer in South and East Asia?' This is very timely because much of this 'high tech farming' has recently evolved in the developed industries of the temperate dairy world. In addition, this chapter addresses the question of sustainability of small-scale farming and dairying in particular.

In the process of developing a series of workshops on dairy production technology for Indonesian smallholder farmers, I prepared a summary entitled, *Tips for proper managing of dairy cows on Indonesian smallholder farms*. This four-page booklet highlights the key features of good feeding, herd and milking management on profitable farms throughout Asia, so it is presented here in a separate section.

Appendices are included to facilitate sourcing specific information and gaining experience in ration formulation. Appendix 1 presents the Temperature Humidity Index, the universal method of quantifying heat stress in dairy stock. Appendix 2 provides conversion factors to the standard metric system from a wide variety of systems used for

describing weights and measures. Appendix 3 presents a currency converter for South and East Asian countries as at March 2009. Tables of nutrient requirements are presented for energy, protein and fibre (Appendix 4). Appendix 5 presents worksheets that provide a structured approach to calculating the nutrient requirements for formulating rations for milking cows. Appendix 6 presents a series of financial statements used to assess business performance. Appendix 7 presents examples of Expectation and Evaluation forms used in FBM workshops.

Full publication details of all sources of information are presented in ‘References and further reading’. A glossary of technical terms and abbreviations used in the manual is also provided. Finally, for ease of finding specific information, the index lists all the key topics covered in the book and their relevant page numbers.

1.3 Role of manual in training programs

This manual is multipurpose in that it forms the basis of structured training programs in smallholder dairying for advisers and educators (for farmer training organisations, agricultural high schools and universities), while also providing background information to researchers and policy makers in tropical dairy industries.

As a guide to the book’s role in technology transfer, Table 1.1 on page 9 presents two structured training programs and highlights those chapters written more specifically for dairy researchers and policy makers. Two FBM programs are outlined. The first is a basic program for farmers and high school students, while the second is an advanced program



Figure 1.3 A farmer feeding his small herd of cows in a cooperative cow colony (West Java, Indonesia)

for more highly skilled farmers, advisers and university undergraduates. It is assumed that participants in the advanced program would be familiar with topics covered in the basic program; if not, the topics should be initially introduced as an abridged basic course.

The basic 'Farm Business Management' course introduces participants to:

- What is Farm Business Management (Chapter 2)
- The importance of record keeping (Chapter 8)
- Categorising farm costs and farm revenue (Chapter 9)
- The key tools of farm business analyses (Chapter 10)
- Measures of farm profit (Chapter 11)
- Feeding decisions driving profit (Chapter 13)
- Key performance measures of farm profitability (Chapter 14).

The advanced 'Improving the business skills of smallholder dairy farmers' course does not duplicate topics from the basic course and introduces participants to:

- Feed production technology (Chapter 4)
- Improved herd management (Chapter 5)
- Harvesting and marketing of milk (Chapter 6)
- Formulating profitable rations (Chapter 12)
- Budgeting for future farm development (Chapter 15)
- Coping with risk in dairy farming (Chapter 16)
- Case studies of profitable tropical dairy farming systems (Chapter 17)
- Planning and conducting workshops in Farm Business Management (Chapter 18).

Many of the chapters in the advanced program would also be relevant to tropical dairy researchers and policy makers. Chapters written more specifically for these people are:

- Smallholder dairy farming in Asia (Chapter 3)
- The base price of raw milk (Chapter 7)
- The future for smallholder dairy industries (Chapter 19).

The chapters are written to be understood by advisers and tertiary students. Hence the trainers must ensure that other target audiences can comprehend their course material. For example, Chapter 16 (Coping with risk) has been excluded from the basic 'Farm Business Management' course, even though parts of it are just as relevant to farmers as they are to advisers and tertiary students. Hence the course planner should select these most relevant sections to incorporate into the basic course. Because the chapters are written as 'stand alone' documents so they can be downloaded from the internet, there is some repetition, but this has been kept to a minimum.

For a book covering such a diversity of tropical dairy industries, every attempt has been made to present information from many countries. For example, Chapter 3 (Smallholder dairying in Asia) presents data from eight South-East Asian and five South Asian dairy industries. This chapter also provides an overview on smallholder dairying in Thailand. In addition, several chapters present more detailed production and financial data from selected countries. Malaysian data are used in Chapters 12 (Formulating

Table 1.1 Suggestions (+) for the selection of chapters from this manual to use in a basic course on ‘Farm Business Management’ (A) and an advanced course on ‘Improving the business skills of smallholder dairy farmers’ (B) and chapters of relevance to tropical dairy researchers and policy makers (C)

Chapter	Topic	A	B	C
1	Introduction	+	+	+
2	What is Farm Business Management?	+		
3	Smallholder dairy farming in Asia			+
4	Feed production technology		+	+
5	Improved herd management		+	+
6	Harvesting and marketing of milk		+	+
7	The base price for raw milk			+
8	The importance of record keeping	+		
9	Categorising farm costs and farm revenue	+		
10	The key tools of farm business analyses	+		
11	Measures of farm profit	+		
12	Formulating profitable rations		+	
13	Feeding decisions driving profit	+		
14	Key performance measures of farm profitability	+		
15	Budgeting for future farm development		+	+
16	Coping with risk in dairy farming		+	+
17	Case studies of profitable tropical dairy farming systems		+	+
18	Planning and conducting workshops in Farm Business Management		+	
19	The future for smallholder dairy industries			+
Appendices	Units and currency converters, worksheets	+	+	+

profitable rations) and 15 (Partial budgets), Thai data are used in Chapter 18 (FBM workshops) while Chapter 17 uses Thai, Vietnamese, Indian and Pakistani data as farm case studies. These data were selected to provide ‘real life’ examples from well researched studies. It is desirable for FBM course planners to seek similar quality data from within the country in which the training programs are to be conducted.

Every profession has its jargon, or words developed specifically for that profession, and agriculture is no exception. There are some very specific terms and acronyms that are routinely used by farm management economists and consultants. These are explained in the Glossary and when they are first used in this book.

2

What is Farm Business Management?

This chapter discusses the basic skills in Farm Business Management such as developing a set of key tasks and making the best use of service providers.

The main points in this chapter

- To be successful, today's farmers must be able to manage their resources to meet the challenges of varying costs, prices and climatic conditions.
- FBM provides a structured approach to decision making.
- Decision making is based on judgements which are influenced by farmers' beliefs as well as their economic, social and cultural values.
- Dairy farming essentially involves developing a set of key tasks for which there are key performance indicators to quantify their success or otherwise.
- Farmers have access to a diversity of expertise, much of which is free of charge, that they can use to improve farming practices and hence profit margins.
- Production technology can be broken down to nine key steps in the supply chain of profitable dairy farming. Just as a chain is only as strong as its weakest link, each step in the supply chain must be properly managed.
- Managing a farm business is essentially a hierarchy of decision-making processes, made more complex if dairying is one of several farming enterprises.

Farm management is about managing farms. Farmers manage farms whereas many other people are interested in how well they are managed. Such is the range of the target audience for this book.

A complete, somewhat clumsy definition of farm management is: 'The process by which resources and situations are manipulated by the farm family in trying, with less than full information, to achieve its goals.' Makeham and Malcolm (1986) consider two major tasks facing today's farmers in pursuing their goals:

- How best to incorporate new technology into the farming enterprise.
- How to be sufficiently flexible, mentally and financially, to adjust their management of their resources to meet the challenges of varying costs, prices and climatic conditions.

To achieve this second task, farmers must then become business managers. In other words, they must successfully manage the business of their farming enterprises. So Farm Business Management (FBM) is just one of a number of disciplines, each of which have important effects on the success (or otherwise) of their farming operations. The other key disciplines are covered in the practical sciences such as cropping, livestock production, farm engineering and resource management.

The skills of FBM are very diverse and many can not be learnt from a book such as this, but only from being a farmer. We call this experiential learning, or learning from experience, because only through making such decisions and living with the consequences do many farmers learn the difference between right and wrong choices, between good and poor decisions, and of most importance, the differences between profitable, less profitable and unprofitable farming practices.

Any form of management requires decision making. This process has six generally recognised steps:

- Having ideas and recognising problems
- Making observations
- Analysing observations and testing alternative solutions to the problem
- Choosing the best course of action
- Acting on this decision
- Taking responsibility for the decision.

Ferris and Malcolm (1999) expressed this concept in a slightly different way when they considered that managing a farm business is a continual process of planning to do something and then changing intentions as time passes and new circumstances, different to those which were previously anticipated, dictate that different actions be taken. Managing a farm business is about manipulating resources in situations where much is unknown, to try to achieve and establish situations in a future which is knowable. It is about deciding how the resources under control are best used to achieve objectives sometime in the future, when the only certainty is that ‘the future will be a different world, where they do things differently’.

Fundamental to good farm management analyses and decision making is identifying the real nature of the problems correctly, bringing to bear on them the technical, human, economic and financial conceptual and analytical skills. The greatest difficulty arises from the nature of the information that has to be used as most of it cannot be known with certainty. The vital information about production responses to inputs and future events has to do with seasons and markets. The ‘numbers’ which have to be used are matters of judgements about the key aspects of farm activities and about the whole farm business.

Economic analyses do not have to be complicated, as the technical foundations of the analyses just need to be sensible while the logic needs to be sound. The logic is ‘What is the situation, what is likely to be the new situation if I do this or that or nothing different at all, and am I likely to be sufficiently better off, all things considered, for it to be worthwhile doing this instead of that or nothing different at all?’

Farm business analysis is then the process of retrieving, organising, processing and analysing information used in business decision making. Put even more simply, three

questions have to be asked, namely, ‘Where are we? Where do we want to be?’ and ‘How do we get there?’

2.1 Decision making is based on value judgements

Farmers are resource managers who manipulate labour, land, capital and other resources to achieve their goals in life. As well as returning a profit from their farming ventures, such goals are very diverse. Providing materially for the farm family is a key goal for Western farmers, as is educating their children and reaching a personal living standard which is on par with that of peers in their community. Increasing the value of their assets may be important to some farmers, that is wealth creation. Many farmers do not own their own land, so their major resources are money, livestock, farm equipment and their own home.

FBM is an economic science essentially developed by Western farm management specialists specifically for farmers living in developed countries. The question then arises about its applicability to farmers living in developing countries who may have different outlooks on life, hence another set of value judgements about why they farm. In other words, can we assume that what motivates a dairy farmer in say Australia, to want to modify his farming practices is the same as for a dairy farmer in say, Vietnam or in Pakistan? Obviously there are many basic differences in the beliefs and values of these different societies, but are these likely to influence the motivation to change farming practices? Maybe yes, if such beliefs and values reflect one’s judgement on what is important in life.

2.1.1. Maslow’s hierarchy of needs

One way of addressing this question is to use a psychological approach called Maslow’s hierarchy of needs (Wikipedia 2008). Each one of us is motivated by needs, with our basic needs inborn, having evolved over thousands of years. Maslow argues that we must satisfy each need in turn, starting with the first, which deals with the most obvious needs for survival itself. Only when the lower order needs of physical and emotional wellbeing are satisfied are we concerned with the higher needs of influence and personal development. Conversely, if the things that satisfy our lower needs are withdrawn, we are no longer concerned about the maintenance of our higher order needs. Under stressful conditions, we regress to a lower needs level. As needs emerge only when higher priority needs have been satisfied, satisfied needs no longer influence behaviour, hence motivation to want to change.

Maslow originally prioritised needs into five levels, but they have since been increased to eight levels. The levels, the basic needs (in italics) and some relevant motivating factors for smallholder Asian dairy farmers to improve their farming practices are:

1. Biological and physiological needs: *air, drink, food, shelter, warmth, removal of body wastes, avoiding pain, sex, sleep*. All farming families require these ‘basics of life’.

2. Safety needs: *protection from elements, overcoming fears and anxieties, security, order, law limits, stability*. Environmental and civic protection are essential for family wellbeing.
3. Sense of belonging and love needs: *work group, family, overcoming loneliness, affection, relationships*. Many farmers like to mix with other farmers to share ideas.
4. Esteem needs: *self-esteem, self-respect, achievement, reputation, independence, status, dominance, prestige, managerial responsibility*. Status within a group is important to some farmers.
5. Cognitive needs: *knowledge, meaning, self-awareness*. The desire to know more about their farming system is important to most farmers.
6. Aesthetic needs: *appreciation and search for beauty, balance, form*. Many farmers place high credence on a neat looking farm.
7. Self-actualisation needs: *realising personal potential, self-fulfilment, seeking personal growth, peak experiences*. Most farmers have business goals to work towards.
8. Transcendence needs: *helping others to achieve self-actualisation*. Many people, including farmers, desire to help others achieve their personal goals.

Hunger and poverty can be a common feature of resource-poor farmers, so for them satisfying Need 1 is paramount. Obviously without fulfilling Needs 1 and 2, motivation to improve their farming business is a low personal and family priority. Once these two are fulfilled, satisfying Needs 3–8 would be similar for Australian, Vietnamese and Pakistani dairy farmers. However, there may be more potential stress factors (actual rather than perceived) with resource-poor farmers. The tendencies of self-actualising people are towards awareness, honesty, freedom and trust, which are not always possible to demonstrate in resource-poor situations.

The important conclusion from this discussion is that, as hunger, poverty and civil unrest would be more of an issue in developing than in developed countries, the motivation to set realistic goals to improve farm performances may also differ.

This conclusion has relevance with government and other support organisations as well as individual farmers themselves. Economic, social and cultural values can influence decision making in group as well as individual situations. This can be demonstrated using examples from developed and developing dairy industries as follows:

- Economic values: differences in the cost of labour relative to other farm costs influence the investment made by farmers on labour-saving devices, such as farm machinery and milking machines. The number of cows managed per labour unit is an important key performance indicator (KPI) in many developed countries but is not as high a priority in Asia.
- Social values: to westerners, Asian farmers appear overserved by government agencies, for example with the number of staff employed at Milk Collection Centres in Malaysia. The provision of employment opportunities is an important role for government agencies in Asia.
- Cultural (and religious) values: sometimes it is not easy to economically rationalise farm decisions that are overlain by religious beliefs, such as slaughter of cull cows in Hindu societies, a religious conviction that also influences income realisation in some Buddhist societies.

As well as understanding the types of value judgements farmers need to make to modify their behaviour (that is to undergo practice change) it is important to assess how close they are to making that decision to change. In other words, what makes farmers decide that they need to change?

2.1.2. Bennett's hierarchy for developing objectives

An American extension specialist developed a seven stage process to describe the hierarchy of decision making, or as he called it, for developing objectives (Bennett 1979). The lowest level are the inputs, or the allocation of resources given to the program, while the highest level, the end result, deals with the impact of the extension program on the farmers' long-term goals. These and the steps in between are as follows:

1. Inputs: Resources to support the program; what sort of personnel, their time input and cost?
2. Activities: Specific extension activities, such as field days, meetings, newspaper articles, workshops or on-farm demonstration sites; how many and of what type?
3. Involvement: Involvement of the stakeholders; who were they, how many and what sort of contact?
4. Reactions: Degree of interest, credibility, perceptions; how were they recorded?
5. KASA: Knowledge (what do they now know?), Attitudes (how do they feel now?), Skills (what can they now do?), Aspirations (What do they want?); how were these modified by the extension activities?
6. Practice change: adoption and application of KASA; what was the adoption of new technology or their change in behaviour?
7. End results: social, economic, environmental and individual consequences of the program; how much did these change?

This process logically follows through a chain of events assumed to characterise most extension programs. It is much easier to quantify the lower order steps, but it is the more difficult higher order evaluations that are the most useful in assessing the program's effectiveness. This is where the impact of the program may vary with the types of value judgements influenced by Manslow's hierarchy of needs.

2.2 A set of key tasks for dairy farm managers

So what encompasses good farm business management for smallholder and large holder dairy farmers in the tropics? How can this book possibly cover the theory of such good farming practices? Jack Makeham's and Bill Malcolm's excellent and easy to read 1986 book, *The economics of tropical farm management*, summarises the essence of successful smallholder farming in the tropics. Of the eight key areas of knowledge they listed, five utilise skills in business management.

They list these key areas, with the three non-business management areas in italics, as follows:

- *Crop production and protection*
- *Animal production*

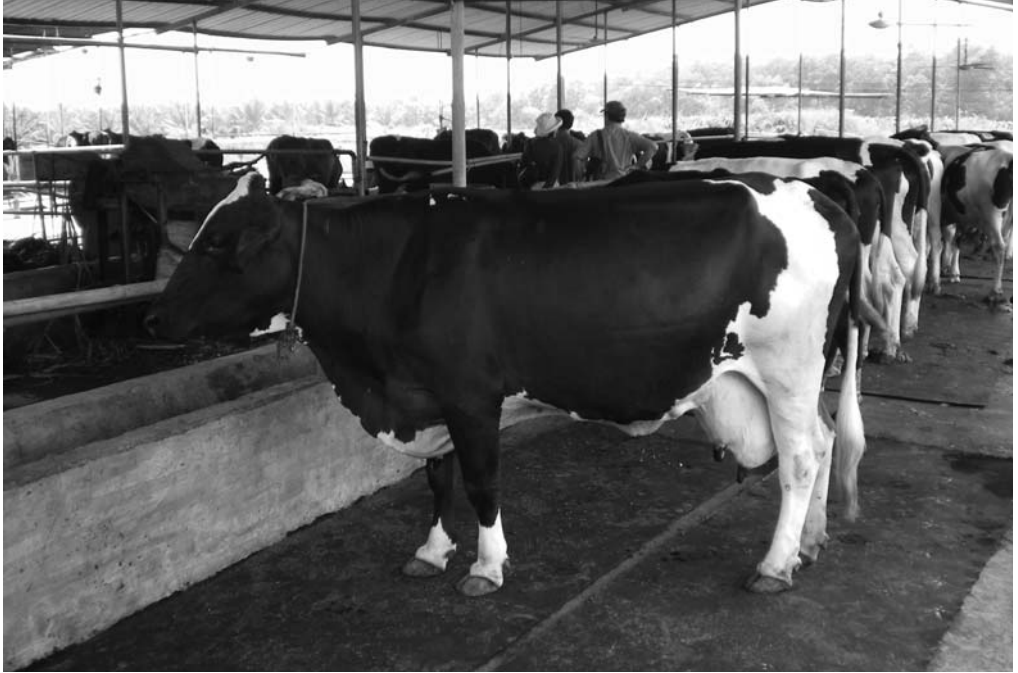


Figure 2.1 A well-bred and fed milking cow, Malaysia

- *Machinery selection and maintenance*
- Economic aspects of farm management
- Credit and finance
- Marketing
- Managing labour and communications
- Information gathering.

From lists such as this, a set of key task areas for good dairy managers can be selected, and within each task area progress can be quantified through developing a series of key performance indicators (KPI). This has been undertaken in Chapter 14. The following example lists of key tasks are for three major management areas on any tropical dairy farm:

2.2.1 Production technology

- Prepare land then plant, fertilise, weed, water (in some situations) and protect the crop; likely to be a forage crop.
- Harvest, store and market the crop (through livestock rather than in the marketplace) to get the best return with minimum waste.
- Feed animals properly, prevent disease outbreaks and recognise disease symptoms.
- Achieve high reproductive and survival rates.
- Obtain or produce nutritionally correct feed at the optimum (generally lowest) cost.

- Provide the right housing for effective production, protection, hygiene and harvesting of the animal product.
- Where machinery is involved, be able to choose the most appropriate types for the job, ensure they are properly maintained and serviced, and when necessary, find a good mechanic.

2.2.2 People skills

- Have harmonious relationships with farm workers by giving them a reasonable amount of responsibility.
- Be interested in the welfare of people working with the farmer.
- Know how to establish a clear chain of command so each person knows to whom they are responsible and so does not have several bosses telling them what to do.
- Set up a system of supervision to ensure the work done is of a proper standard.
- Create a system of communication and involvement, so that all know what progress is being made in achieving the goals and objectives of the farm operation.

2.2.3 Business management

- Use specialist advisers to help analyse the important physical and financial aspects of the farm business.
- Through appropriate records, and other relevant information, be able to work with an adviser to produce annual farm plans, together with budgets, aimed at producing as much food and money as they need or are able to.
- Prepare plans of action in case of abnormal seasons and/or price.
- Plan well in advance so that all inputs are available when required, and in correct quantities.
- Prepare physical and financial reports at regular intervals, which are timely, accurate, relevant, brief and clear for the persons who control the farm.
- Determine the most favourable forms of credit which can be obtained for different activities.
- Develop good honest working relationships with bankers, financiers or other credit managers.
- Be able to prepare realistic applications and finance budgets to obtain credit.
- Have the ability to know when borrowings are too great to be repaid from farm income.
- Assess the different ways of preparing and selling the farm products.
- Work out the best way(s) of marketing (assembling, preparing, transporting, selling) to return the greatest long-term benefit.
- Be able to obtain relevant information about any problem quickly. Information sources could be other successful farmers, extension agents, private agribusiness companies, research workers, libraries, teachers and friends.
- Develop effective thinking and reasoning skills which should be combined with common sense and even mini ‘trial and error’ experiments.

2.3 Making the best use of service providers

A good farm business manager should know exactly what he (and his employed and family labour) has to do on his farm to generate profit, how to find out from others what can be done to improve his profit margins and when to seek outside expertise (labour as well as ideas). Smallholder farmers generally depend on themselves and their family for labour, however there are numerous sources of 'good ideas' available, many of which are free. Such personnel are called service providers and they include suppliers of services, equipment as well as good ideas. All the service providers in the following list may not be readily available in every smallholder dairy farming community but if there is sufficient demand, they can be found, particularly for farmers belonging to a dairy cooperative. In many regions there are dairy equipment suppliers (resellers) or private consultants that can advise on various aspects of farm management. Service providers have a diversity of roles that will help to improve the technical capabilities and the decision-making skills of dairy farmers both small and large scale. These include:

- **Sampling and analysing soils for essential plant nutrients.** This is a routine service utilised by many Western dairy farmers to plan fertiliser programs for their forage crops. It is frequently undertaken by the fertiliser agent in Asia who mainly deals with farmers growing plantation or other cash crops.
- **Selection of most suitable forage crops for the soil type and local climate.** Agronomists working for dairy cooperatives or suppliers of crop seeds can also advise on the optimum agronomic practices such as irrigation scheduling (if available), spreading shed effluent, weed and pest control or harvesting interval for improved grasses and legumes.
- **Purchasing concentrate feeds.** Cooperatives often have the buying power to bulk purchase feeds more cheaply than individual farmers. In some cases they may be the only source of feeds, such as imported calf milk replacers or vitamin/mineral premixes. Cooperatives usually include formulated rations as part of their service to farmer members. It is important for farmers to compare the cost (and milk returns) from formulated concentrates with those for a concentrate mix prepared on-farm, particularly if wet by-products (which have a short shelf life) can be sourced quite cheaply.
- **Purchasing forages.** Because of low labourer's wages in countries such as Indonesia, farmers often spend many hours each day walking around the paddy fields and along the roads to hand harvest forages for their stock. In certain areas, non-farming villagers do this to supply dairy farmers either via direct sale to each farmer or a 'grass market' where farmers can purchase their forage requirements in the marketplace. Forage markets have also been established for purchasing crop by-products, such as maize (or corn) stover, delivered by trucks from distant sweet-corn-growing areas. Following rice harvest, cheap rice straw frequently becomes readily available. It is important to assess its likely milk response and even undertake a cost: benefit analysis to compare it to other forage sources.
- **Nutritional management of the dairy herd.** This is an essential service to get the best out of the young and adult stock in the dairy (or the dairy beef) herd. Nutritionists

can advise on availability and cost of alternative feeds, both roughages and ingredients or home-made concentrate mixtures. They can also advise on the cheapest source of liquid nutrients for milk-fed calves, such as raw milk versus calf milk replacer. Cooperatives or commercial feed mills usually employ nutritionists, but free advice can also be sought from agents dealing with feed additives or other nutritional products. Because feed constitutes the highest cost on-farm (60–70% of total costs), it is important to get ‘a second opinion’ before radically changing the feeding program.

- **Testing feeds for nutrient contents.** There are university, government, or even private laboratories that can undertake this service, usually for a fee. It is essential that managers of dairy cooperatives or feed mills routinely test the range of feeds they use rather than simply depend on an average nutritive value, particularly for concentrations of feed energy and protein.
- **Animal health.** Dairy cooperative or government veterinarians are frequently the major (and only) source of advice on biosecurity and on veterinary drugs and procedures for smallholder farmers. Cooperatives may also employ foot trimmers to routinely treat housed stock, particularly those living on concrete floors. A lot depends on the skills and knowledge of such veterinarians and farmers to ensure the most appropriate action to take for sick stock, and farmers should occasionally seek ‘a second opinion’ from other animal health service providers (such as university staff or resellers of veterinary products). Good dairy managers need to develop a thorough animal health program to plan routine and emergency protocols for all their stock. These include vaccination, drenching and other routine veterinary practices as well as emergencies such as calf scours, heat stress, metabolic diseases or sudden deaths.
- **Best practices for breeding management and artificial insemination.** Dairy cooperatives or government livestock officers usually supply inseminators who should be expected to advise on all things regarding breeding, or at least be able to source the relevant information or equipment. In some areas, commercial suppliers of dairy semen are also available to advise of breeding programs.
- **Milking cow performance, such as herd recording.** These service providers are important to monitor long-term changes in cow milk yields and reproductive performance and other important measures of genetic improvement. Cooperatives frequently have computer programs to facilitate such recording and help plan realistic breeding programs, whether it be herds with 10, 20 or 50 milking cows.
- **Milking machines.** The performance of milking machines should be checked at least once each year, with routine testing of their efficiency by monitoring pulsation rates and vacuum pressure and also assessing the condition of liners and other rubber ware. Checks should be made of temperatures of milk storage equipment and of hot water to clean milk harvesting apparatus. Advice on chemicals for washing and sanitising machines, buckets, sieves and teat washing cloths should also be regularly updated. Suppliers of milking machines should have the necessary skills and measuring apparatus. Some milk processors also employ field officers to visit farmer suppliers and advise them on improving both milking hygiene and farm milk yield, to increase their supplies of quality milk.

- **Routine maintenance of farm machinery.** All machinery requires regular attention such as grease and oil changes for farm vehicles or replacement of worn parts. Such maintenance protocols should be provided by machinery agents.
- **Milk testing.** Most farm gate milk payments are based on measures additional to milk weight or volume, such as milk composition and milk quality. Milk composition measures the concentration of three important components of raw milk: milk fat, milk protein and milk solids-not-fat. Milk quality, on the other hand, measures the degree of bacterial contamination and the inclusion of adulterating agents. Unit price for milk can have a big influence on farm profitability (Moran 2005). Because of its economic importance, milk testing is a routine undertaken by dairy cooperatives and/or milk processors.
- **Milk transport to collection centres.** As dairy regions develop and grow in farmer population, farms can become more distant to milk collection centres. As with every bulk commodity, the situation arises when it is cheaper to pay someone to collect the raw milk from the farm and transport to the central location, rather than have to use farm transport and valuable time to take it, twice each day, to the cooperative or collecting centre.
- **Monitoring farm business management.** This service can be supplied by cooperative staff or government staff and by private accountants/advisers. Lending agencies may also assist but they generally require budgets detailing farm costs and predicted financial benefits arising from their investment in any farm development program. To improve the likely success of such a loan application, smallholders should seek professional advice.
- **Contractors for capital improvement programs.** Because of the high labour costs, dairy farmers in Western countries have access to a wide range of contractors with specialist skills and equipment for a diversity of tasks ranging from forage conservation, routine young stock practices, fencing, building sheds or other farm infrastructure, through to employment agencies to find the 'right person for the job'. Apart from builders to construct cowsheds, such contractors would be hard to find in Asia.
- **Cooperative service providers.** Some dairy cooperatives, for example those in Thailand, provide a range of services for their smallholder farmer members (Moran 2007). These include contract calf and heifer rearing, where the cooperative has a facility to milk rear the calves, using the waste milk from the milk testing laboratory, after which the heifers are group reared, mated, then returned to the farm just prior to their first calving. Some cooperatives also grow fodder crops on communal land, after which they harvest and ensile them either in tower or pit silos. The cooperative might also bulk purchase other wet material for ensiling, such as agro-industrial by-products. Some cooperatives even have feed centres where all the ingredients for total mixed rations are blended and placed in large containers, such as 500 kg old wool sacks. These are then delivered to each farmer every few days already formulated for direct feeding to his milking or dry cows. In other countries, such as Indonesia or China, the cooperative service also extends to machine milking, either using mini milkers if all the stock are housed in the one big shed or a separate milking parlour for larger herds housed at different nearby locations.



Figure 2.2 Smallholder dairy farm in West Java, Indonesia

- **Service provision as part of development projects.** Over the last two to three decades, many national and foreign governments, international aid agencies and private sector/non government organisations have initiated dairy development programs throughout tropical Asia. Such programs provide smallholder farmer support through the provision of technical services (usually at subsidised or nil cost), credit (for specific aspects of farm management or infrastructure) and training. This is still continuing (e.g. APHCA 2008) and will for many years. Astute dairy farm managers take advantage of such opportunities.

The major role of service providers is to allow the farmer to outsource as much of his farm input as possible, so long as it is viable in an economic sense. He can then concentrate his efforts on what he probably does best, namely convert feed (forages and concentrates) into milk.

2.4 The dairy farming business

2.4.1 Breaking down dairy production technology

Dairy farming is a business and as with any business, only by providing the production units (namely the milking cows) with the most appropriate inputs (that is, the correct housing, feeding and herd management), will the business be profitable. In other words, the business of dairy farming starts off with an understanding of the theory and practice of dairy production technology.

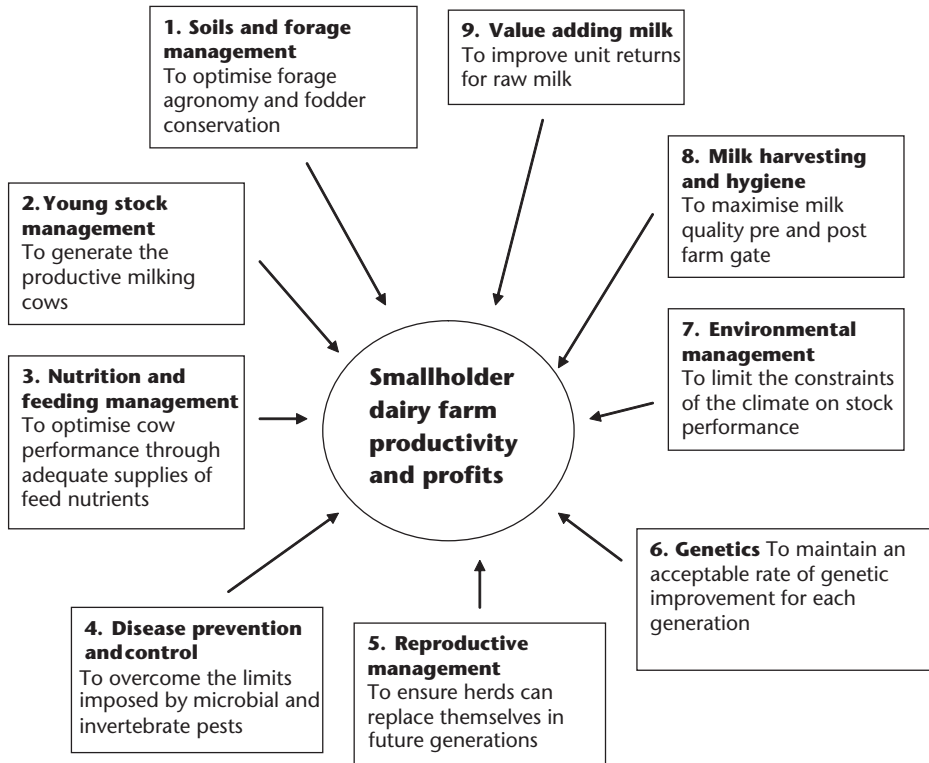


Figure 2.3 The nine steps in the supply chain of profitable dairy farming

On any dairy farm, no matter its size or location, this production technology can be broken down into nine key task areas, which can be considered as steps in the supply chain of profitable dairy farming. These steps are more specific than the key areas suggested by Makeham and Malcolm (1986) because they deal with all the technical complexities of successful dairy farming.

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 2.3.

This book has combined these various links into three chapters on dairy production technology, presented as introductions to the more detailed chapters on farm business management. Chapter 4 discusses Link 1, Chapter 5 discusses Links 2, 3, 4, 5, 6 and 7 while Chapter 6 discusses Links 8 and 9.

2.4.2 Developing a hierarchy of business management

Throughout this book there will be many references to dairy FBM and in this introductory chapter, it is opportune to present a hierarchy of the farm business for the most relevant FBM decisions to be made. This is presented in Figure 2.4.

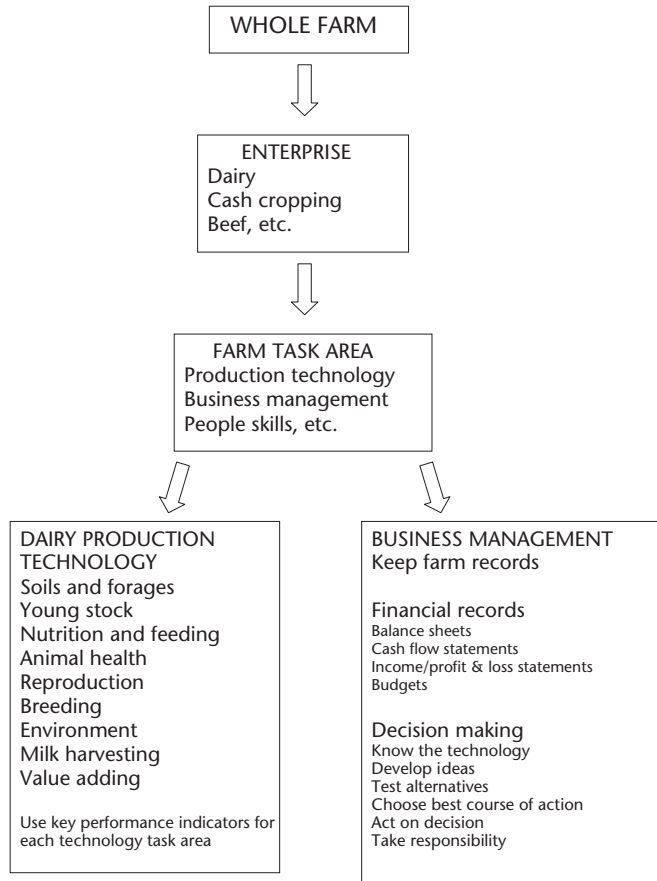


Figure 2.4 The business hierarchy of a dairy farm

Dairying can then be the sole enterprise or one of several enterprises on a mixed farm. Many of the FBM decisions are more complex in the latter case.

3

Smallholder dairy farming in Asia

This chapter describes the importance of livestock to resource-poor farmers in Asia then reviews the past, present and future for smallholder dairying in South and East Asia in terms of demand and production trends, and as an instrument of regional development.

The main points in this chapter

- Smallholder dairy farming has become a good income generator throughout Asia but the cost price squeeze of low milk prices and high production costs still limits farm profitability levels.
- Asia is a major importer of global dairy products and with current high milk prices, there are incentives to increase domestic production levels.
- Potential for growth in their domestic milk industries varies between countries, with Thailand, Vietnam, Afghanistan and Pakistan showing rapid increases whereas Philippines and Sri Lanka have decreasing cow numbers.
- High cost of land and low rural wages are stimuli for smallholder dairy development.
- Thailand is presented as a model for strengthening and enabling smallholder dairy farmers in Asia.

3.1 The importance of livestock to resource-poor farmers

Globally, agriculture provides a livelihood for more people than any other industry. Growth in agricultural production and productivity is needed to raise rural incomes and to meet the food and raw material needs of the faster growing urban populations. Enhancing agricultural productivity contributes to industrial growth by providing cheap labour, capital investment, foreign exchange and markets for manufactured consumer goods.

Livestock production makes an important contribution to economic development, rural livelihoods, poverty alleviation and meeting the fast growing demands for animal protein in developing countries. About half the world's poor (below the US\$1/day poverty line) live in South and East Asia, and half the remainder in Sub-Saharan Africa. However, the number of rural poor in South and East Asia did not decrease between 1993 and 2002 (totalling 390 million people) and will exceed the number of urban poor



Figure 3.1 Making a small pit of Napier grass silage, mixed with molasses, in Central Java, Indonesia

until 2040 (World Bank 2007). For these people, a high priority is then to mobilise agriculture for poverty alleviation.

The case for promoting increased livestock production is pressing given the rapidly growing demand for animal products, and the global aim to halve, by 2015, the proportion of the world population living in abject poverty, most of whom are dependent in part, on food and income derived from livestock.

Livestock provide over half the value of global agricultural output and one-third in developing countries. Rapid growth in demand for livestock products in developing countries is viewed as a 'food revolution'. Because livestock products are more costly than staple foods, their consumption levels are still low in developing countries, although they are increasing as incomes rise. Increased dairy production and greater self-sufficiency save on foreign exchange. Livestock also contribute to rural livelihoods through employment and poverty relief by integrating with and complementing crop production, embodying savings and providing a reserve against risks. In addition, livestock have special roles in traditional culture.

In South and East Asia, smallholder dairying has become a good income-earning occupation for crop farmers in mixed farming systems. This is evident in Thailand, Malaysia and Indonesia where crop farmers turned to small-scale dairying and were able to make enough income and savings to give their children a college education. With further improvement in productivity and reduction in production costs, Chantalakhana and Skunmun (2002) believe that smallholder dairying in these countries can become a very sound and sustainable enterprise.



Figure 3.2 Farmers bringing bags of formulated concentrate from the local cooperative feed mill to their farm in West Java, Indonesia

Milk is nature's most complete food. Furthermore, dairying represents one of the fastest returns for livestock keepers in the developing world. It provides regular returns to farmers, especially to women, enhances household nutrition and food security and creates off-farm employment, as many as one job for each 20 kg milk processed and marketed (Hooten 2008).

3.1.1 Smallholder dairy farmers

There are often arguments as to what constitutes smallholder (as against large-scale) dairying. This book uses the following descriptor of dairy farms:

- Smallholder: up to 20 milking cows plus replacement heifers
- Semi commercial: 20–50 milking cows plus replacement heifers
- Commercial: more than 50 milking cows plus replacement heifers.

Smallholder dairy farmers are generally competitive and are likely to endure for many years to come, particularly where the opportunity costs of family labour and wages remain low. Furthermore, dairying is a viable enterprise in most Asian countries even among the landless and socially marginalised groups.

Policy makers should resist the all too common assumption that development efforts should move from smallholders 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 smallholder dairy enterprises, particularly when they face increasing barriers to participate in value chain markets.

One good model to encourage is ‘colony farming’, which is established in centralised governed societies such as China but only recently evolved through dairy cooperatives in other countries such as Indonesia. With colony farming, smallholders house their herds together in a large dairy shed but are still responsible for feeding and maintaining their animals. These innovations require a large investment in buildings but they do allow smallholders to own and manage their own stock in a well-constructed durable shed and with the benefits of magnitude of size. This allows for communal forage production, large-scale silage making and bulk purchases of concentrates together with specialised labour undertaking machine milking and rearing of young stock.

3.1.2 What matters to dairy farmers most

Dairy farmers around the world have the same goal of running a profitable and sustainable business. These farmers, however, face different challenges in different countries, to achieve their primary goal. IFCN (2005) reported on a survey undertaken with dairy farmers from 30 different countries throughout the world, to prioritise major concerns affecting their business future. The concerns were grouped in various categories with percentages as follows:

- 85% reported that the joint market forces of low output returns and high input prices mattered most.
- 82% considered policy factors (such as global market, local/national market, environmental/animal welfare issues) to be important.
- 80% considered production factors (such as milk quota, labour, capital, land and animals) to be important.
- 50% expressed concern that despite recent advancements in their dairy sectors, many of the farm strategic factors (such as skilled management, optimal farm size, reducing production costs, diversification) lag below optimal levels for the majority of their farmers.
- 50% expressed similar concerns about the direct farm factors (such as feeding, breeding, animal health).

When the findings for China, India and Pakistan were grouped together to represent Asia, the key issues were prioritised as follows:

1. Low milk yield
2. High feed prices and shortages of feed
3. Insufficient veterinary and breeding services
4. Access to credit
5. Access to markets (except in China)
6. Strong informal sector (especially in India and Pakistan)
7. Low adoption of technology.

Improving the productivity, profitability and sustainability of smallholder farming is then a major pathway out of poverty. World Bank (2007) considers that this will require:

- Improving price incentives and increasing the quality and quantity of public investment

- Making product markets work better
- Improving access to financial services and reducing exposure to uninsured risks
- Enhancing the performance of producer organisations
- Promoting innovation through science and technology
- Making agriculture more sustainable and a provider of environmental services.

3.2 Smallholder dairying in Asia

3.2.1 An historical context

Dairy consumption in Asia has more than doubled over the last 25 years to reach nearly 260 000 Kt in 2007, 36% of global totals. With 39% of the world's dairy stock, producing 36% of the milk, imports make up 51% of the world's total dairy imports (FAOSTAT 2008). Since 2000, the dairy impetus has been even more dramatic in South-East Asia, with annual per capita consumption increasing by 10.6% (compared to 1.4% in South Asia and 1.1% globally), annual milk production increasing by 14.6% (compared to 2.9% in South Asia and 2.0% globally) while dairy imports have increased by 3.0% (compared to 1.6% throughout Asia and 2.2% globally).

In 2006 and 2007 long-term structural adjustments in international dairy markets occurred, which shocked dairy consumers worldwide. Global dairy supplies became tight due to the elimination of export subsidies for dairy exports by the European Union (EU) and export bans imposed by India. There were droughts in Australia and floods in South America, while feed grain prices rose due to demands for biofuels. Stocks held by key dairy exporters, such as the European Union (EU) and the United States (US), fell to record low levels in 2007. Constrained by stagnant milk production growth in these countries, the milk product trade declined marginally in 2007. Only 7% of the global production entered the dairy trade, and growth in this trade has been very slow because of fluctuating supplies by the few major exporters and the restricted market access by many countries. International dairy markets are still severely disrupted by extensive use of export subsidies, although this is now declining. The end result of all these occurrences has been the highest global prices ever for dairy products.

FAO use a relative food price index to describe international food prices, based on a trade weighted average of selected products in each food type, where a value of 100 is given for the 1998–2000 global price. This allows a direct comparison of food prices for a range of food commodities at any one time. In December 2007, food price indices were 295 for dairy, 226 for vegetable fats and oils, 210 for cereals, 137 for sugar and 127 for meat (FAO 2008b). Between 1990 and 2006, the dairy price index varied from 70 to 140, highlighting the current crisis experienced by dairy importers worldwide.

These factors are providing unprecedented opportunities for small-scale dairy farming in many developed countries (APHCA 2007), particularly in Asia where over 80% of the milk is produced by smallholder farmers. Another catalyst is the fact that dairy imports by developing countries reached US\$21.3 billion in 2007, up from US\$13 billion the year before. This was fuelled by a 67% increase in import prices which, in combination with escalating prices for basic foodstuffs, such as maize, rice and vegetable oils, raised regional concerns about national food securities.

Translating this into opportunities for local producers, strong consumption gains in Asia over the past 10 years have stimulated the dairy sector with production rising from 138 000 to 222 000 Kt in 2007. In fact, production gains in Asia have accounted for nearly 60% of global totals over the past decade.

Consumption of dairy products has always been strong in South Asia, where in 2007 each person consumed the equivalent of 93 kg milk, compared with the global average of 113 kg. However, the most rapid growth of milk consumption over the past decade has been in South-East Asia, which currently only consumes 31 kg milk/person/yr. Average gains in countries such as China and Vietnam have exceeded 11% pa, fuelled by growing incomes, changing diets and demographic trends favouring Western diets and strong generic promotion of milk products, particularly through the schools.

Asia, an area with high economic growth (5–6% pa in Growth Domestic Product), constitutes an important market for the major dairy exporters, dominated by New Zealand, the EU, Australia, the US and increasingly Argentina. While the region's dairy product imports, particularly those of milk powder, have nearly doubled over the period, from 10 000 to 24 000 Kt, the import dependency of the region has remained stable at nearly 9%.

Regional averages, however, tend to mask local realities and, in fact, while dairy imports by South Asia, limited by strong consumer preferences for fresh milk, availabilities of local product and barriers to imports, constitute only 1% of domestic consumption, imported milk products into South-East Asia region supply nearly 25% of domestic requirements. When calculating dairy imports as a share of processed milk, this share jumps up to over 90% in some countries.

Although Asia imports half of the global totals in milk products, there are import dependencies exceeding 80% in countries like Sri Lanka, Philippines and Vietnam where tariff levels are very low and consumers are familiar with and favour reconstituted milk products. In China, a country with double digit consumption gains over the last decade, imports constitute only 6% of total consumption. However, as they average 2500 Kt/yr, China is the largest importer of dairy products in the world, followed by Mexico, Russia, Egypt, Indonesia, Malaysia and Philippines.

International market prices for milk powder more than doubled over 12 months to reach US\$5000/t in late 2007 (see Figure 7.1 in Chapter 7). However, such high prices were not maintained in the short to medium term. Increasingly, large Asian milk processors are gravitating towards local supplies of fresh milk, thus providing an impetus for developing the smallholder dairy sector.

3.2.2 The growth of dairy industries in South and East Asia

Dairy industries in tropical Asian countries have been developing at different rates over the last two decades, due to a variety of government (internal) and global (external) influences. The following graphs present an overview of the changes in numbers of dairy cows and milking buffalos (Figure 3.3) and their milk production (Figure 3.4) since 1990. For ease of comprehension, data are presented relative to the base data in 1990/92.

Growth in milking cow numbers has been modest in most countries (1–2% per yr), except for:

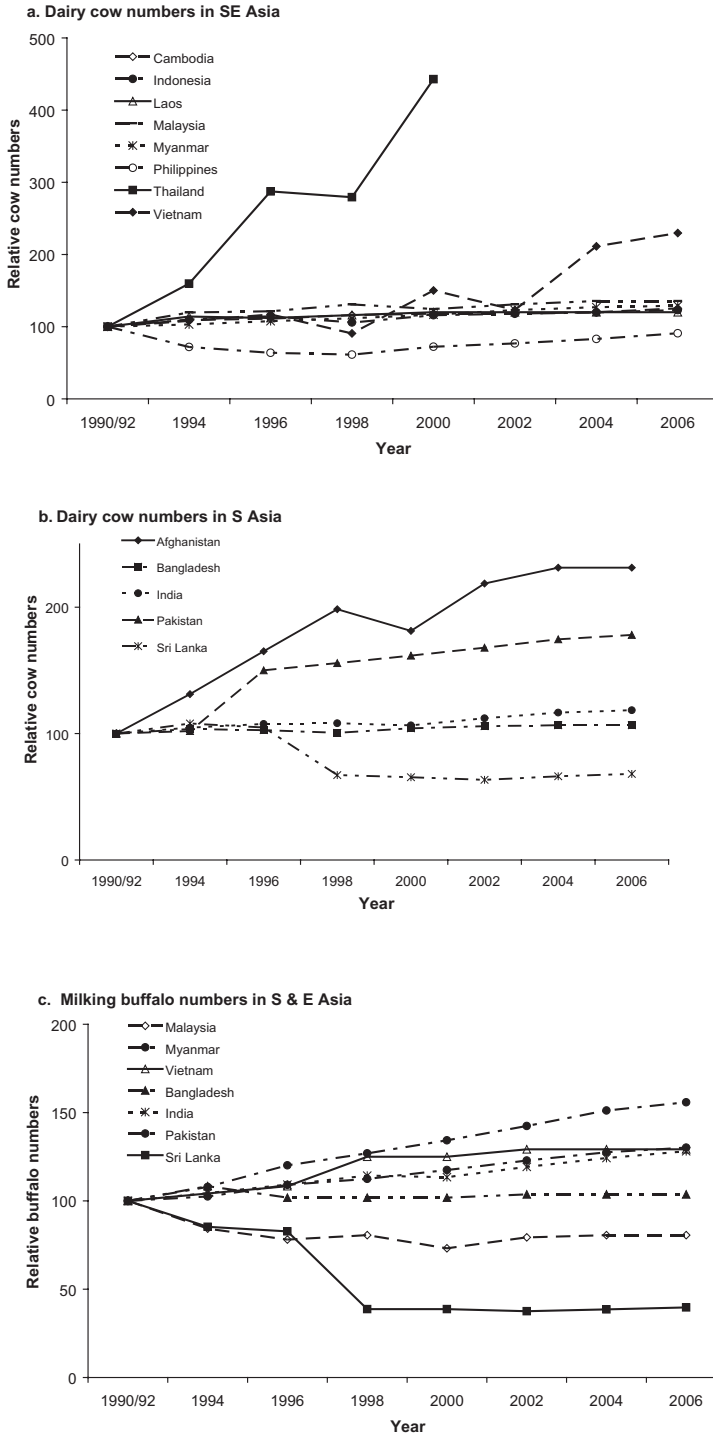


Figure 3.3 Changes in numbers of dairy cows in South-East Asia (a) and South Asia (b), and of milking buffalo in South and East Asia (c) relative to base numbers in 1990/1992

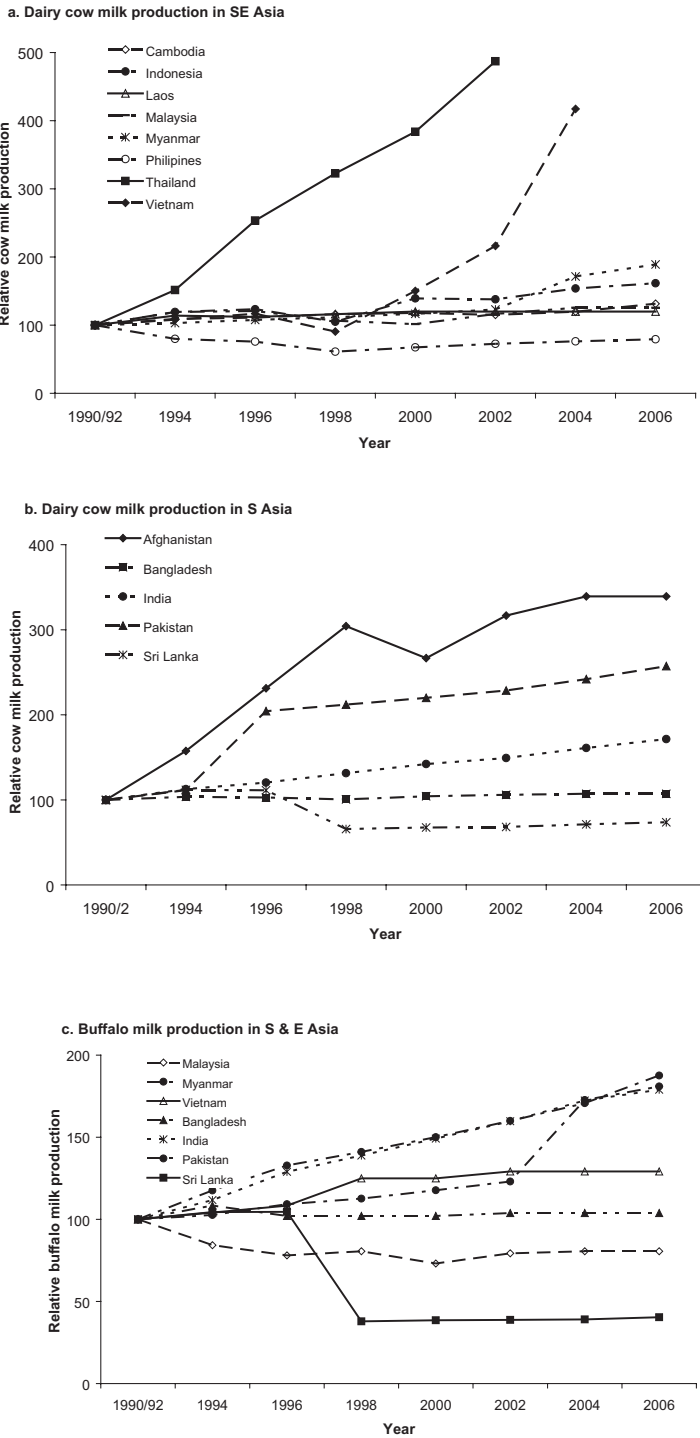


Figure 3.4 Changes in milk production from dairy cows in South-East Asia (a) and South Asia (b), and from milking buffalo in South and East Asia (c) relative to base level of production in 1990/1992

- Thailand, Vietnam, Afghanistan and Pakistan, which have all had rapid increases; Thailand, the fastest growing dairy industry in tropical Asia, had 660% more cows in 2006 than in 1990/92, growing at 40% per yr over this time period
- Philippines and Sri Lanka, where cow numbers actually decreased.

Relative growth in milking buffalo populations have also been modest (2–3% per yr) with Malaysia and Sri Lanka decreasing in numbers over the last 16 years. The fastest growing milking buffalo industry is in Pakistan, where numbers are growing at 4% per year.

Growth in cows' milk production has been modest in most countries (1–5% per yr), except for:

- Thailand, Vietnam, Afghanistan, Pakistan, which have had rapid increases; Thailand, the fastest growing dairy industry in tropical Asia, produced 610% more milk in 2006 than in 1990/92 and grew at 38% per yr
- Vietnam, where cow populations have been increasing at 8% per yr, while their total milk production has been growing at 30% per yr
- Philippines and Sri Lanka, where cow milk production actually decreased.

Growth in buffalo milk production has generally been faster than for dairy cows (namely 2–6% per yr), however, Malaysia and Sri Lanka both recorded reduced milk production from buffalo.

Table 3.1 presents the actual size of each industry in 2006, together with changes in their self-sufficiency in milk (from both dairy cows and milking buffalo, with very small contributions from camels, sheep and goats) since 1995 (the latest data available, GLIPHA 2008). India has the largest dairy industry in the world, which in 2002 accounted for 57% of the world's buffalo and 16% of its cattle. To help get this in perspective, the quantity of milk handled annually in the Indian informal market alone is greater than the annual world trade of exports of all dairy products, measured in liquid milk equivalents. Pakistan has the fourth largest dairy industry with the world's second largest population of milking buffalo. Myanmar's dairy cow numbers are sometimes queried by tropical dairy specialists because their 1.4 million cows are reported to produce less milk than the 300 000 cows in Thailand.

Malaysia and Philippines have consistently produced less than 5% of their consumed milk and dairy products while India, Pakistan, Bangladesh and Afghanistan produce all they require. Indonesia and Sri Lanka have been unable to keep up with increases in consumer demands over the last eight years, whereas Thailand and, in recent years, Vietnam have been slowly narrowing the gap between demand for dairy products and supply of raw milk. To help get national self-sufficiencies in perspective, Asian countries currently constitute more than half the world's importations of dairy products.

3.2.3 Future projections of demand and supply of milk in South and East Asia

Using FAO projections, Dalton and Keogh (2007) have forecast dairy demand and supply in 12 Asian countries, including China, Japan and South Korea, until 2020. They predicted the volume of dairy product consumption to increase in China, India, Pakistan

Table 3.1 The size of selected Asian dairy industries in 2006, and their self-sufficiency in milk in 1995, 2000 and 2003

	Dairy cow population (000 head)	Cow production (Kt or Million kg)	Buffalo population (000 head)	Buffalo production (Kt or million kg)	Self-sufficiency in milk (%)		
					1995	2000	2003
South-East Asia							
Myanmar	1406	808	313	171	88.4	83.1	86.3
Indonesia	374	578	–	–	51.0	48.8	47.3
Thailand	300	826	–	–	22.4	33.3	36.8
Cambodia	127	23	–	–	39.6	44.9	43.3
Vietnam	104	215	31	31	22.0	13.2	19.7
Malaysia	85	38	6	7	3.7	3.1	4.0
Laos	30	6	–	–	24.3	30.4	21.7
Philippines	6	12	–	–	0.9	0.6	0.7
South Asia							
India	36 586	39 775	33 173	52 100	99.9	100.1	100.0
Pakistan	7504	9404	10 130	21 360	99.6	99.7	99.8
Bangladesh	3870	800	56	23	93.2	88.2	88.2
Afghanistan	1850	2035	–	–	99.4	99.9	97.2
Sri Lanka	222	139	54	27	51.3	39.2	37.4

and Indonesia, and to a lesser extent in Thailand. Japan's dairy consumption is anticipated to decline while South Korea will experience a small increase in consumption by 2020. Import demand is projected to increase for Indonesia, Japan, Malaysia, Philippines, Thailand and Vietnam, while China's demands should plateau over the next decade. The only Asian country with dairy export potential is India.

Dalton and Keogh (2007) predicted that dairy product consumption (expressed as whole fresh milk equivalents) in the 12 selected countries will rise by 77 000 Kt, that is 55% above 2007 consumption levels. They considered that only 5200 Kt could be imported from global nations for which net trade data are available, thus requiring an additional 71 800 Kt to be produced domestically. Compared to 2007 production levels (129 000 Kt), this will require a 56% increase above projected levels of milk production from these countries over the next 13 years, or an average increase of 4.3% per year.

The Food and Agriculture Policy Research Institute (FAPRI 2007) have published data on projected demands and supplies of dairy products from selected countries in South and East Asia which is presented in Figure 3.5. The six Asian dairy industries for which predicted data (to 2016) are available vary greatly in size and predicted growth of cows' milk. The fastest growing will be Thailand (7% pa increase in milk production), while moderate growths are predicted for Philippines and Malaysia (3–4% pa), slow growth rates in India and Indonesia (1–2% pa) with Vietnam predicted not to increase

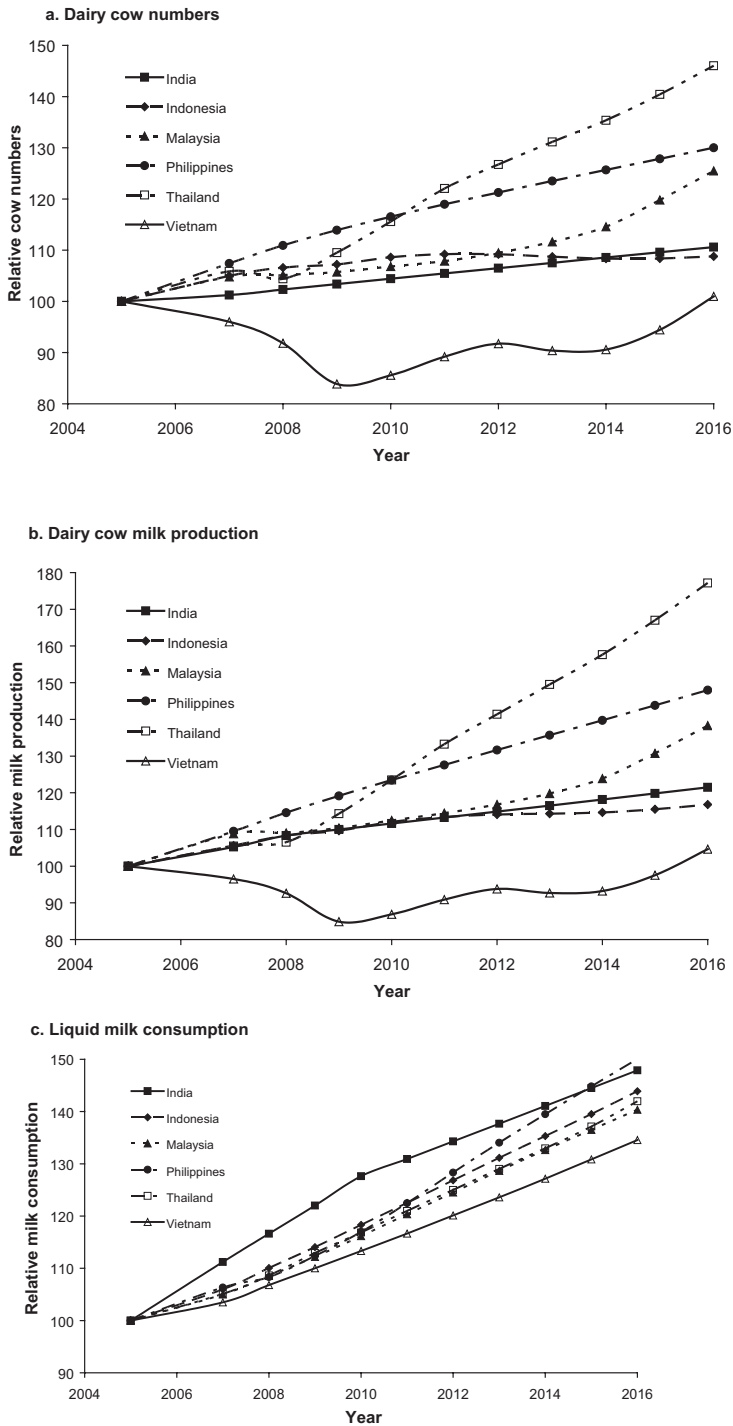


Figure 3.5 Projected changes in (a) dairy cow numbers, (b) milk production from dairy cows and (c) liquid milk consumption in selected countries in South and East Asia to base level of production in 2004/2005

its milk output over the next eight years. With predicted liquid milk consumptions of 3–4% pa in all six countries, there are likely to be major problems satisfying dairy demands in some of these countries. This is very relevant in the light of the findings of Dalton and Keogh (2007) because their prediction of 4.3% per yr dairy industry growth requirements are at the upper level of FAPRI's (2007) projected growth rates. Therefore achieving such high growth in domestic milk supplies will be a major challenge throughout Asia.

3.3 Development of smallholder dairy farming

Smallholder dairy development provides opportunities to address the persistent problem of rural poverty by transferring income from affluent urban households to their poorer rural counterparts, and improve food and nutritional security for poor rural and urban households. Commercialisation and intensification are frequently used as synonyms for development.

3.3.1 Objectives of dairy development

The three major objectives of any dairy development programs are to:

- Raise the living standards of traditional small-scale farmers and dairy market agents.
- Improve the nutrition of poor consumers; and, at the same time
- Sustain the natural resource base to ensure their long-term impact.

Such development can be achieved through:

- Creating employment in rural and peri-urban areas, both on-farm and along market distribution and value chains.
- Generating reliable income and asset accumulation for resource-poor farmers.
- Providing low cost and safe dairy products to poorly resourced (or using a recently coined term, resource-poor) consumers.
- Improving natural resource management and sustained farming systems through recycling dairy farm nutrients.
- Improving infant nutrition and social development in resource-poor households.

The objectives of a model pro-poor development program are to:

- Build on traditional dairy product consumption preferences, but at the same time promote demand for new products.
- Support the traditional domestic markets for milk and dairy products, while promoting a more formal marketing structure.
- Emphasise and support the role of the smallholder as a rural income generator while facilitating the intensification of mixed crop–livestock systems through providing appropriate improved animals, fodder technologies and enhancing farmer participation in local markets.

From work in Kenya, Hooten (2008) reported such policy and institutional changes to benefit both poor producers and poor consumers by decreasing milk margins by 9% through reducing transaction costs, milk spoilage and bribes.

3.3.2 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 policy makers and many readers of this book would 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 generally 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 often 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 which are limited in diversity, and with little emphasis on food safety. In addition, there is great diversity in market behaviour and the farmers have limited input into dairy policy making.
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 have nutrient surpluses both on the farm and in the farm household. There is a high dependency on infrastructure (roads, water, electricity) and 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 policy making.

As with all generalisations, there are invariably exceptions. Indonesia, for example, is unique in that its dairy production sector is based on traditional smallholder farmers, but most of the milk is destined for industrial processing. The farms are located in the highlands of Java whereas the milk is transported long distances to the coastal cities where the processing plants were established, strategically located near the ports to source imported milk powder. The quality of local milk is such that it is best suited to making powder, because of its very limited shelf life as liquid product. Dairy consumption is not part of the Indonesian food culture and in fact, many farming families do not even drink their produce, because they consider it too valuable for local consumption. Chapter 6 provides further discussion on informal v formal milk markets.

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 technical input than do smallholders, and once they become more heavily mechanised, ‘more things can go wrong’. Hooten (2008) argues that in developing dairy industries, the growth and opportunity profile of such



Figure 3.6 Delivering the afternoon milk to a Milk Collection Centre in East Java, Indonesia

investments will eventually become stagnant compared to schemes more directed towards the poor, informal, smallholder dairy farmer. Such an opinion is not at deviance with those of many South-East Asian dairy specialists who attended a recent international animal production conference in Vietnam (Devendra, 2008).

3.3.3 The importance of rural wages and other growth factors

This shift from labour intensive towards capital intensive practices, both on-farm and in the market, is due primarily to the increased opportunity costs for labour. This shift to higher productivity of labour can be used as a measure of dairy development, reflecting change in all parts of dairy value chain.

In fact, Psilos (2008) has suggested that the rural wage rate is a key determinant of the optimum size of smallholder farms. Rising rural wages make other activities more attractive and tend to divert smallholders away from dairy farming. Because such dairy systems are labour intensive, their competitiveness relies on the low opportunity cost for labour. From surveys across the world's tropical smallholder dairy industries, dairy herd sizes grow as rural wage rates rise, when mixed farmers respond with capital investments (such as land for grazing as well as milking equipment and other labour saving devices) thus introducing economies of scale into their long-term plans for profitability and sustainability. Rising rural wages also provide the farming family with greater

opportunities for more remunerative off-farm wages, hence they are less likely to contribute their labour to dairy farming activities. Such farms may transition to specialised, small commercial farms where the emphasis is more on cash remuneration rather than various forms of income and asset building that makes dairying attractive to smallholder multi enterprise farmers.

The role of cow manure as an income generator varies considerably around Asia. In countries such as India and Pakistan, sun dried manure is an important domestic fuel for the kitchen where it can be an important contributor to farm profits. Some countries use manure in constructing houses, although its major sale benefit throughout Asia is as a fertiliser. In dense, subsistence regions in Kenya, Psilos (2008) noted that its sale value on smallholder farms was 130% of the value of raw milk. Financial benefits from manure are reduced when rural wages rise because manure handling is a labour intensive process.

The attractiveness of smallholder dairying then depends on low labour costs and lack of access to other farm investments. Where opportunities for other uses of labour are low and where soil nutrients and land are scarce, smallholder mixed dairy producers can successfully outcompete larger more specialised producers locally because they require lower formal financial returns from sale of milk.

Infrastructure, in the form of roads and milk collection and handling facilities, can also greatly influence the milk marketing sector. In fact, it partially sets the farm gate price for milk as Staal *et al.* (2008) noted that poor feeder roads can reduce milk prices paid to farmers by 3% for each additional km separating farm from market. This is not just due to the simple costs of transport, but also to the seasonal risks that such roads can impose.

Countries that do not have a strong tradition of milk production and consumption are particularly vulnerable to import competition and tend to be less self-sufficient in dairy products. This is more a function of demand rather than a lack of domestic supply. Where there are strong dairy traditions, most demand is for raw milk and traditional products, for which imports cannot easily be substituted, if at all. Supporting the development of traditional markets thus takes on the added feature of helping buffer domestic production from imports.

3.3.4 Losses in the dairy value chain

With regard to milk spoilage, recent FAO studies have quantified such economic losses in several smallholder dairy industries in Africa (FAO 2008a). For example, 27% of all milk produced in Uganda is lost, with 6% wasted at the farm level, while 11% and 10% of production is either lost to spillage or spoilage during transport or marketing, respectively. This amounts to a value of US\$26 million per yr. In Kenya, the annual loss of 95 Kt is valued at US\$22.4 million while in Tanzania, the 60 Kt annual loss is valued at over US\$14 million. Dry season losses in Tanzania amount to 16% of production while losses in the wet season may surpass 25%. It is then likely that spillage and spoilage losses throughout South and East Asia, with similar smallholder dairy infrastructure as in Africa, could amount to 20–25% of total production. As most of these losses occur post farm gate, they have little relevance to the business management of smallholder farmers, so are rarely, if at all, incorporated into any farm based COP analyses.

3.3.5 Dairy development and farm technology

Dairy development is generally associated with technical changes to improve milk yield per cow. However it should be noted that:

- The use of exotic cattle is a rapid and potentially sustainable path to higher productivity, even for small-scale resource-poor farmers and in warm, semi arid or humid climates. However, there have been many repeated failures of such schemes for obvious but often ignored reasons.
- National and local breeding strategies need to address the realities of climate and disease risk to increase the likelihood of successful crossbreeding programs.
- Fodder technology should be an integral part of any dairy development program, particularly if it incorporates importation of stock of high genetic merit (or quality).
- The success or otherwise of intensive fodder production schemes is more likely to depend on availability of cheap labour, scarcity of land and good access to milk markets than it is on agro climatic setting. Where labour is scarce, intensive fodder cultivation practices and the feeding of crop residues to cattle are unlikely to be taken up unless mechanised. Promotion of such schemes should pay very close attention to labour opportunity costs.

Requisites for long-term sustainable dairy development

For dairy development to be sustainable, there must be:

- Adequate infrastructure and marketing opportunities.
- Access to reliable markets for increased milk production.
- Promotion through government policy.
- Availability of credit for purchasing of livestock and planting pastures.
- Available productive and adapted forage species.
- Ready access to information.
- A farm management system which ensures adequate feed throughout the year.
- Management of animal wastes.
- Disease control measures.
- Adequate hygiene for milk collection.

3.3.6 Strengthening and enabling smallholders

Chantalakhana and Skunmun (2002) highlighted some of the challenges to food security in Thailand, which only produces 40% of its dairy products. Such conclusions would apply equally to most, if not all South and East Asian countries. Most smallholder farmers in Thailand have only limited primary education and would have forgotten how to read and write since leaving school. Unless farmers are well informed about new technologies, there is little hope for improved milk production. Such technology transfer is a real challenge, particularly when extension services are generally weak and ineffectual due to Thailand's centralised bureaucratic system. In recent years, government services are being decentralised but this has yet to occur at the local level. Because of a general lack of current market information, rural farmers are usually being

taken advantage of by local traders or middlemen. Easily accessible market information and fair market prices for farm commodities should enable smallholders to make the right choice of what to produce and for what sale price.

Farmer organisations or cooperatives can serve as effective means to strengthen farmers' bargaining power in dealings with the problems of food production, marketing and others. Strong farmer cooperatives are a key to profitable milk production. Successful dairy cooperatives in Thailand commonly involve dedicated farm leaders and little government intervention, except in the initial periods. Promotion and technical support by the government through farmer organisations involving farmers' participation in the process then provides a more effective and transparent means of reaching the grassroots level.

In Thailand, government policies in support of food security remain weak or are lacking in many areas, such as:

- Land reform, because landlord and rich business people have strong influence in political parties
- Land use planning and enforcement, where agro-economic zoning has been largely unsuccessful
- Support for research and development (R&D) for small farmers
- Efficient management of irrigation, where some irrigated and fertile areas have even been converted to housing estates and residential areas
- Support for efficient marketing systems for agricultural products
- Promotion of regional food processing and agro-industry, which has been inconsistent and ineffective in regions outside Bangkok.

Improving small-scale farm productivity

After several decades of dairy development in many Asian countries, average milk yields per cow per day still range between 8–10 kg as compared to average yields of 20–30 kg in developed countries. In addition, the average calving interval of dairy cows in smallholder farms is commonly as long as 16–20 months, when it could be reduced to 14–15 months. This clearly shows their low levels of farm productivity. Some technical solutions are available 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 workers must be able to understand factors influencing the acceptance of technology by farmers. Scientific knowledge alone cannot solve small-scale farm problems.

Some of the major challenges to such service providers are:

- Effective delivery of appropriate technology to benefit small-scale farmers at farm level
- Fair price policy and efficient rural livestock marketing systems promoted by national governments
- Promoting active and workable farmer groups or cooperatives
- Involving farmer participation in research and extension
- Linking public institutions and the private sector in technology delivery.

In conclusion, Chantalakhana and Skunmun (2002) called for new strategies to facilitate dairy development within Thai government industry support and dairy

cooperative structure, and again these are relevant to any developing dairy industry. These include:

- Establishing a national dairy board, consisting of representatives of all the industry stakeholders, to formulate and oversee national dairy policies to promote the smallholder dairy industry.
- Putting major inputs into strengthening dairy training for farmers, for example mobile extension units to provide on-farm advice.
- Establishing a national herd improvement program, firstly to select and multiply superior quality dairy sires and cows, and secondly to cull cows with below average milk yields. These cull cows could either be used for beef production in other areas or if slaughtered, the farmers should be provided with some compensation.
- Continued support for dairy research with highly selected topics aimed at solving 'real farmer's problems'.

4

Feed production technology on smallholder dairy farms

This chapter quantifies the principles of dairy nutrition, namely the supply and requirements for water, energy, protein and fibre, then demonstrates the increase in cow performance through improved feeding.

The main points in this chapter

- Energy requirements change according to cow size, activity, stage of pregnancy, weight gain or loss, and level of milk production.
- Protein requirements vary with stage of lactation.
- High levels of dietary fibre can restrict voluntary intake hence cow performance.
- Feeding larger quantities of high quality grass can improve both milk yield and cow fertility.

This book is primarily about the human side of smallholder dairy farming, that is the farming family and their support structures. My first book (Moran 2005) concentrates on the production technology and in so doing, uses many technical terms and concepts related to quantifying the nutrient requirements of dairy stock, providing these needs and measuring the production responses in terms of milk, live weight gain and calves. For readers to fully comprehend the technical aspects of some chapters in this book, some basic understanding of the principles and measurement in dairy nutrition is desirable. Rather than duplicate the key chapters in *Tropical dairy farming* (Moran 2005), namely:

- Chapter 4: What is in feeds
- Chapter 5: How the rumen works
- Chapter 6: Nutrient requirements of dairy cows
- Chapter 7: How feed requirements change during lactation

this section provides a concise summary of these principles, sufficient to understand these concepts when discussed later in this book.

4.1 Feed nutrients required by dairy cows

Cows are herbivores and have digestive systems well adapted to forage-based diets. Cows belong to a group of mammals known as ruminants. Ruminants have a complex digestive system, which is characterised by a four-chambered stomach. The largest of these chambers is the rumen.

The digestive system of ruminants enables them to digest plant material in a way that non-ruminant mammals with single stomachs, such as pigs, dogs or humans, cannot. The rumen contains large numbers and many types of micro-organisms (often referred to as microbes). These microbes feed on plant material eaten by the cow and they produce end products that are used by the cow, and also by the microbes for their own multiplication and cell growth. The microbes themselves are digested further down the digestive tract.

The ultimate purpose of dairy cows is to produce milk, so their diets must allow them to fulfil the functions of lactation, and of reproducing annually. The nutrients required by dairy cows are water, energy, protein, fibre, vitamins and minerals. These requirements largely determine how we think about the composition of their feed. Feed contains both water and dry matter. The dry matter component of that diet is the part which contains the necessary energy, protein, fibre, minerals and vitamins.

Water. The body of a dairy cow is composed of 70–75% water. Milk is about 87% water. Water is not a feed as such because it does not provide specific feed nutrients. However, it is essential to regulate body temperature and is involved in digestion, nutrient transfer, metabolism and waste removal. Water has structural and functional roles in all cells and all body fluids. An abundant, continuous, and clean source of drinking water is vital for dairy cows.

Energy. Dairy cows use energy to function (walk, graze, breathe, grow, lactate, and maintain a pregnancy). Energy is the key requirement of dairy cows for milk production. It determines milk yield and milk composition.

Protein is the material that builds and repairs the body, its enzymes and hormones, and is a constituent of all tissues (muscle, skin, organs, foetus). Protein is needed for the body's basic metabolic processes, growth and pregnancy. Protein is also vital for milk production.

Proteins are made up of nitrogen which are bound into various amino acid molecules. Amino acids are the building blocks for the production of protein for milk, tissue growth and the development of the foetus during pregnancy.

Cows require 25 different amino acids for normal metabolic functioning. Fifteen of these can be produced by the cow's own metabolism. The remaining 10 are termed essential amino acids because they must either be supplied in the diet (as dietary protein) or as a product of the digestion of the microbes in the rumen (microbial protein).

Protein is usually measured as crude protein. Nutritionists commonly use terms like rumen degradable and undegradable dietary protein and bypass protein.

Fibre. For efficient digestion, the rumen contents must be coarse, with an open structure and this is best met by the fibre in the diet. Fibre contains most of the indigestible part of the diet. Cows require a certain amount of fibre for rumen function.

Table 4.1 The approximate dry matter and moisture content of some typical tropical feeds

Dry matter (%)	Moisture (%)	Feed
0	100	Water
10	90	Banana stems
20	80	Young pasture
30	70	Corn silage
40	60	Mature pasture
50	50	
60	40	
70	30	
80	20	Urea treated rice straw
90	10	Corn grain
100	0	

It ensures that the cow chews its cud (ruminates) enough and therefore salivates. Saliva buffers the rumen against sudden changes in acidity.

Both the length and the structure of the fibre are important. These determine how much chewing a feed requires. Feeds which need extra chewing increase the flow of saliva.

Fibre in the cow's diet also slows down the flow of material through the rumen and thus gives the microbes more chance to digest the feed. Products of fibre digestion are important for the production of milk fat.

4.2 Sources of feed nutrients

4.2.1 Dry matter

Dry matter (DM) is that portion of the feed remaining after all the water has been removed. The DM part of a feed contains the nutrients: energy, protein, fibre, vitamins and minerals. DM is measured by weighing samples of feed before and after they have been dried at 100°C. The proportion of DM in a feed is usually expressed as a percentage of the fresh feed. Table 4.1 shows how different feeds contain different proportions of DM and water.

The chemical composition of tropical feeds is sometimes expressed in terms of percentage of fresh feed, in which case that value should be divided by the DM content, expressed as a proportion (not a percentage). For example, if the protein content of fresh grass is 2% (of its fresh weight) and its DM content is 20%, then its protein content is $2 \div 0.2$ or 10% on a DM basis.

4.2.2 Energy

The energy in feed is a measure of that feed's ability to help the cow function and be productive. As feed energy is digested in the cow, various components are removed. The

energy content of the feed when eaten is called its gross energy. Some of the gross energy is lost in the faeces leaving behind the digestible energy. From the digestible energy, further energy losses occur in the production of urine, as well as gas. All the remaining energy is known as metabolisable energy. Three measures of energy are digestibility, metabolisable energy and total digestible nutrients.

- **Digestibility**, measured as a percentage, relates to the portion of food which is not excreted in the faeces and so is available for use by the cow. Digestibility is not a direct measure of energy, but it does indicate overall feed quality. Because cows are able to digest and use more of it, the greater the digestibility, the greater the benefit of that food to the cow. The higher the digestibility, the higher the energy content.
- **Metabolisable energy**. The energy in a feed that a cow can actually use for its metabolic activities, that is maintenance, activity, pregnancy, milk production and gain in body condition, is called metabolisable energy (ME). The ME content of a feed can be calculated directly from its digestibility. The ME content of a feed (also called its energy density) is measured as megajoules of metabolisable energy per kg of dry matter (MJ ME/kg DM). Intake of ME is expressed in MJ/day. The higher the energy content of a feed, the more energy is available to the animal. If a feed contains 10 MJ/kg DM, then each kg of dry matter of that feed supplies 10 megajoules of metabolisable energy to the cow. A feed containing 12 MJ/kg DM then has a higher energy content than a feed containing 10 MJ/kg DM.
- **Total digestible nutrients (TDN)** is an alternative method to describe feed energy. This is a very old energy system but is still used in the US and some Asian countries. TDN is calculated from the proportions of digestible crude protein, crude fibre, nitrogen free extract and ether extract (or crude fat). Nitrogen free extract is the difference between the total dry matter and the sum of ash, crude protein, crude fibre and ether extract. TDN is a less accurate measurement of energy than ME, because it does not take into account energy losses via methane (from rumen digestion) and urine. TDN content is expressed as a percentage, with TDN intake expressed in kg/d. The two systems are interchangeable (see Table 4.2 and 4.3) through the use of conversion equations as follows:

$$\text{TDN} = 5.4\text{ME} + 10.2$$

$$\text{ME} = 0.185\text{TDN} - 1.89$$

Throughout this book, references to the energy density of feeds will be given in these two measures, either as ME (as MJ/kg DM) and TDN (as %). References to cows' energy requirements or intakes will also be presented in these two measures, either as ME (MJ/day) or TDN (kg/day).

4.2.3 Protein

There are various ways to describe dietary protein, namely crude protein, non-protein nitrogen, rumen degradable and undegradable protein.

- **Crude protein**. Dietary protein is commonly termed 'crude protein'. This can be misleading because crude protein percentage (CP%) is not measured directly but is calculated from the amount of nitrogen (N%) in a feed as follows:

Table 4.2 Relationship between dry matter digestibility, metabolisable energy and total digestible nutrients

Dry matter digestibility (%)	Metabolisable energy (MJ/kg DM)	Total digestible nutrients (%)
40	4.8	36
45	5.6	41
50	6.5	45
55	7.3	50
60	8.2	54
65	9.0	59
70	9.9	64
75	10.7	68
80	11.6	73
1 unit	0.17 unit	0.9 unit

$$CP = N \times 6.25$$

- **Non-protein nitrogen (NPN)** is not actually protein, it is simple nitrogen. Rumen microbes use energy to convert NPN to microbial protein. In the forage-fed cows, however, the rumen microbes use NPN with only 80% efficiency (compared to the amino acids in true protein), which reduces the overall value of crude protein. Urea is a source of NPN.
- **Rumen degradable protein (RDP)** is any protein in the diet that is broken down (digested) and used by the microbes in the rumen. If enough energy is available in the rumen, some of this RDP will be used to produce microbial protein.
- **Undegradable dietary protein (UDP)** is any protein in the diet that is not digested in the rumen. It is digested 'as eaten', further along the gut. That's why UDP is sometimes called 'bypass protein'.

Table 4.3 Interconversion between metabolisable energy and total digestible nutrients

Metabolisable energy (MJ/kg DM)	Total digestible nutrients (%)	Total digestible nutrients (%)	Metabolisable energy (MJ/kg DM)
4	32	30	3.7
5	37	40	5.5
6	43	45	6.4
7	48	50	7.4
8	53	55	8.3
9	59	60	9.2
10	64	65	10.1
11	70	70	11.1
12	75	80	12.9
1 unit	5.4 units	1 unit	0.185 unit

Table 4.4 Categories used to assess ability of feeds to supply undegradable dietary protein (UDP)

Category	Undegradable dietary protein	Rumen degradable protein
High	More than 69%	less than 31%
Good	69–50%	31–50%
Moderate	49–30%	51–70%
Poor	29–10%	71–90%

(Source: Target 10, 1999)

Nutritionists may want to know how much of the crude protein in the feed is RDP and how much is UDP. This analysis is called protein degradability. The degradability of protein in the diet depends on many factors including DM intake, how long feed stays in the rumen, the degree of processing, the total protein intake and the supply of dietary energy to the rumen microbes. Therefore, the proportions measured in a laboratory test for RDP and UDP may not necessarily be the same as when that feed is eaten by a cow.

Nevertheless, a system describing the degradability of protein has been developed to help assess the UDP supply in feeds. This classification is shown in Table 4.4. A feed with lower RDP, hence higher UDP, has more milk production potential.

4.2.4 Fibre

For efficient digestion, the rumen contents must be coarse, with an open structure and this is best met by the fibre in the diet. Fibre is the cell wall, or structural material, in a plant and is made of hemicellulose, cellulose, and lignin. Some of the fibre is digestible, some is not. There are three methods of describing the fibre in feeds.

- **Neutral detergent fibre (NDF)** is a measure of all the fibre (the digestible and indigestible parts) and indicates how bulky the feed is. Some of it is digested, and some is excreted. A high NDF might mean lower intake because of the bulk while lower NDF values lead to higher feed intakes.
- **Acid detergent fibre (ADF)** is the poorly digested and indigestible parts of the fibre, i.e. the cellulose and lignin. If the ADF is low, the feed must be very digestible (i.e. high quality).
- **Crude fibre (CF)**, although sometimes used to indicate fibre content, is now considered an unacceptable measure because it does not take into account the digestible fibre which is nutritionally useful to the animal, both as a source of energy in the diet and as a substrate for some of rumen bacteria. However, it is commonly analysed because it is required in the calculation of TDN.

Sometimes the fibre in the diet is expressed as kg DM; but more often, fibre is expressed as % DM. For example, if a feed contains 25% NDF, one-quarter of its dry weight is fibre.

4.2.5 Vitamins and minerals

Vitamins are organic compounds that all animals require in very small amounts. At least 15 vitamins are essential for animals. Vitamins are needed for many metabolic

processes in the body, for example, for production of enzymes, bone formation, milk production, reproduction and disease resistance.

The vitamin needs of most ruminants are met under normal conditions by natural feeds, microbial activity in the rumen and tissue synthesis. Vitamins A, D and E are usually present in adequate amounts in quality forage. Members of the B-vitamin group and vitamins K and C are synthesised in the tissues and rumen.

Vitamins are either water soluble or fat soluble. The water-soluble vitamins of importance to cows are the B group of vitamins and vitamin C. The important fat-soluble vitamins are A, D, E and K. Vitamins are normally expressed in international units (IU). Vitamin deficiencies are rare in normal forage feeding situations.

Minerals are inorganic elements. They are needed for:

- Teeth and bone formation
- Enzyme, nerve, cartilage and muscle function or formation
- Milk production
- Blood coagulation
- Energy transfer
- Carbohydrate metabolism
- Protein production.

About 21 minerals are essential for animal health and growth. However, many of these can become toxic if the animal eats too much of them. Mineral deficiencies are less likely if forages constitute the major part of the diet.

High-producing herds fed diets high in cereal grain or maize silage may require added minerals. The mineral content of feed is expressed in units of weight: gram (g) or milligram (mg).

4.2.6 Essential nutrients and sources summary

Essential nutrients, their sources in feed and the units by which they are measured are summarised in Table 4.5.

Table 4.5 Sources and units of measurement of nutrients essential in the diet of dairy cows

Nutrient	Source in feed	Unit of measurement
Energy	Carbohydrates Fats and oils Protein	Megajoules of metabolisable energy (MJ ME/kg DM) kg of total digestible nutrients (kg TDN/kg DM)
Protein	Rumen degradable protein (RDP) Undegradable protein (UDP) Non-protein nitrogen (NPN)	Crude protein percent (CP %) % degradability of protein
Fibre	Structural carbohydrates	% Neutral detergent fibre (% NDF) % Acid detergent fibre (% ADF) % Crude fibre (% CF)
Vitamins	Present in feeds Some synthesised by microbes in the rumen	International units (IU)
Minerals	Present in feeds	Grams (g) or milligrams (mg)

4.3 Predicting cow performance from nutrient intakes

Cows require nutrients to survive and be productive. It is possible to describe these requirements in terms of dietary energy, protein and fibre. Through knowledge of intakes of ME (or TDN) and the contents of protein and fibre in the total diet, the performance of a dairy cow can be predicted. Reference tables for energy, protein and fibre form Appendix 4 of this book, while Appendix 5 contains worksheets to allow calculations, either per cow per day or as a proportion of the total diet. Full details of how to undertake these calculations are presented in *Tropical dairy farming* (Moran 2005).

4.3.1 Water

Lactating dairy cows in the tropics require 60–70 L of water each day for maintenance, plus an extra 4–5 L for each L of milk produced.

Water requirements rise with air temperature. An increase of 4°C will increase water requirements by 6–7 L/day. High yielding milking cows can drink 150–200 L water/day during the hot season. There are many factors influencing water intakes such as DM intake, diet composition, humidity, wind speed, water quality (sodium and sulphate levels), and the temperature and pH of the drinking water.

4.3.2 Energy

Cows need energy for maintenance, activity, pregnancy, milk production and for body condition.

Maintenance. Energy is used for maintaining the cow's metabolism. This includes breathing and maintaining body temperature. Physical activities such as walking and eating add to the maintenance requirement, as do environmental temperature and physiological state (i.e. pregnancy and lactation). With most cows in the tropics housed indoors, physical activity is negligible. Appendix Table A4.1 shows the energy needed for maintenance at various live weights, in terms of ME or TDN. These values include a 5% safety margin to take into account the energy required to harvest and chew the feeds. Cold stress is unlikely to directly influence the energy requirements of milking cows in South and East Asia. When animals are heat stressed to the point that they are panting, their energy requirements for maintenance can be increased by up to 10%.

Activity. On flat terrain, 1 MJ ME (or 0.1 kg TDN) per kilometre should be added to provide the energy needed to walk to and from the dairy. In hilly country, this increases up to 5 MJ ME (or 0.4 kg TDN) per kilometre.

Pregnancy. A pregnant cow needs extra energy for the maintenance and development of the calf inside her. From conception through the first five months of pregnancy, the additional energy required is approximately 1 MJ/day for each month of pregnancy. Energy requirements for pregnancy only become significant in the last four months. Appendix Table A4.2 shows the average daily energy requirements during these last months in both ME and TDN.

Milk production. Energy is the most important nutrient to produce milk. The energy needed depends on the composition of the milk (i.e. fat and protein content). The Appendix presents the energy needed to produce a litre of milk with a range of fat

and protein tests, in both MJ of ME (Appendix Table A4.3) and kg of TDN (Appendix Table A.4).

Dairy industries in many tropical countries do not measure protein contents of milk delivered from smallholder farmers, alternatively using solids-not-fat (SNF) content to measure non-fat milk solids. SNF comprises the protein, lactose and minerals in milk, with lactose and mineral contents being stable. Assuming lactose is 4.7% and minerals 0.7%, milk protein can be calculated as follows:

$$\text{Milk protein (\%)} = \text{SNF\%} - 5.4$$

From Appendix Table A4.1 to Table A4.3, the ME requirements of:

- a 550 kg cow
- housed, hence with no activity allowance
- in the sixth month of pregnancy
- producing 13 kg of milk (containing 3.6% fat and 3.2% protein)

are:

1. 59 + 0 + 8 or 67 MJ/d (for maintenance, activity and pregnancy) plus
2. 5.1 MJ/kg milk for 13 L (5.1 x 13) or 66 MJ/day for milk production hence
3. A total of 67 + 66 or 133 MJ/d.

Body condition. When an adult cow puts on body weight, it is mostly as fat. Some of this fat is apparent on the backbone, ribs, hip bones and pin bones and around the head of the tail. This extra subcutaneous fat gives rise to a system of body condition scoring by visual appraisal, out of 8 points. A very thin cow might score 3 or lower while a fat cow might score 6 or greater. This body condition score system is fully described in *Tropical dairy farming* (Moran 2005).

An alternative to scoring the extra condition on a cow would be to weigh her. Weighing a cow to determine if she has put on condition is more accurate, because condition score is affected by the cow's body shape. More fat is needed to produce one extra body condition score on a large-framed cow than on a small-framed cow. It takes longer to notice visual changes in body condition (four weeks at least) than it does to monitor changes in live weight (one to two weeks). Appendix Table A4.5 shows how many kilograms are equivalent to a change in one condition score at different live weights. Generally, the amount of weight gain required to increase the cow's condition by one condition score is about 8% of the cow's live weight.

Energy is stored as fat when a cow gains body condition. Conversely, energy is released when body condition is lost, or taken off. For cows gaining weight, their daily energy requirements are more than those with stable weight, whereas for cows losing weight, their daily energy requirements are less.

Appendix Table A4.6 shows how much energy is needed for condition gain and how much is released when condition is lost. Gaining a kilogram in the dry period takes more energy than gaining it in late lactation. Although it is worthwhile for cows to gain condition when dry, it is more efficient to feed extra energy during late lactation to achieve the desired condition score prior to drying off the cow.

The calculation of this extra energy needed, and the number of days to gain body condition, requires an estimation of a realistic rate of live weight gain. For example, a 550 kg cow requires 1936 MJ of ME (44 kg/condition score x 44 MJ/kg live weight gain) to gain one condition score which, if gaining 0.5 kg/d live weight, requires feeding an additional 22 MJ/d for 88 days during late lactation.

From Appendix Table A4.1 to Table A4.6, the ME requirements of:

- a 550 kg cow
- housed, hence with no activity allowance
- one month after calving
- producing 20 kg of milk (containing 3.6% fat and 3.2% protein)
- losing 0.5 kg/d live weight

are:

1. $59 + 0 + 0$ or 59 MJ/d (for maintenance, activity and pregnancy) plus
2. 5.1 MJ/kg milk for 20 kg (5.1×20) or 102 MJ/day for milk production less
3. 0.5 kg/d x 28 MJ/kg (0.5×28) or 14 MJ/d hence
4. a total of $59 + 102 - 14$ or 147 MJ/d.

For another cow, the ME requirements of:

- a 550 kg cow
- housed, hence with no activity allowance
- in seventh month of pregnancy
- producing 10 kg of milk (containing 3.6% fat and 3.2% protein)
- gaining 0.5 kg/d live weight

are:

1. $59 + 0 + 10$ or 69 MJ/d (for maintenance, activity and pregnancy) plus
2. 5.1 MJ/kg milk for 10 L (5.1×10) or 51 MJ/day for milk production plus
3. 0.5 kg/d x 44 MJ/kg (0.5×44) or 22 MJ/d thus
4. a total of $59 + 51 + 22$ or 132 MJ/d.

4.3.3 Protein

The amount of protein a cow needs depends on her size, growth, milk production, and stage of pregnancy. However, milk production is the major influence on protein needs. Appendix Table A4.7 shows crude protein needs at different levels of milk production. As discussed earlier, protein is measured as crude protein, which is the sum of RDP plus UDP.

When calculating the protein requirements of the herd, crude protein, RDP or UDP figures can be used. Remember though that requirements for RDP and UDP are only 'guesstimates'. To work out how much RDP and UDP is required, the protein requirements of the rumen microbes and of the cow need to be considered. The microbial protein made available (after it is flushed from the rumen) also needs to be calculated.

Any shortfall in protein can then be made from all protein sources (i.e. UDP). However, not all microbial protein or UDP eaten becomes available to the cow. Factors

such as digestibility of amino acids reaching the small intestine, as well as feed intake, will influence the type and amount of protein used by the cow. As a result, RDP and UDP requirements can only be calculated estimates.

Above a certain level of milk production, some protein in the diet must be UDP. There is a limit to the rumen's capacity to use RDP to produce microbial protein, which can then be flushed on to the small intestine for digestion. Microbial protein coming out of the rumen can sustain milk production to 12 kg/day. In other words, when milk production is 12 L/day or less, all the protein in the diet can be RDP (i.e. protein that the microbes can use). However, for milk production over 12 kg/day, at least some protein in the diet must be UDP.

4.3.4 Fibre

Cows need a certain amount of fibre in their diet to ensure that the rumen functions properly and to maintain the fat test. Appendix Table A4.8 shows the levels of fibre cows need in their diet. It should be stressed that the fibre requirements listed are the absolute minimum values. Acceptable levels of NDF in the diet are in the range 30–35% of DM.

Low-fibre, high-starch diets cause the rumen to become acid. Grain poisoning (acidosis) may occur. Adding buffers such as sodium bicarbonate to the diet reduces acidity and hence reduces this effect. Buffers are usually recommended when grain feeding exceeds 4–5 kg grain/cow/day. Buffers are not a substitute for fibre. Long-term feeding of low-fibre diets should be avoided. Appendix Table A4.9 presents the maximum daily intake as influenced by the NDF content of the total diet. These data were derived from high yielding cows fed feedlot rations based on temperate forages, so they are only a guide as to the likely effects of the content of NDF in the total ration on predicted voluntary feed intake of cows in tropical smallholder dairy farms.

4.4 Increasing dairy farm profitability through improved pasture technology

Growing quality forages is the key to profitable dairy production throughout the world, whether it be an intensive dairy feedlot in the US (where sourcing these quality forages at a competitive price is the issue), a heavily stocked grass-based dairy in southern Australia or a smallholder farm in South-East Asia. In all cases forages are generally cheaper than concentrates and the more feed nutrients that stock can consume in their forage base, the fewer are required from the purchased concentrates.

A recent paper from Vietnam has provided additional evidence of the potential benefits arising from improved grass technology (Mui *et al.* 2003). Around three major cities in Vietnam, feed costs comprise 50% (Hanoi) to 64% (Saigon) to 68% (Hatay) of the total production costs for peri-urban dairy farmers. Green feed can reduce feed costs by replacing concentrate ingredients and increasing milk yield. Because only 10% of the farmers grow grass for livestock fodder, farmers are forced to use dry and fresh rice straw to meet the shortfall, frequently reducing cow performance.



Figure 4.1 Well-managed Guinea grass (left) and Napier grass (right), requiring different harvest intervals (South Vietnam)

Farmers are encouraged to use correct fertiliser levels, which Mui *et al.* (2003) report in field plots, can increase yields of Napier grass (*Pennisetum purpureum*) from 150–400 t fresh/ha/yr (or 26–69 t DM/ha/yr). More realistic commercial yields are 250 t fresh or 42 t DM/ha/yr from six harvests per year. Another high yielding pasture species is Guinea grass (*Panicum maximum*) which can produce 148 t fresh or 28 t DM/ha/yr.

Not only are high forage yields possible through this improved grass technology, but cow performance also improves. Table 4.6 presents data from 91 cows either fed rations based on less than 10 kg/d fresh grass or over 20 kg fresh/d. Unfortunately the authors did not present the DM contents of the various diet ingredients, making it difficult to accurately calculate the percentage of grass in the diet DM.

Feeding more grass (1.5 to 4.1 kg DM/cow/d) increased milk yields from 10.7 to 15.2 kg/d, reduced the number of services per conception and the days from calving to mating.

Additional data suggest that a reasonable economic efficiency can be achieved in crossbred Friesians when fed 28–36 kg Napier grass in their diet, with cows producing 3000–3500 L/lactation.

One way of promoting the improved technology is through ‘grass fairs’, attended by dairy farmers and suppliers of grass seedlings, fertilisers and pesticides. This enables farmers to buy high quality, high yielding grass seedlings. Farmers can grow grass for sale to the peri-urban farmers, selling the forage for 150–300 VND/kg fresh, although this can increase to 500 VND/kg in areas of high demand.

Table 4.6 Effect of forage intake on dairy cow performance (Mui *et al.* 2003)

	Ration A	Ration B
Feed (kg/cow/d)		
Grass	9.6	24.0
Concentrate	5.1	5.6
Brewer's grain	9.2	8.9
Soybean residue	5.8	4.7
Cassava waste	4.2	7.1
Pineapple peels	5.4	–
Rice straw	5.0	3.0
Sugar cane tops	7.0	9.0
Cow performance		
Milk yield (kg/cow/d)	10.7	15.2
Insemination/conception	2.1	1.7
Days calving to 1st oestrus	79	74
Days calving to mating	102	90
Days calving to pregnancy	133	144

Table 4.6 clearly demonstrates how relatively simple improved technology, namely pasture species and fertilisers, can greatly benefit smallholder dairy farmers.

4.4.1 Recent sources of information on tropical forages

In recent years, several excellent sources of information have been developed to assist with forage selection for Asian livestock producers. These include:

1. A concise bulletin on selecting forages for livestock feeding in South-East Asia was published by Horne and Stur (1999).
2. The growing and conserving of quality tropical forages for Asian smallholder dairy farmers has been covered in detail in Chapters 8 and 9 of *Tropical dairy farming* (Moran 2005).
3. A CD on which is presented a process for forage species selection based on their optimum climate, soils, production system and management (Cook *et al.* 2005).
4. A CD on which is collated the FAO database of 600 species of tropical forages and legumes (FAO 2005a).
5. A CD on which is collated the profiles of 14 Asian countries detailing their climate, livestock and forage resources (FAO 2005b).

5

Improved herd management on smallholder dairy farms

This chapter reviews the key aspects of dairy production technology influencing the persistency of milk yields during lactation, milk responses to extra feeding and breeding and replacement heifer rearing.

The main points in this chapter

- Understanding the principles of the cow's lactation cycle, particularly her peak level and persistency of milk yield, are the keys to productive and profitable dairy farming.
- When offered extra feed, milk responses follow the law of diminishing returns in that there comes a point when milk yields plateau.
- Special attention should be given to young stock as they are a key investment in future herd performance. Likewise, improved reproductive management will provide economic benefits through increasing the proportion of income generating cows in the herd.
- Generally speaking, the importance of genetics is overshadowed by feeding management.

This chapter contains several sections from *Tropical dairy farming* (Moran 2005) because these highlight the essential principles of dairy production technology that need to be understood for farmers to become more effective business managers of their smallholder operations.

These principles include:

- Farmers are in the business of generating profits from the production and sale of milk. Over a 300-day lactation, the same dairy cow can produce anything from less than 2000 kg milk to more than 5000 kg milk, depending on her feeding and herd management. The more milk she produces, the more income she will generate, which generally leads to more profit, that is total income from sale of milk and other animal products (such as calf, manure and cull cow) less total production costs (feed, herd and overhead).

- Farmers have to feed cows better to produce more milk. The milk response to an extra feed can vary from less than 0.25 kg milk to more than 1 kg milk; that is a fourfold variation.

Throughout this book milk production is quantified either in kg/d or L/d. Western dairy specialists tend to use volume as this is measured by most milking machines. In contrast, Asian dairy specialists tend to use weight as this is measured by most hand milking operators. With specific gravities in raw milk varying from 1.024–1.032, 1 L milk can weigh between 1.024 kg to 1.032 kg. Interchanging the volume and weight of milk can then introduce an error of 2–3% in milk yields.

- Before cows can produce milk, they must have a calf and this can happen when the cow (called a heifer) is as young as 24 or as old as 40 months. Obviously the older she is, the greater her rearing costs as a calf and heifer.
- To maintain a regular milk supply, the cow must regularly have a calf, and this can happen every 12, 18 or 24 months. In addition, she should keep producing milk every lactation right up until about two months before she is due to have her next calf. Lengthy calving intervals, particularly associated with short lactations, mean that the cow spends many months ‘dry’ or not producing milk
- To offset the high costs of rearing her as a replacement heifer, she should be able to remain a productive member of the milking herd for many years, certainly more than five years. She should only be sold when her ability to generate profit falls below a certain level. So cows producing six or even eight calves during their productive life will be more profitable than those which have to be culled from the dairy herd after only one or two calves.

This chapter deals with several key aspects of dairy production technology, namely:

- Exactly what is the ‘lactation cycle’?
- How cow management should be directed towards maximising persistency of milk production
- How we should understand milk responses to extra feed
- Young stock and reproductive management
- Exotic breeds and crossbreds for milk production.

There are other key aspects of herd production technology, such as animal health and environmental management, but space will not allow for these to be covered in this book.

5.1 The lactation cycle

A number of changes occur in cows as they progress through different stages of lactation. As well as variations in milk production, there are changes in feed intake and body condition, and stage of pregnancy.

Following calving, a cow may start producing 10 kg/d of milk, rise to a peak of 20 kg/d by about seven weeks into lactation then gradually fall to 5 kg/d by the end of lactation.

Although her maintenance requirements will not vary, she will need more dietary energy and protein as milk production increases, then less when production declines. However, to regain body condition in late lactation, she will require additional energy.

If a cow does not conceive, she has no need for additional energy or protein. Once she becomes pregnant she will need some extra energy and protein. However, the calf does not increase its size rapidly until the sixth month, at which time the nutrient requirement becomes significant. The calf doubles its size in the ninth month, so at that stage a considerable amount of feed is needed to sustain its growth.

Cows can usually use their own body condition for about 12 weeks after calving to provide energy in addition to that consumed. The energy released is used to produce milk, allowing them to achieve higher peak production than would be possible from their diet alone. To do this, cows must have sufficient body condition available to lose, and therefore they must have put it on late in the previous lactation or during the dry period.

This chapter introduces the lactation cycle with its varying goals for feeding strategies. Further chapters will enlarge on management to achieve these strategies.

5.1.1 From calving to peak lactation

Milk yield at the peak of lactation sets up the potential milk production for the year; one extra kg/day at the peak can produce an extra 200 kg/cow over the entire lactation. The full lactation response to extra milk at peak yield varies greatly with feeding management during mid and late lactation. There are a number of obstacles to feeding the herd well in early lactation to maximise the peak. The foremost of these is voluntary food intake.

At calving, appetite is only about 50–70% of the maximum at peak intake. This is because during the dry period, the growing calf takes up space, reducing rumen volume and the density and size of rumen papillae is reduced. After calving, it takes time for the rumen to ‘stretch’ and the papillae to regrow. It is not until Weeks 10–12 that appetite reaches its full potential.

If the forage is very moist, say with a dry matter content of only 12–17%, the rumen cannot hold sufficient fresh forage to meet the DM needs of the cow. Peak milk production occurs around Weeks 6–8 of lactation. So, when a cow should be gorging herself with energy, she is physically restricted in the amount she can eat. Figure 5.1 presents the interrelationships between feed intake, milk yield and live weight for a Friesian cow with a 12-month inter-calving interval, hence a 300-day lactation. Such a lactation cycle is more typical of temperate dairy systems rather than smallholder tropical ones. However, as it is possible in the tropics, it has been included in this manual as a target.

The level of feed intake is primarily determined by stage of lactation, but can be manipulated. Table 5.1 shows the feed intakes required for cows to meet their energy needs to produce target milk yields. By providing a high quality diet during early lactation (10 v 8 MJ/kg DM of ME), the physical restrictions of appetite would be reduced.

The farmer has two feeds available to give to the cows:

- mature pasture, with an energy density of 8 MJ/kg DM of ME, and
- green, leafy grass, with an energy density of 10 MJ/kg DM of ME.

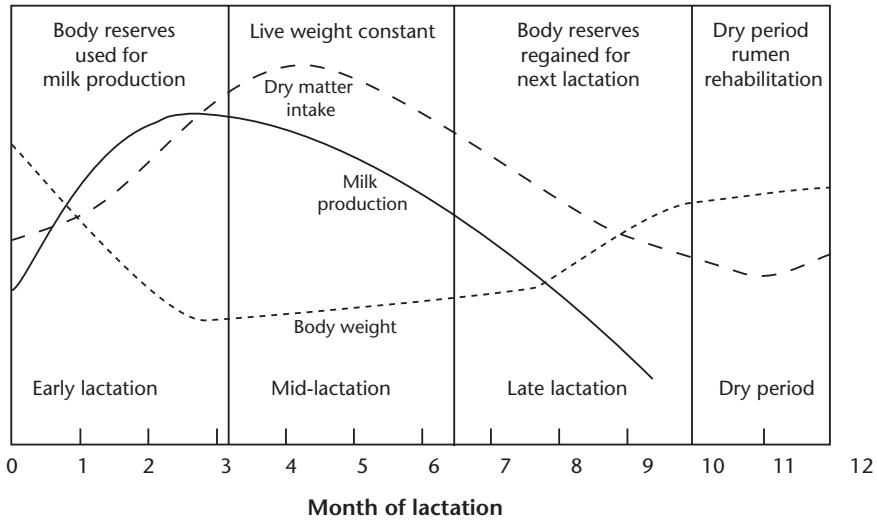


Figure 5.1 Dry matter intake, milk yield and live weight changes in a cow during her lactation cycle

To produce more milk, a cow must eat more DM. If lower quality (i.e. lower energy density) feed is provided, the cow must eat more of it. To produce 20 kg of milk on the mature pasture, a cow must eat 20 kg DM/d, a virtually impossible task.

The 20 kg/d cow could probably not even eat 20 kg DM of feed at 8 MJ/kg DM of ME at any time during lactation, let alone in early lactation when intake is restricted. During early lactation, they will produce more milk from more energy-dense feeds because they have to eat less DM to receive an equivalent intake of energy. Nutritional requirements generally exceed voluntary food intake until Week 12, so body fat reserves are drawn upon to make up the nutrient deficit.

5.1.2 The rest of lactation

Following peak lactation, cows' appetites gradually increase until they can consume all the nutrients required for production, provided the diet is of high quality. From Figure 5.1, cows tend to maintain weight during this stage of their lactation.

Although energy required for milk production is less demanding during mid and late lactation because milk production is declining, energy is still important because of

Table 5.1 Quantities of dry matter consumed by cows fed diets of different energy density and producing three levels of milk

Milk yield (kg/d)	Daily energy requirement (MJ ME/d)	Required intake (kg DM/d)	
		8 MJ/kg DM	10 MJ/kg DM
13	125	15.6	12.5
17	146	18.2	14.6
20	161	20.1	16.1

pregnancy and the need to build up body condition as an energy reserve for the next lactation.

It is generally more profitable to improve the condition of the herd in late lactation rather than in the dry period. While lactating, cows use energy more efficiently for weight gain (75% efficient compared to 59% efficient when dry).

5.1.3 The dry period

Maintaining (or increasing) body condition during the dry period is the key to ensuring cows have adequate body reserves for early lactation. Ideally, cows should calve in a condition score of at least 5, and preferably 5 to 6 (out of 8 points). If cows calve with adequate body reserves, feeding management can plan for one condition score to be lost during the first two months of the next lactation.

Australian studies have found each condition score lost (between score 3 to 6) in early lactation to be equivalent to 220 kg of milk, 10 kg of milk fat and 6.5 kg of milk protein over the entire lactation (Robins *et al.* 2003). Furthermore, each additional condition score at calving can reduce the time between calving and first heat by five to six days. The sooner the cow begins to cycle, the sooner she is likely to get into calf.

If cows calve in poor condition, milk production suffers in early lactation because body reserves are not available to contribute energy. In fact, dietary energy can be channelled towards weight gain rather than being made available from the desired weight loss. For this reason, high feeding levels in early lactation cannot make up for poor body condition at calving.

5.2 Persistency of milk production throughout lactation

The two major factors determining total lactation yield are peak lactation and the rate of decline from this peak. In temperate dairy systems, total milk yield for a 300-day lactation can be estimated by multiplying peak yield by 200.

Hence a cow peaking at 20 kg/d should produce 4000 kg/lactation, while a peak of 30 kg/d equates to a 6000 kg full lactation milk yield. This is based on a rate of decline of 7–8% per month from peak yield, that is, every month the cow produces, on average, 7–8% of peak yield less than in the previous month. Actual values can vary from 3–4% per month in fully fed, lot fed cows to 12% or more per month in very poorly fed cows, for example, during a severe dry season following a good wet season in the tropics.

The higher this number the faster the rate of decline, hence the less milk produced. Persistency is calculated as follows:

$$\text{Persistency (\%)} = \frac{[(\text{Peak milk yield}) - (\text{Current milk yield})] \div [\text{Peak milk yield}]}{\text{Months after peak milk yield}} \times 100$$

For example, if cows peaked at 17 kg/d and currently produce 12 kg/d, three months after the peak,

$$\text{Persistency} = \frac{[17 - 12] \div 17}{3} = 10\%$$

If these cows still produced 14 kg/d, their persistency would be 6%, whereas if their milk yield had decreased to 10 kg/d, their persistency would be 14%.

The rate of decline from peak, or persistency, depends on:

- Peak milk yield
- Nutrient intake following peak yield
- Body condition at calving
- Other factors such as disease status and climatic stress.

Generally speaking, the higher the milk yield at peak, the lower its persistency in percentage terms. Underfeeding of cows immediately post-calving reduces peak yield but also has adverse effects on persistency and fertility. Dairy cows have been bred to utilise body reserves for additional milk production, but high rates of live weight loss will delay the onset of oestrus. Compared to temperate forages, the lower energy and protein contents and higher water and fibre contents of tropical forages reduce appetite for these forages, thus requiring higher intakes of high quality concentrates to compensate. Underfeeding of high genetic merit cows in early lactation is one of the biggest nutritionally induced problems facing many smallholder farmers in the humid tropics.

It is induced because cow quality has been overemphasised in many South and East Asian dairy industries without the necessary improvements in feeding systems to utilise this genetic potential. If imported high genetic quality cows are not well fed, milk production is compromised, but most importantly, they will not cycle until many months post-calving.

Thin cows have less body reserves, therefore cannot partition as much to milk yield, thus reducing peak yield and persistency. Unhealthy and heat stressed cows have reduced appetites, hence poorer persistency of lactation.

5.2.1 Theoretical models of lactation persistency

Table 5.2 and Figure 5.2 present data for milk yield over 300-day lactations in cows with various peak milk yields and lactation persistencies. Such data provide the basis of herd management guidelines for temperate dairy systems with 12-month calving intervals. Depending on herd fertility, hence target lactation lengths, similar guidelines could be developed for 15- or 18-month calving intervals.

Table 5.2 and Figure 5.2 only present data for cows with peak yields of 15, 20 and 25 L/d. Smallholder dairy farms in the humid tropics with good feeding and herd management should be able to achieve 15 L/d peak yield, and for those with high genetic merit cows, 20 or 25 kg/d is realistic. Lactation persistencies of less than 8% per month may be achievable in tropical dairy feedlots but more realistic persistencies are the 8–12% per month presented in the Table and Figure.

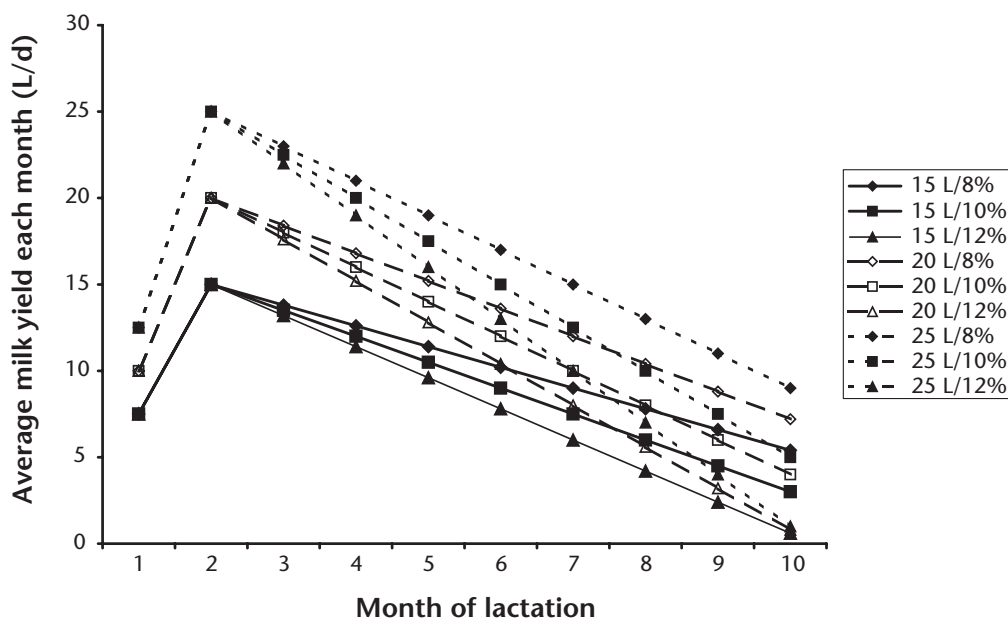
Virtually every smallholder farmer records daily milk yield of his cows, so they know peak yield and can easily determine the monthly rate of decline from peak in kilos per day, hence the percentage decline. This then provides a simple monitoring tool to assess their level of feeding management.

Unless feeding management can be improved, it may be better in the long run to import cows of lower genetic merit. For example, importers may request '5000 L cows'

Table 5.2 Effect of peak milk yield and persistency on 300-day lactation yields

Peak yield (L/d)	Persistency (%/month)	Monthly milk decline (L/d)	Full lact yield (L)	Average milk yield (L/d)
15	8	1.2	2980	9.9
	10	1.5	2650	8.9
	12	1.8	2330	7.8
20	8	1.6	3970	13.2
	10	2.0	3540	11.8
	12	2.4	3110	10.4
25	8	2.0	4960	16.6
	10	2.5	4420	14.8
	12	3.0	3885	13.0

(that is cows that peak at 5000 L under good feeding management, with a persistency of 8%/month). If, through poor feeding, their persistency is reduced to 12% per month, 300-day lactation yields are only 3900 L and they do not cycle for many months after calving, '4000 L cows' may be a better investment. From Table 5.2, such cows would produce similar milk yields if they could be fed to 8% per month milk persistency and they are more likely to cycle earlier.

**Figure 5.2** Milk yields each month for cows varying in peak yield and persistency. Legend shows peak yield (L/d) and persistency (% decline/month)

5.3 Milk responses to feeding

5.3.1 The law of diminishing returns

The response to any farm input is never linear. As an input is increased from a low level there may be an increased response up to some point, but eventually the response will plateau and then, at very high levels of the input, the response may even decrease. This is the concept of diminishing returns and it applies to all aspects of dairy farming. With forages there is a point when applying more fertiliser (either as organic cow manure or dairy shed effluent or as inorganic fertilisers such as urea or superphosphate) will grow so little extra forage that it is not worth applying.

5.3.2 Marginal milk responses to extra feeding

As the intake of feed increases above a certain point, the amount of extra milk produced from each extra unit of feed decreases. In other words, the marginal, or additional, milk response decreases as the level of supplement intake increases.

The major reason for this decreasing marginal milk response is that, with successive increments of feed energy, the cow increasingly partitions nutrients from milk production towards body tissue deposition as milk production approaches the cow's genetic potential. In addition, the stage of lactation has an influence on how much of the supplement's nutrients 'go into the bucket' and how much 'go on the back'. Cows in early lactation tend to lose weight to divert additional nutrients towards milk while those in late lactation tend to repartition nutrients to replace previously lost body reserves.

A second reason for declining marginal responses is that utilisation of one feed type can change with increasing intake of a second feed type, which is known as an associative effect. Efficient digestion of forages, particularly low quality forages, requires an adequate population of fibre-digesting microbes in the rumen. By feeding increasing amounts of high starch concentrates, the proportion of these microbes will decrease as more starch-digesting microbes propagate as a result of the higher starch intake. Consequently, the digestion of the forage can decrease with increasing intakes of such concentrates. Additional starch excretion may also occur, further reducing feed utilisation. This can be particularly important when feeding high levels of supplements rich in fermentable carbohydrates, as rumen pH can decrease dramatically reducing fibre digestion.

Supplementary feeding usually results in higher total feed intakes. Increasing intakes are the result of decreased times that consumed feed spends in the rumen where it is exposed to microbial breakdown. If less of that feed is digested and the nutrients absorbed into the bloodstream or pass down the digestive tract, less dietary energy becomes available for use by the animal. The cow partly compensates for this through decreased losses of energy via methane and urine with increasing feed intake. Although this may not be important unless total feed intakes dramatically increase through supplementation, it can contribute to declining marginal milk responses to supplements.

Another factor decreasing milk responses is the often incorrect assumption that all of the supplement is actually consumed. Rarely is there nil wastage, particularly if the supplement is a roughage. Fortunately, stall feeding minimises such wastage, compared to feeding cows while outdoors.

The major difficulty when predicting milk responses to supplementation, even if substitution rates are known, is the lack of information on the relative importance of the above factors. Without such knowledge, dairy advisers can only, probably incorrectly, assume additive effects when feeding a mixture of various feed types, which would tend to overestimate such milk responses particularly when:

- a) There are marked differences between basal roughages and supplement type, and
- b) Large amounts (say 5 kg DM/cow/d or more) of supplement are fed.

5.3.3 An example of marginal milk responses

Table 5.3 and Figure 5.3 present theoretical data for milk responses to feeding increasing level of formulated concentrates to Friesian crossbred cows fed a basal ration of 40 kg/d fresh of a high quality tropical forage. The data are based on actual results from studies conducted in Victoria with Friesian cows grazing temperate pastures during summer while fed a cereal based concentrate (Gibb *et al.* 2006) adjusted for the levels of milk production expected on smallholder tropical dairy farms. The average milk response is the increase in milk yield for increasing levels of concentrates divided by the total level of concentrates fed. The marginal milk response is the increase in milk yield for each increasing increment of concentrates fed.

This graph highlights several very important points which influence the decisions frequently made by farmers. The peak marginal response, 0.90 L/kg, occurred at 4 kg/d of concentrates, whereas the peak average milk response, 0.77 L/kg occurred at 5 to 6 kg/d. Most advisers would recommend farmers feed 5 or 6 kg/d of concentrates to maximise the milk responses. However the more appropriate level to feed would be 4 kg/d. Above that level, the law of diminishing returns takes effect, in that marginal milk responses decrease as more is fed. The range of possible reasons for this phenomenon has been discussed in the previous section (5.3.2).

Knowing the cost of the concentrates and the milk return allows the calculation the most economical level of concentrates to feed. So long as the value of the extra milk

Table 5.3 Milk responses to feeding increasing level of concentrates to cows fed a basal diet of quality tropical forages

Concentrate intake (kg/day)	Milk yield (L/day)	Average milk response (L/kg)	Marginal milk response (L/kg)
0.0	8.0	0.00	0.00
1.0	8.5	0.50	0.50
2.0	9.3	0.63	0.75
3.0	10.1	0.70	0.85
4.0	11.0	0.75	0.90
5.0	11.9	0.77	0.85
6.0	12.6	0.77	0.75
7.0	13.2	0.74	0.60
8.0	13.7	0.71	0.45

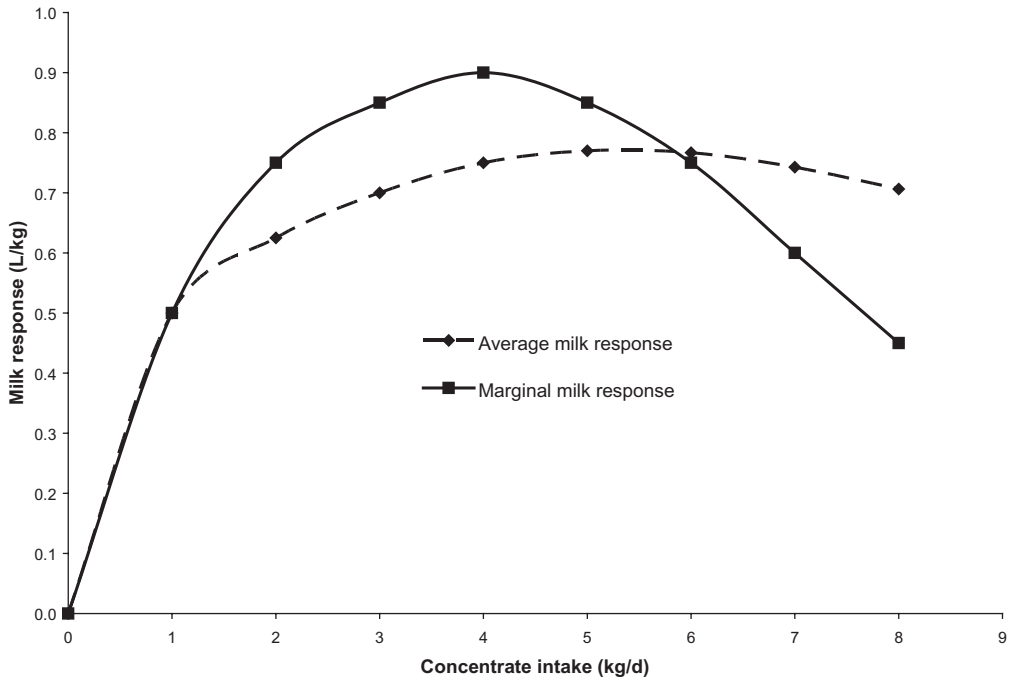


Figure 5.3 Average and marginal milk responses to feeding increasing levels of concentrates to milking cows fed a basal quality tropical forage ration

produced is greater than the cost of the additional concentrates to feed, it is more profitable to feed more up to this point. The 'break even' point would be the level of concentrate feeding when returns from the additional milk produced just cover the costs of the extra feed required.

Unfortunately, such milk response curves are very rare and are likely to differ with the quality of forages and concentrates, and other constraints such as environment (heat stress) and herd management (animal health, genetics) not to mention farmer skills. In fact, data such as the above are sadly lacking from any tropical dairy research study and until they become available, theoretical graphs (such as Figure 5.3) based on the limited temperate dairy research will have to suffice.

5.3.4 Immediate and delayed milk responses

Responses to supplementary feeding have both immediate and delayed components. Some of the supplement goes immediately to milk production and some goes to body fat, which contributes to milk production at a later stage when this condition is mobilised.

To manage the feeding of supplements effectively, it is important to know how cows respond to them. The response is variable. It depends on the circumstances in which the supplement is fed.

The response in milk yield is generally due to the extra energy in the supplement. Unless the supplement improves the use of nutrients already in the diet or stimulates



Figure 5.4 A cow's daily intake of good quality grass/clover pasture

intake of the basal forage, farmers will not get any more milk than that produced from the energy the supplement contains.

In practice, forage substitution almost always occurs, resulting in the response being less than that predicted from the amount of energy in the supplement. The response will be reduced at least by the equivalent of the energy in the forage no longer eaten. Also, some of the energy in the supplement goes to condition score rather than directly into milk. So the immediate milk response will be smaller again. Most experiments have only measured the immediate response to supplements. Because they are short term (usually only several weeks), they cannot measure the delayed milk response from body condition, hence the total milk response.

We know most about the immediate response to supplements from studies in temperate countries. Whether these will be similar to responses in tropical countries requires further research. The major differences between temperate and tropical climate zones is the poorer quality of tropical forages and the fact that many supplements are based on by-products, which vary greatly in nutritive value in tropical countries. Another difference may be the poorer quality control in feed mills, hence the greater variation in energy and protein contents of formulated concentrates in tropical countries. Therefore, it is highly likely that milk responses in South-East Asia will be lower than those in temperate countries.

Guidelines for temperate grazing dairy systems

In early lactation, the average immediate response to feeding concentrates containing 12 MJ/kg DM of ME is 0.6 L of milk per kg of supplement DM, ranging from 0.2 > 1.0 L. In mid-lactation to late lactation, the average immediate response is 0.5 L of milk per kg of supplement DM, ranging from 0.3 > 0.8 L. One generalisation sometimes made is that you get half the response now and the other half later, when the condition score energy is converted back to milk.

Improved feeding management for Asian smallholder dairy farmers has been covered in detail in various chapters in *Tropical dairy farming* (Moran 2005), namely:

- Chapter 10: Supplements for milking cows
- Chapter 11: Milk responses to supplements
- Chapter 12: Formulating a diet
- Chapter 13: Problems with unbalanced diets
- Chapter 14: Diet and milk production
- Chapter 18: Body condition scoring
- Chapter 20: Future developments in feeding management in the humid tropics.

5.4 Rearing replacement heifers

Well-grown dairy heifers are a good investment in the milking herd. To ensure they grow to become productive and efficient dairy cows, their management must be carefully planned and begin the day they are born.

A well-managed heifer rearing system aims for:

- Good animal performance with minimal disease and mortality
- Optimum growth rates to achieve target live weights
- Minimum costs of inputs, such as feed (milk, concentrates and forages), animal health needs (veterinary fees and drugs) and other operating costs (milk-feeding equipment) to achieve well-reared heifers
- Minimum labour requirements
- Maximum utilisation of existing facilities such as sheds for rearing and quality forages for feeding.

There is no single best way to milk-rear calves. All sorts of combinations of feeding, housing and husbandry can be successful in the right hands and on the right farm. Successful calf rearing is a specialist job requiring suitable facilities. It also requires a genuine concern for the welfare of young calves and quick responses to early symptoms of disease. If farmers are unable to commit the time and resources to rearing their own replacement heifers, they should seriously consider paying someone who is better placed to do a good job.

The first three months are the most expensive period in the life of any dairy cow. During that time, mortality rates are high, 10–20% in many cases. Calves need protection from the extremes of sun, wind and rain, no matter what the rearing system. Disease prevention and treatment can be costly during early life. Typically, raising heifers is the second largest expense on the dairy farm, requiring 15–20% of the total expenses.

Only feed costs for the milking herd take a greater share of farm expenses, 50–60%. Deaths of young stock should not exceed 2–4%, while the incidence of calf sickness should not exceed 10%.

All too often, farmers rear their heifer calves carefully until weaning but neglect them thereafter. Calves that are poorly managed after weaning are disadvantaged for their entire life. Even if they are well fed after mating, their ultimate mature size is restricted and if they do put on extra weight, it tends to be fat. Most of the growth in skeletal size occurs before, not after puberty.

Weaned heifers do, however, require less attention than milk-fed calves and milking cows. Dairy heifers need to be well fed between weaning and first calving. If growth rates are not maintained, heifers will not reach their target live weights for mating and first calving. Delayed calving costs money both through higher expenses and delaying the onset of lactation when farmers begin to recoup the money invested in rearing the heifer. In the US, it takes 1–1.5 lactations of milk production to reimburse the cost of rearing, and a six month delay in calving, from 24–30 months, increases this to two full lactations. So reducing heifer rearing costs is not a good investment.

Undersized heifers have more calving difficulties, produce less milk and have greater difficulty getting back into calf during their first lactation. When lactating, they compete poorly with older, bigger cows for feed. Because they are still growing, they use feed for growth rather than for producing milk. Many studies have demonstrated the benefits of well-grown heifers in terms of fertility, milk production and longevity.

Young stock management is discussed in detail in Chapter 16 of *Tropical dairy farming* (Moran 2005).

5.5 Reproductive performance

Improved reproductive performance provides many benefits to farmers such as:

- A greater proportion of milking cows are generating farm income.
- Higher average milk yields each day. Cows with poor reproductive performance will spend more of their time in late lactation, when daily milk yields are lower.
- Fewer cows that have become excessively fat because they have failed to conceive.
- Less compulsory culling of cows failing to become pregnant.
- Reduced insemination and semen costs.
- Heifers calving at a younger age.
- Increased number of calves produced each year, thus providing more animals for sale or as replacements for the milking herd.
- More efficient feed utilisation as a result of the above benefits.

A large-scale Australian study identified six factors which have large influences on herd reproductive performance in both temperate and tropical dairy production systems. Three are non-nutritional and three are nutritional. They are:

- The length of the voluntary waiting period, that is the number of days delay after calving before farmers begin inseminations. This is 50–55 days in the herds with the best fertility.

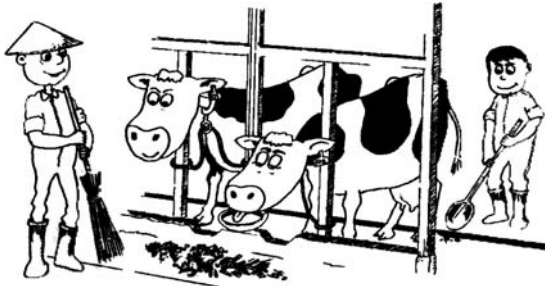


Figure 5.5 Happy cows on a well-managed smallholder farm

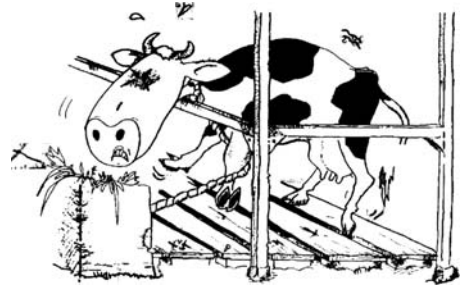


Figure 5.6 An unhappy cow on a poorly managed smallholder farm

- Heat detection. Farmers can make two types of mistakes, they can diagnose heat in cows not on heat (called a false positive) or miss a heat identification (undetected heat). Missed heats are more common. The higher the heat detection rate, the higher the submission rate. Farmers with over 80% heat detection rates had 73% 80-day submission rates.
- Artificial insemination (AI) practices. There are many skills in AI, but discussion of these is outside the scope of this manual. Good first insemination rates were 45–48%.
- Body condition. Cows calving at condition scores of 4.5 to 5.5 (where 1 = emaciated and 8 = extremely fat) had higher 100-day-in-calf rates (54%) than those calving at less than 4.5 (41%). Cows calving in very high score (6.0 or more) may lose condition more rapidly after calving and can suffer reduced fertility.
- Feed intake. Better fed cows have higher fertility. Better feeding can improve 100-day-in-calf rate from 41–57% and reduce 200-day not in-calf rate from 15% to 9%.
- Heifer live weight. The occurrence of the first oestrus in yearlings depends on live weight. So better feeding practices in early life will lead to younger age at first calving in virgin heifers. These heavier animals will also cycle earlier after calving.

Reproductive management is discussed in detail in Chapter 15 of *Tropical dairy farming* (Moran 2005).

5.6 Exotic breeds and crossbreeds for milk production

The most significant economic impact of exotic dairy breeds on the development of dairy farming in Asia has been through crossbreeding with the Friesian, and to a lesser extent Jersey, Brown Swiss and Red Dane, with local dairy cattle as well as with some Zebu dairy breeds such as Sahiwal and Red Sindi (Chantalakhana and Skunmun 2002). When properly fed and managed, Friesians in Thailand produced 5700, 6900 and 7500 kg milk (at 4% milk fat over 305 days) respectively in their first second and third lactation while their purebred daughters averaged 5300 kg milk in all three lactations. However, other data from Thailand (Himarat and Lynch 1994) showed that the cost for purebred Friesians to produce milk was higher than farm gate milk prices. Therefore,

Table 5.4 Performance of purebred Jersey v Friesian and crossbred (XB) Jersey v Friesians in the tropics, with number of animals in each mean value (Tibbo *et al.* 1994)

Trait	Jersey	Friesian	Jersey XB	Friesian XB
Milk yield (kg)	2400 (95)	3620 (35)	1903 (108)	2545 (48)
Lactation length (d)	315 (59)	309 (24)	317 (61)	328 (25)
Milk fat (%)	4.8 (30)	3.6 (11)	5.0 (21)	4.4 (13)
Age at first calving (months)	29.5 (42)	31.2 (16)	32.7 (67)	33.4 (37)
Dry period (d)	93 (16)	88 (8)	–	–
Calving interval (months)	13.9 (47)	14.1 (23)	13.7 (52)	14.0 (28)
Services per conception	2.0 (14)	1.5 (4)	2.0 (14)	2.3 (7)
Conception rate (%)	59 (10)	48 (3)	51.6 (5)	41.8 (3)

local farmers preferred to raise crossbred cattle (62–75% Friesian), because they required lower cash inputs and could still profitably produce 8 to 12 kg/d (2400–3600 kg over 305 days) under smallholder conditions of feeding, management and health care.

Worldwide tropical data (from 190 reports) of the productivity of Jerseys and Friesians, both purebred and crossbred, were reviewed by Tibbo *et al.* (1994). Their summary, presented in Table 5.4, highlights the milking superiority but the poorer reproductive performance, of the Friesian. Purebred Brown Swiss in India have produced 2700 kg while Red Dane in Thailand have produced 2300 and 2800 kg in their 1st and 2nd lactations. The Friesian is then the temperate dairy breed of first choice for upgrading tropical native cattle. Upgrading programs using Zebu dairy breeds can introduce other management problems such as poor milk letdown. Consequently, smallholder dairy farmers prefer to grade local cattle up to 75–87% temperate dairy breeds.

Extensive research in India and Pakistan has monitored breeding programs to upgrade Zebu dairy breeds (Sahiwal and Red Sindhi) with temperate dairy breeds, also finding Friesian the breed of first choice. However, the Friesians' higher milk production and lactation length has generally been at the expense of calving interval, which is up to one month longer than in Brown Swiss and Jerseys. Similar conclusions were reached on South-East Asian smallholder farms with the added advantage of a wider genetic pool to source Friesian semen compared to other temperate dairy breeds.

The question of optimum level of temperate dairy infusion in local stock seems to vary from country to country depending on farmer experiences, veterinary services, milk price and other socio economic factors. In most countries 50–75% Friesian appears optimum, although farmers with experience in dairy feeding and management may prefer 87% (or more) Friesian.

Crossbreeding programs can utilise hybrid vigour (or heterosis) but the theoretical benefits arising from this are confounded by the other management factors (feeding, heat stress, disease), when the genotype by environmental influences (GxE) come into play (Moran 2005). In addition, specially bred tropical dairy genotypes such as the

Australian Milking Zebu (based on Jersey and Red Sindhi), the Australian Friesian Sahiwal or the New Zealand Sahiwal Friesian have been introduced to many Asian countries over the last two decades. However, the general conclusion (Chantalakhana and Skunmun 2002) is that they are no more productive than local crossbreeds of similar genetic makeup.

In summary, improved genetics can be a good investment so long as the other links in the supply chain for a profitable dairy enterprise do not limit their potential, notably Links 1, 2, 3, 4, 5 and 6 in Figure 2.1. In many countries selection or culling of crossbred dairy cattle has not been practiced due to many reasons, such as lack of record keeping, which makes national average production level very low. Such internal as well as external genetic development programs are necessary to optimise progress in improving the merit of any nation's dairy gene pool.

5.7 Describing environmental stress for dairy cows

The comfort zone for milking Friesian cows is 6 to 18°C. Within this range, there are no measurable fluctuations in their physiological processes while the energy input to output shows good biological efficiency, in that all body processes will be functioning in their expected ranges. Between -5 and +5°C, appetite will be stimulated while at the upper level above 27°C, appetite is depressed and both biological and economic efficiencies decline. Above 24°C, dry matter (DM) intake decreases by about 3% for every rise of 1.2°C.

The best single descriptor of heat stress is the Temperature Humidity Index (THI), as this combines temperature and relative humidity into a single comfort index. The higher the index, the greater the discomfort, and this occurs at lower temperatures for higher levels of humidity. The THI is presented in Appendix 1 while its effect on cow performance is briefly summarised in Table 5.5.

Environmental management is discussed in detail in Chapter 19 of *Tropical dairy farming* (Moran 2005).

Table 5.5 Effects of Temperature Humidity Index (THI) on dairy cow performance

	THI	Stress	Comments
A	<72	None	–
B	72–78	Mild	Dairy cows adjust by seeking shade, increasing respiration rate and dilution of blood vessels. Cow performance is adversely affected with reproduction more so than milk yield.
C	78–89	Severe	Both saliva production and respiration rates increase. Feed intakes decrease while water intakes increase. Milk production and reproduction are both reduced.
D	89–98	Very severe	Cows will become uncomfortable due to panting, high saliva drooling and high body temperatures. Milk production and reproduction will markedly decrease.
E	>98	Danger	Potential cow deaths can occur.

6

The harvesting and marketing of milk from smallholder farms

This chapter explains how returns for raw milk depend on milk quality and composition, how milk is marketed via informal and formal schemes in different Asian countries, and the role of cooperatives in smallholder dairy development.

The main points in this chapter

- Milk composition, quantified by contents of milk fat and solids not fat, is very much influenced by feeding management.
- Milk quality is very dependent firstly, on the preparation for, and the process of, milk harvesting, and secondly, on the post harvest handling of raw milk.
- Milk grading schemes provide for a matrix of milk payments, but with vastly different standards for different countries in South and East Asia
- In Asian countries with a long history of milk consumption, raw milk has traditionally been marketed through informal networks, whereas Asian countries where milk has only in recent years become part of the diet, have developed formal marketing systems.
- Dairy cooperatives provide a useful marketing process as they increase the bargaining power of individual farmers and provide a sound infrastructure for dairy development, as has been shown in India and Thailand.

This chapter discusses some of the key local issues affecting the farm gate milk price, such as milk composition and quality and the type of marketing infrastructure established in the farmers' locality. It provides an example of how two countries – Malaysia and Indonesia – provide price signals to improve the marketability of the raw milk via incentives and penalties for achieving set standards for milk composition (contents of milk fat and solids-not-fat) and milk quality (bacterial contamination and temperature). Milk composition is largely controlled by feeding management. Milk quality, on the other hand, is the result of firstly, the preparation for and the process of milk harvesting and secondly, the post harvesting handling of the raw milk.

Milk is the most perishable of all farm produce. Unlike other animal products such as meat, milk is frequently harvested in very unhygienic conditions where, all too frequently, the current practices of cleaning and sterilising the containers used for its collection and transportation leave much to be desired. Not only is bacterial contamination in buckets and milk cans a major problem, but because the tropical environment encourages rapid growth of these bacteria, the prolonged time delays in cooling the milk to 4°C, reduce its quality even further. The government legislation controlling milk harvesting systems in countries with developed dairy industries, ensure a consistently superior milk quality that is just not currently possible in most of the dairy smallholdings throughout Asia.

The very diverse history of consuming dairy products throughout South and East Asia has led to a wide range in marketing systems, and some of these will be described in this chapter. For countries with a long history of milk consumption (either as raw milk or dairy products), informal milk markets have evolved over many decades, whereas countries with shorter histories have chosen more formal marketing structures, such as through dairy cooperatives or direct sale to milk processors. Dairy cooperatives have good track records in dairy development programs in some countries such as India and Thailand.

The larger national and international issues affecting the farmers' return for delivering a quality product to the market place, are discussed in Chapter 7. This book does not discuss value adding to milk via the manufacture of the myriad of dairy based products that are produced in the farm kitchens and dairy cooperatives throughout South and East Asia.

6.1 Improving unit returns for milk

Sanderson (2004) argues quite rightly that there is absolutely no point in focusing on nutrition, breeding and other improved herd management if the infrastructure of the industry is not in place to ensure that the raw milk is supplied to the milk processor in a clean and safe manner. Too often, particularly in warm climates, breakdowns in milking hygiene have led to serious outbreaks of food poisoning. Even for dried milk products such as powder, the processing costs can be dramatically increased and the longevity of the end product can be markedly reduced in raw product with high levels of bacterial contamination.

6.1.1 Milk composition

Milk is produced in the mammary gland by the udder tissue. About 500 L of blood pass through the udder to produce one litre of milk. Blood delivers water, glucose, fats and amino acids to the udder where the cells in the udder tissue use these substrates to form and secrete milk.

For smallholder dairy cows, the typical ranges of milk constituents are:

- Water: 87.5–89.5%
- Milk solids: 10.5–12.5%



Figure 6.1 A well-equipped milk testing laboratory at a dairy cooperative in Thailand

- Milk fat: 3.0–6.6%
- Milk lactose: 4.8%
- Milk protein: 2.6–4.4%
- Minerals: 1.0%.

The key measures used to describe milk composition are the concentrations of milk solids (called total solids, TS, or total dissolved solids, TDS), milk fat and milk protein. Because lactose and mineral contents are very stable, milk protein is often estimated using Solids Not Fat (or SNF). The methods of testing for milk composition are:

1. TS: calculated from the density of raw milk, measured with a hydrometer adjusted for milk temperature.
2. Milk fat: traditionally measured in the laboratory using a centrifuge to separate out the milk fat which had been coagulated with a strong acid solution, although more modern techniques allow for rapid measurements.
3. SNF: calculated from TS and milk fat.

The level of fat and protein in milk varies with many factors such as the breed of cow, stage of lactation, body condition and the diet. The importance of feeding management is highlighted in Table 6.1 which summarises its influences on the concentrations of milk fat and milk protein.

Table 6.1 Effects of feeding management on milk composition

Feeding management	Milk fat	Milk protein
Maximum intake	Increase	+ 0.2 to 0.3% units
Increase grain feeding frequency	+ 0.2 to 0.3% units	Small increase
Underfeed energy	Little effect	– 0.1 to 0.4% units
High fibre	Small increase	– 0.1 to 0.4% units
Low fibre	–1.0% units or more	+ 0.2 to 0.3% units
Low protein	No effect	Decrease if marginal
Excess fat	Variable	– 0.1 to 0.2% units
Grinding/pelletising of concentrate	– 0.1 to 0.2% units	Little effect
Heat stress	Variable	– 0.1 to 0.3% units
Restrict water	Increase	Increase
Improving body condition at calving	+ 0.1 to 0.3% units	Little effect

As already mentioned, improving milk composition, or the content of milk fat, protein or SNF, can increase unit milk returns. Each South and East Asian country has developed its own unique milk pricing structure, which incorporates premiums and penalties based on milk composition. Countries with developed milk analytical laboratories can test for milk fat and protein (and even lactose) while less developed countries test for milk fat and SNF. Other countries only use TS in their pricing structure. Examples of such payment schedules are presented in Tables 6.2 and 6.3.

6.1.2 Milk quality

Milk quality refers to the level of various contaminants in milk, be they bacterial, chemical or any other adulterations that can be detected. However, in many South and East Asian countries, the ‘term milk’ quality covers milk composition, hygiene and adulteration.

Adulteration of milk can be intentional or unintentional. Intentional adulteration occurs when farmers add compounds to the raw milk, such as water and sugar, in an attempt to increase its volume and at the same time, maintain its density, so the hygrometer will not detect changes in specific gravity. If successful, such farmers will receive a higher payment for volume with a similar payment for estimated total solids content. Organoleptic (or taste) and alcohol tests can normally detect such adulterations with the resultant penalty, or even outright rejection. Antibiotics can also be classified as intentional adulteration, occurring when farmers do not follow the recommended drug withholding periods following animal treatments. Tests for antibiotics and inhibitory substances are now routine in most Asian countries.

Consumer confidence in dairy products is currently a very sensitive issue, following the intentional adulteration post-farm gate of melamine, such as was first detected in China during August 2008. This has had dire consequences on consumer acceptance of raw milk in many Asian countries, to the detriment of the innocent dairy farmers in these countries as well as in China.

Unintentional contaminations can occur either from within the milking cow, such as mastitis, or more usually following milk harvesting. The somatic cell count detects mastitis while an initial screening can be done using the Californian (or Rapid) Mastitis Test.

Inferior milking hygiene is the major cause of poor milk quality and can occur on-farm, through poor cleaning and sterilising practices of milk harvesting equipment or post-farm gate, due to unclean milk handling and storage equipment and delays to cooling.

The key to any successful domestic milk production system is the establishment of a satisfactory milk harvesting, storage and transport infrastructure. Milk must be harvested in a clean and hygienic manner and cooled as quickly as possible, if it is to have any value for processing. There are a variety of measures of milk contamination following harvest, transport and storage such as Total Plate Count (TPC), Methylene Blue Reductase Test and Resazurin Test. TPC is measured in millions of colony forming units per ml milk (M/ml). These tests and the key principles of good milking hygiene practices are fully described in the final report on our Indonesian and Malaysian milking hygiene workshops (Moran *et al.* 2004).

6.1.3 Examples of two milk grading schemes

To give examples of the magnitude of measures of milk composition and quality on unit returns of milk from smallholder dairy farmers, the 2007 payment schedules for raw milk in Malaysia and the 2005 payment schedule for a milk processor in Indonesia are presented in Tables 6.2 and 6.3. Smallholder dairy industries are very different in these countries in that the infrastructure to handle raw milk post-farm gate is very poor in Indonesia, leading to considerable bacterial contamination once milk leaves the farm.

The Malaysian government rewarded farmers for high TS but penalised them for high TPC levels, with levels over 1 M/ml being severely penalised. The milk processor in Indonesia also used TS and TPC as measures of milk quality while, because of the problems with maintaining milk temperature during transport, it included a bonus for milk below 6°C.

Milk produced in Indonesia still suffers from low TS% and very high TPC levels. In 2005, the base payment was given to milk with 11.3% TS, 20–30 M/ml TPC and 6–8°C, compared to 11.5% TS and 0.20 M/ml TPC in Malaysia in 2007. Note the marked difference in acceptable TPC levels in raw milk from these two countries.

Table 6.2 Milk quality payments used in 2007 by Malaysian government

Grade	TS (%)	TPC (M/ml)	TS bonus (MR/kg)	TPC penalty (MR/kg)	Final price (MR/kg)
A	>12.5	<0.20	+0.15	–	1.50
B	11.75–12.49	<0.20	+0.05	–	1.40
C	>11.75	0.20–0.50	–	–0.15	1.20
D	>11.00	0.50–1.00	–	–0.30	1.05
X	–	>1.00	–	–0.85	0.50

Source: DVS, (pers. comm.)

TS, total solids; TPC, Total Plate Count; MR, Malaysian ringgit

Base price is 1.35 MR/L for milk with 11.5% TS and 0.20 M/ml TPC

Table 6.3 Milk quality payments used in 2005 by an Indonesian milk processor in West Java

Milk composition		Milk quality			
TS (%)	Bonus (Rp/kg)	TPC (M/ml)	Bonus (Rp/kg)	Temp (°C)	Bonus (Rp/kg)
<10.7	-25	<1	100	>8	-10
10.7–10.9	-20	1–3	75	6–8	0
11.0	-15	3–5	50	<6	10
11.1	-10	5–10	40		
11.2	-5	10–15	20		
11.3	0	15–20	10		
11.4–11.6	20	20–30	0		
11.7–11.9	30	30–40	-10		
>12.0	40	>40	-20		

Source: Moran *et al.* (2004)

TS, total solids; TPC, Total Plate Count, temp, temperature; Rp, Rupiah

Base price is 1720 Rp/kg

One session in our milking hygiene workshops is called ‘Milk quality makes money’ (Moran *et al.* 2004), because of the large financial benefits arising from improved milking hygiene practices. For Malaysian farmers, improving milk grade from D to A (see Table 6.2) through reducing TPC levels from 0.50 to 0.20 M/ml will increase unit milk price by 25%. For farmers with poorer milk harvesting practices, improving milk grade from X to C, through reducing TPC levels from more than 1.00 M to less than 0.50 M/ml, will increase unit milk price by 300%.

Financial benefits are less clear in Indonesia because milk quality is not monitored for individual farmers, just for the dairy cooperative they supply. If such a cooperative handling 30 t/d of raw milk can reduce TPC levels from 30 M/ml to 5 M/ml, it would generate an additional 3% from milk sales, or 45 M Rp/m. Reducing TPC levels from 30 M/ml down to 1 M/ml would generate an additional 6%, or 90 M Rp/m. As well as returning some of these premiums to individual farmers, there are many opportunities to invest in better milk handling equipment and practices, such as those suggested by workshop participants and reported by Moran and Miller (2004).

6.2 Formal and informal milk markets

Milk marketing through the dairy value chain takes place in many ways. The term ‘dairy value chain’ refers to the stages through which milk and dairy products pass from the farmer to the consumer. Milk markets are often categorised into two main types, informal and formal. Some of the key features of these markets are:

- Informal markets are usually small-scale, local markets involving few participants. The milk is more often sold as a raw product, hence not processed. For the consumer these traditional markets are at the lower cost end where price is considered to be more important than milk quality. Most people think of informal milk marketing as

the direct sale procedure by a middle man, who collects the raw milk from the farmer then sells it directly to the consumer.

- Formal markets are usually medium to large-scale, more distant markets involving more participants where the milk is processed prior to sale. For the consumer, they are at the higher cost end where quality and food safety are important. Most people think of formal milk marketing as the process by which raw milk is bulked and chilled after collection from many farmers prior to transport to the milk factory where it is processed, package and distributed to a dairy reseller, either a small or large retailer.
- Where formal market chains are established, they frequently handle more product. However, informal markets normally return a higher unit price to the farmer. Informal and formal markets often overlap as farmers or farmer organisations seek several market outlets.
- Informal markets provide opportunities to value add the raw milk at the village level, whereas formal markets commonly use more industrial methods. Such kitchen-based value adding is a great provider of labour, as Hooten (2008) reported that informal markets employed five times more people per 100 kg milk throughput than did formal markets. In addition, they earned more than the minimum wage, usually the basis of payment in formal industrial processing.
- Most population growth in developing countries will be amongst urban, rather than rural dwellers, and they are better served by formal milk markets, particularly as consumers become more affluent.

In countries with a culture of consuming dairy products, traditional informal markets play a key role in dairy development, such as in Pakistan (where they comprise 98% of marketed milk), India (76%) and Sri Lanka (40%). They are not a result of lack of investment in formal market channels or of non-reinforcement of national milk standards. Rather they thrive because of the continued strong demand for the products and services they offer. Investment in formal dairy processing facilities, both in private and public sectors, has often failed, leading to underutilised capacity with the market surviving on subsidies or abandoned milk processing plants and cooling facilities. For example in Pakistan, one major processor has a shortfall of over one million litres per day in processing capacity. The only sustainable way to source milk is through offering a competitive price with the informal market, which does not always occur.

In some cases there is a strong demand for traditional products by high income consumers as well as the resource-poor, so growth in disposable income may not necessarily reduce demand for traditional products. Furthermore, formal market structures are not necessarily required to stimulate dairy development. In fact, formal market share can be less a result of market forces but rather due to public investment decisions. Poorly managed formal market institutions provide less effective linkages between farmers and consumers than the traditional informal market. Because of their lower cost structures, traditional markets can more easily offer price incentives to both producers and consumers.

The traditional informal markets have clearly provided an effective functional link between farmer and consumers which respond to consumer demands and certainly should not be regarded as market failures. Moreover, these markets serve the needs of

small-scale farmer and resource-poor consumers and in addition, they provide good employment opportunities and better market access in areas with poor infrastructure and long distances between producers and consumers. Because traditional products are not easily substituted, they provide a good buffer to dairy imports. However, urbanisation will reduce their role because of the higher costs of mass supply (Hooton 2008).

Public policy makers should engage constructively with traditional markets rather than oppose them directly, particularly as demand for food safety will grow with disposable incomes. Policies should allow the continued functioning of such markets, yet support increased milk quality and food safety. Policies that simply oppose and attempt to police such markets are likely to impact negatively on small-scale farmers, consumers and small-scale market agents. The key features of informal markets are continued demand for 'traditional' products and processing and the lack of 'modern' health standards.

Adulteration of raw milk with liquids (ice or water) and thickeners (such as chalk), once collected from the farm, prior to direct sale to consumers is an all too common feature of informal markets and this will be difficult to stop. However, the consumer knows all too well the potential for sickness if this milk is not boiled prior to consumption or used to make traditional dairy products (such as ghee or yoghurt). Apart from paying for the milk 'additives', the individual consumer treats the adulterated product with due respect, ensuring a relatively safe food. However, this is not always the case as was evident from the 2008 China incident when melamine entered the food chain due to milk processors being unable to guarantee food safety.

Market forces will influence the degree of acceptance from particular milk marketing middle men. However, it would be difficult, in fact nigh impossible, for governments to enforce food safety standards on such an informal marketing structure, although Hooton (2008) is optimistic that from experiences in Africa, quality and efficiency issues can be addressed through training and certification and by working closely with milk trader groups.

6.3 The role of dairy producer cooperatives

Most farmers sell their products to businesses which are much bigger than their business. Consequently, in many countries, farmers attempt to increase their bargaining power by forming cooperatives. Cooperatives are jointly owned by farmers, membership is usually voluntary and members are supposed to receive benefits in line with the extent of their ownership of the cooperative. Historically, cooperatives have failed because of two major factors. Firstly, the marketing services the cooperative were set up to improve were already done efficiently by competing marketers. Secondly, if the cooperative succeeded and raised net returns to members, the benefits went to both members and non members in the form of higher prices and increased competition. Thus an incentive was created for producers to reap the benefits without incurring a cost of being a member. This is why governments introduced 'compulsory cooperatives' called marketing boards.

Producer cooperatives for processing and marketing of milk have proved viable and sustainable in high income countries of northern Europe, North America and Australia. Cooperative dairies have also been established successfully in some developing countries, such as the Anand Milk Producers Union (AMUL) in India.

With AMUL, a producer-based organisational structure was adopted, with village level primary producer societies delivering milk to district unions for processing and product manufacture, that in turn were grouped into state level federations charged with coordination of marketing functions. During the 20-year program, average milk procurement through cooperatives increased from less than 2.5 Kt to more than 11 Kt, 7% of India's total milk production. The informal market still handles over 85% of India's milk. As a result of AMUL and other dairy development programs, India is now self-sufficient in raw milk supplies.

Dairy cooperatives play a significant role in fostering dairy development in many developing countries in Africa (Kenya) and South-East Asia (Indonesia, Thailand), primarily by providing a stable market environment and delivering services to farmers.

Collective action by producer organisations can reduce transaction costs in markets, achieve some market power and increase representation in national and international policy forums. For smallholders, such organisations are essential to achieve competitiveness. They have expanded remarkably rapidly in number and membership, often in an attempt to fill the void left by state withdrawal from marketing, input provision and credit, and to take advantage of democratic developments in civil governance. For example, in Africa between 1982 and 2002 the percentage of villages with producer organisations rose from 8 to 65% in Senegal and from 21 to 91% in Burkina Faso. The Indian Dairy Cooperative Network has 12.3 million individual members, many of them landless and women, who produce 22% of India's total milk supply.

In spite of any successes, producer organisations' effectiveness is frequently constrained by legal restrictions, low managerial capacities, exclusion of the poor and failure to be recognised as full partners by the state. Donors and governments can assist by facilitating the right to organise, training leaders and empowering weaker members, in particular women and young farmers. However, providing this assistance without creating dependency remains a challenge.

In summary, dairy cooperatives:

- Play an important role in providing a base for service delivery to farmers, stable agricultural knowledge systems for uptake of improved technology and increased management skills among farmers.
- However, they may be no more effective than other market channels in linking poor farmers to output markets. Pakistan illustrates very dramatically that strong market growth can occur in the absence of dairy cooperatives.
- Their development is heavily dependent on transparent cooperative management. To be sustainable, they require honest and effective investment of resources and must be accountable to the interests of farmer members. Political and governmental influences need to be minimised.
- They often cannot easily tap into the strong demand for traditional products and raw milk, and generally remain tied to demand for formally processed products. While traditional demand remains the driving force, dairy cooperatives face the same growth impediments as the formal private sector.
- Investments can be effective and pro-poor, if they are well managed, remain independent of any strong political forces and are linked to strong demand. Because

of these constraints, they should not be the primary focus of dairy developmental efforts. Rather they should be a part of a mix of market channels, including the formal private sector and the small-scale traditional sector.

- Other less formal forms of farmer groups, such as self-help groups, can play important roles in local cases.
- Not all governments encourage dairy cooperatives and not all farmer groups want to be part of them.

6.3.1 Types of services offered by dairy cooperatives

Nong Pho in the Rachaburi province of Thailand, is one of the oldest dairy cooperatives established in Asia. It was established in 1971 and now has over 4000 farmer members. Chantlakhana and Skunmun (2002) list its services as follows:

- Purchasing and processing raw milk and dairy products.
- Marketing and distribution of milk and dairy products.
- Cooperative credit and loans.
- Farmer training on dairy farming and cooperative practices.
- Feed mill and dairy concentrate feeds.
- Providing AI services and other technical advice.
- Selling dairy tools and equipment.

The farmers are organised into 32 different zones with each zone electing a group leader. Of these 15 are annually elected by overall members to form the Executive Committee, whose duties include policy formulation as well as overseeing the management of the cooperative services.

Most farms are within a 20 km radius of the processing plant, with the most distant being 30 km. Raw milk is delivered twice daily either by the farmer or a middleman who collects the milk from the farmer. Farmer payments are made every 10 days based on milk composition (total solids and milk fat) and milk quality (bacterial contamination). About half the milk is pasteurised into plastic sachets and the remainder is ultra high temperature (UHT) treated into hard packs.

The feed mill produces 100 t/d (in 1992) of formulated concentrates for feeding to stock, which is sold to farmer members on credit with payment deducted from their milk cheques. The AI service uses both local and imported semen. Animal health services are provided by both university and government veterinarians with farmers paying only for the drugs. Cooperative fees are based on unit volume charges of the daily farm milk output.

The success of dairy cooperatives depends on four types of factors, namely:

1. **Technical inputs:** The primary requisites consist of suitable dairy breeds, availability of good quality feeds (especially roughages) and clean water, good farm management and herd husbandry and appropriate animal health.
2. **Institutional support:** These include credit agencies, farmer training facilities, milk collection and processing centres and research and extension services. Extension services provide AI, health care and farmer technical training. Research is directed



Figure 6.2 Delivering the milk to a collection centre in Sri Lanka

towards problem solving, socio economic and policy issues as well as technical constraints. The infrastructure to better utilise agro industrial wastes for livestock feeding is another common constraint to smallholder farming.

3. Government policies: In many countries these include import regulations requiring importers of dairy products to source local milk in a particular purchase ratio, and promotion campaigns and school milk programs to encourage consumption of fresh milk. Other policies in Thailand include diversification schemes to convert rice paddies to dairy farms.
4. Socio economic initiatives: There are many initiatives influencing the success or otherwise of smallholder dairy farming and the farmers' decisions to expand and improve their operations. These include the availability of capital investment, farm gate milk prices, land prices, labour availability for farm workers, off-farm wages for dairy farming family, farmer education and training and the retail milk price for consumers.

The success of farmer cooperatives in Thailand can be measured in terms of key performance indices on smallholder dairy farms (Chantalakhana and Skunmun 2002). Milk yields have increased from 8–10 kg/cow/d to 10–15 kg/cow/d (or 4500 kg for a 300-day lactation) and calving intervals have been reduced from 15–16 months to 12–13 months.

7

The base price for raw milk

This chapter discusses the key influences on the price of raw milk delivered to the marketplace.

The main points in this chapter

- Of all the farm costs and returns, milk price generally has the biggest bearing on farm profits.
- Milk price depends on intrinsic (on-farm) as well as extrinsic (beyond farm gate) factors.
- Milk composition and quality are within the farmer's control and formal markets generally develop milk grading schemes to send the price signals back to the farmer who can modify farm practices to improve milk returns.
- External factors include currency exchange rates, international (global) market pressures, national government policies and free competition within the local informal and formal markets.
- There are wide variations between Asian countries in their farm gate milk prices varying from 9 US c/kg in Cambodia and 37 US c/kg in Malaysia.
- The 2007 rise in global dairy products led to large increases in farmer milk returns which stimulated dairy production throughout Asia.

The price that smallholder dairy farmers receive for their raw milk generally has the biggest bearing on farmer profits of all the costs of farm inputs and returns for other dairy outputs. For example in Chapter 15, a partial budget was undertaken for a 30-cow farmer in Malaysia to assess the financial implications of increasing the size of his milking herd and contracting someone to rear his replacement heifers off-farm. A series of sensitivity analyses were carried out to predict the effects of variations in other farm costs and milk yields on his farm profits, as quantified by net benefits of these changes in farm practices. A 10% change in milk prices influenced net benefits by 10%, compared to a change of only 2% arising from a 10% variation in concentrate costs, a 10% change due to fluctuating lactation milk yields by 250 L and a 3% change in net benefits due to

16% variation in daily heifer rearing costs. Clearly milk price is the major profit driver in this scenario.

The base price for raw milk is the unit price farmers receive for milk of a pre-determined composition and quality when delivered to the marketplace. In most informal markets, milk composition and quality is rarely monitored, with milk acceptability based purely on subjective criteria such as smell and taste. Formal markets are more discerning, testing the end product before deciding on their final price.

7.1 Factors affecting the base price of milk

Milk price is dependent on many factors, those intrinsic (on-farm) and those extrinsic (beyond the farm gate). The intrinsic ones, those mentioned above, are influenced by the farmer's management skills in producing and harvesting the milk. However, the extrinsic ones are generally outside his control. They include currency exchange rates, international (global) market pressures, national government policies and free competition within the local informal and formal markets.

In developing countries, analysing the impact of changing milk prices requires assumptions about the domestic market potential. Assumed rates of growth in population and their relative wealth are crucial, as are 'Westernisation trends' in many markets. In determining supply responses, industry structure (number, size and market share of milk processors) and the state of infrastructure are crucial. Local versus multinational ownership in term of access to, and cost of, capital as well as the extent to which foreign direct investment can avoid market access limitations and affect quality and procurement standards, will also affect market conditions.

7.1.1 Internal influences

In the previous chapter, Tables 6.2 and 6.3 presented examples of recent milk grading schemes from Malaysia and Indonesia respectively.

Because of pressures from the milk processors, there are strong price signals for Total Plate Count (TPC) in that milk prices in Malaysia are effectively halved once the milk exceeds TPC levels of 1 M/ml (of colony forming units or CFU). Such price signals vary in different countries because of the accepted level of milking hygiene on smallholder farms. With regard to the highest price paid for premium quality milk as measured by TPC levels, these are 1 M/ml in Indonesia, 200 000/ml in Malaysia and only 20 000/ml in Australia (Moran *et al.* 2004).

Market pressures in different countries also influence the relative returns for milk composition. For example, for Australian dairy farmers, a kilogram of milk protein returns virtually double that of a kilogram of milk fat because milk processors (as driven by consumers) value dairy products based on milk protein more highly than those based on milk fat.

7.1.2 External influences

The market influences of supply and demand have led to dramatic fluctuations in international milk and dairy prices over the last few years. Figure 7.1 presents the unit

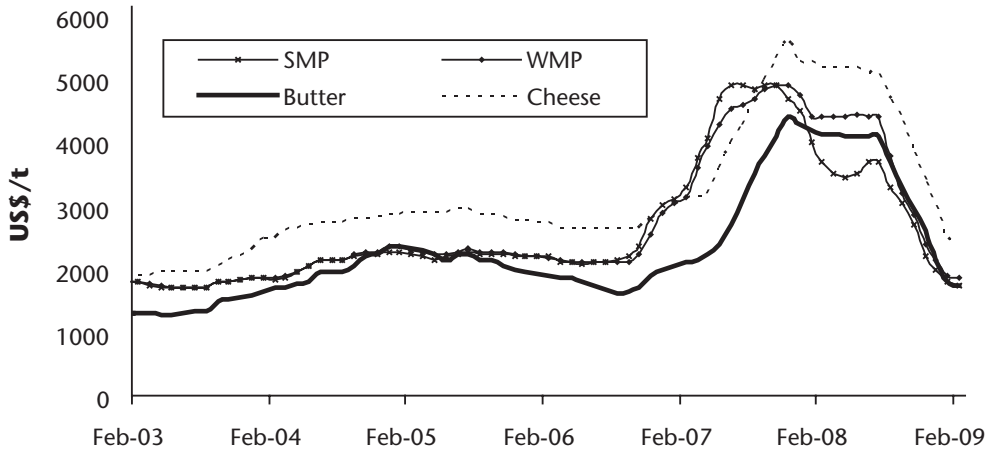


Figure 7.1 Global milk prices for various dairy products (2003–2009). WMP is whole milk powder and SMP is skim milk powder.

price (in US\$/t) for various dairy commodities between February 2003 and February 2009. Global dairy prices virtually doubled over the 12-month period from June 2006 to June 2007, but have since fallen back to 2005 prices.

The rapidity and magnitude with which global milk prices change makes it difficult to source the most relevant up-to-date data on local milk prices. Most published data (e.g. FAOSTAT and APHCA) are two or more years old when first published. In addition, milk prices in developing countries are more difficult to determine due to the high incidence of small farms and the existence of informal markets. Herd sizes are often very small. For example, in India, the world's largest producing country, the average herd has 1.3 cows, while in Pakistan the average is 1.8 cows.

Relative to many developed countries, farm gate milk prices are quite low in Asia. For comparative purposes, milk prices are generally quoted in terms of US\$/100 kg or US cents/kg of milk standardised to 4% fat and 3.3% protein. FAO (2006) data summarise milk prices from 1996 to 2003 as follows:

- European Union farmers received 29 to 40 c/kg.
- North American farmers received 28 to 38 c/kg.
- Australian and New Zealand and South American farmers received 16 to 17 c/kg.
- Argentinean farmers received only 12 c/kg.
- In Asia, Thai farmers received 28 c/kg, while those in China and India received 20–22 c/kg and those in Pakistan received 15 c/kg.

They concluded that at 2006 international prices for dairy products, only those producers with domestic milk costs currently at or below 18 c/kg would be competitive in the absence of price support.

With regard to the cost of producing that milk, IFCN (2004) estimates this ranges throughout the world from less than 18 to more than 45 c/kg. Available data from Asia are:



Figure 7.2 Value adding raw milk as pasteurised flavoured milk (West Java, Indonesia)

- 11 to 12 c/kg in Pakistan and Vietnam.
- 12 to 18 c/kg in India and China (small farms).
- 18 to 28 c/kg in Thailand and China (large farms).

7.2 Local prices for raw milk

7.2.1 Annual variations in different countries

The following graphs present annual variations in raw milk prices for selected countries in South and East Asia from 1991 to 2005, the latest year available from APHCA. Figure 7.3 presents changes in farm gate prices expressed in local currency units, relative to the base price in 1991/92. Myanmar and Laos appear to be outliers in this data set, because milk prices markedly increased in the late 1990s, reaching 600% of the 1991/92 prices by 2001. Increases in other countries over the 14-year period were much smaller, with Malaysia and Thailand increasing by only 150% and Philippines and Sri Lanka by 290%.

Figure 7.4 presents changes in actual farm gate prices converted to US cents/kg. For reconstituted milk containing 10% milk solids, global milk powder prices of US\$2500 and US\$5000/t (or US\$2.50 and US\$5/kg powder) correspond respectively to 25 and 50 c/kg. Therefore, when considering the overlap of years in Figures 7.1 and 7.4, the global whole milk powder (WMP) prices in 2005 correspond to farm gate milk prices of 30 c/kg. When converted to US currency at the varying annual exchange rates for each country, local milk prices have not greatly varied over the last 14 years, even during the Asian financial crisis of the late 1990s. In 2005, farm gate milk prices varied from 9 c/kg

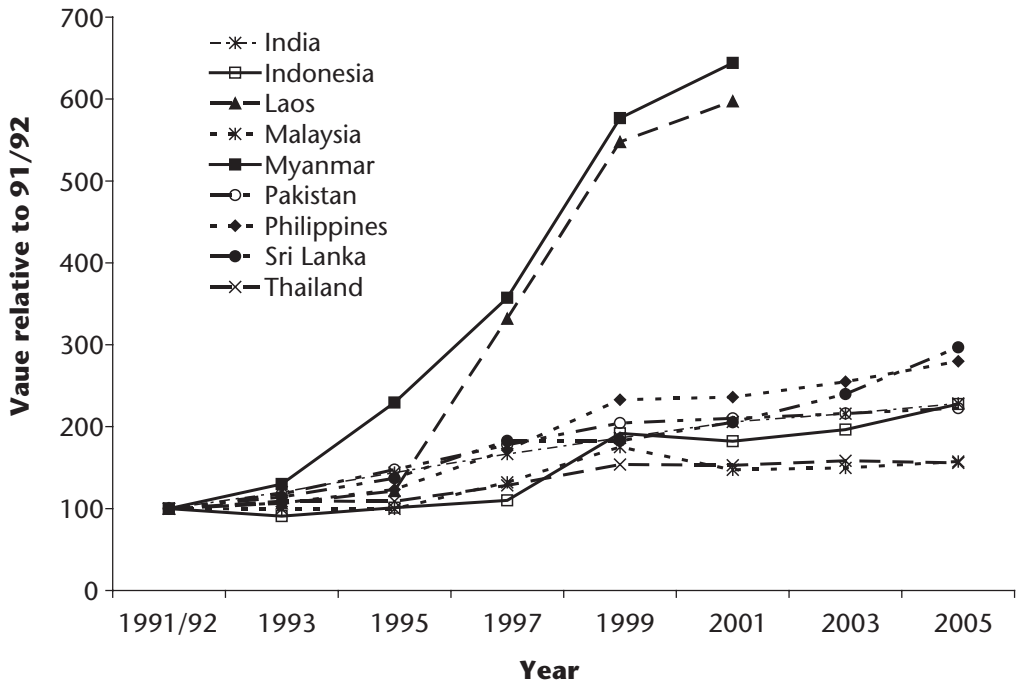


Figure 7.3 Changes in farm gate price for raw cow's milk, in local currency units, for nine selected countries in South and East Asia, relative to the base price in 1991/92

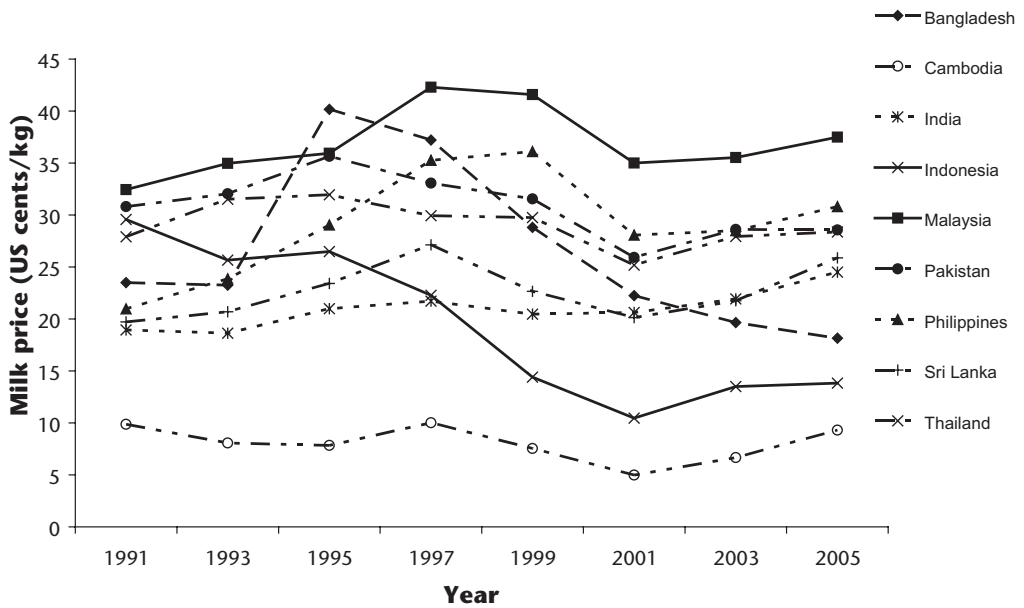


Figure 7.4 Changes in farm gate price for raw cow's milk, in US cents/kg, for nine selected countries in South and East Asia between 1991 and 2005

Table 7.1 Categories of milk price in selected Asian dairy industries in 2006

	Milk price category	Milk: feed price ratio
South-East Asia		
Malaysia	B	–
Myanmar	B	B
Philippines	B	A
Thailand	B	B
Vietnam	C	D
Indonesia	E	A
South Asia		
Pakistan	E	B
Bangladesh	D	C
India	D	C
Sri Lanka	D	A

Source: Hemme (2008)

Milk price (in US c/kg), A, >40; B, 30–40; C, 25–30; D, 20–25; E, <20

Milk: feed price ratio; A, 0.5–1.0; B, 1–1.5; C 1.5–2.0, D, 2–2.5; E>2.5

in Cambodia to 37 c/kg in Malaysia, with an even spread of prices between these extremes for South and East Asian countries.

The International Farm Comparison Network (IFCN) has been closely monitoring milk prices and farm production costs over the last few years and has developed an extensive data base. Hemme (2008) summarised the most up-to-date data (2006), by designating each country's farm gate price in one of five categories, these being presented in Table 7.1. The highest farm gate returns (30–40 c/kg) were in Malaysia, Thailand, Philippines and Myanmar, with the lowest (<20 c/kg) in Pakistan and Indonesia.

To relate dairy farmer returns to production costs, Hemme (2008) compared countries on their milk:feed price ratio, using the IFCN feed price indicator for a concentrate formulation of 30% kg soy bean meal and 70% maize grain. These data are also presented in Table 7.1. Relative to feed prices, farm gate milk returns were lowest in Indonesia, Philippines and Sri Lanka and highest in Vietnam.

7.2.2 Current farmer returns for fresh local milk

Unless for the reasons of good economics, protectionist policies, government support programs and import quotas and tariffs, domestic milk production would need to compete with international milk prices. In the absence of any government support or import restrictions and tariffs (practices which are increasingly being considered by world trade organisations as inappropriate), the benchmark for the value of domestic milk at the factory door is the cost at which it can be produced from imported ingredients at international prices. In 2004, Sanderson (2004) considered this to be US 28–30 c/kg, but it could dip as low as US 20 c/kg when international prices were their lowest. Therefore, in a free market situation, milk processors would not wish to pay more

Table 7.2 Fresh milk prices in Feb 2005 and in Oct 2008 in local and US currency units for selected South and East Asian countries

Country	Currency unit	2005 milk price	2008 milk price	% increase from 2005 to 2008	2005 milk price (US c/kg)	2008 milk price (US c/kg)
Malaysia	Ringgit (MR)	1.23	2.00	63	32.3	63.3
Thailand	Baht (Bt)	12.0	18.0	50	30.3	57.1
Vietnam	Dong (VND)	3200	7500	134	20.2	46.5
Indonesia	Rupiah (Rp)	1720	3000	74	18.7	32.6
Sri Lanka	Rupee (Rs)	22	27.5	25	–	25.5
Australia	Aust cents	28.0	50.0	79	21.5	40.0

than this for fresh local milk. Such conclusions have become dated in the light of increases in global dairy prices since 2007.

What did South-East Asian smallholder dairy farmers receive for their product prior to and following the 2007 global price rises? Table 7.2 compares February 2005 with October 2008 milk returns in both local currency units and US c/kg. These milk returns are base prices for fresh milk in each country, prior to the inclusion of premiums or penalties for milk composition and quality.

Despite wide variations in the increases in farmer milk prices over these three years, from 25 to 134% in Table 7.2, the relative position of countries in South-East Asia has hardly changed. Malaysian farmers still receive the highest return (in US c/kg), followed by farmers in Thailand, Vietnam, then Indonesia. Relative to those in Indonesia, Malaysian milk producers received more in 2008 (248%) than they did in 2005 (173%).

In their strategic plan for Asia's dairy industries, FAO (2008c) concluded that while prices of internationally traded milk powder are expected to subside gradually from their historic peak of near US\$5000/t in late 2007, the perceived competitiveness of larger holder dairy processors heavily reliant on increasingly higher priced imported inputs is expected to erode. Increasingly, large dairy processors in the region are gravitating towards local suppliers of fresh milk, and in many regions, this implies stronger institutional linkages with smallholder producers.

Milk prices are usually set by processors with some input from government, and after lobbying from producers. Farmers are rarely happy with the milk price and consumers complain about the high cost of dairy products, however, in each country the industry continues to develop, often with the impetus of government school milk programs. There are always some dairy farmers leaving the industry and there may be temporary downturns in milk supplies, such as during the 1997–1998 Asian economic crisis. However, in most South and East Asian countries, dairying farming is a growth industry.

8

The importance of record keeping

This chapter describes the range of farm records that could be kept to improve the efficiency of technical and financial management and the ease of decision making on the farm.

The main points in this chapter

- Without written records, farmers have to depend on their memory when making decisions to modify their farm practices. Memories can become unreliable, particularly after a few days, months or years.
- Some records are compulsory, such as data for taxation purposes, whereas most are advisory. There must be good reasons to collect farm records.
- There is a diversity of useful records to keep, such as production and financial transactions in the dairy enterprise. Many are not difficult to collect but all should be easily accessible. Farm diaries and other recording systems such as notebooks, filing systems and computers must be organised.
- This is particularly important with financial records because they are routinely used for bookkeeping purposes, to prepare balance sheets, as well as cash flow and income (or profit and loss) statements.
- Benchmarking, or comparative farm performance, is a useful way to become more aware of the important performance indicators that are most relevant to each dairy production system.

Keeping track of what is happening on the dairy farm requires some records. Good farm management requires having a good useful set of farm records. Good records do not ensure the farm will be successful, however, success is unlikely without them. Farm records are like the report cards students receive at school. With a farm report card, farmers can tell how well they are managing their operation compared to other producers in their 'class'. They can also see the strengths and weaknesses in their operation.

Having accurate facts and figures is most useful when borrowing money, seeking government support and completing tax returns. From reliable farm records, equity (or

proportion of total assets actually owned) can be updated to assist with future farm investment programs. Farm records can help evaluate the dairy enterprise on a mixed farm while farm advice will be more effective if the adviser knows exactly what is happening on the farm. Records and statements show what has occurred or is occurring on the farm while budgets predict what might happen in the future.

Records provide the farm manager with data, information and knowledge. There are four uses for farm records:

1. They are frequently used as a service tool. The types of services provided are income tax calculations, estate planning, business arrangement reconciliation and obtaining and managing credit.
2. They can be used to provide data for financial analysis and other diagnostic instruments, such as identifying the strengths and weaknesses of the business.
3. They can be used as an indicator of progress. A series of records are necessary to monitor progress.
4. They are a good forward planning tool. Past records can be used to project future cash flows for current and modified farm management practices.

8.1 What records should be taken?

Keeping full records just for the sake of keeping them is a waste of time and energy. A little time spent keeping a few orderly records that will be used is a good investment in managing the farm business.

8.1.1 Farm records to keep

- **Farm diary.** A small notebook in which to record the key facts and figures of the farm business and the day-to-day activities as they occur is the most useful, practical (and often the only) form of record keeping. Farmers who do use a diary find that important facts and figures that could easily be lost or forgotten are permanently recorded for future reference, though they may not be easy to find quickly.
- **Crop records.** It is sometimes useful to record what happens to each plot or crop each year, such as type of crop, fertiliser applications (time and amount), agronomy (seeding, weeding, sprays), visual impression of crop, harvest interval of forage crops and if known, crop yield.
- **Livestock records.** See the herd performance list below.
- **Unit costs** of all major farm inputs, such as fertilisers, fuel, irrigation water, concentrates and/or their ingredients, purchased forages, stock purchases. These are necessary for routine bookkeeping and also to monitor seasonal changes and hence to plan future purchases.
- **Unit returns** from all farm outputs, such as milk, cull cows and heifers, sale steers or bulls, manure, excess feed, to plan future sales.
- **Livestock inventory accounting.** The main purpose of livestock accounts is to monitor net losses and gains in income, and to distinguish the increases and decreases due to changes in market value. When quantifying total livestock value you have to take into account both changing herd size and change in unit price.

- **Plant and improvement records.** Examples of relevant records include date and cost of purchase or installation, annual depreciation, insurance and registration, fuel use, hours use (to plan services), major repairs and maintenance.
- **Key financial records,** such as interest and principal repayment schedules, to plan repayments.
- **Other key farm management records** such as rates and government charges, other administrative costs such as telephone and office upkeep, labourer's wages, capital investments, unusual weather events, dates of important meetings, credit repayments, changes in valuation of capital items such as land and livestock categories.
- **Personal expenses,** to ensure the manager and farm family's imputed wages are realistic and that people are living within their means. This should include a valuation of any farm produce used for personal consumption.
- **Multicolumn records.** Books with multicolumn pages help with financial records. Each column can be given a heading which fits the specific situation on the farm. For example, with crops, columns could list for each plot the cost for fertiliser, seeding, spray, labour, water, machinery, harvesting, processing, transport and selling. Wages could be broken down into different farm activities.
- Many farmers keep all relevant records as scraps of paper in a box. Transferring them to a book will save time in the long run.
- Farm costs can be partitioned into variable (herd, shed and feed) and overhead (cash and imputed) as in Chapter 9.

8.1.2 Livestock records to keep

With dairying being such an intensive form of livestock production, keeping track of individual animals is very important. Such information will be essential in preparing realistic budgets for future farm developments, rather than depend on generic estimates of farm performance. Some of the key records to keep include:

- **Calving dates,** to follow through different stages of each cow's lactation and to assess weight for age of young stock. Also to update annual livestock inventory as stock change classification, e.g. from calves to yearlings. They are also useful to identify cows that are due to be mated.
- **Daily milk yields,** for closer animal observations if they suddenly and unexpectedly change.
- **Daily herd milk yield,** to check up on milk payments and to finetune feeding programs.
- **Regular milk composition data,** if provided by the cooperative or processor, to closely monitor the effects of diet.
- **Mastitis treatment** for individual cows and other treatments requiring milk not being sold. The drug withholding period must be followed to ensure milk quality is not compromised.
- **Routine monitoring of feed offered** (forages as well as concentrates) and actually consumed, which can indicate if cows are on heat or subclinically sick.
- **Live weight and body condition of adult cows** to monitor milking performance during the entire lactation and better plan feeding programs.



Figure 8.1 The author showing a farmer how to measure a cow's chest girth to estimate her live weight (Malaysia)

- **Live weight and body condition of young stock**, to monitor feeding management required to achieve growth targets.
- **Dates when each cow is on heat**, to manage artificial insemination (AI) programs as well as predict expected dates of calving.
- **Dates and results of pregnancy diagnoses**, if undertaken, to predict expected calving dates.
- **Animal sickness, veterinary visits and drug treatment**, to follow through animals' responses to treatment. With replacement heifers, it also provides a guide as to whether the heifer's lifetime productivity might be compromised.
- **Routine vaccination and drenching**, to ensure they are timely and to plan future programs.
- **Stock purchases and sales of culls**, to update livestock inventory.
- **Stock deaths and probable causes**, to update livestock inventory and also monitor general herd health.
- **Age when culled** from the milking herd, reason for culling and number of lactations while in milking herd.
- **Milk and concentrate intakes of young calves**, to plan weaning and calculate total rearing costs.
- **Yields of forage crops**, to better utilise fertilisers and plan forage purchases.



Figure 8.2 Scoring body condition is an easy skill to learn (Guizhou province, China)

- **Other dairy enterprise sales**, such as stock fattened for sale, cow manure and any excess forages, for accounting purposes.

8.1.3 Financial records to keep

Data are not knowledge and often are not even information. The conversion of data to information requires a set of principles, concepts, methodologies and formulae that are accepted as standards by the community using the information. Separate balance sheets should be constructed for business and personal applications. The lack of standards in agricultural finance is obvious when looking at the numerous methods to describe a farm's business performance.

Farm transactions can be recorded when they occur or when cash changes hand. The accrual method of accounting (when it occurs) is more useful than the cash method (when money is received or disbursed) because it documents when things were done due to management decisions at the time. For example, when recording sales of milk for a specific time period, all the expenses needed to generate that milk are relevant when calculating the cost of production. The major roles for financial accounts are to assist in farm management rather than satisfy the tax man and other government officials. To use accrual methods, resources must be inventoried regularly.

Every physical item on the farm can be placed into one of five economic categories, namely:

1. **Assets:** what is used to generate income, either owned or purchased on credit. This is a combination of physical and monetary values, with the physical quantity multiplied by a unit price to obtain its monetary value.

2. Liabilities: what you still have on credit.
3. Equity: assets less liabilities.
4. Revenue: what your business generates.
5. Expenses: the costs to your business of generating the revenue.

The range of relevant financial records for smallholder dairy farmers will be covered in future chapters in this book and these are all combined to form the basis of the annual financial accounts presented in Appendix 6, namely:

1. Opening balance sheet: to record all assets and liabilities at the beginning of the financial period (usually 12 months).
2. Closing balance sheet: to record all assets and liabilities at the end of the financial period.
3. Cash flow: to record all cash inflows and outflows into the business.
4. Income statement, also called profit and loss statement, to calculate dairy enterprise profit (or loss) before or after income tax. This shows the 'bottom line' from the year's farming or trading operations.

8.1.4 Recording the data in the farm office

One key aspect of record keeping is where, how and when they are recorded.

Recommendations for setting up a farm office:

First, find an area at home or in the dairy shed that can be dedicated to keeping records. It must have a desk and good lighting. It must be a quiet place to set up the office files (preferably in a filing cabinet) and computer (if the manager has or needs one) and office supplies. The farm manager will need a system of storing and easily accessing all the financial paperwork. These include files relating to farm production (milk yields, veterinary reports, other stock and forage crop production data) and for each of the vendors (feed suppliers, veterinarians, cooperatives etc.), creditors, milk supply centre and any other farm related agents. It is preferable to separate files from the dairy enterprise with those from other farm enterprises and it is important to separate these business files from any personal financial files. A file will need to be kept on unpaid bills. A simple recording system for payment of bills (with details of how they were paid) and receiving receipts from sale of farm produce should be developed.

The how and when of keeping farm records depends on the person recording them. Computers are very convenient but require money to purchase and skills to operate efficiently. As computers can break down, 'hard' (paper) backup copies should be routinely made. Record keeping should be given as high a priority as other farming activities so should not be 'put off' until the last job each day when simple bookkeeping mistakes can more easily be made.

8.2 Describing the farm's physical and financial resources

It is important that description of any farm follows a consistent approach to allow accurate documentation of farm performance for any production or financial analysis. A

suggested series of definitions of farm physical resources and herd performance are presented below.

1. **Location of farm:** state or province and distance from the nearest large town.
2. **Farm area:** farms consist of various components which should be differentiated. These are:
 - a) Total area of the entire farm which includes houses, dairy sheds and other buildings, infrastructure such as laneways and other non-forage production areas, and areas used for other farming enterprises, such as cash cropping or other livestock enterprises.
 - b) Area of dairy enterprise, that part of the farm devoted to dairy production.
 - c) Forage production area, that part of the dairy enterprise devoted to growing forage for milking cows and young stock. Some may be for grazing while other areas are for 'cut and carry'. This is sometimes called the milking area.
 - If the farm grows a variety of forages for the dairy enterprise, this should be included in the farm description.
 - With mixed farms it may be difficult to identify areas specifically devoted to the dairy enterprise. When sourcing fodder from non-dairying areas, then this fodder should be given a monetary value to be 'purchased' from one enterprise to feed dairy stock.
 - Some of this area may be owned outright by the farmer with other areas leased, and this should be included in the farm description.
 - It is likely that all or most of this area is on the home farm, but for a dairy farming area in another location, this should be included in the farm description.
 - It would be useful to describe physical features of the farm, such as topography (hilly or flat) and soil type (if this is known).
 - A farm map overlain by clear plastic is very useful, so annual activities on each area can be recorded and updated.
3. **Livestock:** Throughout this book, dairy cattle have been categorised into five classes, namely:
 - a) Adult cows (milking and dry cows) which have had a calf. This includes first calf heifers, although sometimes it is useful to place them in a different class. These stock are collectively called the milking herd, with other dairy stock (except bulls) categorised as the replacement herd.
 - b) Yearlings (heifers older than 12 months) yet to have a calf.
 - c) Heifers (3–12 months of age).
 - d) Calves (0–3 months of age).
 - e) Bulls (older than 12 months) including steers, used for either breeding or grown out for slaughter.
 - All dairy farms sell stock (cull cows) for slaughter but some dairy stock may be grown out for dairy beef production, such as bulls or steers older than three months of age. In this case, they can be either be considered as dairy stock or as part of a separate beef enterprise.

4. **Water resources:** As water is a major driver of fodder production, some description of the available water would be useful, such as:
 - a) Rainfall, if known, and actual months of the wet and dry seasons,
 - b) Irrigation water, if available from underground sources, rivers or irrigation channels with estimates of how much is used each year.
5. **Labour resources:** For each unit of paid labour, some estimate of weeks worked per year and average hours worked per day would be useful. It would be good to convey some idea of the role of the farming family in dairy activities such as, the farmer and/or his wife spend x hr per week in off-farm employment and the farmer's family spend y hr per week on dairy related activities.
6. **Feed resources:** A brief description of the feeds grown and purchased for the dairy enterprise and approximately what proportion of the annual forage consumed by the dairy stock is actually grown on the farm, with other details such as:
 - a) The types and sources of other forages fed to the dairy stock
 - b) Whether some of the forage area is grazed or the entire area is harvested by hand (or machine) for feeding housed stock
 - c) Whether some of these forages had been conserved as hay or silage
 - d) The types and sources of concentrates (formulated and/or ingredients) fed to dairy stock
 - e) A 'typical' ration formulation for milking cows during the wet season and the dry season.
7. **Other farm resources:** Description of all farm buildings (and their purpose), other fixed assets and farm constructions (such as silage pits and milking equipment), machinery and farm equipment, feed and other consumable resources on hand.
8. **Financial resources:** Current loans (with details of repayment process) plus other current, intermediate and long-term liabilities, cash on hand, investments generating farm income and other current, intermediate and long-term assets.
9. **Milk production:** Total annual milk produced by the farm should be an easily accessible measure. An average annual milk yield per cow is acceptable but average milk produced/cow/day would suffice. It would also be useful to quantify the average lactation length (the number of days milking and number of days dry), as well as some indication of milk composition (total solids, milk fat and solids-not-fat).
10. **Key herd information:** There are a number of useful farm measures to describe herd management. These include average age of first calving, inter-calving interval, number of services per conception (if using AI) and calf mortality (during milk feeding). These will be discussed in later chapters of this book.
11. **Personal information on structure of the farm business:** It would be good to know more about the people involved in the business and how the business is structured. For example, the age of the decision makers in the farm family and their years of experience in dairying, for how many years they have been milking cows on this farm, if the business is a partnership or if there are other investors in the business. Other relevant information would be how the farm got to where it is now and where the farm family want it to be say, in one, five and ten years time. It may or may not include targets for the size of the milking herd, the annual farm milk output, and

even financial targets, such as profit margins, for future years. These are sometimes clarified in ‘the goals and vision for the farm’.

12. **Any previous physical and financial evaluation** of the dairy enterprise would be useful as it provides good background information on the farm and also indicates that the farmer may know what relevant data to collect. Depending on the quality of any historical data collected and its analyses to produce relevant key performance indicators, it could form a useful starting point for an ongoing farm assessment.

8.3 Comparative farm performance or benchmarking

Appraisal of the financial performance of individual farm businesses generally forms the basis for farm management advice. This inevitably involves collecting data on that farm and comparing it with results for similar farms. This procedure is also called benchmarking. The data may be at a whole farm level, for example overall farm profit, or of outputs or costs on that farm, such as milk sales or total labour costs. These comparisons are normally made on a per hectare or per adult cow basis to remove the effects of differences in farm and herd size. Further ratio analysis is often undertaken to compare relationships between farm input and farm output. Deeper analyses can be carried out by comparing the performance of individual enterprises, such as yield, output or direct costs per milking cow.

Traditional comparative analyses of this sort have a number of problems (Cain and Venus 2000). First, the comparison is often made with the average results for a collection of similar farms. This ‘average of the sample’ farm, although broadly similar, may well be different from the target farm. Secondly, the comparative data may require complex recalculations of farm accounts that have been produced for a different purpose, such as taxation rather than farm advice. Thirdly, the interpretation of the data may not take into account all the interactions within the farm, such as season of collection or the proportion of fodder collected off-farm. Other people have queried the role of comparative farm analyses in improving farm performance because you cannot treat the past as a predictor of the future, and farm management is about the future, not the past. As technological change over time moves operations to different cost levels, how can the past predict the future? In addition, benchmarking implies a cause and effect relationship and this may or may not be true. However, if benchmarking encourages farmers to look more critically at their cost structures, it has achieved a major purpose.

It is important to clearly categorise farm type, generally based on herd size or number of milking cows. For such comparative analyses to be valid, they must be restricted to farm units that use similar technology and operate under similar conditions. They should also consider the other enterprises on the farm, in that mixed farmers who only have a small proportion of their on-farm income derived from dairying are likely to place less emphasis on investing in their shed or fodder production area than would farmers who are 100% dairy farmers.

Comparative analyses have a very useful role for single farm comparisons to monitor a single enterprise over time. In that case, they are analysing trends in performance of a particular business which will overcome the major concern about comparative analyses, namely ‘you should only ever be comparing yourself with yourself’.

9

Categorising farm costs and farm revenue

This chapter categorises dairy enterprise costs and returns (or revenue) for ease of monitoring.

The main points in this chapter

- Farm costs can be split into two main types: overhead (or fixed) and variable (or direct) costs.
- Overhead costs are not directly related to the level of production and must be paid regardless of whether anything is produced or not. For the purposes of this book, all labour costs (whether paid or imputed) will be considered as overhead costs.
- Variable costs are directly related to the level of milk produced in the dairy enterprise and include such items as feed (fodder and concentrate), fertiliser, herd and shed costs.
- Farm labour can be supplied either by employed staff or the farm family, who receive no cash payments. Family labour must be costed and it is usually based on the opportunity cost or the cost of employing someone else to undertake the farm tasks.
- Capital investments are not normally included as farm costs, just their depreciation, usually based on the replacement value at the end of their effective working life.
- Personal costs, or household expenses, are either categorised separately from farm costs or included within part of the farm operator's allowance (or imputed salary).
- Dairy enterprise costs on Asian smallholder farms can conveniently be broken down into four categories, two variable (herd and shed and feed) and two overhead (cash and imputed) costs.
- Farm revenues are derived from farm income, sales of capital items and other farm related cash sources.
- Inventories of farm assets record imputed income such as changes in value of live stock.



Figure 9.1 A dairy adviser calculating farm input costs following the interview with the smallholder farmer (North Vietnam)

It is not easy to say precisely how much it costs to own and operate, or even to operate a rented dairy farm. To some extent, dairy enterprise costs and revenue are what the farmer considers they are. Some are obvious and easy to measure, such as cash costs and income, while others are 'hidden' and depend on opinions and assumptions.

Hidden costs include non-cash ones, such as depreciation and opportunity costs. The amount of these hidden costs depends on value judgements made by the farmer. For example, how long is the working life of a piece of machinery and how much would the farmer receive for it if he worked off-farm?

9.1 The costs of farm production

Actual costs of production are the sum of two components:

- Overhead (or fixed) costs which are not directly related to the amount of milk sold by the farmer, as they must be paid whether or not anything is produced. These include land rent, government land taxes, loan repayments and other finance costs, and living expenses
- Variable (or direct) costs which are directly related to the farm's milk output and so to the amount of variable inputs, such as fertilisers, purchased concentrate and forages, and herd costs. Labour costs can be categorised either as overhead or variable, but in this book they will all be considered as overhead costs.

9.1.1 Overhead costs

As overhead costs are there no matter how much milk is produced, they are major components of farm costs for low production farms. However, the more milk the farm produces, the lower the overhead costs per kg of milk produced. Overhead costs can then be diluted by increasing farm output.

The average cost of production highlights the gains that can be made from having a farm large enough to spread the overhead costs and produce each unit more cheaply than is possible with a smaller sized operation. This is called achieving economies of scale. In addition to the inefficiencies arising from being too small, there can also be inefficiencies from being too large. For example, poor farm management can reduce farm output and have a dramatic effect on-farm costs.

With higher total overhead costs per hectare of land, the smallholder farmer (with say eight milking cows and one hectare of forage crop) has to spend more before his costs start to cover the variable inputs such as fertiliser and weed control, which are the important inputs to increase forage yields. Therefore, for the same amount of money spent per ha, the larger farmer (with say 24 milking cows and three hectares of forage crop) is at an advantage with a greater proportion of his investment covering the variable production costs.

Makeham and Malcolm (1986) break overhead costs down to two categories, total and operating:

- Total overheads are those unavoidable costs that have to be met each year. These include essential living costs of the farm family, workers wages, finance costs, rent, replacement of capital items, government taxes, administration costs (e.g. insurance, telephone), running costs of farm vehicles, repairs and maintenance to farm infrastructure.
- Operating overheads are those associated with the annual business operation of the farm. This takes into account the operator allowance (or imputed labour), depreciation, registration of farm vehicles, other business expenses.

Whether there is much to be gained in managing the farm business by this breakdown of overhead costs is debatable.

With mixed farming, the relevant overhead costs should be shared between the different farm enterprises, using some criteria to determine the proportion allocated to the dairy enterprise, for example, the gross cash output generated by each one.

9.1.2 Variable costs

Overhead costs have to be met regardless of whether the farm is producing or not. Farmers have more decision-making choices over variable costs. For example, if things are going badly and the farm is losing money, the farmer might think about whether to continue operating. If he is more than covering variable costs, and therefore is able to meet some of the overhead costs, which reduce the overall loss, he would be better off continuing to operate, at least for a short term. However, if he is not even covering variable costs, he would be better off closing down.

Variable costs are proportional to the level of intensity of each farm activity, whereas within limits, overhead costs hardly change. For example, a well-managed forage crop, producing say 20 t DM/ha/yr, would require higher variable costs (but not necessarily twice as much) as a poorly managed crop only yielding 10 t DM/ha/yr. Identifying the variable costs for a particular farm activity provides the farmer with some indication of how they can change if he expands or contracts this activity.

As a contribution to production costs, variable costs vary a lot less than do overhead ones, but they are not constant because of reduced efficiencies of production. As more and more variable inputs are used, there comes a point when each extra input adds less to output. In other words, it then takes more and more input to produce an extra unit of output, because of the principles of diminishing returns. This is best understood by considering the changing level of farm production and the concept of average and marginal levels and efficiencies of production, as discussed in Chapter 5.

For the smallholder farmer, who is generally operating at the low level of farm performance, the principles of diminishing returns are a lot less relevant than the ability to dilute overhead costs by increasing farm output.

9.1.3 Opportunity and labour costs

The opportunity cost is that incurred when using money to operate the farm. There are other opportunities for using these funds rather than dairy farming. This is particularly important when considering the operating farmer's labour. If there is a real chance for him to do something else with his own labour, rather than manage his dairy farm, or it is likely he would consider doing something else, then he should consider the opportunity cost of using his labour to run his farm. The opportunity cost of his labour would then be the income forgone by not working off the farm or by not using farm labour in some alternative enterprise on the farm. It could also be defined as the cost of employing someone else to do his work on the dairy enterprise.

As many smallholder dairy farmers are also mixed farmers who grow cash crops as well as milk cows, the opportunity cost of labour and variable costs of milk production are very relevant to his decision making. He should cost out each enterprise on his farm, firstly to help decide how big each one should be at this particular time, but of equal importance, to analyse the effect of changing farm returns for his cash crops or his raw milk, on the optimum size of each enterprise. Sensitivity analyses will assist in this decision, and these are discussed in Chapter 15.

As real incomes increase across economies, wage demands by labourers also rise and the dairy sector is forced to assess its opportunity costs and hence its scale of production. Increased labour costs bring about substitution of capital and/or land for labour input on the farm, which typically requires shifts in technology, including higher productivity of stock and feed. Larger herds per labour unit need to produce higher returns and production systems based on family labour are replaced by those employing hired labour. Increases in land values also influence production systems in that extensive grazing systems are replaced by labour intensive systems based on planted fodder, stall feeding and more purchased feed. Low labour costs and high land values are a most

common feature of traditional smallholder dairying and are key reasons for its predominance in developing countries. In fact, with low labour costs, there are few economies of scale in production due to limited incentive or means to invest in scale-dependent technology.

9.1.4 Capital investments

Capital assets are defined as assets that contribute to farm production over at least a medium-term period, of 12 months, for example, such as land, buildings, farm machinery and equipment. Investing in capital assets can be funded through farm profits or loans from credit organisations. These investments occur at irregular intervals and usually add to the productive resources and hence long-term profitability of the farm. They differ from overhead costs which are annual and largely unavoidable farm costs that are a prerequisite to generating farm income. Accordingly, capital costs are not normally included in an annual financial analysis, just the depreciation of those purchased items that are usually replaced at the end of their useful life. As expressed succinctly by Malcolm (pers. comm.), capital is not a cost; depreciation of capital is the cost. Depreciation is generally calculated using the ‘straight line’ approach by assuming that items lose value by the same amount each year. Some capital items such as land can appreciate over time, but unless the land is actually sold, it is only an imputed source of farm revenue.

Livestock would be included within the definition of capital assets, however, they are treated differently in annual farm business analyses. They are considered separately within an annual livestock inventory and stock trading account. The stock inventory takes into account their births and deaths, change from one class of stock to another, such as heifer calves growing into yearlings or from yearlings to milking cows, and of most importance any changes in their value. The stock trading account quantifies the actual sales and purchases of the stock. For most farms, the value of the stock inventory increases each year so it is a source of imputed revenue rather than a cost.

9.1.5 Finance costs

Loans generally require an agreement for them to be repaid over a predetermined period, with additional costs incurred as interest. Repayments of the principal of such loans, being considered as capital costs, are not normally included in annual financial analyses. However, the interest on the borrowed capital investments is part of the overheads as a finance cost, as are other charges from banks or lending agencies. Finance costs also include rent or lease costs on land and other farm capital assets.

9.1.6 Personal expenses

Personal or household expenses include purchased food, clothing, medical, education (school fees, excursions), family travelling/holidays and any other non-farm personal drawings. These can either be categorised separately or included within the farm operator’s allowance. In farm business analyses it is normal practice to include them within the farmer’s imputed labour costs.

9.2 Breaking down costs on smallholder dairy farms

For the purpose of calculating the cost of production (COP) of milk production on smallholder dairy farms in later chapters, farm costs have been broken down in Table 9.1 and Figure 9.3 on pages 110 and 111 into four categories, two variable and two overhead as follows:

1. Variable costs. These are broken down into:
 - Herd and shed costs: to maintain the entire dairy herd and to harvest the milk
 - Feed costs: to feed the milking herd.

The more milk produced and the bigger the dairy herd, the greater these variable costs.

2. **Overhead** costs. These are broken down into:
 - Cash overhead costs which involve actual payments, such as for employed labour and interest on borrowed money, rates and other farm administration costs.
 - Imputed overhead costs, or hidden costs because no cash changes hands. Family labour is the classic example where the farmer and his family work the farm but all too frequently don't pay themselves for their labour. Depreciation of farm equipment is another imputed cost which becomes obvious when the equipment must be replaced.

The question often arises, what is the farm manager worth to the business? The answer is either what he could earn if he spent that time being paid to do other work (that is the opportunity cost of his farm labour), or what it would cost to employ someone else to do his job. With regard to the latter, as it requires more skills to manage a large dairy herd (say 100 cows) than a small one (say 10 cows), the bigger the herd and the more complex the job, the greater should be the manager's operator's allowance or imputed labour costs. This is rarely considered in Asian smallholder dairy farming.

This COP analysis includes finance costs on borrowed money. There are other measures of farm profit, discussed in Chapter 11, that do not take into account such finance costs. It is the choice of the farm adviser as to whether interest on loans is included as a cost of producing milk on Asian smallholder farms. Because they can constitute a major cash outlay each year for smallholder farmers, they should be included in his annual financial commitments and future farm budget projections. Consequently, they have been incorporated into this particular COP analysis. This decision highlights the importance of clearly describing the particular components of any financial analyses so the reader is clear as to exactly what is and what is not included in the final 'bottom line' measure of COP. Unfortunately, this is rarely the case, leaving the reader unsure as to how such data can be interpreted, and importantly, compared with other COP estimates undertaken by other dairy farm management specialists, probably using different methodologies.

Fuel and oil are normally included in the feed costs although some farm economists consider repairs and maintenance of farm machinery as an overhead rather than a variable cost. It doesn't really greatly matter so long as it is only included once.



Figure 9.2 Home-grown grass is usually the cheapest and most nutritional forage source for milking cows (Central Vietnam)

FAO (2008a) recently documented the enormous wastage of milk in some African countries, through loss to spillage or spoilage between the farm and consumer, with losses as high as 20–25%. As these losses occurred outside the farm, they are not relevant to the farmer. However, they do introduce the possibility that not all milk collected from the cows may be accounted for in farm gate sales or consumption by the farm family. For example, it may have been spilt while milking the cows, during the process of being bulked into containers for transport, or even during transportation to the collection centre. In addition, some could have become soured through poor and lengthy on-farm storage, hence rejected prior to transport. If such milk requires farm inputs for production and harvesting, then it should be included as a farm cost, even though it did not generate farm income or nutrients for the farm family. This is rarely, if ever, included in farm financial analyses but should be, when relevant. Milk fed to calves should also be taken into account, although such milk indirectly generates dairy income through calf growth.

Some economists include personal (household) expenses in the farm costing rather than family labour. This does not allow for inclusion of any personal profit in the financial analyses, which is not the same as farm profit.

As dairying is frequently just one of the enterprises on many smallholder farms, it is important to only consider the costs relevant to, and the income generated from, the dairy enterprise. Such apportioning of farm finances is often not easy because labour units, machinery and farm facilities are frequently used for a diversity of farm enterprises. In addition, if feed for any dairy animals (young stock as well as adult cows)

Table 9.1 Categorising farm costs on smallholder dairy farms

Category		Detail
Variable costs	Herd & shed costs	<ol style="list-style-type: none"> 1. Artificial insemination: inseminator, semen, drugs associated with reproductive management 2. Young stock: raw milk or calf milk replacer, concentrates and roughages and herd management to point of calving 3. Animal health: veterinarian visits, drugs, vaccines and drenches 4. Milk harvesting: rubber liners, detergents and sanitisers, maintenance of milking machines, hot water, transport to milk collection centre, cooperative commission
	Feed costs (for milking and dry cows)	<ol style="list-style-type: none"> 1. Purchased concentrates: formulated or ingredients 2. Purchased forages: grass, roughage by-products 3. Home-grown forages: fertilisers, irrigation, processing/storage, weed and pest control 4. Machinery: fuel and oil, repairs and maintenance
Overhead costs	Cash overhead costs	<ol style="list-style-type: none"> 1. Paid labour 2. Finance: interest, bank fees 3. Farm: rates, rent 4. Administration: office equipment, insurance, telephone, other
	Imputed overhead costs	<ol style="list-style-type: none"> 1. Family labour, such as operator's allowance 2. Depreciation

Dairy enterprise costs are presented graphically in Figure 9.3.

is produced from a cropping enterprise on-farm, such as rice straw or maize stover, it should be given a cost to the dairy enterprise.

The total COP is then the sum of all farm costs included in Table 9.1. Unfortunately one still finds published estimates of COP for smallholder dairy operations that do not include family labour and finance costs. These create a false assessment of the true costs of dairy farming, and if used as a basis for government policies for dairy development and even milk prices (as in some countries), they do not paint the true picture of the economics of smallholder dairy farming.

9.2.1 Cost efficiency indicators

Further analyses of farm costs can provide some key performance indicators (KPIs) as to how efficiently the farm is operating. Target values of these KPIs vary with different dairy production systems and countries.

$$\text{Feed cost ratio (\%)} = \frac{\text{Total feed costs}}{\text{Total farm income}} \times 100$$

$$\text{Variable cost ratio (\%)} = \frac{\text{Total variable costs}}{\text{Total farm income}} \times 100$$

$$\text{Overhead cost ratio (\%)} = \frac{\text{Total overhead costs}}{\text{Total farm income}} \times 100$$

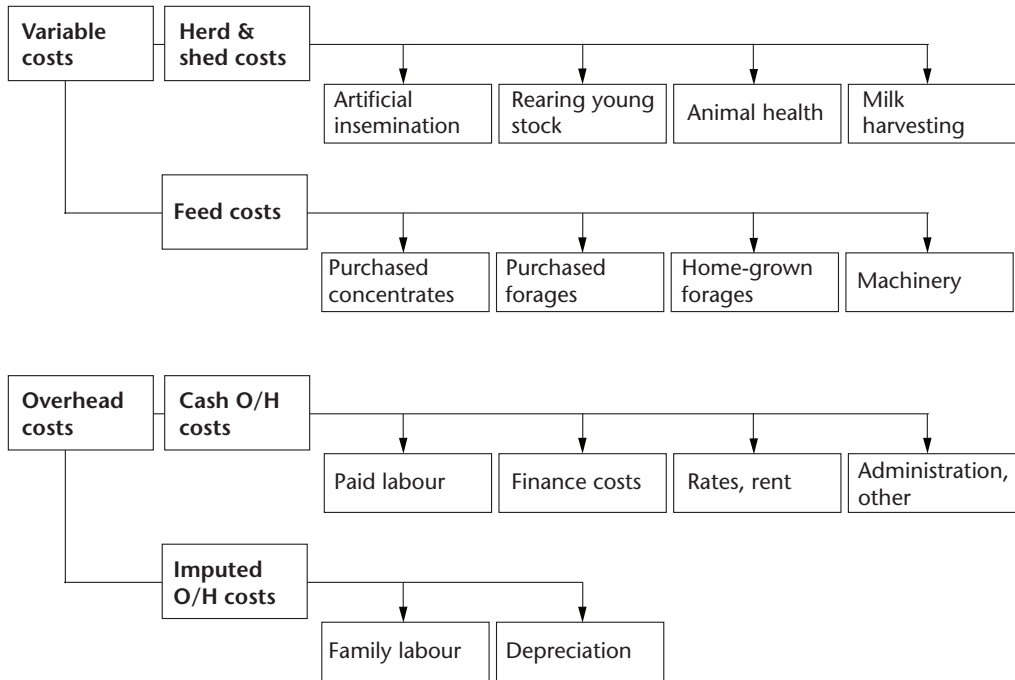


Figure 9.3 Farm costs for smallholder dairy farms

$$\text{Finance cost ratio (\%)} = \frac{\text{Finance costs}}{\text{Total farm income}} \times 100$$

$$\text{Production cost ratio (\%)} = \frac{\text{Total cost of production}}{\text{Total farm income}} \times 100$$

9.3 Increases in farm revenue

Farm revenue comes from three main sources, namely:

1. Farm income, which originates from the sale of produce, the consumption of farm produce by the farm family, non-cash income (such as livestock inventory) and dividends from dairy cooperatives.
2. Sales of capital items, such as land, machinery and other items which are not a normal product of the farm's business.
3. Money from credit organisations or other farm-related organisations, such as banks, lending agencies and dairy cooperatives.

Off-farm employment and household receipts not derived from farming are not classified as farm income. Farm revenue can also be called farm returns, but the former word is preferred because of the frequent use of 'return' as a ratio of farm efficiency (see Chapter 11).

9.3.1 Farm income generated by farm produce

Smallholder farmers generate income from their dairy enterprise in a variety of ways, either as cash or non-cash (that is imputed) income.

Cash income originates from the sale of their enterprise products, such as:

- Raw milk
- Value added dairy products
- Cull cows
- Excess dairy stock, such as bull calves
- Dairy stock specifically grown out for beef
- Manure
- Excess fodder
- Grass cuttings for planting material
- Biogas, from dairy effluent.

Imputed income originates from assets that would generate finance following their sale, such as livestock or land.

Regular monthly records should be kept to ensure accurate recording of sales of farm produce. Aspects of the sale of raw milk are also discussed in Chapter 6.

9.3.2 Imputed income from stock inventories

The value of the dairy herd (adult and young stock) does not remain constant from year to year, but varies depending on changes in stock numbers and the unit value of each category of stock. Stock numbers can vary as a result of purchases, sales, births and deaths. Sales can be due to culling excess, sick or underperforming stock, while some stock sales arise from planned programs such as growing out male dairy beef stock to target live weights or ages. The unit value of stock is usually their cost if they were purchased in the marketplace. It is also possible that stock still owned by the dairy business has been moved off-farm, for example for agistment.

As most of the stock remains on the farm for several years, sometimes many years, their changing value does not generate any cash. In other words, their value is imputed from year to year. As with changing land values, this is a form of indirect income and is an asset to the dairy business. Therefore, it should be taken into account when assessing both the value of, and the income generated from, the dairy enterprise. Such calculations are usually undertaken once each year when business managers review their annual performance and plan future farm activities and development programs.

Stock on a dairy farm can be classified in various ways as in Table 9.2, with each class of stock being given a unit value, usually at the beginning of each financial year, when farm accounts are finalised. A common method of classification on Australian dairy farms is:

- Adult cows (milking and dry cows) which have had a calf. This includes first calf heifers.
- Yearlings (heifers older than 12 months) yet to have a calf.
- Heifers (3–12 months of age).

Table 9.2 Typical livestock schedule for developing a stock inventory

	Number	Value	Total		Number	Value	Total
Opening stock				Sales			
Cows				Cows			
Yearlings				Yearlings			
Heifers				Heifers			
Calves				Calves			
Bulls				Bulls			
Births				Deaths			
Purchases				Closing stock			
Cows				Cows			
Yearlings				Yearlings			
Heifers				Heifers			
Calves				Calves			
Bulls				Bulls			
TOTAL				TOTAL			

- Calves (0–3 months of age).
- Bulls (older than 12 months) including steers, used for either breeding or grown out for slaughter.

This stock inventory comprises two sources of revenue:

- Stock trading account as cash from actual sales and purchases of dairy stock.
- Imputed from changes in value of the entire dairy herd.

On established dairy farms where herd numbers are relatively stable, stock trading accounts can form a large source of farm revenue, as there is a normal turnover of stock, through selling bull calves and cull cows, and using the natural increase of the milking herd to generate replacement heifer calves. However, on newly developing farms, purchasing yearling heifers or adult cows can be a major investment, particularly in countries with government policies of importing high genetic merit dairy heifers from established dairy industries. On smallholder farms, with relatively small annual milk receipts, such large purchase costs can greatly reduce annual cash profits, but this is compensated by a corresponding increase in stock inventory value.

Imputed income can also be generated from changing land assets. However, the land must be owned to be part of the farmer's equity, although any change in area of land farmed, or its unit value, is an asset to the dairy business enterprise. Rented or leased land, although an asset to the farmer, is not part of his equity, so cannot generate imputed revenue.

9.3.3 Farm income from creditors

Creditors or lending agencies make value judgements when deciding to provide loans to farm businesses. They must decide the risk in lending the money and then structure the loan around that risk. It is up to the farm business to present the case in a professional way to maximise the success rate of the application and minimise the costs in sourcing the loan. The relevant documentation is discussed in Chapter 10 with an example set of financial statements presented in Appendix 6.

Interest on loans can vary tremendously and is often expressed in various ways. For example, interest rates can be as low as 5% per annum in some countries or as high as 1.5–2% per month (equivalent to 18–24% per annum) in others.

Having debt is part of operating most businesses. Its effective use is important in the creation of farm wealth over the long term. Ineffective use of debt can pose a significant risk to wealth creation. Business managers need to ask the following key questions:

- Is my level of debt a problem in the long-term survival of my business?
- Can my level of debt be better managed to improve my financial security?
- If so, what are my options to restructure my debts?

The options available depend on the farmer's goal and priorities, whether risk or serviceability are the key issues and what level of risk the farmers and creditor are most comfortable to work with. In general, low risk investments offer low returns, while investments with higher potential returns also come with high risks. The other important issue is the ability of the business to service debt repayments without affecting its requirements for working capital. In other words, debt may threaten the business's profitability and viability if debt servicing means it cannot purchase variable inputs when they are needed.

Farmers should not consider selling off working assets to repay debt, for example milking cows, because this reduces both their equity and the rate at which they can repay the finance costs and eventually the debt.

The ability to repay farm loans can best be answered by preparing two key documents, a balance sheet and a cash flow statement (Dairy Australia 2005). Balance sheets provide guidelines on whether the assets are fully committed as security or there is capacity for additional borrowings. Cash flow statements show the money flowing into and out of the business, to analyse the management of cash. Both are discussed in Chapter 10.

10

The key tools of farm business analyses

This chapter explains the benefits of accurately documenting farm assets and liabilities, as well as farm costs and income, to monitor the business performance of the dairy enterprise and plan for future growth.

The main points in this chapter

- The four key tools of farm business analyses are:
 1. Balance sheets: to provide listings of the enterprise's assets and liabilities.
 2. Cash flow records: to indicate the flow of funds into and out of the business.
 3. Income statements: to convert cash flow to business earnings.
 4. Budgets: to organise information about the enterprise.
- Key data from these documents provide important insights into the business health of the dairy enterprise.
- Keeping financial records up-to-date provides early warning signs of impending financial difficulties.

The written documents of farm business analyses are the basic tools of decision making on dairy farms of any size and production system. Not only do they present farm finances in a logical and ordered way, these documents provide the essentials with which to monitor the business health of the dairy enterprise and to develop budgets to plan future farm development.

The tools of farm business management are:

- Balance sheets: to provide listings of the enterprise's assets and liabilities.
- Cash flow records: to indicate and project the flow of funds into and out of the business.
- Income statements or profit and loss statements: to convert cash flow into business earnings for the period of consideration, usually 12 months.
- Budgets: for planning future farm developments.

Analyses of these documents help determine the financial health of the business and the selection of the most appropriate changes in operations or organisational structure.

10.1 Balance sheets

Balance sheets assist in calculating growth in net worth of the business by calculating the change in assets less the change in liabilities. They represent the financial foundation on which the business is built and are simply a list of assets owned and debts owed, at a given time, with monetary values attached. They are then:

- Basic building blocks for financial analysis
- Pictures in time, usually at the end of the business financial year
- Indicators of the business's ability to handle risk
- The net result of past decisions
- Very important ways to track and monitor financial progress
- The first step in analysing the debt position of the business.

The term 'balance sheet' implies some sort of balance as part of the document. That balance represents the relationship between assets on one side, and liabilities on the other, and the basic accounting principle that assets always equal liabilities plus equity. Consolidated balance sheets reflect business and personal affairs, while personal balance



Figure 10.1 A proud farmer shows off his best cow (Sri Lanka)



10.2 Many smallholder farmers source forage from around cropping areas (Central Java, Indonesia)

sheets are limited to personal assets and liabilities. This book deals specifically with business balance sheets. The key items for inclusion in balance sheets are presented in Appendix 6.

10.1.1 Assets

Assets are those parts of the business that are owned or controlled. As well as any property owned by a person or business, they include cash, land, buildings, livestock, farm equipment and dairy-related shares. Details and terms commonly used when listing assets:

- Their value is measured at the end of two consecutive financial years.
- The main items of change are stock numbers, area of land owned, bank account balances and loans owed.
- *Current debt owed or current liabilities*: debtors paid during the year or yet to be paid even though their goods and services have been delivered.
- *Produce and materials on hand*: an inventory of goods, such as concentrates, forages and other farm materials should be undertaken.
- *Current assets* are those that can be easily realised, that is, converted to cash within 12 months, and may include cash, accounts received and money due within one year, short-term investments, inventories and pre-paid expenses. Inventory items (feed, fertiliser fuel) and livestock raised for sale are also current assets.
- *Intermediate assets* are those that can impact on the business after one year but within 10 years. This category includes assets used to produce income, such as breeding livestock, retirement accounts and longer-term securities. They also include plant

and equipment such as fixed farm machinery (milking machines, vats, forage and other feed-processing machinery), tractors, farm vehicles, motorbikes and also any equipment with a reasonable asset value, such as cultivation and spray equipment. These values are also used to calculate depreciation.

- *Long-term assets* are primarily land and improvements and their definition may depend on the term of any associated loan.
- *Non-farm assets*: if they are used in part for the farm business, a portion of their value should be included.

10.1.2 Liabilities

These are a measure of debt carried by the business at a given point in time. They include all short- and long-term loans, finance, lease and hire purchase debt balances, overdraft balances and trade creditors. They can be grouped either as secured or unsecured liabilities. Those secured are backed by other assets owned by the borrower, while unsecured loans do not have this backing, hence are higher risk to the lender and often attract higher interest rates and fees. Like assets, they can be categorised as current, intermediate or long-term using similar time-related definitions.

When listing such debts, principal repayments in any budget should be matched with reductions in liabilities between years. It is important to discriminate between these on-farm and other non-farm liabilities, such as property loans and hire purchase loans not related to the farm, car loans and credit card balances.

Working capital quantifies the amount of money readily available to operate the business, being what is available after meeting debts. This indicates the ability of the business to meet cash obligations as they come due without having to borrow money or cash in some of its medium and long-term capital. It is then a measure of liquidity or the ability to borrow further money. As a rough guide, it should be close to expected net farm income otherwise there may be insufficient investment in the farm.

$$\text{Working capital} = (\text{Current assets}) - (\text{Current liabilities})$$

10.1.3 Equity or net worth

Calculation of equity, or the owner's share of the farm assets, is one of the key functions of balance sheets. As equity (which is sometimes called net worth) is the difference between what you own and what you owe, it is the difference between total assets and total liabilities. If the equity is positive, the business is solvent.

Equity (and net worth) are expressed in monetary terms while equity can also be expressed as a percentage as follows:

$$\text{Net worth} = (\text{Assets}) - (\text{Liabilities}), \text{ in local currency units}$$

$$\text{Equity (\%)} = \frac{\text{Assets} - \text{Liabilities}}{\text{Assets}} \times 100$$

Some creditors use equity on property as a guide to how much liability (or mortgage) debtors can secure against the value of their land.

$$\text{Equity on property (\%)} = \frac{\text{Assets} - \text{Liabilities}}{\text{Value of land and buildings}} \times 100$$

10.1.4 Ratios to describe credit risk

There are various ways that debt and equity can be used to describe the risk that creditors face when lending money to a farm business.

The leverage ratio is a good measure of solvency as it measures the extent to which the creditors have financed the business compared to the owners. The greater the proportion of financing provided by the creditors, the higher the value of the ratio, which increases more rapidly as debt increases. If this ratio exceeds 100%, it means that the creditors have financed more of the business than the owner.

$$\text{Leverage ratio (\%)} = \frac{\text{Liabilities}}{\text{Equity}} \times 100$$

The debt to asset ratio measures the degree to which farm assets are financed by debt and is a second measure of solvency. It is sometimes called the net capital ratio and is a good way of expressing risk exposure of the farm business.

$$\text{Debt to asset ratio (\%)} = \frac{\text{Assets}}{\text{Liabilities}} \times 100$$

The debt structure ratio quantifies the ability of the business to meet its current liabilities:

$$\text{Debt structure ratio (\%)} = \frac{\text{Current assets}}{\text{Total liabilities}} \times 100$$

The current ratio measures the current assets as a proportion of the current liabilities. This provides a guide to the overall financial management of the business, because a very low current ratio could indicate poor liquidity whereas a large current ratio may indicate poor management of working capital.

$$\text{Current ratio (\%)} = \frac{\text{Current assets}}{\text{Current liabilities}} \times 100$$

Because cows are the major income generators in a dairy enterprise, debt per cow is frequently used by creditors as a measure of risk or the ability of the debtor to repay the loan.

$$\text{Debt per cow} = \frac{\text{Total liabilities, in local currency units}}{\text{Herd size}}$$

10.2 Cash flow records

Analyses of cash flow are based on transactions in which cash is transferred. They provide an opportunity to examine cash inflows and outflows from the farm business. They are useful when:

- Monitoring cash flows into and out of the farm on a monthly, quarterly or annual basis
- Borrowing money
- Estimating the time required to pay off the capital invested in a farm change
- Examining decisions on financial management and repayments, such as when the peak debt occurs, if sufficient funds are available, when the net cash flow will become positive, when the loan can be paid off.

In cash flow analyses, all cash income and expenses are included. Income includes sales of farm produce and capital items, non-farm income and personal income. Expenses include farm expenses, personal expenses, capital expenses, such as machinery purchases, tax charges and returns, interest charges and loan repayments. Non-cash items such as depreciation or non-paid family labour are not included. The key items for a cash flow statement are presented in Appendix 6.

Cash flow statements are historic records from previous months while cash flow budgets are projections into the future. It is useful to prepare cash flow statements from the same months in previous years to more accurately develop budgets, because some expenditure, such as rates or insurance, occur at the same time each year, so the statement can serve as a prompt to the types of expenses likely to occur during the ensuing year. Preparing overoptimistic budgets to impress creditors is unrealistic and pointless.

Because of the seasonal nature of farming, balance statements and budgets should be completed on a monthly basis because they provide valuable business information such as:

- Total income projection each month
- Total expenditure each month
- Surplus or deficit each month
- Regular bank balances
- Comparing predicted against actual income and expenditure
- Predicting the time of peak cash deficit so it can be accommodated within future bank overdrafts.

Cash flows also quantify the surplus or deficit each year to provide each farmer with his unique debt management policy. Predicting the size of the surplus will assist in planning for future:

- Debt servicing
- Income tax
- Capital investment, including new equipment and farm development
- Personal expenses.

The net cash surplus is the spare cash remaining after paying for these four items. It provides a margin to cover future downturns in the industry and can be used to spread risk by diversification of investments. It can also be used for extra on-farm investments

in ‘good’ years that will allow for less on-farm investment in ‘not so good’ years, such as building up stores of fertilisers, feed or other consumable items.

Cash flow says nothing about the profitability of the business; that is only available from the income or profit and loss statements (see below). Cash flow includes no consideration of inventory change, accounts payable or receivable or depreciation. The absence of the important adjustments means that profitability decisions based on cash flow will be grossly misleading.

Caution must be exercised when using cash flow to evaluate the health of a farm business. Cash flow can only indicate if current returns will pay current expenses, debt, family living and other current obligations included in the cash flow document. An analysis of business health should include a review of the balance sheet and income statement, as well as the cash flow.

A farm cash flow analysis can be divided into five broad areas:

1. Income: from all sources, but not to include any off-farm income unless it is directly related to the farm business
2. Operating activities: cash production costs such as herd, shed and feed costs
3. Financing activities: debt servicing such as interest payments and lease costs
4. Investment activities: cash investments on-farm in the form of capital (stock purchase, machinery and improvements) and/or off-farm investment
5. Personal expenses.

Cash is the lifeblood of any farm business, hence careful management of cash flow is critical to its survival. In a ‘perfect world’, cash flows would be predictable, but in reality and especially in farming, they rarely are. Therefore cash flow budgeting should involve sensitivity analyses in which the impact of the key profit drivers can be assessed. Sensitivity analyses can be used to predict changes in cash flow and net cash surplus when economic or seasonal conditions change for the better or worse, and so provide a business risk profile. They involve predicting cash inflows and outflows, hence balances as key variables change. For example, predictions could be made for changes in cash flows when milk prices or feed prices increase or decrease by say, 10 or 20% or when bank interest rates increase by say, 1 or 2% units. Sensitivity analyses are discussed along with farm budgets in Chapter 15.

10.2.1 Cash operating surplus

The cash operating surplus (COS) is the difference between farm cash income and working expenses. It does not include any imputed income or costs or any debt payments, tax expenses, capital purchases or personal drawings. COS can be expressed in monetary terms or as a percentage of farm income.

$\text{COS} = (\text{farm cash income}) - (\text{farm cash costs}), \text{ in local currency units}$

$$\text{COS} (\%) = \frac{\text{COS}}{\text{Farm cash income}} \times 100$$

10.3 Income statements

The income statement is the only tool of farm business analyses that measures profitability. Budgets, the balance sheet and cash flow projections are essential management tools, but do not indicate if the business is profitable. Income statements are also called profit and loss statements.

The income statement measures business earnings resulting from business operations as opposed to business ownership. While appreciation in value of the business may increase its net worth, that source of funds is only available if the business is liquidated. In contrast, the earnings reflected on the income statement are the result of operations which may be used for current expenditures or as an addition to the farmer's equity (Jenkins 2008).

Most income statements are computed annually which is consistent with the production cycle for livestock and crop enterprises and with calendar (or financial year) record keeping and tax filing obligations. This approach permits comparison of farm profitability from one year to the next.

There are three major sections of the income statement, namely receipts, expenses and adjustments. The adjustments are necessary to convert cash flow to annual earnings by including inventory change, accounts payable and receivable and depreciation. Key items for inclusion in an income statement are presented in Appendix 6, which includes a full description of the relevant adjustments.

- Gross farm operating receipts. These include cash receipts from sale of farm produce, government payments and other sources of cash.
- Gross farm operating expenses. These include outlays for seed, fertilisers, chemicals, machine hire, feed, veterinary bills, interest and other cash operating costs. These do not include finance costs to service loans.
- Adjustments. These affect farm earnings but are not reflected in cash transactions. They include (1) value of farm products consumed by the farm family (to accurately reflect total farm production), (2) changes in the farm inventory (such as feed and fertilisers reserves, livestock and land and improvements), (3) changes in accounts payable and receivable (to accurately reflect the annual farm finances) and (4) depreciation. The adjustments are calculated by summing the first three items then subtracting the fourth item.

10.3.1 Key measures from income statements

Gross farm income (GFI) is the sum of the cash generated from the sale of farm produce and the changes in inventories (stock and land), whereas net farm income (NFI) takes into account farm operating costs.

Gross farm income = (farm cash income) + (adjustments), in local currency units

$$\begin{aligned} \text{Net cash farm operating income} &= (\text{gross farm operating receipts}) \\ &\quad - (\text{gross farm operating expenses}) \end{aligned}$$

$$\begin{aligned} \text{Net farm income} &= (\text{gross farm operating receipts}) - (\text{gross farm operating expenses}) \\ &\quad + (\text{adjustments}) \end{aligned}$$

NFI is the ‘bottom line’ of the farm business and represents return to unpaid farm family (imputed) labour, equity capital and management. Over the long term, net farm income is the amount available for discretionary use by the family and for business development. If a withdrawal for family living is made, then this represents the amount available for business expansion and risk taking.

The finance cost ratio measures the ability of the farm to repay the total finance costs (interest and lease costs but not principal repayments). The lower this ratio, the less the business will be adversely affected by interest rate rises. Businesses with higher COS (as a percentage of farm income) can commit a greater proportion of their income to servicing loans.

$$\text{Finance cost ratio (\%)} = \frac{\text{Finance costs}}{\text{Gross farm income}} \times 100$$

The total debt servicing ratio includes any principal repayments in servicing of the loan.

$$\text{Total debt servicing ratio (\%)} = \frac{\text{Finance costs} + \text{principal repayment}}{\text{Gross farm income}} \times 100$$

The operating ratio and margin can be used to evaluate NFI. The operating margin represents the share of income available to cover family living, business fixed obligations and business expansion.

$$\text{Operating ratio (\%)} = \frac{\text{Total operating expense}}{\text{Gross farm income}} \times 100$$

$$\text{Operating margin (\%)} = \frac{(\text{Gross farm income}) - (\text{Gross farm operating expenses})}{\text{Gross farm income}} \times 100$$

Rate of return on total capital is a third analysis variable computed by making minor adjustments to NFI.

$$\text{Rate of return on capital (\%)} = \frac{\text{NFI} + \text{interest paid} - \text{operator labour}}{\text{Average capital investment}} \times 100$$

This can be compared with off-farm securities such as shares, property or other investments. However, it is a valid comparison only if the farm business is liquidated to realise appreciation of land, stock and other long-term assets. Comparisons with similar farms must be undertaken with caution because it is essential that such operations have similar livestock (and crop) programs, using similar technology and located in similar climatic and soil areas.

10.3.2 Anticipating problems by interpreting farm business data

There are certain finance signals that provide early warning of impending financial difficulties. Keeping up-to-date financial records allows them to be identified early and addressed quickly. These include:

1. Increasing ‘Accounts payable’ or inability to pay bills on time. Lack of sufficient funds for payment of bills for feed, fertilisers and fuel may indicate more severe problems in the not too distant future.

2. Shortage of working capital, difference between current assets and current liabilities, could lead to problems in obtaining short-term credit.
3. Failure of earning (that is NFI) to grow from one year to the next is another early warning sign of potential difficulty. The manager should also establish if the earnings result in a positive cash flow or if the deficiency is such that existing income will not pay operating costs, family living, debt repayments and fixed obligations such as tax.

The income statement is the focal document in considering problems with earnings. It is the only financial tool that provides information about business profitability. NFI and return to capital are two key derived variables that should be reviewed. Once the scope of the problem has been established, it should be addressed. For example, is it due to temporary or permanent influences? Temporary influences include low yields (due to weather, insects, disease), prices fluctuations or inventory changes. Permanent influences relate to basic management decisions, which can be caused by organisational or operation problems.

Organisational problems involve the way resources (land, labour, capital) are used and may require a redistribution of farm resources or even of on-farm enterprises. Operational problems relate to day-to-day decisions, such as when tasks are completed, how technology is used and the amount of variable input to be applied to fixed resources. The three basic principles required to address any identified operational problems are:

1. Do a better job than what is now being done by improving efficiencies and management to increase earnings per unit through increasing yields, improving marketing or reducing costs of production.
2. Do more (or less) than what is now being done by reallocating resources.
3. Liquidate the enterprise and redirect the use of resources. This is a drastic and usually stressful change which may involve a complete reorganisation of the business assets and liabilities.

Severe financial problems have no easy solutions and are usually related to financial difficulties rather than management of production. Some possible solutions include:

- Increasing income without incurring added expenses. The magnitude of debt on some farms makes this less feasible, but it is possible through substituting paid labour with family labour and/or seeking off-farm income to reduce debt.
- Maintaining a good working capital position. This can be accomplished by restructuring debt, say to maintain a better balance of short-term and long-term debt, although this may not be easy with very low working capital.
- Refinancing. However, initially, the underlying production management or financial management problems must be found and corrected. Some creditors view refinancing as the first step towards business liquidation.
- Obtaining lower interest rates. This may be possible but unlikely.
- Selling unproductive assets, such as waste land or underutilised machinery, which will reduce debt without reducing income.

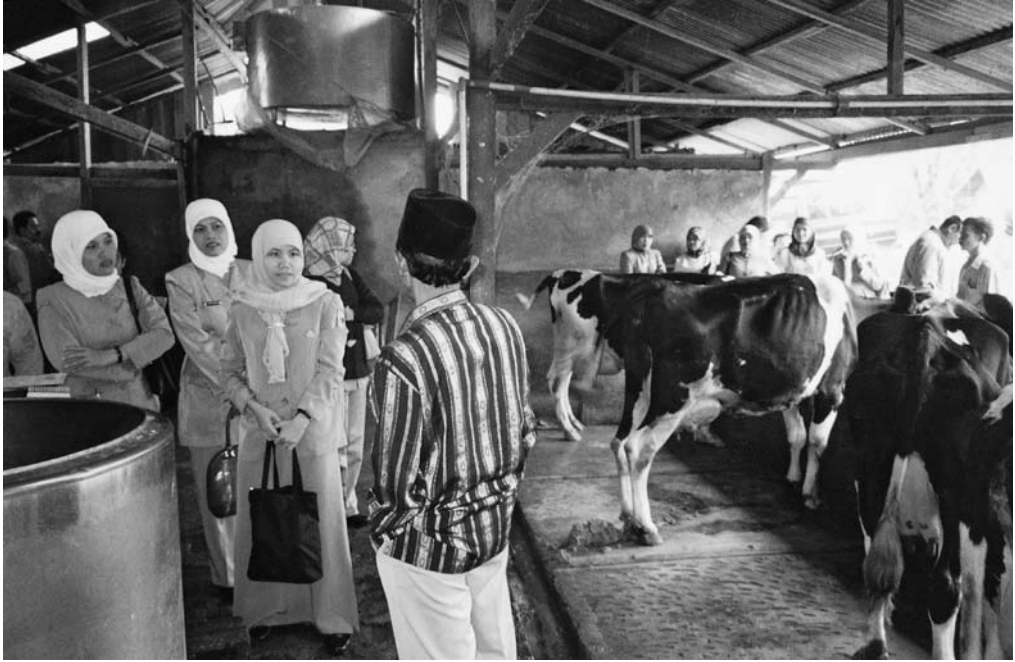


Figure 10.3 Advisers at a dairy production course in Sumatra, Indonesia

- Selling productive assets to reduce the size of the business, which can reduce interest and principal repayments. However, scaling back can create new problems, such as matching large machinery with a small operation. With a partial liquidation of business assets, it is crucial that expenses are reduced more than income.

The fourth major tool of farm business analyses, namely budgets (for planning future farm developments) is discussed in Chapter 15.

Measures of farm profit

This chapter introduces three different measures of farm profit and presents ratios to assess business health.

The main points in this chapter

Profit can be expressed in three ways: cash, efficiency and wealth creation.

- Does the farm generate enough cash to pay the bills, repay the loans and reward the farmer for his work? This is quantified using cash operating surplus and milk gross margin?
- How efficiently are the farm resources being used, both the total farm assets and what the farmer actually owns? This is quantified using return on assets and return on equity?
- Does the farmer own more this year than he did last year? This is quantified by using change in net worth?
- By understanding the major influences on farm profit, greater attention can be paid to them. These are both external (largely outside the farmer's control) and internal (under the farmer's control).
- Business health can be assessed using a set of four financial ratios, which monitor liquidity, solvency, profitability and efficiency of business performance.
- Two examples of computer software to quantify farm profits are presented, both of which are available, at no cost, from the author.

In order to improve profit, it must first be measured. Most farmers think of profit in terms of cash or money left over from income after deducting all the costs involved in earning that income. In other words, to them profit generally refers to some surplus of income over costs, or in economic terms, the difference between the gross income and the operating costs. This may be the simplest measure of profit, but it is not necessarily the best. Profit can be expressed in three ways.

1. Cash. Does the farm generate enough cash to pay the bills, repay the loans and reward the farmer for his work? This can be expressed by a range of indicators such

as cash operating surplus, milk income less feed costs, milk gross margin or economic farm surplus.

2. Efficiency. How efficiently are the farm resources being used? For a general overview of the business performance, this is expressed as return on assets, while for a more detailed assessment of what the farmer actually owns (namely his equity), a more suitable measure is return on equity.
3. Wealth creation. Does the farmer own more than he did last year? This is expressed as capital gains or more suitably as the difference between the two years' equity.

11.1 Quantifying cash and non-cash profit

The simplest measure of cash profit is cash operating surplus (COS) which quantifies the sum of all the cash flows on the farm.

$$\text{COS} = (\text{farm cash income}) - (\text{farm cash costs})$$

Milk income less feed costs (MIFC) is a useful measure of cash profit because it is relatively easy to measure and provides a guide to how well the cows are being fed. It does not take into account the costs of feeding the non-productive stock on the farm, namely the dry cows and replacement heifers.

$$\text{MIFC} = (\text{milk income}) - (\text{feed costs for milking cows})$$

Another way to quantify cash profit on dairy farms is to use the milk gross margin (MGM). This calculates the income from milk sales less the variable costs to produce that milk.

$$\text{MGM} = (\text{milk income}) - (\text{variable costs})$$

The most sophisticated methods to quantify farm profit, uses non cash farm income (changes in stock and land values) to calculate gross farm income (GFI) first, and then non cash farm costs (imputed labour and depreciation) to calculate net farm income (NFI).

$$\text{GFI} = (\text{Total farm cash income}) + (\text{changes in stock inventory})$$

$$\text{NFI} = \text{GFI} - (\text{variable} + \text{overhead cash costs} \{\text{excluding finance costs}\} + \text{imputed costs})$$

Net farm income is also known as economic farm surplus (EFS) or operating profit. Operating profit does not include finance costs because these are the cost of acquiring the services of the assets used, and are not directly related to their performance. Earnings Before Interest and Tax (EBIT) is sometimes used as a measure of NFI, this being a relatively new term in farm management economics, and is defined as farm revenue less farm expenses before the payment of interest on loans and income tax.

There are three different descriptions of profit which require some explanation. Operating profit describes the return to all capital, and by removing finance costs it

becomes the return to the farmer's equity, so quantifies his net profit. Finally, subtracting his income tax from the net profit quantifies his growth in equity or addition to wealth.

Break-even milk price is another way of expressing farm profit. It is the indicative milk price required to cover the cash costs of production, but not principal repayments and any capital expenditure. It also excludes other farm income, just dealing with milk production. When compared to the farm gate milk price received, the difference provides a measure of the profit or loss incurred by the farmer on a per kg milk basis.

11.2 Quantifying change in farm efficiency

The term 'capital' refers to all the farmer's production resources. The most important are land, buildings, improvements (such as built-up soil fertility and irrigation), machinery, stock, fuel, labour management skills and credit. Many of these could be converted to cash by selling them. The cash sum available from their sale is the farm assets. After paying off any debts owed on the farm, they are the farmer's own capital, his net worth or his equity. Total assets are a good measure to compare the business performance of that farm with others of similar size of operation, however, a more meaningful measure for that farmer relates to his total equity in the farm.

The market value of the total resources on the farm is sometimes known as the total capital of the farm. This is calculated by summing the market value of the land, improvements and animals, plus the machinery and feed reserves. With the numerator net farm income, return on assets (ROA) is calculated as follows:



Figure 11.1 Good quality forage in a well-designed shed: the essence of profitable smallholder dairy farming (Sabah, Malaysia)

$$\text{ROA (\%)} = \frac{\text{Net farm income}}{\text{Assets}} \times 100$$

This calculation takes no account of debts owed so quantifies the earning rate of the total bundle of resources employed in the business. In practice, the farmer has to manipulate the total resources under his control, not just those which are debt free. ROA provides a guide to those responsible for the use of capital (this could be an individual, a cooperative or a government department). It also allows the performance of this capital, invested as it is, to be compared with alternative possible investments.

As the farmer probably does not own all the farm assets, he is more interested in how efficiently he is using his own assets. The farmer's equity is calculated by adding the market value of all the resources he owns, then subtracting it from a total of all the money he owes (his liabilities). Equity, expressed in monetary terms, quantifies the net worth of the farmer. However, it is usually expressed as a percentage, calculated as follows:

$$\text{Equity (\%)} = \frac{\text{Assets} - \text{Liabilities}}{\text{Assets}} \times 100$$

Expressing the farm's annual profit, after paying interest and taxes, as a percentage of this capital, is one measure of the effectiveness of the management of the farm's resources. As the calculation does not take into account any debts, it must also exclude the finance costs associated with these debts. The return on equity (ROE) is then calculated as follows:

$$\text{ROE (\%)} = \frac{\text{Net farm income} - \text{finance costs}}{\text{Resources owned}} \times 100$$

The ROE measures the farmer's effectiveness as a combination of annual inputs such as labour, irrigation, fertilisers, machinery and other resources used to operate his dairy enterprise. It also quantifies the rate of earning of his capital committed to his farm relative to the rate of earning if it were used in some other income generating enterprise.

Calculating his ROE shows the farmer how efficiently he is running the annual operations of his farm business. If it is very low, the farmer should consider alternatives by asking the questions:

- Can he increase his ROE by using better farming methods, borrowing extra money to improve production or diversifying my farm enterprises?
- Should he transfer his capital from this farm and move to a different locality where it is likely to be higher?
- Should he sell up and move into another form of investment?
- Is his ROE low because there has been a large increase in value of his assets?
- Should he use his increased equity to borrow more money to further develop his farm and earn more income?

The more rapid the annual increase in asset worth, the more difficult it is to maintain a constant ROE. An increase in asset value provides more collateral against which to borrow to invest in the operation to increase farm income. It can also mean an increase in land tax, hence greater farm costs.

A useful measure of farm efficiency is asset turnover (also known as financial efficiency) which quantifies how well the farm assets are being used to generate farm income.

$$\text{Asset turnover (\%)} = \frac{\text{Gross farm income}}{\text{Assets}} \times 100$$

Another useful measure of farm efficiency is profit margin which is NFI expressed as a percentage of total farm income. This quantifies the proportion of farm income kept as operating profit, or the amount of profit generated in each dollar (or local currency unit) of revenue.

$$\text{Profit margin (\%)} = \frac{\text{Net farm income}}{\text{Gross farm income}} \times 100$$

Gearing is another term describing business risk, and measures the ratio of debt to equity that makes up total capital. If other people's money costs less than the rate at which money grows in the business, then borrowing is a good business decision. The benefit of gearing is that the owner's capital can grow faster than would be the case if he relied solely on his own resources. However, this does not take into account the principle of business risk. If the farm makes an operating loss instead of a profit, the farmer's net worth will decline. The likelihood of business risk grows with farm debt because the chance of losses increase. Accordingly, lenders generally charge higher interest rates, which could further increase the size of any losses should they occur. This is very relevant with farming because of the variability of the seasons in different years. Expressing it simply, a heavily geared investment grows faster, if 'things go well' but if 'things go badly', it loses value faster.

The leverage (or gearing) ratio then describes the extent to which equity has been multiplied by the use of debt. A highly levered (geared) business offers higher returns when it is performing well but will also increase losses when it is performing poorly, when carrying a greater financial risk.

$$\text{Leverage ratio (\%)} = \frac{\text{Liabilities}}{\text{Equity}} \times 100$$

The solvency ratio describes the degree of debt per unit of assets. The higher the value, the greater the degree of business risk. The inverse of this ratio, the debt to asset ratio, can also be used to describe business risk.

$$\text{Solvency ratio (\%)} = \frac{\text{Liabilities}}{\text{Assets}} \times 100$$

$$\text{Debt to asset ratio (\%)} = \frac{\text{Assets}}{\text{Liabilities}} \times 100$$

Other measures are available to assess the relative risk of the dairy enterprise. The interest cover quantifies the ability of the farm to repay interest bills (but not any principal repayments).

$$\text{Interest cover (\%)} = \frac{\text{Finance cost}}{\text{Net farm income}} \times 100$$

The debt to income ratio quantifies the ability of the farm to repay both interest and principal.

$$\text{Debt to income ratio (\%)} = \frac{\text{Total liabilities}}{\text{Gross farm income}} \times 100$$

Calculations for mixed farming

Because dairying is frequently just one of the enterprises on many smallholder farms, it is important to only consider the costs relevant to, and the income generated from, the dairy enterprise. Such partitioning of farm finances is often not easy because labour units, machinery and farm facilities are frequently used for a diversity of farm enterprises. In addition, if feed for any dairy animals (young stock as well as adult cows) is produced from another enterprise on-farm, such as rice straw or maize stover, it should be given a cost to the dairy enterprise.

11.3 Quantifying wealth creation

Increase in the capital value can occur simply from a rise in market value of the land. It may also increase by well chosen investments on-farm, such as developing an irrigation system or purchasing high genetic merit breeding heifers. It is calculated by deducting the cost of capital investments made from the total increase in value of the assets over a given period, usually 12 months. There is no direct cause and effect relationship between capital investment and capital gain. For example, an expenditure of \$1000 on renovating a farm building does not necessarily mean that the value of the farm will rise by \$1000, as they may not suit the plans of a prospective buyer, hence be valued by them at much less.

Since farm assets can be owned outright by the farmer, or a proportion of it is still owned by the lending agency, capital gain is usually expressed as change in equity (or net worth).

$$\begin{aligned} \text{Change in net worth} &= (\text{equity value of farm assets in Yr 2}) \\ &\quad - (\text{equity value of farm assets in Yr 1}) \end{aligned}$$

This could be considered as the ‘ultimate’ measure of farm profit because business wealth can usually be added to personal profit to create personal (and family) wealth, one of our major motivators to ‘go to work’ each day. Figure 11.2 presents a flow chart of the various measures of profit discussed in this chapter.

Livestock as capital investment

Livestock are capital assets, namely something that has been produced but has not yet been used up. It should produce a return, in terms of increased income, or welfare, in the future. Livestock fit this definition because they have been produced and should yield returns directly in the form of meat, milk and hides/skins, and indirectly through manure or draught power used in raising income from crops.

Investment is the acquisition of capital assets. It necessitates saving, or forgoing current consumption. The consumption forgone may be agricultural produce, such as eggs from poultry, or stock retained for breeding. The money used to purchase stock or

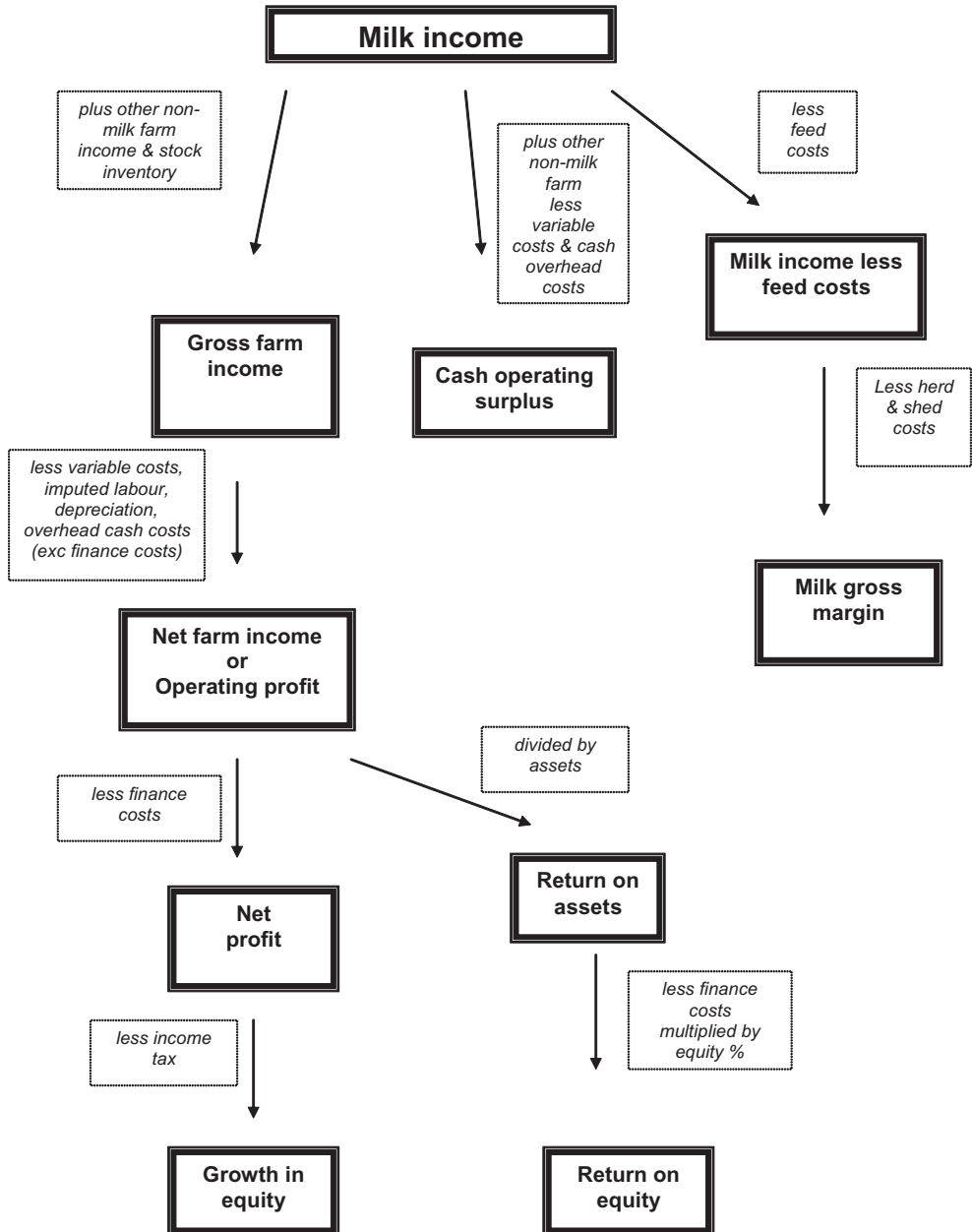


Figure 11.2 Flow chart of measures of farm profit on smallholder dairy farms

equipment might otherwise have been used to buy food or other consumed goods. If the asset is acquired on credit, then someone else has done the saving and may require ‘interest’ to be paid on the loan.

Investments in livestock have very low transaction costs, once the first breeding female has been acquired, and mated, since herd growth follows from reproduction.



Figure 11.3 A well-grown heifer (standing), 2 years and 4 months old, in calf, on a very profitable smallholder farm in North Vietnam.

11.4 Drivers of profit

By knowing the major influences on farm profit, greater attention could be given to these. These are called the key profit drivers. With greater knowledge about how they operate, it is even possible to create computer models to assess their relative importance.

There are external profit drivers over which the farmer has minimal influence:

- Milk price, although milk quality and composition has an influence.
- Interest rates for farm loans, although these could be reduced with higher equity.
- Price of purchased feed, both concentrates and forages.
- Price of stock, such as replacement cows.
- Cost of labour, both paid and imputed.

The following farm activities are considered operational and contribute to profit through improved management which increases output per unit input. These are called the internal profit drivers:

- Cows, through increased milk yield per cow.
- Feeding (home-grown and purchased feed) by increasing milk income above feed costs.
- Reproduction, through increased calves born per cow bred or reduced inseminations per conception.
- Health, through reduced veterinary costs per heifer reared or cow milked.
- Longevity of milking cows, which increases the number of lactations or reduces culling rate.



Figure 11.4 Good farm records help plan farm management in South Vietnam. On this farm they use a reproductive ‘wheel’ to monitor the expected dates of cow calvings.

- Replacement heifers, which reduces calf mortality and heifer wastage rate.
- Land, by increasing forage production per ha.
- Labour, by increasing cows per labour unit or reducing the hours of labour per cow milked.
- Overheads, by increasing milk produced per unit overhead costs.

The above emphasises the importance of paying close attention to each of the nine links in the supply chain of a profitable dairy enterprise (see Figure 2.3 on page 22). In addition, many of these profit drivers have been highlighted in Chapter 14.

Farm profit should be considered separately to personal profit. For wage earners, personal profit is money left over from wages after paying all the household expenses. Wage earners generally do not use any of their personal assets, except their work skills. Farm profit, on the other hand, is excess wealth, in terms of both cash and assets, generated by the dairy enterprise within the farm business.

There is no single best measure of farm profit. For example, it is possible for ROE to fall while the cash profits actually increase, due to a sharp rise in land or stock values. It is then important for farm profits to be quantified using several of the above measures.

11.5 Assessing the business ‘health’ of Asian smallholder dairy farms

Just as a doctor examines our symptoms to judge our overall health, farmers can look at records of a business to assess its financial health, both now and to some extent in the

future. It is obviously too late to correct what has happened in the past, but decisions can be made from past trends to steer the business towards its financial objectives. This examination uses various ratios taken from the financial statements to illustrate trends over time. One year's figures have limited use, but a series of these figures over time shows where the business is heading and helps make decisions to alter course, if need be. Many of these ratios have been discussed in this and previous chapters. They can be grouped into various categories to provide the necessary indicators of business health. There are four main categories, namely liquidity, solvency, profitability and efficiency (Blokland 2003).

For each of the 25 ratios listed below, there would be recommended values above or below which farmers need to be concerned. Such values may be available for dairy farms in developed countries. Because many of these ratios have only become relevant for farms in South and East Asia over the last decade, they have yet to be quantified for Asian smallholder dairy farmers. Guidelines then need to be sought from local dairy specialists firstly, as to which are relevant to Asia and secondly, what their threshold value might be. This is an exhaustive list, so it is up to readers to select the most appropriate ones for their specific purposes.

A word of caution about financial ratios: From this and previous chapters, it is apparent that the same formula can be given different names (such as NFI, operating profit and EBIT). It also follows that the same financial measure can sometimes have a different formula. So, before simply accepting the financial measure as being the most relevant to the needs of the analyses, it is important to check that the formula accurately quantifies these needs.

Most agencies throughout the world, be they government or private, have developed computer programs to assist with documentation of raw data and calculation of financial indicators of the business health of dairy farms or enterprises. To ensure consistency of data input, each agency must have a series of definitions for each farm costs and income sources as well as descriptors of each financial indicator calculated by the computer program. One excellent example of such a service provided free of charge to every dairy farmer in the country is Australia's 'Taking Stock' program (Dairy Australia 2005).

11.5.1 Liquidity

Liquidity is a short-term concept showing the ability of the business to meet debts when they become due. It indicates potential financial troubles. The three main indicators are:

1. Debt structure ratio, see Chapter 10.1.4
2. Working capital, see Chapter 10.1.2
3. Debt to asset ratio, see Chapter 10.1.4.

11.5.2 Solvency

Solvency is a long-range concept which shows the ability to meet all debts when assets are sold. The five main indicators are:

1. Net worth or equity, see Chapter 10.1.3

2. Leverage ratio, see Chapter 10.1.4
3. Solvency ratio, see Section 11.2
4. Debt to asset ratio, see Section 11.2
5. Debt to income ratio, see Section 11.2.

11.5.3 Profitability

The main indicators and ratios are derived directly from the income statement discussed in Chapter 10.

1. Net farm income, see Chapter 10.3.1
2. Off-farm income. This originates from non-farm jobs and custom work on other farms
3. Net income shows what is available to pay for principal repayments, new farm investments, family living expenses and family off-farm investments. Net income is the ‘bottom line’ of the business and arguably the single most important indicator of profitability. It becomes more important as off-farm work becomes more available.

$$\text{Net income} = \text{NFI} + (\text{Off-farm income}) - (\text{income tax})$$

4. Change in net worth, see Section 11.3
5. Profit margin ratio. This is also a measure of business efficiency

$$\text{Profit margin ratio (\%)} = \frac{\text{Net farm income}}{\text{Gross farm income}} \times 100$$

11.5.4 Efficiency

These measure various relationships between farm inputs and outputs, expressed as ratios, either physical or financial. Financial efficiency measures the degree to which the farm uses its assets to generate income and the degree to which management controls expenses in relation to sales.

1. Physical measures, such as kg milk/cow/d or kg milk/kg concentrate fed
2. Asset turnover or financial efficiency, see Section 11.2
3. Return on assets, see Section 11.2
4. Return on equity, see Section 11.2
5. Operational ratios. These compare major expenses and net farm income to gross sales.

- a. Operational expense ratio = $\frac{(\text{Total expenses}) - (\text{depreciation} + \text{interest})}{\text{Gross farm income}} \times 100$

- b. Depreciation expense ratio = $\frac{\text{Depreciation}}{\text{Gross farm income}} \times 100$

- c. Debt to income ratio = $\frac{\text{Liabilities}}{\text{Gross farm income}} \times 100$

- d. Interest expense ratio = $\frac{\text{Interest}}{\text{Gross farm income}} \times 100$
- e. Profit margin ratio, see Section 11.2
- f. Variable cost ratio = $\frac{\text{Variable costs}}{\text{Gross farm income}} \times 100$
- g. Overhead cost ratio (%) = $\frac{\text{Overhead costs}}{\text{Gross farm income}} \times 100$
- h. Finance cost ratio (%) = $\frac{\text{Finance costs}}{\text{Gross farm income}} \times 100$

11.6 FEEDPROFIT and FARMPROFIT, two computer programs to quantify farm profits

FEEDPROFIT is an Excel spreadsheet, written by the author in collaboration with Daniel Nugraha (an Indonesian dairy adviser), which calculates the MIFC for a milking herd. The range of feeds available and their nutritive value are typical of those in Indonesia, but these can be replaced with local data to modify the program for other countries. FEEDPROFIT.xls calculates the nutrient requirements to achieve target milk yields then, from a local feed database, presents the cost of a selected ration and the MIFC achieved.

FARMPROFIT is an Excel spreadsheet, written by the author in collaboration with a team of Vietnamese dairy advisers, which tabulates all the costs and returns for a smallholder dairy farmer, to produce a series of key performance indicators of farm profit. These include measures of cash and non-cash profit, farm efficiency and wealth creation and cost of production (per kg milk), all in Vietnam Dong (VND). However FARMPROFIT.xls can be easily converted into local finance units for use in other countries.

Both FEEDPROFIT and FARMPROFIT are available at no cost from the author, Dr John Moran, at john.moran@dpi.vic.gov.au or jbm95@hotmail.com.

12

Formulating profitable rations

This chapter presents examples of milking rations formulated to optimise their profitability, as quantified by milk income less feed costs.

The main points in this chapter

- One of the simplest measures of profitable feeding is milk income less feed costs (MIFC), as this takes into account the cost of the specific feed nutrients required to produce milk.
- To assist with selecting the most cost effective feed, all feeds should be compared on the unit cost of each kg of dry matter, MJ of energy and kg of protein.
- The first step in ration formulation is to calculate the daily energy requirements of cows. These will vary with cow live weight, pregnancy status, yield and composition of milk and change in body condition or live weight.
- When formulating milking rations, it is also important to consider requirements for protein and the adverse effect of excess dietary fibre levels.
- This chapter presents three case studies for feeding cows in early lactation, when producing different yields of milk (17 v 13 v 10 kg/d) and during the dry season in late lactation.

Feed costs comprise more than half the variable costs on a dairy farm, so sourcing ingredients and formulating cost effective rations can greatly benefit farm profitability. Chapters 12 and 13 concentrate on the mechanics of matching feed supplies to cow requirements with close attention to profit margins.

12.1 Defining 'Milk income less feed costs'

One of the primary skills of dairy farm business management is to be able to quantify the day-to-day profits from correct feeding practices. Feed costs make up 50–60% of the entire variable (or the day-to-day) costs in smallholder dairying, so are an important contributor to the overall cost of production (COP).

The simplest single measure of the economics of feed management is milk income less feed cost (MIFC). This can be defined as:

$$\text{MIFC} = (\text{income from milk sales}) \text{ less } (\text{feed costs})$$

where

$$\text{Milk income} = (\text{milk volume in kg}) \times (\text{unit price in local currency/kg})$$

Milk income can be influenced several ways. Firstly, milk yield increases with better feeding practices; secondly, in many regions, unit price increases with improved milk composition, that is, producing milk which contains more milk fat and/or protein. This again is the result of providing additional feed nutrients, mainly through increasing milk protein content. Reducing the bacterial contamination or improving milk quality, can also increase unit price.

Feed costs is the total money spent on feeding milking cows on a daily basis. It does not take into account the costs of feeding dry cows and young stock, although these are part of the total dairy feed costs because every milking cow must spend part of her life as a heifer or dry cow.

Total feed costs are calculated from all the feed consumed, both forages and concentrates. Much of the forage may be home-grown, but it still has a cost. There are many definitions about the cost of home-grown forages, but the simplest definition is its 'opportunity cost' or what it would cost to purchase directly from another source.



Figure 12.1 The most profitable farmers place great emphasis on home-grown forages (Malaysia)

The end point of profitable ration formulation is to formulate a ration to satisfy the nutrient requirements of the animal to achieve a target level of production at the minimum feed cost. This is called a 'least cost ration' and is used routinely by commercial feed mills to manufacture concentrate mixtures formulated to certain specifications based on the cheapest ingredients. In this case, the concentrate mixture is usually formulated using computers, because it only involves a series of simple calculations. Computer programs are also used to develop least cost rations in intensive animal production units, such as piggeries or beef cattle feedlots, where the nutrient requirements have been fully documented. Computer aids to ration formulation have been discussed in *Tropical dairy farming* (Moran 2005). A new Excel spreadsheet, FEEDPROFIT, has recently been developed to formulate rations and calculate MIFC. This program can be used to undertake the formulation of the rations presented in this chapter and is available at no cost from the author, Dr John Moran at john.moran@dpi.vic.gov.au (or jbm95@hotmail.com).

This chapter presents a series of case studies for smallholder dairy farmers. They are examples of the types of decision-making processes possible once you have some knowledge about cow requirements, the nutritional value of available feeds and their costs. There are many ways in which such information can be used in dairy farm business management, for example, deciding when to purchase feeds that vary in cost throughout the year.

Because cows are herbivores, production rations should be based on feeding as much good quality forage as possible, then supplementing with concentrates. Ideally, the unit cost of the forage is reduced as more of it is grown to feed the milking herd. That is certainly the case with grazing herds in Australia, although it may not always be the case on all Asian smallholder farms.

12.2 Case studies of smallholder dairy farmers

12.2.1 Introduction to case studies

This section contains three case studies for smallholder farmers in Malaysia. The unit of energy is Metabolisable energy (ME) and the unit of currency is the Malaysian ringgit (MR) or sen (100 sen per MR). Appendix 3 presents the unit of currency in other Asian countries, together with their relative values in March 2009. The feed costs in the following tables should not just simply be converted from ringgits into the currency of the country of interest because their relative purchase (or grown) values will depend on the market forces in that particular country.

This particular Malaysian farmer has a wide variety of feeds available (see Table 12.1) for his herd of 10 milking cows, many at different stages of their lactation cycle. Cows differ in their levels of milk production and milk composition, and in their pregnancy status. The forages range from good quality (immature grass, leucaena leaves, maize silage) through to very poor quality (oil palm fronds). The concentrates range from formulated to high energy (palm kernel cake) and high protein (soybean meal). Feed prices and milk returns are for Malaysian farmers in 2009.



Figure 12.2 Truckloads of maize stover for feeding to feed dairy and beef cattle in Sumatra, Indonesia

Note that this farmer has purchased maize silage, not maize stover silage. Maize grain is the major contributor of energy, so the farmer has decided to invest in the maize including the cob, not just the stover. Maize stover silage would obviously be cheaper, but its nutritive value would also be much lower.

The nutritive values of the feeds, presented in Table 12.1, are ‘typical’ values for dry matter, crude protein (CP), fibre (NDF) and energy (ME) (Moran 2005). The cost of the

Table 12.1 Nutritive values and price of feeds available to smallholder dairy farmers in Malaysia

Feed	Price (sen/kg)	DM (%)	ME (MJ/kg DM)	CP (%)	NDF (%)
Forages					
Immature grass	8	20	9.2	10	55
Mature grass	6	30	7.4	8	70
Leucaena leaves	10	25	9.0	20	55
Maize silage	10	28	10.1	8	50
Oil palm fronds	2	30	6.0	4	75
Concentrates					
Formulated concentrate	100	90	12.0	16	25
Palm kernel cake	70	90	12.0	15	65
Brewer's grain	10	26	10.0	29	57
Rice bran Grade A	40	90	11.1	14	30
Soybean meal	150	90	13.0	45	25

The costs of specific feed nutrients (Table 12.2) can be calculated using Worksheet 3 from Appendix 5.

Table 12.2 Costs of energy and protein in feeds available to smallholder dairy farmers in Malaysia

Feed	Feed cost (sen/kg)	DM cost (sen/kg)	Energy cost (sen/MJ of ME)	Protein cost (sen/kg CP)
Forages				
Immature grass	8	40	4.3	4.0
Mature grass	6	20	2.7	2.5
Leucaena leaves	10	40	4.4	2.0
Maize silage	10	36	3.5	4.5
Oil palm fronds	2	7	1.2	1.7
Concentrates				
Formulated concentrate	100	111	9.2	6.9
Palm kernel cake	70	78	6.5	5.2
Brewer's grain	10	38	3.8	1.3
Rice bran Grade A	40	44	4.0	3.1
Soybean meal	150	166	12.8	3.7

energy and protein contained in all these feeds is presented in Table 12.2. Oil palm fronds is a cheap but very poor quality forage so its use is very limited for milking cows. The cheapest energy sources are brewer's grain and rice bran (and mature grass), while the most expensive is maize silage. The cheapest protein source is brewer's grain and the most expensive is formulated concentrate.

If the profitability of dairy feeding systems was only based on the cost of feed nutrients, ration formulation would be a relatively simple exercise. However, this is not the case, because ration formulation requires cows to be fed the correct balance of nutrients to produce milk, before nutrient costs can be considered. Not only must diets provide sufficient energy and protein, but fibre levels must not be too high. Appendix Table A4.9 provides a guide to the influence of NDF content of the entire ration on the potential appetite of lactating cows of various live weights.

In his herd of 10 milking cows, this farmer has seven mature cows, weighing on average 550 kg, at different stages of lactation, and with daily milk yields ranging from 0 to 20 L/cow. Their energy requirements are presented in Table 12.3, calculated from Appendix 5 Worksheet 1.

Cow 7, although not lactating, was in poor body condition prior to drying off. Consequently, she must be fed to gain 1 kg/d of live weight during the last month of pregnancy. The energy requirements for late pregnancy and such high growth rates are greater than for Cows 4, 5 and 6, all still producing milk. Therefore, even though cows may not be lactating, their daily energy requirements can still remain high.

12.2.2 Case study 1: Formulating least cost rations

This farmer wants to formulate a ration for Cow 1 (in Table 12.3) supplying 147 MJ/d of ME. The cow is in early lactation, non-pregnant, losing 0.5 kg/day and producing 20 L/d

Table 12.3 Energy requirements of smallholder's milking cows (in MJ of ME/day) at different stages of lactation and pregnancy status

Cow details							
Description	Cow 1	Cow 2	Cow 3	Cow 4	Cow 5	Cow 6	Cow 7
Live weight (kg)	550	550	550	550	500	500	500
Month of pregnancy	Empty	Empty	Empty	3rd	6th	7th	9th
Milk prod (kg/d)	20	17	13	10	8	6	0
Fat test (%)	3.6	3.6	3.6	3.6	4.0	4.0	0
Protein test (%)	3.2	3.2	3.2	3.2	3.8	3.8	0
LW gain/loss (kg/d)	-0.5	0	0	0	0	+0.25	+1.0
Energy requirements (MJ of ME/d)							
Maintenance	59	59	59	59	54	54	54
Activity	0	0	0	0	0	0	0
Pregnancy	0	0	0	0	8	10	20
Milk production	20 × 5.1 = 102	17 × 5.1 = 87	13 × 5.1 = 66	10 × 5.1 = 51	8 × 5.5 = 44	6 × 5.5 = 33	0
Weight gain or loss	-0.5 × 28 = -14	0	0	0	0	0.25 × 44 = +11	1.0 × 55 = +55
Total energy requirements	147	146	125	110	106	108	129

of milk, which at 2.00 MR/kg generates a milk income of 40 MR/d. The basal forage is immature grass and the main supplement is formulated concentrate. A ration of 40 kg fresh grass and 6.7 kg concentrate will supply the required energy to achieve 20 kg/d of milk. Five feeding strategies are presented in Table 12.4 as follows:

1. Feeding 40 kg/d of immature grass plus 6.7 kg/d of formulated concentrate.
2. Increasing ration protein content by substituting some of the grass with leucaena leaves.
3. Increasing ration protein content by substituting some of the concentrate with soybean meal.
4. Reducing cost by substituting some of the concentrate with rice bran.
5. Reducing cost by substituting some of the concentrate with brewer's grain.

Without a computer and a specific ration formulation program it is very difficult to calculate a ration to provide the exact nutrient requirements, so compromises must be made.

In this case, all rations supplied 142–149 MJ/d of ME, and from Appendix Table 4.9, their NDF contents would not limit appetite to below the calculated intakes. Cows in early lactation require 16–18% CP, which was only supplied by the most expensive Ration 3. This high protein requirement may be the case for intensively fed cows producing 25 or 30 kg/d of milk, but for smallholder cows producing only 20 kg/d of

Table 12.4 Case study 1: Five feeding strategies for Cow 1 (in Table 12.3) to produce 20 kg/d of milk in early lactation

	Feeding strategy				
	1	2	3	4	5
Fresh feed intakes (kg/d)					
Immature grass	40	30	40	40	40
Leucaena leaves	–	10	–	–	–
Formulated concentrate	6.7	6.7	4.7	4.7	4.7
Soybean meal	–	–	2.0	–	–
Rice bran	–	–	–	2.0	–
Brewer's grain	–	–	–	–	6.9
Ration descriptors					
Total DM intake (kg/d)	14.0	14.5	14.0	14.0	14.0
Total ME intake (MJ/d)	146	149	147	144	142
CP (%)	12.6	14.2	16.3	12.2	14.2
NDF (%)	42	43	42	43	46
Intake limit (kg DM/d)	15.8	15.4	15.8	15.4	14.4
Total feed costs (MR/d)	9.9	10.1	10.9	8.7	8.6
Milk income less feed cost (MR/d)	31.1	29.9	29.1	31.3	31.4

milk, lower protein levels should suffice. Therefore, 13–14% total dietary protein would be adequate. Feed costs are reduced by substituting 2 kg of formulated concentrates with rice bran in Ration 4, but its lower protein content may limit nutrient supplies, hence depress milk yields below the desired 20 kg/d. Substituting some of the concentrate with brewer's grain (Ration 5) produced an even cheaper ration but with sufficient protein.

The cheapest ration, to produce the same level of milk (valued at 2.00 MR/kg), means it also generates the highest milk income less feed costs, 31.4 MR/d.

12.2.3 Case study 2: Feeding cows in early lactation

It costs more money to feed higher yielding cows, but in the long run, it is more profitable. Table 12.5 presents rations formulated to satisfy the energy requirements of Cows 2, 3 and 4 (from Table 12.3) when fed a basal ration of 40 kg immature pasture.

The 'bottom line' of Table 12.5, the milk income less feed costs, clearly indicates that better fed cows produce more milk, and despite their higher feed costs, generate more income. Compared to the highest yielding Cow 2, Cows 3 and 4 only generate 74% and 54% of the milk income over feed costs.

12.2.4 Case study 3: Feeding cows during the dry season

The supply of forages during the dry season is generally the major limiting factor to farm expansion. Oil palm fronds (leaves of the oil palm tree) are becoming a regular forage

Table 12.5 Case study 2: Profits from feeding Cows 2, 3 and 4 (in Table 12.3) to produce 17, 13 and 10 kg/d milk

	Cow		
	2	3	4
Fresh feed intakes (kg/d)			
Immature grass	40	40	40
Formulated concentrate	6.7	4.7	3.3
Ration descriptors			
Total DM intake (kg/d)	14.0	12.2	11.0
Total ME intake (MJ/d)	146	125	110
Milk yield (kg/d)	17	13	10
CP (%)	12.6	12.0	11.6
NDF (%)	42	45	47
Intake limit (kg DM/d)	15.8	14.7	14.1
Total feed costs (MR/d)	9.2	7.4	6.2
Milk income less feed cost (MR/d)	24.8	18.6	13.8

source throughout Asia as more countries establish plantations to meet increasing global demands for palm oil. However, like rice straw, it is a very low quality roughage source for milking cows. Maize silage, on the other hand, is an excellent forage, but from Table 12.2, it is a more expensive energy source than oil palm fronds (3.5 v 1.2 sen/MJ of ME). The relative energy costs of these two forage sources is one way of deciding which one to feed, but it should not be used in isolation with other important principles of feeding milking cows to efficiently produce milk. It is unlikely that cows fed oil palm fronds will produce much milk, because their appetites would be limited from the very high amounts of NDF consumed. Table 12.6 presents three example rations (X, Y and Z) based on these forages, two of which have over 65% of the forage comprising mature grass. For Cow 5, this would limit appetite because of excessive levels of NDF.

These are just examples of various ways to feed cows when fresh quality forages are in short supply. In this case study, there are large differences in NDF% of these three rations, such that the intake limits are severe when oil palm fronds were fed (Ration X) compared to maize silage (Rations Y and Z). The difference between the formulated DM intake and that calculated from NDF% is presented in Table 12.6 as the value 'A-B', which is highest on Ration X. Therefore, the cows would be unlikely to be able to consume all of Rations X and Y, leading to drops in milk yields, hence a lower milk income less feed costs compared to Ration Z. Despite its higher energy cost, the more maize silage fed, the higher the profit.

Table 12.6 Case study 3: Three dry season feeding strategies for Cow 5 (in Table 12.3) to produce 8 kg/d of milk

	Ration		
	X	Y	Z
Fresh feed intakes (kg/d)			
Mature grass	20	20	–
Oil palm fronds	10	–	–
Maize silage	–	10	30
Formulated concentrate	2.5	1.5	–
Soybean meal	1.5	1.5	1.5
Ration descriptors			
A. Total DM intake (kg/d)	12.5	11.5	9.7
Total ME intake (MJ/d)	105	106	103
CP (%)	12.4	13.2	13.0
NDF (%)	59	55	47
B. Intake limit (kg DM/d)	9.8	10.9	12.8
A–B (kg DM/d)	2.7	0.6	–
Total feed costs (MR/d)	6.1	5.9	5.2
Milk income less feed costs (MR/d)	9.9	10.1	10.8

13

Feeding decisions driving profit

This chapter presents examples of manipulating farm resources to improve the feed efficiency of milk production, hence increase farm profits.

The main points in this chapter

- It is always energetically more efficient to feed fewer cows better. To produce 50 000 kg milk/yr, a milking herd of 10 cows utilises 81% of its annual feed energy for milk production, compared to 78% with 13 cows and only 76% with a 17-cow milking herd.
- There may be other benefits through better milk quality and composition and improved reproductive performance.
- To provide sufficient quality of home-grown forage for a well balanced diet to all stock, the typical 0.5 ha smallholder farm should have no more than two to five milking cows plus replacement heifers, depending on the management of the forage production area.
- There are many profit drivers on a dairy farm that can be managed by the farm operator to improve nutritional efficiency, and these are presented in a series of flow charts.

Manipulating farm resources to improve the feed efficiency of milk production, hence increase farm profits, is good evidence of effective business management. This chapter demonstrates this, firstly through optimising herd size or forage production area and, secondly, by taking into account all the farm management practices driving farm profit.

In any dairy system, whether it is a temperate grazing or an Asian smallholder operation, the principles for feeding milking cows should be to feed sufficient quality forages first, then supplement with concentrates which are formulated to overcome specific nutrient deficiencies, in order to achieve target milk yields.

With knowledge of the feeding value of the forages and concentrates, and their relative costs, more objective decisions can be made on how much concentrate should be fed to achieve target milk yields.

13.1 Determining the optimum herd size

It is always energetically more efficient to feed fewer cows better. The same total farm volume of milk can be produced with fewer better fed cows. Table 13.1 presents three annual energy audits for herds producing 50 000 kg/yr of milk, with varying numbers of milking cows. Herd A has 10 cows each producing on average 17 kg/d, Herd B has 13 cows, each producing 13 kg/d, while Herd C has 17 cows each producing 10 kg/d. Daily energy requirements are the same as those for Cows 2, 3 and 4 described in Chapter 12 (Table 12.3). The cows produce milk for 300 days and are dry for 65 days. Each herd has a 30% heifer replacement rate, meaning that the farmer must rear three, four or five heifers each year. Total energy requirements to rear one heifer for one year are assumed to be 22 000 MJ of ME.

Cows in the higher yielding Herd A use less of their daily energy intakes for maintenance (40 v 46 v 52%), allowing them to be more efficient on a day-to-day basis. Compared to Herds B and C, milking cows in Herd A then require 12% and 29% respectively less of their daily energy intakes to produce the same total volume of milk.

After taking into account all the farm dietary energy costs associated with producing milk (including maintaining dry cows and rearing heifers), Table 13.1 expressed this as the total energy requirements to produce the same volume of milk. In MJ/kg milk, this amounted to 11.0 for Herd A compared to 12.8 for Herd B and 15.0 MJ/kg for Herd C.

Table 13.1 also presents the 'Productive feed energy' or the proportion of total farm energy used by milking cows when lactating. Again Herd A is the most efficient with 81% of its annual feed energy used by to produce milk in the lactating cows, compared to 78% (Herd B) and 76% (Herd C).

Table 13.1 Annual energy audit for three herds producing 50 000 kg/year of milk

	Herd		
	A	B	C
Milking cows	10	13	17
Total milk yield (kg/cow/yr)	5000	3846	2941
Average milk yield (kg/cow/d)	16.7	12.8	9.8
Daily energy requirements (MJ/d)	148	128	113
Energy for maintenance (%)	40	46	52
A. Total farm energy for milk prod ('000 MJ/300d)	444	499	576
Daily energy cost to produce milk (MJ/kg)	8.9	10.0	11.5
B. Total farm energy for dry period ('000 MJ/65 d)	39	51	66
C. Rearing heifer replacements ('000 MJ/yr)	66	88	110
Total farm requirements or A+B+C ('000 MJ/yr)	549	638	752
Productive feed energy (%) = A/(A+B+C)	81	78	76
Total energy cost to produce milk (MJ/kg)	11.0	12.8	15.0

This table clearly shows the energetic efficiency of feeding fewer higher yielding cows. However, as well as considering the costs of sourcing that energy, other factors must be taken into account when determining herd profitability, and these will be discussed in the following section.

13.1.1 Other factors influencing herd profitability

‘Milk income less feed costs’ (Chapter 12) is based on the daily feed intake of milking cows and, because Herd A is energetically the most efficient, this would also be expected to be higher than for the other two herds, as they are for Cow 2 in Table 12.5. However, this conclusion is based on the assumption that the milk responses to supplements do not differ between herds. Consequently, the profitability of feeding supplements in Herd A, compared to those in Herds B and C, may be reduced as Herd A cows would have been fed better to produce more milk.

Another factor influencing herd profitability is the marginal cost, or the cost of each additional unit of energy that is fed. For example, higher quality forages and concentrates often cost more, and better fed cows may require these higher quality feeds. To maintain their higher levels of milk production, Herd A cows would require rations providing extra protein and less fibre. Higher yielding cows have greater demands for protein even if their marginal energy requirements are the same per litre of milk produced. Furthermore, such animals must maintain higher feed intakes, which would be more adversely affected by high fibre diets. The cost of providing such rations for high yielding cows may be higher than for lower yielding cows. As this would increase feed costs, profitability levels are likely to decline.

Milk composition depends on nutrient intake and Herd A cows would be fed a better balanced ration supplying more energy and protein and less fibre each day than Herds B and C. It is then likely that milk composition may vary between herds. Herd A cows would produce milk with more milk protein, because of their better energy status, and more milk fat, unless their ration becomes deficient in dietary fibre, which is unlikely because all tropical forages have such high fibre levels. In most Asian countries, higher milk solids contents return a higher unit milk price, thus providing financial benefits to better fed herds.

Unit milk price can also be affected by milk quality, or the level of bacterial contamination. This is greatly influenced by on-farm hygiene. In Asia, milk quality payments are given on both objective and subjective assessments. For example, in Thailand, the objective assessments are actual measures of bacterial contamination, while the subjective assessments are based on inspection of farm equipment and facilities. For cows in Herd A to produce 5000 kg milk/lactation, their overall farm management must be excellent. Not only does this include feeding, but also the health, milking, reproduction and rearing of young stock. It is then likely that any subjective assessment for milk quality would provide maximum premiums, hence increase unit milk price, hence milk income less feed costs.

Table 13.1 was calculated on the assumption that cows produced one calf each year and 30% of the heifers were used as herd replacements. Cows provided with adequate energy have higher fertility because they are more likely to cycle earlier post-calving. It is

quite likely that Herd A cows will cycle earlier than Herds B or C cows because of their higher feed, hence energy intakes. Consequently, heifer replacement rates may differ as a result of different culling pressures in the three herds.

If 'Milk income less feed costs' were calculated on a whole farm basis over a 12-month period, Herd A would be the most profitable. Its higher energetic efficiency and greater unit milk price would offset any greater substitution rate and higher unit feed costs discussed above. The above factors highlight the complex interactions between feeding management, milk responses and herd profitability. Ideally we should express all biological responses in terms of financial returns less cost inputs. At least in nutrition, we now have the tools to do this with more confidence than in other areas of farm management.

13.2 Determining optimum on-farm stocking capacities

Very rarely do farmers and advisers calculate the optimum stocking capacity of any one farm. Unfortunately herd sizes are usually the result of 'trial and error' whereby farmers increase cow numbers until they become too expensive to feed or their milk yields decline below acceptable levels. Estimated forage yields must be taken into account when determining how many cows and young stock can be adequately fed from a particular sized smallholder dairy farm.

The following scenarios are to assist in such a mathematical exercise. To calculate stocking capacities, a series of assumptions have to be made:

1. Forages contain 15% DM (not the 20% as often assumed) and yield:
 - 10 t DM/ha/yr (67 t fresh/ha/yr) under poor management, e.g. only fertilising with cow manure.
 - 20 DM/ha/yr (130 t fresh/ha/yr) under average management, e.g. fertilising with cow manure and limited inorganic fertiliser.
 - 30 t DM/ha (200 t fresh/ha/yr) under good management, e.g. fertilising with sufficient inorganic nitrogen and phosphorus fertilisers to match forage requirements.
2. The management allows for forage conservation to transfer wet season excess pastures for dry season feeding.
3. Smallholder farmers use their forages to rear replacement heifers as well as feed their adult cows, when lactating and dry. Farmers rear 20% of their milking herd as replacements, which first calve at 27 months of age.
4. An adult cow milking unit is therefore one adult cow plus 20% of a replacement heifer.
5. In year-round calving systems, only 75% of the adult cows are milking at any one time. Therefore each year, adult cows milk on average for 275 days and are dry for 90 days.
6. The forage feeding program allows for feeding:
 - 50 kg/day of fresh forage (7.5 kg DM/day) to milking cows.
 - 30 kg/day of fresh forage (4.5 kg DM/day) to dry cows.



Figure 13.1 Smallholder dairy farmers source a wide variety of forages, many of which are very low in nutritive value for milking cows (West Java, Indonesia)

- 20 kg/day of fresh forage (3.0 kg DM/day) to heifers, averaged over a full 24 months of feeding weaned stock.
7. Concentrates are fed to provide the balance of the diet to achieve target milk yields. However, such feed inputs are not relevant to these scenarios.

The annual forage requirements for each milking unit are then:

- 13 750 kg fresh (or 2065 kg DM) for the milking cow (71% of total).
- 2700 kg fresh (or 405 kg DM) for the dry cow (14% of total).
- 2920 kg fresh (or 438 kg DM) for 20% of a replacement heifer (15% of total)

or a total of 19 370 kg fresh (or 2905 kg DM) for each milking unit.

The stocking capacities, or number of stock that could be fed from one hectare of forage, are presented in Table 13.2.

Therefore, to provide sufficient quality home-grown forage for a well-balanced diet to all stock, the typical 0.5 ha smallholder farm should have no more than two to five milking cow units, that is two to five adult cows plus one replacement heifer, depending on management of the forage production area.

This is further evidence that farmers should concentrate on feeding fewer cows better. With increasing dependence on purchased forages, feed costs are invariably more expensive and dietary quality generally poorer than when basing dairy production systems on home-grown forages.

Table 13.2 Optimum stocking capacities for smallholder dairy farms with different levels of forage management

Quality of forage management	Poor	Average	Good
Forage yield t DM/ha/yr	10	20	30
t fresh/ha/yr	67	130	200
Milking units/ha forage	3.4	6.9	10.3
Adult cows/ha forage	4.0	8.1	12.1

One milking unit is one adult cow plus 20% of a replacement heifer
 Assumed forage intakes: 7.5 kg DM/day for 275 d/yr for milking cows
 4.5 kg DM/day for 90 d/yr for dry cows
 3.0 kg DM/day for 365 d/yr for 20% of a replacement heifer

13.3 Flow charts of feeding decisions that drive profit

Figures 13.3 and 13.4 present flow charts of the major feeding management decisions driving profit. For each component in Figure 13.3, the feed inputs, the cost of home-grown inputs depend on their quality and availability, both of which are under farmer control. However, the cost of purchased feed inputs are driven by market forces, although farmers can influence these by purchasing when in plentiful supply, when they are likely to be cheaper.

For fresh forages, such as maize green chop or grasses, or for wet by-products, such as brewers grain or soybean curd, total costs must include conservation (as silage) until required. Dry feeds could also be purchased when cheapest but would then require some



Figure 13.2 Smallholder cropping farmers growing forage maize under contract for a large feedlot dairy farm in East Java, Indonesia

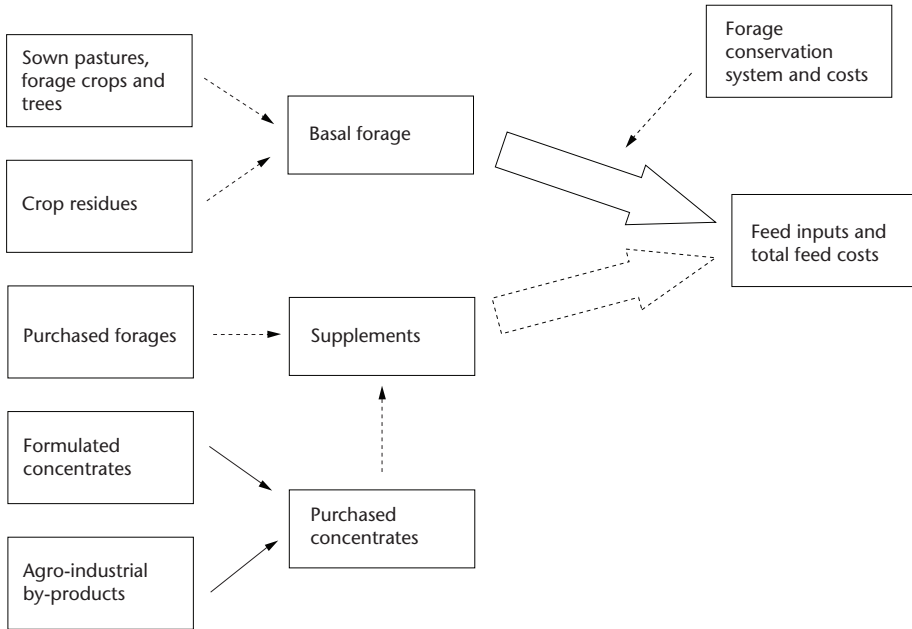


Figure 13.3 Components of feed inputs in smallholder dairy farms

storage costs. In addition, such purchases may necessitate relatively large cash investments, hence some opportunity cost (such as ongoing interest rates) should be incorporated.

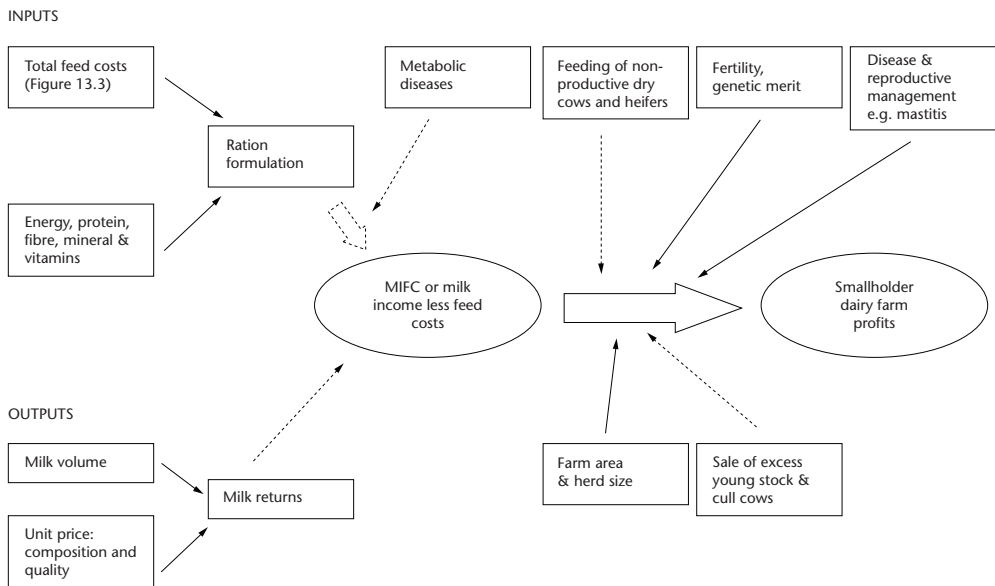


Figure 13.4 Feeding management decisions driving farm profits

Home-grown forages should also be fully costed, preferably on the basis of cost per unit nutrient, keeping in mind that agronomic decisions to optimise quality, such as using inorganic fertilisers or using a short harvest interval, may increase cost per unit DM, but not necessarily per unit feed nutrient. Furthermore, the cost of supplementing with additional nutrients from other feed sources is included in the final calculation of daily total feed costs per animal. This often leads to the conclusion that an investment in optimising forage quality (which can also improve milk yield) is worthwhile as it reduces supplement costs and/or increases milk return thus increasing MIFC.

Figure 13.4 incorporates other factors influencing overall farm profits, such as feeding non-productive dairy stock, disease, fertility and cow genetic merit. Costing such factors is beyond the scope of this manual.

Key performance measures of farm profitability

This chapter presents a series of key performance indicators (KPIs) to help farmers identify the possible causes of inadequate farm performance and profitability.

The main points in this chapter

- When assessing poor farm profitability, the KPIs can be split into two types: those diagnosing problems with feeding management and those indicating poor herd management.
- As home-grown forage is generally cheaper to source than purchased forage, the more produced on-farm, the better. Too many stock on limited land is a common feature on Asian dairy smallholdings.
- Unlike other forms of livestock, milking cows have very high nutrient requirements, therefore high quality forages and concentrates are essential for profitable dairying.
- Milk income less feed cost is one of the simplest and easiest ways to measure KPIs of farm profitability, and the quickest to respond to small changes in farm practices.
- Problems with herd management can be diagnosed using measures such as the proportion of cows actually milking in the herd, or their peak yield and persistency of production. There are also simple KPIs of herd reproductive performance and of health and growth of young stock that assist in searching for the underlying causes of poor farm profitability.

A rather simplistic way of looking at the economics of milk production is to use the following equation:

$$\text{Milk profits} = (\text{Profit margin}) \times (\text{Milk quantity})$$

Profit margin is the difference between milk returns and all expenses, expressed per kg of milk sold. Quantity is the amount of milk sold, expressed in kg. Together, they determine milk profits. On smallholder dairy farms, this is what largely pays for farm expenses, capital expenditure, loans, and finally for family living.

Without a good margin, farmers have to produce large volumes through milking more cows and/or increasing milk yield per cow. If they have a good margin but a low volume, farmers will not be able to generate a reasonable income for their family living.

Increasing milk volume can improve milk profits in two ways. Firstly, the profit margin is applied to more volume and secondly, unit costs for feed, other variable and

overhead costs are diluted over a larger quantity. Table 13.1 on page 150 highlights the energetic efficiencies of higher per cow milk production.

Knowing their margin, hence cost of production (COP), is then critical to operating a profitable dairy enterprise. Another way of looking at margins is that saving money in producing milk (that is, reducing the COP) is the financial equivalent of increasing milk returns. Farmers must do more and better planning if they are to achieve greater profits. Profits are not something they end up with at the end of the year. Rather, they are something farmers must plan for.

This chapter presents a range of key performance indicators (KPI) to help farmers monitor the profitability of their dairy enterprise.

14.1 Simple measures of farm performance

Comparative farm analyses or benchmarking (see Chapter 8) involves collecting data from farms with similar production systems, then generating relevant physical and financial KPIs to better interpret their farm's productivity and profitability. Farmers can use these KPIs to identify weaknesses in, as well as set targets for, their farm's performance. Farmers are likely to try to improve their systems if they know they are less profitable compared to others. If such an approach encourages farmers to look more critically at their cost structures, it has achieved a major objective of benchmarking. Expressed simply, benchmarking is a diagnostic tool to help farmers identify production weaknesses that adversely affect their financial performance. This chapter describes an initial attempt to document some of these KPIs to provide farmers with a structured approach to address farm profitability. It must be stressed that no single KPI should be used in isolation as each one is the end result of interactions between numerous farming practices. It is important that there is a balance between them so that one KPI target is not achieved at the expense of others within the farm.

The following 10 series of questions should be asked on any farm, big or small, because up to 60% of farm costs are feed related. The first six questions are directly related to feeding management. Even though the remaining four are more related to overall herd management, they are still very feed dependent. Some of the KPIs can be quantified. However, for others, there is no ideal single value because for some, the higher the better (such as on-farm forage production or forage quality) while for others, the lower the better (such as total feed costs, calf mortality and heifer wastage rates). When KPIs are presented, they are best presented as ranges rather than a single value as this emphasises the fact that they are only guidelines. Ten of these key factors are presented in Table 14.1.

14.2 Feed-related key factors influencing farm profitability

14.2.1 Stocking capacity

Forages almost always provide a cheaper source of the key feed nutrients (energy and protein) than do concentrates. It is usually cheaper to grow these forages on the farm

Table 14.1 Ten key measures of dairy farm performance

Measure	Description
Feeding management	
1. Stocking capacity	Is the farm carrying too many stock for the available forage supplies?
2. On-farm forage production	How much of the farm's annual forage requirements must be purchased?
3. Forage quality	Is the forage being harvested or purchased at its optimal quality for milking cows?
4. Concentrate feeding program	What is the quality of the concentrates being fed and how much is allocated per milking cow?
5. Total feed costs	Are the forages and concentrates costing too much per MJ of energy or kg of protein?
6. Milk income less feed costs	How does this compare with those of other farmers with good feeding management?
Herd management	
7. Percent productive cows	What is the percent of adult cows actually milking? What is the proportion of milking cows in the entire dairy herd, expressed as a percentage?
8. Pattern of milk production	What is the peak milk yield of the herd and what is its lactation persistency (rate of decline from peak milk yield)?
9. Reproductive performance	How many days after calving do cows cycle? What are the herd's submission and conception rates? What are the herd's 100-day-in-calf and 200-day-not-in-calf rates?
10. Heifer management	What is the calf mortality rate and the wastage rate from birth to second lactation? What is the age and live weight at first calving of the replacement heifers?

rather than purchase them. It is easier to control forage quality on-farm, through fertiliser and harvest interval, than with purchased forages. When relying on off-farm forage supplies, farmers depend on what is available, either from traders who harvest the roadsides, paddy fields, tree plantations or forests, or from other farmers who sell their excess supplies, either as crop by-products (such as rice straw or corn stover) or forage crops specifically grown for sale.

Table 13.2 on page 154 presents the optimum stocking capacities for smallholder dairy farmers with different yields of home-grown forages. Data are presented for farmers who run replacement heifers on the same farm as their milking herd, and for farmers that have them reared off-farm. The calculations included three levels of forage management, namely poor, average and good, to produce 10, 20 and 30 ha forage DM/ha/yr respectively.

For a farmer growing the maximum quantities of quality forages, to feed his milking cows well, he should have no more than 8–10 milking cows per hectare of forage grown on his farm. However, most dairy smallholders do not manage their forages well enough to produce the highest yields of forage. Therefore, a more realistic recommendation



Figure 14.1 Cows will not perform well if maintained in overcrowded unhygienic conditions (Malaysia)

would be six to eight milking cows (plus the replacement heifers) per hectare of forage grown on-farm.

Unfortunately, most smallholder dairy farmers like to keep more cows than this recommendation, meaning they must either have to purchase forages off-farm, underfeed their milking cows (and heifers) with less forage or, if they aim to produce high yields of milk (say more than 12–14 kg/day), feed excessive levels of concentrates to each milking cow. This is a more expensive way to produce milk, and frequently leads to digestive problems, such as subclinical acidosis. Not only will feed efficiency decrease, it will increase the cost of production and reduce farm returns. Therefore, as all astute businessmen know, farmers should be stocking their dairy farms at the optimum level to maximise farm efficiencies and hence profits. In other words, farmers should not put too many cows on their farm, particularly if they cannot feed and manage them properly.

14.2.2 On-farm forage production

If it is generally cheaper to grow quality forages on-farm, the less purchased the cheaper the feed bill. With well-planned dairy production systems it should be possible to supply 95 to 100% of the forages from on-farm supplies. Strategic purchases of small quantities of very cheap, lower quality forages (such as rice straw) for stock with lower daily nutrient requirements, such as dry cows, may still be a good management decision.

The biggest problem with on-farm forage supplies is to produce them 12 months of the year. Forage growth rates are markedly reduced during periods of low rainfall or low temperatures. In Asia, farmers must calve their cows year-round to provide a regular



Figure 14.2 Sheds must be built for optimum cow comfort, not like this shed (Malaysia)

cash flow, so cannot practice seasonal calving to match herd requirement with forage growth rates. Conserving forages through silages and hay during periods of peak forage growth is the best way to overcome seasonal forage supplies. Hay making requires many more days of dry weather than silage making and this is rare during wet seasons when excess forage supplies are more likely. Making silage from forage crops or quality crop by-products (such as legume tree leaves, corn stover or other cash crop residues) can augment supplies of other conserved wet season forages.

14.2.3 Forage quality

To produce milk and calves, dairy cows require feed nutrients which are supplied through both forages and concentrates. To produce acceptable milk yields, say 15 kg/day, cows require a ration containing at least 10 MJ/kg DM of metabolisable energy (ME). The more of this supplied by forages, the less required by concentrates. For milking cows, a realistic KPI for forage quality would be 9.5–10.0 MJ/kg DM of ME and 12–14% crude protein.

The higher the quality of the forage, the less concentrates necessary to achieve the desired milk yield. This was demonstrated by Devendra (1975), as presented in Table 14.2, who calculated the amount of concentrates required for target milk yields in 400 kg milking cows (non-pregnant with zero weight change) when fed ad lib forage of varying qualities. For these calculations, he assumed the concentrate to be home-mixed containing 12.2 MJ/kg DM of ME and 24% protein.

Table 14.2 Required concentrate intakes (kg DM/day) for cows fed forages of varying quality to achieve target milk yields

Milk yield (kg/d)	Forage quality (MJ/kg DM of metabolisable energy)			
	7.3	8.2	9.0	9.9
6	3.2	0.7	–	–
10	4.9	2.5	0.8	–
14	6.6	4.8	1.1	0.3
18	8.2	6.0	3.0	0.7
22	9.8	7.7	5.4	1.7

(Source: Devendra 1975)

14.2.4 Concentrate feeding program

The selection of concentrate ingredients and their formulations is discussed in *Tropical dairy farming* (Moran 2005), so will not be covered here. Relevant KPIs for lactation concentrate quality would be 11–12 MJ/kg DM of ME and 16–18% crude protein.

Many Asian dairy advisers use a general ‘rule of thumb’ that farmers should feed 1 kg concentrate for every 2 kg of milk produced. This is a safety measure because of the lack of knowledge about the nutritive value of the feeds, particularly the forages. It also provides supplemental energy to cows when they are fed only limited amounts of forage.

With knowledge of the feeding value of the forages and concentrates, and their costs, more objective decisions can be made on how much concentrate should be fed to achieve target milk yields. This requires more knowledge and greater effort than following the ‘feed 1 kg concentrate per 2 kg milk’ rule, but such decisions can greatly reduce feed costs hence improve profitability, when expressed as milk income less feed costs.

Table 14.2 listed the level of concentrates required to achieve target milk yields with varying forage qualities. These feeding decisions have been converted into milk:concentrate ratios in Table 14.3. When cows are fed better quality forages, more milk is produced per kg concentrate fed. The 2:1 (for every 2 kg milk, feed 1 kg concentrate) rule is only applicable with very low quality forages, namely those with ME contents of 7–8 MJ/kg DM.

Table 14.3 Milk: concentrate ratios (kg milk produced/kg concentrate DM fed) to achieve target milk yield in cows fed forages of varying quality

Milk yield (kg/day)	Forage quality (MJ/kg DM of metabolisable energy)			
	7.3	8.2	9.0	9.9
6	1.8	8.6	–	–
10	2.0	4.0	12.5	–
14	2.1	2.9	12.7	46.7
18	2.2	3.0	6.0	25.7
22	2.2	2.9	4.1	12.9

(Source: Devendra 1975)

14.2.5 Total feed costs

Chapter 12 discussed formulating profitable rations, with examples for a Malaysian dairy smallholder. The choice of available feeds for milk production will differ from country to country as do their relative costs. The principle of formulating profitable rations is to select various feeds on the basis of their cost per unit energy, because energy is nearly always the first limiting nutrient. When protein deficiencies limit cow performance, the unit cost of protein becomes important. The fibre content of each potential feed ingredient should also be considered to ensure that the voluntary intake of the cow is not too restricted and she cannot eat all that she is offered.

When formulating rations, one has to be confident that the costs and nutritive values of the ration ingredients are representative of the feeds offered on that farm.

14.2.6 Milk income less feed costs

Milk income less feed costs (MIFC) is one of the simplest and easy to measure KPIs of farm profitability. In addition, changes in MIFC are quick to monitor because of the rapidity with which milking cows respond, even to small variations in their feeding management. When introducing new feeds into the diet or varying their amount, the cows' milk responses will reflect these changes within a few days as will their MIFC within a week or two.

Calculations for ration formulation, total feed costs and MIFC have been made easier with a new computer program (FEEDPROFIT) which is available at no cost from the author, at john.moran@dpi.vic.gov.au (or jbm95@hotmail.com).

Chapters 12 and 13 discuss the economics of feeding management and from these chapters it is apparent that the development of generic KPIs for total feed costs and MIFC depend greatly on the base costs of feeds in different dairy regions.

14.3 Herd-related key factors influencing farm productivity

14.3.1 Proportion of productive cows

Proportion of cows milking of those that have calved

One good measure of the performance of the milking herd is the proportion of cows actually producing milk. For herds with a 12-month calving interval, lactation length should be 300 days (for a 65-day dry period), so lactation length would be the calving interval less 65 days, meaning that 82% of the cows are milking at any one time with 100% calving rate. However, in most year-round calving systems, only 75% of the adult cows are milking. The longer the dry period, the lower the number of cows milking at any one time. The number of cows milking at any one time is influenced by several factors, the most important ones being lactation length, inter-calving interval and calving rate. The effects of these factors on percentage of cows and first calf heifers milking in the adult herd have been quantified in Table 14.4. It is assumed that cows with a 12-month inter-calving interval were dried off 65 days prior to calving. It also assumes no cows were culled for poor fertility or production and there were no mortalities among the milking herd. This table highlights the adverse effects of inter-calving interval on the

Table 14.4 Proportion (%) of cows and first calf heifers milking in the adult dairy herd as influenced by lactation length, inter-calving interval and calving rate

Lactation length (d)	Calving rate (%)	Inter-calving interval (mo)		
		12	15	18
330	90	–	65	54
300		74	59	49
270		67	53	44
240		59	47	39
330	80	–	58	48
300		66	53	39
270		59	47	35
240		53	42	32
330	70	–	51	42
300		58	46	38
270		52	41	35
240		46	37	31

proportion of productive cows in the herd and this can easily fall below half the adult cows in the milking herd.

One way to demonstrate the importance of having as many of the adult cows milking as possible is to create a table, as in Table 14.5, in which the percentage of days any one cow is milking is related to the herd's inter-calving interval, the length of the dry period, hence the average lactation length. This is essentially the same as calculating the percentage of adult cows milking for 100% calving rate.

KPIs for tropical smallholder dairy farmers are:

- 74%: excellent
- 60–73%: acceptable
- 50–59%: below average
- 40–49%: not good.

Cows milking as a proportion of the complete dairy herd

Another useful measure is the size of the milking herd as a percentage of the total dairy herd, which includes milk fed and weaned replacement dairy heifers, breeding bulls (if any), dry cows and milking cows. As well as lactation length, inter-calving interval and calving rate, there are other important factors such as heifer wastage, age at first calving, culling of cows for poor performance and mortalities among the milking herd. Heifer wastage quantifies the combination of pre-weaning calf mortality and losses between weaning and second calving.

Based on a model developed by Wattiaux (1999), Table 14.6 presents the effects of some of the key factors, namely lactation length, calf and heifer mortality (up to 24

Table 14.5 Proportion (%) of days milking as influenced by calving interval and lactation length

Calving interval (d)	Dry period (d)	Lactation length (d)	% days milking
365	65	300	82
	90	275	75
	115	250	68
400	65	335	84
	100	300	75
	125	275	69
	150	250	62
450	65	385	86
	115	35	74
	150	300	67
	175	275	61
	200	250	55

months of age) and age at first calving, on the percentage of milking cows (and first calf heifers) in the total dairy herd. A series of assumptions had to be made on other key variables in this model. These were a lactation length of 300 days, calving rate of 90%, with half of the calves born being heifers, and 10% of these heifers were sold before calving, while there was also a 35% annual culling rate within the milking herd.

From this table, the proportion of milking cows decreases with age of first calving because heifers spend a longer time as young stock prior to joining the milking herd. The proportion of milking cows increases with higher calf and heifer mortalities because there were fewer heifers. Longer inter-calving intervals have the most dramatic effect on

Table 14.6 Proportion (%) of cows and first calf heifers milking in the entire dairy herd as influenced by lactation length, inter-calving interval and calving rate

Age at first calving (mo)	Calf and heifer mortality (%)	Inter-calving interval (mo)		
		12	15	18
25	10	44	40	35
30		40	36	33
35		37	34	31
25	15	47	41	37
30		42	37	33
35		39	35	31
25	20	48	42	37
30		43	40	35
35		40	36	32

milking cow numbers. This table highlights the fact that at any one time, less than half the dairy herd (ranging from 31 to 48%) are generating income.

KPIs for tropical smallholder dairy farmers are:

- 48%: excellent
- 40–47%: acceptable
- 35–39%: below average
- 30–34%: not good.

14.3.2 Pattern of milk production

The two major factors determining total lactation milk production are the peak lactation yield (within six to eight weeks post calving) and its rate of decline from this peak (or lactation persistency). The persistency quantifies the average rate of decrease in yield for each month after the peak. The higher this number, the faster the rate of decline, hence the less milk produced. The mathematics of calculating persistency is discussed in Section 5.2.

In Asia, lactation persistencies of less than 8% per month may be achievable on very well managed farms but more realistic levels are 8–12% per month. Over a 300-day lactation, a cow with a peak milk yield of 15 kg/day and an 8% persistency produces 9.9 kg/day average and a total of 2980 kg, while a 12% persistency would equate to 7.8 kg/day average and 2330 kg total. A cow peaking at 20 kg/day with an 8% persistency produces 13.2 kg/day and 3970 kg total, or with a 12% persistency, she would produce 10.4 kg/day and 3110 kg in total. A more productive cow, say with a 25 kg/day peak and 8% persistency, produces 16.6 kg/day average and 4960 kg in total, while a 12% persistency would produce 13.0 kg/day average and 3885 kg total. Such average and full lactation milk yields for the same peak and persistency will vary with lactation lengths. In summary, milk yields at any one time are the result of peak milk yield and persistency. If they are below expectations, it is important to diagnose the cause.

A very high persistency value, indicating a rapid drop off in milk yield post peak, can be indicative of poor feeding management during mid lactation (see Figure 5.1 on page 60) which often, particularly in high quality dairy cows, leads to a rapid weight loss and a delay in the first post-calving oestrus hence reduced fertility. In well bred dairy herds, feeding management must be directed towards supplying adequate nutrients, particularly energy in early lactation, to achieve high peak yields, and also in mid lactation to maintain milk yields.

14.3.3 Reproductive performance

For year-round calving herds, there are four useful measures of reproductive performance. These are:

- **100-day-in-calf rate.** This calculates the percentage of the cows in the herd that become pregnant by 100 days after calving. It also describes how many cows will calve within about 13 months of their previous calving. High 100-day-in-calf rates indicates fewer cows with long intervals between calving and fewer cows culled as empty. Cows that conceive within 100 days of calving will calve again within 13 months

and generate higher profits than cows that take a longer time to conceive or fail to get pregnant. This measure usually allows for the voluntary waiting period (the days between calving and the first mating) of say 55 days plus two oestrus cycles of AI (say 42 days) before cows are put out for natural mating.

- **200-day-not-in-calf rate.** This calculates the percentage of cows not pregnant by 200 days after calving. Farmers want as many cows as possible to calve no more than 15–16 months after their previous calving. This coincides with six months after which non-pregnant cows are often culled. It cannot be calculated until many months after cows have calved, but because it is closely related to 100 days in-calf-rate, it can be estimated from that measure. It cannot be calculated unless the whole herd is pregnancy tested.
- **Submission rate** is the percentage of the herd which received at least one insemination within a specified number of days after calving. To achieve a high 100-day-in-calf rate, a high percentage of cows in the herd must be submitted for insemination soon after calving. An 80-day submission rate is the percentage of cows that receive at least one insemination by 80 days after calving.
- **Conception rates** are the number of services resulting in pregnancy divided by the total number of services. This describes the percentage of inseminations that are successful and result in pregnancy. This has always been considered an important measure of reproduction but it does not fully describe overall herd performance. For example, herds can have high conception rates but poor 100-day-in-calf and high 200-day-not-in-calf rates. Sometimes the first insemination conception rate is calculated by including only the first services after calving in the analyses.

For a smallholder milking herd in Asia, target KPIs are:

- 100-day-in-calf rate: 55–60%
- 200-day-not-in-calf rate: 13–15%
- Submission rate: 65–70%
- Voluntary waiting period: 50–60 days
- Conception rate to first insemination: 45–50%
- Inseminations per conception in an AI program: 1.8–2.0.

Better fed cows have higher fertility which can improve 100-day-in-calf rates from 41 to 57% and reduce 200-day-not-in-calf rates from 15% to 9%.

These measures of reproductive performance are rarely used in Asia, because they require routine pregnancy testing of the entire herd. More typical reproductive measures are days from calving to first service and inter-calving interval. Targets are for cows to be first mated 60–80 days post calving which should lead to 12–13 month inter-calving interval.

STOAS (1999) compared reproduction and calf survival in two rearing systems to calculate their relative replacement rates for a dairy herd with stable stock numbers in Table 14.7. System A's measures presented in this table could be considered as a set of KPIs.

Assuming cows remain in the milking herd for 4–5 lactations, 20–25% should be replaced each year. The supply of 36% heifers from System A allows for the sale of young

Table 14.7 Measures of reproduction and calf rearing to produce replacements for a stable dairy herd.

Rearing system	A	B
Calving interval (month)	12	18
Calving rate (%)	85	65
Stillborn calves (%)	2	5
Calf mortality from 0–24 month (%)	8	20
Non pregnant heifers (%)	5	10
Heifer calves born (%)	36	15

(Source: STOAS 1999)

breeding stock or a higher culling rate to better address genetic improvements in the herd. Only one in every six or seven cows could be replaced annually in System B (in Table 14.7), which would hardly be enough to maintain herd numbers, let alone allow for much genetic selection.

With high ages at first calving (>30 months) and long inter-calving intervals (>15 months), it is very difficult to increase herd size through natural increases. That is why it is so important to seek the underlying causes of herds with high percentages of dry cows, or a high proportion of heifers to cows. The most likely cause is poor feeding management, but there could be others such as disease, heat stress or poor reproductive practices.

14.3.4 Heifer management

Poor heifer management is a major problem in many (if not most) Asian smallholder dairy farms. Young stock receive insufficient attention because they do not generate income for many months while their first three months are the most expensive period in the life of any dairy cow. A low calf mortality rate indicates that early milk rearing practices are adequate and allow for greater opportunity for economic and genetic improvement in the herd. When a heifer dies, there are fewer opportunities for culling unprofitable cows.

There are many hidden costs arising from poor management of the replacement dairy herd. The milking potential of small stunted animals that do not calve until three years of age has been markedly reduced, while very high mortality (death) and morbidity (sick) rates in calves during their milk feeding period represent an enormous waste of genetic potential in the dairy herd as well as cash outlay.

There are easily quantifiable benefits in having more newly calved heifers available to replace older unprofitable cows as heifer and reproductive managements improve. These benefits are:

- 1–2% more first calf heifers for every month reduction in age at first calving
- 3–5% more first calf heifers for every 10% reduction in calf mortality
- 2–3% more first calf heifers for every month reduction in inter-calving interval

Farmers should aim to rear 20–25% of their milking herd each year as replacements, to calve down for the first time by about two years of age and produce at least five calves during their productive life. Realistic KPIs for tropical dairy systems are:



Figure 14.3 A poorly managed veterinary storage is often indicative of other poor farming practices (Sri Lanka)

- Calf mortality up to weaning, 4–6%
- Heifer wastage rate, from birth to second calving, 20–25%
- Live weight at mating, 250–300 kg at mating
- Live weight at first calving, 400–500 kg (depending on breed type)
- Age at first calving, 28–30 months.

Another good indication of heifer management is first lactation milk yield, expressed as a percentage of mature cow production, with a target of 80–85%. If this is less than 75% of the mature equivalent, then the heifer rearing program should be reviewed.

Wither height (or height at the shoulder) is a good measure of bone growth and potential body frame size in heifers. Frame size can influence ease of calving and appetite of milking cows. Farmers should aim for wither heights of 115–120 cm by 15 months and 125–130 cm by 24 months of age.

14.4 Ease of collecting raw data to calculate KPIs

Each of the above KPIs can provide a valuable insight into the farm resources and management skills of individual smallholders. However, it is important to prioritise them based on:

- Their relevance to the farmer's current stage of farm development
- The farmer's ability to interpret the data and use it in future decision making
- The ease and accuracy of collecting the necessary raw data.

The ability of smallholder dairy farmers to collect the raw data would vary greatly with their management skills, level of education, support from service providers and – of most importance – their motivation to want to use the particular KPI in their farm decision making.

Some of the easiest to collect are the raw data to calculate the proportion of productive cows (KPI 7 from Table 14.1) as virtually every smallholder farmer knows the number of milking cows, dry cows, heifers and calves in his herd. In a matter of minutes, the author collected such data from a dozen smallholders at a dairy farmer conference in Vietnam, which indicated that most of these particular farmers had acceptable values for the percentage of milking cows in the milking herd and the percentage of milking cows in the entire herd (KPI 7). Another 'easy to collect' data set is the stocking capacity (KPI 1), as most farmers know their forage production area. These same farmers had eight to nine total stock/ha and five to six adult cows/ha, indicating that they did not overstock their farms. As they were selected to attend the conference, one could assume they were considered to be 'good' farmers.

It is not difficult to collect raw data on patterns of milk production (KPI 8) as many farmers record daily milk yields from individual cows. The level of concentrate feeding (KPI 4) is another data set readily available while many farmers could estimate their daily forage feeding program (as a guide to KPI 2). Likewise, some of the reproductive (KPI 9) and heifer data (KPI 10) can be easily calculated from raw data on dates of inseminations, calvings and ages at first calving, while a chest girth tape can provide estimates of live weights of different classes of stock.

With limited experience, the raw data for the two spreadsheets described in section 11.6 (FARMPROFIT and FEEDPROFIT) can be quite easily collected, thus providing valuable measures of farm profits, such as KPIs 5 and 6.

14.5 A final word about KPIs

The above diagnoses require the calculation of many KPIs to allow a value judgement to be made on business performance. It is timely to issue a word of caution about KPIs. Many KPIs are simply ratios or proportions assessing some level of output in relation to some level of input. Others measure success simply with numbers or amounts, such as target forage quality or heifer live weight. Although they are valuable guides, there is no all encompassing or perfect indicator of business success. All KPIs must be viewed within the whole business, with each one contributing only a part.

It is possible to achieve high performance in an indicator which does not translate into business financial success. For example, a farmer whose farm has very poor quality soils may not be able to grow as good a quality forage as he can purchase at a good price, close by. Therefore, it would be more profitable to let someone else grow the bulk of his forages.

Low performance measures in some key factors, well below the KPI, often lead to high performance measures in other key factors, which can produce a false sense of security about the ability to achieve some of the production targets. One example is low peak milk yield and short inter-calving intervals in cows of low genetic merit. Because such cows are not ‘genetically programmed’ to use their body reserves to supplement the limited intakes of feed nutrients during early lactation, their live weight will hardly change and they may cycle soon after calving. When farmers plan to improve the genetic merit of their herd through using imported cows or high grade semen, they must improve their feeding management during early lactation. If not, peak milk yields may not greatly improve and herd fertility is likely to drastically fall.

This has occurred (and is still occurring) all too frequently in national dairy development programs where over the last two decades, many thousands of purebred and crossbred Friesian heifers have been imported and placed on smallholder farms but with little attention given to the farmer’s ability to provide the necessary feed supplies. Many of these expensive imported heifers had very poor fertility, with the program having little impact on national milk production targets. The blame was unfairly placed on the imported stock rather than their poor feeding management.

As discussed in Chapter 2, profitable dairy farming can be broken down into nine key task areas, which can be considered as steps in the supply chain of profitable dairy farming (see Figure 2.3 on page 22). 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.

15

Budgeting for future farm development

This chapter introduces the concept of budgets to predict the current costs and future returns. Sensitivity analysis provides an assessment of the impact of major cost items on predicted future earnings.

The main points in this chapter

- Budgets are of two types: full development budgets for major changes in farm management and partial budgets for smaller changes in farm practices.
- Cash development budgets usually involve assessing changes in the entire collection of costs and returns, taking into account that patterns of cash flow may not allow any repayments for the first year or two, leading to increasing debt levels.
- Preparing a partial budget requires the calculation of added returns, reduced costs, added costs and reduced returns arising from the development project. The net benefits can then be determined to decide if the alternative may have economic advantages.
- Another valuable outcome from a partial budget is the prediction of return on marginal capital invested in the project, to decide if this is acceptable when compared to other forms of on-farm and off-farm investments.
- It is possible to quantify the range of likely impacts on predicted profit, of variation in the costs of some of the major input items. Such sensitivity analyses provide realistic measures of 'best' and 'worse' case scenarios.
- Because benefits can occur over many years, discounting procedures can be incorporated into budgets to take into account the fact that today's money is worth more now than in the future.

Budgets are a projection into the future of farming operations using knowledge from the past. They predict the expected profitability of the business, and so whether in the long term, it will remain viable to be able to generate adequate income and repay the farm's

debts. Budgets also help farmers to communicate to others where their business is heading financially.

15.1 Types of budgets

There are two types of budgets, full and partial budgets. A full budget is a detailed financial analysis necessary in the event of significant changes in cash flow or income, such as a large change in milk returns which might lead to major farm management decisions. It can also be routine, say every few years, just to ensure enough cash is available to service ongoing debts and capital purchases. Partial budgets, the major topic of this chapter, estimate the effect on profit of a proposed change affecting only part of the farming operation.

15.1.1 Cash development budgets

Medium-term development requires investment of borrowed capital, with a pay-off which will take several years. Assuming that the physical program has already been planned, the cash flow budget simply tests whether this plan is financially feasible. It is often necessary to test three or four plans before making a final decision on the best program. In many cases, repayments are not planned on loans during the first or second year, thus leading to an increasing debt. Such patterns of cash flow need to be fully comprehended by the creditor. Many development programs have failed because of insufficient credit being provided in the early years.

When considering borrowing money to improve farm income, the return on extra capital is usually calculated using a partial budget. Partial budgets are a quick simple method to assess proposed farm changes. They are designed to only look at the net effect of a change with minimal information required. They are generally used as a first step in analysing a proposed change to the farm. More complex changes require more detailed analyses such as whole farm budgets and cash flow and developmental budgets.

With any major change in farm management practices, a cash flow budget is important. Invariably the change requires some cash outlays up-front and a higher flow of income or reduced cost some time in the future. In this case, the cash flow budget can be extended to a developmental budget to provide a predicted cash flow over an extended period of time. The progression of a developmental budget involves several steps:

1. Decide what change you want to undertake.
2. Decide how long it will take to achieve.
3. Identify the physical and financial aspects of the proposed change, for example, the increase in herd number and the capital required.
4. Construct cash flow budgets covering the start-up period until a 'steady state' is reached.
5. Examine and modify the budget and plan if necessary.

Cash flow budgets are then an integral part of any farm development program, as they can predict money received for the program less the money spent. Bankers and other credit agencies consider them essential, because without them, farmers are unlikely

to be able to borrow for that purpose. Cash flows take into consideration the following questions:

- How much money will the program generate and how much will it cost?
- When will this money be required and when will it yield a return?
- If all the money is not made available, how will the shortfall be covered? Does the farmer have other sources of finance he can use?
- What is the time span for the loan to be fully paid out?

Cash flow budgets then provide continuous feedback or monitoring during the development period. The farmer, adviser or lender can then compare the actual cash income and costs with the original estimates. If they greatly differ, then steps can be taken to modify the program. By regularly tabulating budgeted versus actual moneys, say every month, rapid changes can be made in the program. Cash flow budgets focus on cash whereas other budgets covering longer periods, such as profit budgets, include non-cash items such as inventory valuations and depreciation.

15.1.2 Partial budgets

Partial budgets provide planning and decision-making frameworks to compare the costs and benefits of alternative farm practices, which focus on the changes in income and expenses resulting from that alternative. Thus, all aspects of farm profits that are unchanged by the decision can be safely ignored. In a nutshell, partial budgeting allows farmers to get a better handle on how a decision will affect the overall profitability of their farm enterprise.

This framework does not account for changes in the value of money over time. If analyses are required to focus on effects that occur for more than a year or two, the net present value approach should be used, which discounts the money in future years to account for its lower value compared to current year values. This is discussed in a later section in this chapter.

Planning includes taking an inventory of farm resources, devising alternative uses of these resources and choosing the best alternative. By employing budgeting principles the farmer can compare costs and returns of a range of alternative actions. Ideally, he should aim to choose a course of action that most clearly matches his long-term goals.

The key principals of budgeting are to prepare for the unexpected and to measure past performance against future profits. Good budgets begin with specific measurable goals that provide clear direction to all involved in the business. These goals can be personal as well as business, such as ‘providing additional income for educating the children over the next ten years’.

Partial budgets are useful to evaluate changes, for example:

- Modifying a current activity, e.g. getting someone else to rear all your heifer replacements off-farm.
- Expanding an activity, e.g. increasing herd size.
- Introducing a new activity, e.g. conserving home-grown forage rather than buying in dry season forages.

- Evaluating a capital investment, e.g. installing a bucket milker instead of hand milking the cows.
- Assessing variations in marketing procedures, e.g. changing from an informal to formal milk market.
- Determining a 'break even' price, namely the unit return for key farm outputs, to ensure that the change in a farm practice is cost neutral, that is, its net benefits are zero.
- Determining a 'break even' yield, namely the yield of key farm outputs at their current returns, to ensure the budget is cost neutral, that is, their net benefits are zero.
- It can be beneficial to use 'best case' and 'worse case' scenarios to establish a range for the partial budget analysis. Such sensitivity analyses are discussed below.

Partial budgets are generally based on predicting gross margins (that is income less variable costs), although they can include overhead costs when the farm change is significant. In that case, there is no differentiation between variable and overhead costs within the budget analysis. If capital costs are involved, the value of their annual depreciation should be factored into the calculations. Even though purchased livestock could be called a capital investment to the farm, their values are not depreciated over time as with other items of capital equipment.

The success of the partial budget is reliant on its predictive accuracy, which depends on the accuracy of the information and estimates it contains. The farmer needs to collect factual data about the proposed change and provide reasonable estimates of such items as future prices, yields and gains. Factual information includes current costs of the production inputs, costs of capital, current commodity prices or other items pertinent to the change.

It is difficult to generate estimates for the unknown, particularly prices. The farmer must then estimate yields and prices to get an idea of what returns will or will not be. Yield and production estimates can be obtained from several sources. The best approach to use is a combination of historical farm data from both his and other nearby farms, predictions from reputable government or cooperative advisers and finally his own intuition. These can be incorporated into a sensitivity analysis (see later in this chapter) using a range of prices and production responses. The unit used to analyse the change can be any size, say per milking cow, with the result multiplied as necessary to show the economic impact on the whole enterprise.

15.2 Steps for a partial budget

There are eight steps to the successful use of partial budgets analyses as a decision-making tool. Each step serves a specific, unique purpose and is vital to an accurate, meaningful analysis:

1. State the proposed change. It is important to have a clear understanding of exactly what alternative is being analysed.
2. List the added returns. Identify new revenue streams or increasing existing streams.
3. List the reduced costs. Identify the general areas where a choice might lower expenses.



Figure 15.1 A well-designed milking parlour in Pakistan where summer temperatures can reach 40°C

4. List the added costs. In the situation of capital purchases, a depreciated cost must be claimed annually, not the total purchase cost.
5. List the reduced returns. Will revenues be decreased as a result of choosing a particular alternative? Will it decrease yields?
6. Summarise the net effects. Once the individual positive (steps 2 and 3) and negative (steps 4 and 5) aspects of the alternative have been identified, they should be aggregated to determine a total cost and total benefit of the alternative. The net benefit is found by subtracting total costs from total benefits. If the result is positive, then that alternative may have some economic advantages. However, if it is negative, the business would be better off staying with the current situation, or analysing a different alternative.
7. If capital is invested in the development, it is useful to calculate the return on that marginal capital. The question must then be asked, 'What is an acceptable return on this marginal capital?' It certainly should be more than current interest rates for investing that money in other ventures, either off-farm or on-farm. In making a value judgement, advisers often seek a value of at least 25–30% to take into account the risk and uncertainty of the calculated net benefits (step 6) actually being realised.
8. Consider non-economic and other factors. These must be taken into account but are difficult to quantify. If the alternative involves increasing herd size, it is important to



Figure 15.2 A well-designed cow shed in Pakistan where summer temperatures can reach 40°C

consider the existing farm infrastructure, such as the capacity of the dairy sheds and the milking parlour; if these are already stocked to near full capacity, they may have to be enlarged, thus requiring additional capital investment. Other considerations may include the social aspects of having less labour on the farm, increased or decreased leisure time, the need for increased or specialised knowledge and safety and/or ease of use of new equipment. Placing a monetary value on some of these subjective factors may be nigh impossible.

15.2.1 A case study for partial budgeting

A Malaysian dairy farmer with 30 milking cows wants to increase his herd size to 40 milking cows by contracting the local dairy cooperative to rear his eight replacement heifers (from three until 27 months of age). His farm is seven hectares in size and he currently uses no fertilisers to grow his forages, depending entirely on dairy shed effluent. His dairy shed will house the additional 10 cows, partly because he will rear eight less heifers. Each heifer consumes 1000 kg DM forage/yr and 500 kg/yr of formulated concentrate during rearing. As well as removing his eight heifers, he plans to introduce urea fertiliser onto his existing forage production area to increase forage production by 25%, so he will not have to purchase more forage for his extra cows, just additional concentrates. Milking cows consume 2500 kg/yr forage DM plus 1800 kg/yr concentrate and produce 13 kg/d or 4000 kg/yr milk. Because he currently doesn't use



Figure 15.3 A well-designed storage facility for milking machine equipment (southern Thailand)

any inorganic fertiliser and only has a stocking capacity of 6.2 cows/ha forage, he can expect the marginal response to urea fertiliser to be 10 kg forage DM per kg urea applied. The time saved from not having to feed the eight heifers will be spent on growing and harvesting his extra home-grown forage.

Many of the assumptions listed above originated from *Tropical dairy farming* (Moran 2005) together with recent (2007) personal discussions on farm costs with Malaysian dairy farmers and advisers in MR (Malaysian ringgits).

- Cows cost 5000 MR each to purchase
- Milk returns: 2.00 MR/kg
- Stock income: 900 MR/cow/yr (sale of bull calves and cull cows)
- Formulated concentrates: 0.80 MR/kg or 800 MR/t
- Urea fertiliser: 1.20 MR/kg or 120 MR/t forage DM grown
- Contract heifer rearing charges: 3.00 MR/heifer/d
- Reduced heifer rearing costs on-farm: 10 MR/heifer/yr. These do not include feed for young stock
- Herd and shed costs for cows (mating, veterinary, milk harvesting): 100 MR/cow/yr. These do not include feed for young stock.
- Feed cost (such as running costs for grass chopper, fuel and oil, repairs and maintenance), 50 MR/cow/yr.

Using the approach described above, the eight steps are detailed below then summarised in Table 15.1:

1. The partial budget is to increase the size of his milking herd by 33%, contract rear eight replacement heifers and apply extra urea fertiliser to farm
2. Added returns per cow:
 - 4000 kg milk @ 2.00 MR/kg or 8000 MR/yr
 - Stock income @ 900 MR/yr
 - Total is 8900 MR/cow/yr or 89 000 MR/yr for 10 cows.
3. Reduced costs for not rearing heifers on the farm, on a per heifer basis
 - 1 t DM forage @ 120 MR fertiliser cost/t DM or 120 MR/yr
 - 0.5 t concentrate @ 800 MR/t or 400 MR/yr
 - Veterinary etc. costs @ 10 MR/heifer/yr
 - Total is 530 MR/heifer/yr or 4240 MR/yr for 8 heifers.
4. Added costs amount to:
 - a) 10 cows @ 5000 MR/cow or 50 000 MR. This is a once-off investment so is not part of the annual budget
 - b) Cost per cow;
 - 2.5 t DM/cow forage @120 MR fertiliser cost/t DM or 300 MR/yr
 - 1.8 t concentrate @ 800 MR/t or 1440 MR/yr
 - Herd and shed costs @ 100 MR/yr
 - Feed costs (excl. forage and concentrates) @ 50 MR/cow
 - Total cost is 1890 MR/cow/yr or 18 900 MR/yr for 10 cows.
 - c) Cost for contract rearing heifers;
 - Annual contract @ 3.00 MR/heifer/d or 8760 MR/yr for 8 heifers
 - Total additional costs are 27 660 MR/yr.
5. Reduced returns. This development program will not adversely affect farm returns.
6. Net benefit. This is (added return + reduced costs) – (added costs + reduced returns) or

$$(89\ 000 + 4240) - (27\ 660 + 0) = 65\ 580\ \text{MR/yr.}$$

Table 15.1 Annual partial budget (in MR/yr) for increasing herd size on a Malaysian smallholder farm

Positive effects	Negative effects
Added returns Extra milk = 89 000	Added costs (Cow purchases = 50 000) Cow variable costs = 18 900 Contract heifer rearing costs = 8760 Total annual costs = 27 660
Reduced costs On-farm heifer rearing costs = 4240	Reduced returns Nil
Net benefit	65 580
Return on marginal capital	131.2%

7. Return on marginal capital. For an investment of 50 000 MR, the annual net benefit is 65 580 MR which yields a 131.2% return on marginal capital.
8. Non-economic factors. There are no capital investments in sheds or farm equipment while labour inputs have not changed. There are no interest charges because all payments are made frequently, so do not require any large one-off payments.

The main advantage of partial budgeting is that it provides a procedure to consider each cost item in turn, asking the question ‘In what way will this cost item change as a result of other changes on the farm?’ The main disadvantage is that it is a cumbersome and time consuming way of considering several alternatives. It is, however, by far the best way of objectively assessing the effect of any proposed changes in farm management strategies on the likely profit.

One of the problems, as with all planning, is the need to make decisions without really having the knowledge or time to work out the effect of the proposed change on the profit. For example, in the above example, you could pose the question ‘Will it pay me to purchase this forage for the extra milking cows rather than grow it on-farm with higher fertiliser inputs?’

In practice there is not enough time to evaluate all the alternatives. Computers can be used to calculate ‘What if’ situations. The danger then is that the issues become too confusing. ‘Back of the envelope’ calculations, despite modern technology, are still often the best way to make decisions, particularly if one has to back one’s hunches as to possible future trends in profitability. For example, in the above case study, if the demand for contract rearing increases in the region, so might prices for its cost. Budgeting is only part of the decision-making process. Anticipating the future is of equal, if not greater, importance.

15.3 Sensitivity analysis

When varying the level or costs of farm inputs and monitoring their effects on outputs, it is apparent that some inputs have a large influence on profits while others have very little influence. In addition, farm inputs often do not operate in isolation, but interact with others. For example, if concentrate prices increase, so might the cost of contract heifer rearing. This can be quantified using a sensitivity analysis. With the above case study, two of the major cost items are milk returns and concentrate prices.

Table 15.2 presents a sensitivity analysis on changes in the net benefits and the return on marginal capital for the case study farm above as milk returns and concentrate prices vary by 10% above or below their values in Table 15.1’s partial budget.

Table 15.2 highlights the importance of unit milk returns on the profits arising from increasing herd size. A change of 10% in milk return influenced net benefit by 10% whereas a change of 10% in concentrate prices influenced net benefits by less than 2%. The return on marginal capital always exceeded 100%, indicating that the investment of 50 000 MR to purchase 10 cows will be recouped within the first 12 months.

The predicted milk yield of the new cows (13 kg/d) was based on feeding each cow a total of 1.8 t concentrate over 300 days lactation or an average of 6 kg/cow/day. This is

Table 15.2 The effects of a 10% change in milk returns or concentrate prices on net benefits (in MR) and return on marginal capital (% in italics) derived from the partial budget for increasing herd size on a Malaysian smallholder farm

		Concentrate price (MR/t)		
		720	800	880
Milk return (MR/kg)	1.80	58 700 (117)	59 580 (119)	60 460 (121)
	2.00	64 700 (129)	65 580 (131)	66 460 (133)
	2.20	70 700 (141)	71 580 (143)	72 460 (145)

similar to the milk response depicted in Table 5.3 (page 65) of Chapter 5. However, milk yields are dependent on the forage quality as much as level of concentrate fed. Cow genetics can also be important particularly if there is a shortage of available cows for sale, thus limiting the opportunity for the farmer to select good quality cows. Contract heifer rearing costs could also have an important influence on farm profits. The effects of milk yield (valued at 2.00 MR/L) and contract heifer rearing costs are presented in the sensitivity analyses in Table 15.3.

A drop in 250 kg milk over the entire lactation would lead to a 8–9% decrease in net benefits while an increase of 0.50 MR in daily contract heifer rearing costs would decrease net benefits by 2–3%. These two tables (15.2 and 15.3) highlight the ease with which the relative impact of costs for farm inputs can be quantified using a sensitivity analysis approach. Greatest attention should be given to the ‘high impact’ ones to ensure they are predicted most accurately.

15.4 Accounting for time in a budget

Budgets involve investing finance to improve farm performance over time. The finances are normally invested in a relatively short period whereas the benefits occur over a much longer time period. Because of inflation, a dollar today is worth more to a farmer now than it will be some time in the future, since that dollar can be invested to earn income. For example, investing a dollar today in a bank will return us more than a dollar in six years’ time. One dollar invested today at 5% interest will in fact return \$1.34 in six years’ time.

A good example of this is spending money today on improving the feeding and management of dairy replacement heifers. They are the future of the dairy herd, so any improvement in their management today will show up as improved production when

Table 15.3 The effects of milk yield and heifer rearing costs on net benefits (in MR) and return on marginal capital (% in italics) derived from the partial budget for increasing herd size on a Malaysian smallholder farm

		Contract heifer rearing cost (MR/heifer/d)		
		2.50	3.00	3.50
Milk yield (kg/lactation)	3500	57 040 (114)	55 580 (111)	54 120 (108)
	3750	62 040 (124)	60 580 (121)	59 120 (118)
	4000	67 040 (134)	65 580 (131)	64 120 (128)

they first calve down in two years' time. These benefits will continue for their entire life in the milking herd. Therefore, when predicting cash flows from heifer development schemes into the future, say over five years, budgets should be based on what is called 'discounted cash flows'. Discounting means deducting from the scheme's expected earnings, the maximum amount that investment could earn if it was invested elsewhere. This then involves budgeting all the annual costs and returns, and adjusting these cash flows back to their equivalent present value over the 5-year-period that the benefits would flow. This is called the net present value (NPV) of the benefits from the investment. These economic benefits are also expressed in terms of their internal rate of return (IRR), which is the discount rate that will result in a zero NPV to the investment. The IRR can be interpreted as the maximum interest rate farmers could afford to pay for the heifer rearing enterprise if they borrowed all the funds required and were still able to refund the capital borrowed, plus interest. A discount rate of 10% is the usual one to use in such discounted cash flows.

For every year that the benefits from the initial investment is made, the NPV has to be calculated annually so the final added returns (as in the partial budget in Table 15.1) can be summed to decide if the initial investment was a good decision. Rather than present a detailed example of the calculations involved, which would normally be done by a lending agent, it is sufficient to say that when investments in farm practices require a long period of time to reap their benefits, their ultimate return must take into account their discounted monetary value compared to what it would be worth today.

One other problem with medium- and long-term dairy enterprise budgets is obtaining a realistic estimate of the ability of the milking herd to multiply in size. As well as buying replacement cows and selling cull cows, the natural increase of the herd needs to be predicted. Calving rates, inter-calving intervals, number of services (inseminations) per successful conception are notoriously difficult to predict as are pre-weaning calf mortality rates and herd wastage rates (that is the proportion of heifer calves born and reared that remain in the herd for their second calving). Using sexed semen in future years will introduce another unknown, the percentage of heifer calves in each year's calf drop. Recommended KPIs have been presented in Chapter 14.

16

Risk in tropical dairy farming

This chapter introduces the concept of risk and how smallholder farmers have to live with it.

The main points in this chapter

- Risk is basically uncertainty about the future, hence the difficulties farmers have to live with when trying to predict their farm performance and profitability in years to come.
- There is business risk and there is financial risk. Business risk is the cost of inputs, returns from outputs and the level of farm production, while financial risk is concerned with the uncertainty about using other people's money.
- Sources of risk can be external and internal. External sources arise from natural, economic, social and political environments, while internal sources are those to do with the farm manager, such as his health, attitudes and aspirations.
- There is short-term and long-term risk. Variations in milk prices are a good example of long-term risk currently influencing the smallholder dairy farmer.
- Farmers can develop risk management strategies, such as planting more drought-tolerant forage legumes as well as higher yielding forage grasses.
- Farm budgets and sensitivity analyses are useful tools for managing risk.
- Biosecurity against introducing cattle diseases and other animal health problems is a good example of risk management.

The concept of risk can be summarised by the following statements made by Malcolm (pers. comm.):

- If the future was known with certainty, it would have happened.
- Life is risky as we cannot remember the future.
- The future is going to happen anyway, so prepare for it.
- If you know what is going to happen, it's easy; it's preparing for what you don't know that is hard.
- Last year doesn't happen; it's been.

As we cannot remember the future, we have to imagine it instead. Things might happen, but they might not. The good thing about this is that risk and uncertainty make it possible to earn good profits. If there was not much risk, there would not be much profit either.

A dairy business is made up of a mix of people, livestock, natural resources, technology, economics and finance. Farmers buy their inputs to production and sell their milk in the markets. What they do is subject to laws and affected by things governments do. Running a farm business means dealing with lots of risks. There is risk about how much grass they can grow, how much milk their cows will produce and of what quality, hence unit price. There is risk about what their farm production will cost and how much it is worth. There is risk affecting how much spare cash they will have to pay interest to the people who have loaned funds to their farm business. There is risk about what governments all over the world might do that will affect how the farmer's business is able to operate. The 2008/09 global financial crisis is a direct result of unpredicted risk!

In other words, farming is a risky business. Most farm decisions involve risk or uncertainty. Risk and uncertainty challenge the technical and managerial abilities of all farmers. They impact on every part of farming: its productivity, stability, resilience and equity. Uncertainty is defined as imperfect knowledge, or not knowing what is going to happen in the future. Decisions that do not have a single outcome are then uncertain decisions. Risk is only present when the uncertain outcomes of a decision are regarded as significant or worth worrying about. Rather than the risk, it is the consequences of the risk that matter because they have to be managed to achieve resilience in the farm business.

Resilience is the ability of the system to withstand severe, usually unpredictable, disturbing factors and includes consideration of the rate and degree of recovery from that disturbance. Resilience then depends on how well the risks are understood and incorporated into farm decisions, the ability of the farm business to respond to unforeseen events and the capacity of the farmer to cope in the face of adverse outcomes.

Uncertainty means that the financial performance of the farm business cannot be controlled and accepting this makes a good manager. The key objective of farming is long-term survival, and farmers should focus on defining and working towards the farm's productive potential. This will position the farm to more fully exploit business opportunities as they arise.

16.1 Types of risk

16.1.1 Business v financial risk

There are two main types of risk in farming, business risk and financial risk (Chapman *et al.* 2007):

Business risk stems from variable yields of crops, reproduction rates, disease outbreak, climatic variability, unexpected changes in markets and prices, changes in government policies and laws, fluctuations in inflation and interest rates and personal mishaps. Sources of business risk can be condensed to price and production. These exist regardless of financial matters, such as how much money is borrowed. Price risk refers to

change in prices of inputs and outputs, whereas production risk results from factors such as weather and pests that affect output yields. These risks affect the ability of the business to pay for the inputs used, to service any debt and to appropriately reward labour and management.

Financial risk derives from other people's money that is used in the business relative to the proportion of the owner-operator's capital. The higher the ratio of debt to equity, the higher the financial risk. Any new farm practice must be assessed both as a business and financial risk. It could look good from a technical viewpoint or after considering the market forces beyond the farm, but it must be financially feasible before it should be adopted. If it requires borrowing large amounts of capital and reducing equity to dangerously low levels, this could make it vulnerable in adverse circumstances. Therefore, it becomes too high a financial risk and should be rejected at this particular time.

16.1.2 External v internal sources of risk

Another way of looking at risk is whether it originates from sources external to the farm or the internal ones affecting the farm's operating efficiency (McConnell and Dillon 1997).

External sources of risk arise from the natural, economic, social and political environments. Of most importance is the natural or climatic environment (that is, nature). Farming is profoundly affected by nature, which provides all the basic elements for biological growth and production, such as short-term and long-term weather, as well as the many natural hazards such as the recent earthquakes, tsunamis, volcanic eruptions and landslides seen in Indonesia over the last few years. All these affect yields and market supply, hence global and local prices.

Risks of the economic environment relate to the market (demand and supply), hence prices of farm inputs and outputs, inflation and interest rates and productivity through the availability and merit of new technology.

The social environment is not a major source of risk, although over time, it can influence education and lifestyle, hence impacts on farm labour supply. Social upheavals such as civil conflicts are certainly becoming more important in developing countries.

Political factors influencing risk include change in government policies which can influence commodity prices and marketing, availability and cost of credit, public infrastructure, environmental standards, labour and import laws, exchange rates and many other government reactions to the globalisation of our food production. Other more typical political influences are changes in political ideology, such as moving from a socialistic centrally planned, to a capitalistic free market economy, as occurred in Sri Lanka during the 1970s. This had a great influence on agricultural policy, including the supply of local milk, compared to imported milk.

Sources of internal risk affect the operation of each individual farm and include the health of the farm household, their interpersonal relations as influenced by personality, changing values, attitudes and aspirations. They also include the farmer's approach to conservation of farm resources, use of credit to finance farm development and inter-generational transfer of farm ownership. There is an additional one involving any external farm advice, namely its relevance to, and its likely impact on, that particular

farm. Such a change in farm practice could impose additional pressures on the social, biological or economic aspects of the current farming system.

This can be particularly important for near subsistence dairy farmers with little contact with their potential markets. Milk can be sold through formal or informal markets, while in more subsistence operations, the milk may be consumed on-farm or bartered for other goods. Increasing the farm's output of raw milk may lead to a change in market outlets, and a new set of risks for the farmer.

16.1.3 Risk in short-term and long-term decisions

Changes in product prices and yields are the most important short-term risks, because the cost of the key variable inputs (such as purchased concentrates and fertilisers) are either known and/or determined by the farmer at the time of the decision. In the long term, all yield price and cost variables are uncertain, even those under government 'control'. Yields can be predicted with some degree of confidence without the occurrence of unpredictable climatic events. The increasing costs of importing cereal grains is one classic uncertainty adversely affecting Asian smallholder dairy farmers in recent years. The extreme volatility of cost of imported dairy products is another long-term uncertainty, as this affects farm gate milk prices.

All these uncertainties make farmers very cautious with their decision making because their survival depends more on surviving adverse outcomes than benefiting from good outcomes. On the whole, farmers, particularly resource-poor smallholders, exhibit risk aversion rather than risk neutrality or risk preference. Small farmers are more susceptible to downside risk than are other sectors of society. They are more exposed to the vagaries of nature and don't have easy access to insurance or futures markets because of their small-scale structure. Unlike larger operations, they don't normally use the more formal market based institutional approaches to risk management such as bank lines of credit or overdrafts, crop and livestock insurance, forward pricing through price, futures or options contracts or market guarantees through vertical integration.

16.1.4 Good and bad risks

People outside farming generally view risk as something to be minimised. Farmers clearly know that minimising risk can minimise farm returns as well. Risk is then the source of above average profits and losses. Risk and uncertainties create opportunities and rewards that people are in business to capture. If the future was known with certainty, the profits would have already been made.

Fundamental to understanding risk in farming is to distinguish between good and bad risks, and right and wrong decisions. A good decision is based on the best information and judgement available at the time. Whether it turns out to be right or wrong depends on the outcome of subsequent events. For example, the decision to increase herd size should be based on an expected increase in demand for feed nutrients and their supply from home-grown forage supplemented with purchased feeds (additional forage and concentrates) when required. Such a decision can be classified as a good one if it is made using sound information on historically typical forage growth

rates and purchased feed costs. However, increasing herd size could turn out to be the wrong decision if seasons and costs vary substantially from the expected. Bad decisions are those made without considering the best information available and these often have little prospect of success if the expected conditions prevail. Only good luck can make a bad decision the right decision.

In far too many situations, smallholder dairy farmers may decide to increase herd size or purchase high genetic stock without taking into account their increased feed requirements. They invariably find that although the farm may produce more milk, the per cow milk production actually decreases and with it, the efficiency of converting home-grown and purchased feed into milk. Granted, the farm has more stock, hence more assets, although the equity may not change if money had to be borrowed to purchase them. However, if each cow produces less milk because of less feed being available, the decision to increase herd size or purchase superior stock, will adversely affect the overall business performance of the farm. Not only was it a bad decision, but the farm now has an increased risk to higher unit price changes for feed supplies (both on-farm and purchased).

One major problem to decision making in tropical dairy farming is the lack of objective data available with which to make such major farm decisions. Without a good knowledge of yields and quality of home-grown forages, it is difficult to make good decisions on optimum stocking capacities on smallholder farms. Table 13.2 (page 154) presents theoretical estimates of the forage produced under various levels of forage management and the forage requirements of the entire dairy herd. The bottom line is that to provide sufficient quality home-grown forage for a well balanced diet to all stock, the typical 0.5 hectare smallholder farm should have no more than two to five milking cow units, that is two to five adult cows plus one replacement heifer, depending on management of the forage production area. Therefore a good ‘rule of thumb’ is – for a farm depending entirely on home-grown forage and with a typical level of forage agronomy – no more than eight cows (together with their replacements) should be kept per ha of forage production area.

16.2 Strategies for managing risk

There are a variety of risk management strategies that smallholder dairy farmers can use and these are summarised in Table 16.1.

In drought-prone areas, diversification of cropping systems is a risk management tool. Use of different varieties and sowing them in different sequences (rotations and location within the farm) can improve yield and income stability because crop mixtures generally yield better than monocultures under stress conditions. In addition, they can reduce the incidence and build-up of pests and diseases and even exhibit compensatory yields. Differences in terms of days to maturity and variability in resistance or tolerance to stress also reduce the chance of total crop failure. This applies to both cash crops, which often supply by-products for livestock enterprises, as well as forage crops grown specifically as livestock fodder. Planting more drought-tolerant forage legumes as well as higher yielding forage grasses is a good example of risk management. A recently released CD presents a process for selecting forages for smallholder dairy farmers throughout the

Table 16.1 Risk management strategies available to smallholder dairy farmers (McConnell and Dillon 1997)

Management activity	Strategy	Type of risk reduced
Production	Use of stable enterprise – dairy genotypes	Yield, technology, policy
	Use of proven forages – e.g. Napier grass	
	Diversifying enterprises – in livestock – in cash crops – within seasons – across farm area	
	Maintain flexibility – over time – in durable assets	
	Keep reserves – seed – fodder – concentrate ingredients	
	Use risk reducing inputs	
	Share-leasing	
	Assess new technology	
	Seek information	
	Marketing	Spread sales over time
Arrange alternative outlet		
Seek barter opportunities		
Financial	Maintain high equity ratio	Financial, yield, price
	Maintain creditworthiness	
	Maintain a cash reserve	
	Develop relationship with cooperatives	
	Maintain farm assets	
	Maintain social network	
	Off-farm employment	

tropics based on their optimum climate, soils, production system and management (Cook *et al.* 2005).

16.2.1 Analysing risk in farm management

Farm management can be defined as a process by which resources and situations are manipulated by the farm manager in trying, with less than full information, to achieve his goals. When a change is made on a farm, the final outcome will not be precisely that which is thought most likely to happen at the time the change was made. Many different



Figure 16.1 Quality silage is a valuable risk management strategy (North Vietnam)

outcomes are possible. Farmers make decisions based on their best guesses about the responses of outputs to inputs and the variability of these responses.

The resilience of farm systems is most severely tested by the relatively rare but most severe circumstances that may occur when drought (hence low yield), for example, coincides with high feed costs, low milk prices and high interest rates. Or, in an extended run of dry conditions, poor prices and high interest rates. Conversely, the risk of encountering a combination of favourable events with resulting high incomes, needs to be prepared for. Weather and economic conditions may be more stable in the humid tropics than elsewhere, such as in Australia. In any one decade, Australian farmers can experience two or three poor years, a run of ordinary years then three to four good years. A similar scenario can be developed for any Asian country.

Suppose the question is whether in a particular situation, one system of dairying has more potential for profit than a feasible alternative. For example, the decision comes down either to maintaining a farm stocking capacity of eight milking cows per ha forage production or increasing it to 12 cows per hectare and relying more on purchased forages. One approach would be to undertake a risk analysis to:

- Test the effects on milk production of different levels of stocking capacities either singly or in combination, say 8 versus 10 versus 12 cows per hectare.

- Test the performance of the various systems under the full range of possibilities for feed costs (home-grown and purchased), herd costs, farm milk yields and reproductive performance and for various milk prices.

Once the raw data are available for undertaking such a series of analyses, whole-farm budgets could be developed. The result is that instead of a single value of operating profit for different farm stocking capacities, probability distributions of operating profits, net present values, internal rates of return and net cash flows for the various systems can be generated.

Without any raw data, they would have to be generated for these farm stocking capacities from a series of theoretical assumptions, such as those used in Section 13.1. Clearly, these data need to be validated from on-farm trials.

The key to managing risk is then information. This information must be about technical, human, financial, and beyond-farm elements of the system. The resilience (survival) of farm systems is ultimately determined by circumstances experienced. In addition, the quality of such management decisions depends critically on the quality of information available and the quality of processing that information. This involves judgement and intuition, which is knowledge gained from experience and past learning and understanding the whole system. Part of decision analysis and decision making is testing intuition, using analytical tools such as whole-farm budgets and risk analysis (Chapman *et al.* 2007). It is not necessary to know everything about everything to make a decision – just enough about enough. The best approach is to attain maximum information from minimum data.

Being rational, farmers typically make their risky decisions in a reasoned way, on the basis of their experiences, traditional knowledge and whatever other information is available to them. Firstly, they would assess the alternative choices, develop a set of uncertain outcomes associated with each alternative then finally use their personal subjectivity to choose their line of action. For smallholder farmers, such a decision is usually carried out in an informal (implicit) rather than formal (explicit) manner. Larger operations, utilising the services of professional farm advisers, would be more likely to use a more formal approach to major farm decisions. One such approach is the sensitivity analysis, which could be easily applied to any farming situation.

A sensitivity analysis assesses how sensitive a decision's outcome is to changes in the major variables affecting that decision. It is quantified by testing the effects of variations in selected cost and benefit variables on budgeted outcomes of the decision. These variations are calculated for a percentage change above and below the values used in the base budget. Sensitivity analyses and partial budgets are discussed in Chapter 15.

16.3 Biosecurity as a risk management strategy

Ideally every dairy farm should be separated from the outside world, but as this is not practical, a risk-based approach should be developed (Jubb, pers. comm.). Such an approach requires the farmer to:

- Identify the pathogens and their potential impact.
- Identify the likelihood of these pathogens establishing on the farm.
- Decide on whether the disease risk is worth controlling or not.

The most significant risks for introducing diseases come from many sources, such as:

- Animals and insects: sick or dead cattle, introduced stock, neighbouring stock, wild birds and animals (including rodents), pets, flies and other insects.
- People: family and friends, visitors, farm staff, livestock agents (including veterinarians), tradesmen.
- Inorganic material: borrowed farm equipment, market equipment (trailers), vehicles (motorbikes, utility trucks, stock transport).
- Organic material: surface water, farm manure, introduced feed, potentially contaminated feed (opened bags of feed).

Animal disease comes in many forms so requires different approaches depending on its type. These are six categories of disease sources:

1. Viruses, such as foot-and-mouth disease, rotavirus, infectious bovine rhinotracheitis, enzootic bovine leucosis, pestivirus, warts
2. Bacteria, such as *E. coli*, clostridia, salmonella, anthrax, leptospirosis, brucellosis, tuberculosis, Johne's disease, pink eye, vibriosis, haemorrhagic septicaemia, mastitis
3. Protozoa, such as cryptosporidea, coccidiosis, neospira
4. Parasites, ticks, lice, internal parasites, tick fever
5. Fungi, such as ringworm
6. Others, such as genetic defects, drug resistance, bovine spongiform encephalopathy (or mad cow disease).

The risk management strategy can vary depending on the potential level of risk:

- Accept the risk if it is too small to worry about or too expensive to control.
- Avoid the risk by removing it altogether, such as not purchasing the item or changing farm suppliers.
- Transfer the risk, such as contracting someone to rear the calves.
- Mitigate the risk by taking actions to lessen the probability of it occurring.

There are various ways to manage the risk such as:

- Building barriers against the pathogen, both physical and procedural.
- Increasing resistance in the dairy herd, through vaccinations and good management.
- Early detection by routine disease monitoring and increased surveillance.

General management practices include:

- Selecting reputable farm suppliers with good hygiene.
- Reducing build-up of pathogens.
- Limiting vehicle and people access to farm.

- Establishing quarantine areas for introduced stock.
- Segregating stock classes.
- Developing standard operation procedures and checklists for routine farm tasks.
- Ensuring good farm hygiene and cleanliness.
- Developing an emergency plan in case of disease outbreak.

Case studies of profitable tropical dairy farming systems

This chapter presents a series of case studies to quantify the profitability of different dairy production systems varying in herd size and location (both between and within countries).

The main points in this chapter

- The possibility of differences in assumptions and terminology between report authors makes it difficult to confidently compare, or bulk, results from different studies.
- From a study of four herd sizes in Thailand (from 5–117 milking cows), the net profit, or difference between farm return and farm costs, did not greatly differ (1.6–3.7 Thai baht/kg milk).
- From a comparison of smallholder farms in Vietnam and Thailand, the authors concluded that the optimal herd size increased from five cows in Vietnam to 20 cows in Thailand.
- Comparing rural and peri-urban farms in India and Pakistan, the authors concluded that milk can be produced 40–50% cheaper on rural farms, but that investment in a peri-urban farm was more profitable.

Assessing the skills of smallholder dairy farmers to integrate the principles of good farm business management, as discussed in this book, is best undertaken by closely examining the end results of any improvements in their management practices, in terms of their annual profit margins. Such detailed case studies can also highlight some of the limitations of existing systems. For example, a 12-month whole-farm economic analysis of cost of production (COP) on 10 smallholder dairy farms in Thailand by Chantalakhana and Skunmun (2002) found that only 54% of the total farm costs were directed towards the milking cows, with 34% used to grow out replacement heifers and 12% used to maintain the adult cows when dry. To improve their profit margins, they concluded that the farmers needed to:

- Reduce feed costs by sourcing cheaper non-conventional roughages during the dry season.



Figure 17.1 Well-managed calf rearing is an integral part of profitable dairy farming (Sri Lanka)

- Reduce the number of replacements kept on-farm to 20–25% of the milking herd.
- Keep daily cow performance records and cull low yielding cows.

This chapter presents more recent case studies to provide further insight into the practical application of FBM. Such detailed case studies help farmers and advisers to more fully understand how the ‘bottom line’ was reached. However, these studies can be fraught with danger because of the different assumptions and methodologies used by different report authors. As we say in Australia, you must compare apples with apples and not with oranges. This means that any economic measure, such as COP or profit margin, must be clearly defined so as to allow only truly comparative data to be compared.

17.1 Cost of production of dairy farming in Thailand

A comprehensive financial analysis of smallholder dairying in Thailand was undertaken as part of the worldwide International Farm Comparison Network (IFCN) for four case study farms in Chiang Mai province of Thailand (Garcia *et al.* 2005) with differing herd sizes. The information was derived from farm records in 2003.

Details of the four farms were as follows:

1. Five crossbred cows plus heifer replacements, 0.8 ha land, family labour with some off-farm income, hand milking, 1200 hr labour/milking cow/yr, 0.3 kg concentrate/kg milk.



Figure 17.2 A grass auction in East Java, Indonesia, where smallholder farmers can purchase forages

2. 14 cows plus replacements, 2.1 ha land, family labour, machine milking, 480 hr labour/milking cow/yr, 0.5 kg concentrate/kg milk.
3. 21 cows plus replacements, 0.6 ha land, family labour with some off-farm income, machine milking, 320 hr labour/milking cow/yr, 0.6 kg concentrate/kg milk.
4. 117 cows plus replacements, 3.0 ha land, hired labour (6 units) plus some off-farm income for family, machine milking, 284 hr labour/milking cow/yr, 0.6 kg concentrate/kg milk.

All farms fed crop by-products (rice straw, sweet corn stover) and freshly harvested tropical grasses, together with high protein concentrates (including minerals). Cows produced 3150–3350 kg milk over their 280–300-day lactations, averaging 11–12 kg/day, with milk containing 3.8% fat and 3.1% protein. Virtually all the milk was sold through the local dairy cooperative. Calf mortality was 10–20% and all calves were fed milk for 12 weeks.

The farms had three to four family members of which off-farm work comprised 25% of the family utilisation on the 5-cow farm, and 35% on both the 21- and 117-cow farms. In addition to milk, the 14-cow farm produced poultry and mangos while the 21- and 117-cow farms sold cow manure. Local wages were valued at 10–15 Bt/hr.

The varying size of the farms and differing stocking rates influenced the value of their land and stock as proportions of total farm assets. For example, the 14-cow farm had 60% of its assets as land and 28% as stock in contrast to the 21-cow farm, which had 22% as land and 49% as stock.

Table 17.1 Breakdown of farm costs and income for four farms in Chiang Mai in 2003 (Bt/kg milk produced)

Herd size (cows)	5	14	21	117
Herd milk yield (t/yr)	15.8	46.8	67.8	396.0
Farm returns (Bt/kg)				
Milk sales	11.7	11.3	11.3	11.6
Stock sales	4.6	3.9	3.3	3.7
Manure sales	0	0	1.7	0.1
Total	16.3	15.2	16.3	15.4
Milk prod costs (Bt/kg)				
Purchased feed	7.5	9.2	9.6	10.8
Other cash costs	1.2	1.6	1.7	2.5
Labour	3.1	1.3	0.8	1.2
Capital	0.7	0.4	0.5	0.6
Land	0.1	0.2	0.0	0.0
Total	12.9	12.7	12.6	13.8
Dairy enterprise profit	3.4	2.5	3.7	1.6
Profit margin	44%	33%	32%	17%

The breakdown of farm costs and income are presented in Table 17.1. Dairy enterprise profit is the difference between farm return and farm costs (in Bt/kg milk). Profit margin is the net cash farm income as a per cent of total farm returns, in other words, the proportion of total revenue generated that remains as income.

In their analyses, Garcia *et al.* (2005) do not include a specific cost component for home-grown feed, only including purchased feed. The contribution of home-grown feed would vary considerably between farms, considering the very high stocking rates on the 21- (35 cows /ha) and 117-cow farms (39 cows /ha) compared to the 5- and 14-cow farms (7 cows/ha) and the fact that the 5-cow farm was only feeding concentrates at half the rate as the 21- and 117-cow farms.

For such a diversity of farming systems, it is surprising that total farm costs and returns (in Bt/kg milk produced) were so similar. Purchased feed comprised 58–78% of the total milk production costs. Labour costs varied because of inefficiencies on the 5-cow farm. The 117-cow farm had the lowest profit (Bt/kg milk and percentage) because of the high amount of purchased feed and other herd cash costs. The 21-cow farm did not hire labour and had lower land costs. Compared to the 14-cow farm, its higher profit margin highlights the benefits of intensification, with smaller farm size and higher purchased feed inputs. The manure sales from the 21-cow farm, 1.7 Bt/kg milk, was greater than the difference in profit between the 21- and 14-cow farms (1.2 Bt/kg milk).

Most of the milk produced in the Chiang Mai area is destined for UHT and pasteurised milk either for local consumption or the School Milk Program. In 2003, the farmers received on average 11.0 Bt/kg, the co-op sold it for 12.5 Bt/kg with formal markets receiving 28.9 Bt/kg for UHT and 23.4 Bt/kg for pasteurised milk. The farmers then received only 38–47% respectively of the returns, which for UHT milk is low compared to smallholder dairy industries in other countries, such as Bangladesh (52%) and India (45%) (Garcia *et al.* 2005).

The 14-cow farm of this study was also used as a case study farm in one of the FBM workshops conducted in Thailand. This analysis, presented in Table 18.8 (Chapter 18), compared the financial responses to three different milk production scenarios, with varying herd average peak milk yields and yield persistencies.

17.1.1 Competitiveness analyses

When assessing the competitiveness of these case study farms, the authors differentiate between ‘private’ and ‘social’ price scenarios. They conclude that all four farms are profitable under a private price scenario (returning 3.4, 2.5, 3.8 and 1.7 Bt/kg respectively for the four farms). However, the 21-cow farm was the only one profitable after applying social prices (returning –2.5, –0.4, +1.3 and –0.4 Bt/kg respectively for the four farms).

The differences between the two scenarios represent the so-called ‘net transfer’ and give an indication of the money transfers Thai society incurs to permit these dairy farms to operate and make current levels of private profit. Hence the five-cow farm requires external support of 5.9 Bt/kg and the 117-cow farm requires 2.1 Bt/kg. Such external support arises from two sources. Firstly, farmers receive higher private prices for their outputs than those prevailing on the world market (in 2003) and secondly, farmers pay lower private prices for domestic factors of production than would be the case without policy intervention (Garcia *et al.* 2005).

The authors then concluded that under the existing system, Thailand has a comparative disadvantage in milk production, which is counterbalanced by national policy measures. Without such support, domestic milk production would be not economically viable and hence would discontinue.

17.1.2 Comments on IFCN methodology

The IFCN analysis was developed to create a standard format to compare production data of major agricultural products. It uses a single and homogeneous method to calculate the costs of production for all participating countries.

It is based on the principle of ‘total costs’, which include:

- Direct costs and margins
- Indirect (fixed) costs, such as depreciation and interests of the infrastructure used
- Opportunity costs for owned assets and production factors (family labour, land capital).

The first step is to define a typical milk production system of the major dairy regions in any country. The second step is to collect all the required data using a standard input format. IFCN does not aim to collect data from an individual farm nor be an arithmetic mean. It was developed to represent real and common situations of the region and show clearly the predominant technology and infrastructure.

In other words, IFCN was not developed to analyse the business performance of a single dairy enterprise. To obtain a true and meaningful interpretation, the required inputs may be too detailed for any one particular farm. Being a ‘one size fits all’ approach, various assumptions have to be made, some of which may not be valid for farms in specific areas, such as calculating capital costs below.

ICFN calculates returns from the dairy enterprise as follows:

- Milk price: Average milk price adjusted to 4% milk fat
- Cattle returns; returns from sale of cull cows, male calves, surplus heifers +/- livestock inventory
- Other returns: sale/home use of manure.

Associated costs are calculated as follows:

- Costs for means of production: all cash costs (such as fuel, fertiliser, concentrate, insurance, maintenance) plus non-cash costs (such as depreciation for machinery and buildings)
- Labour costs: costs for hired labour + opportunity cost for family labour
- Land costs: based on land rents paid + calculated land rents for owned land
- Capital costs: non-land assets* interest rates (which are equity *3% or liabilities *6%)
- Opportunity costs: costs for using own production factors (land owned, family labour, equity).

Economic assessments are as follows:

- Profit margin: farm income/total returns
- Entrepreneur's profit: farm income less opportunity cost allocated to dairy enterprise
- Return to labour: (entrepreneur's profit + labour cost)/total labour input.

Clearly IFCN have developed a robust system for calculating COP which could be simplified to make it more 'farmer friendly' for use when collecting FBM data from a number of farms in any one region.

One area that has not been addressed is remuneration for farmer's management skills. For example, the farmer with a 117-cow milking herd (compared to the one with 14 milking cows) should ideally be rewarded more for his skills in feeding, herd, labour and other aspects of farm management.

17.2 Comparing dairy farm production economics in Thailand and Vietnam

This IFCN approach, to standardise COP estimates in different countries, provides opportunities to assess impacts of dairy policies on different farm types. This is important because with the worldwide trend towards trade liberalisation, there are increasing pressures for countries to bring the level of competitiveness of their dairy sectors to international standards. This is easier for countries where farmers receive little or no farm support and are efficient dairy producers. In other words, these farmers are less dependent on public support. Garcia *et al.* (2007) recently compared the farm economics of dairy industries in countries with high support (Germany), intermediate support (Vietnam and Thailand) and zero support (New Zealand) under their current policy frameworks, and also once such policy distortions were eliminated. It is within the interest of readers of this book for some comments to be made on the farms surveyed in Vietnam and Thailand. The

comparative currency is US\$, with the milk price being expressed in US\$/100 kg energy corrected milk (ECM), to standardise milk to the same fat and protein contents. A milk return of US\$20/100 kg ECM is then equivalent to 20 c/kg.

The specific Thai farms selected for the analyses were the two larger farms, with either 14 and 117 cows, as presented in Table 17.1. Details of the two Vietnamese farms (located near Hanoi) selected were as follows:

1. Two crossbred cows plus replacement heifers, renting 0.5 ha government land. The stock are fed crop residues and high protein concentrates, plus a mineral premix for milking cows. Only 93% of the milk is sold to the local Milk Collection Centre. The main income source is cash crops.
2. Four crossbred cows plus replacement heifers, renting 0.47 ha government land. The feed base is the same for Farm 1. The only difference is that income sources are either from dairy farming or off-farm employment.

Details of the four farms are presented in Table 17.2. The economic terminology is the same as used in Section 17.1.

High beef and heifer prices play a key role in determining the profits of dairying in both Vietnam and Thailand. The positive entrepreneurial profit on all farms suggests they are sustainable in an economic sense at the ongoing farm costs and returns.

The authors then reported a favourable situation for dairy farming throughout South-East Asia, due mainly to the governments' focus on promoting milk production through setting high farm output prices and encouraging the use of local resources for food production. Despite their high profitabilities, the productivity levels of two Thai and Vietnamese farms were low. However, raising productivity would be discouraged, firstly by the high profits these farmers are already making and secondly, the countries' taxes on tradable inputs required to raise farm performance, such as concentrates, machinery and other farm equipment.

The authors conclude that the optimal herd size in Thailand was 20 milking cows while in Vietnam, it was only five cows. They believe that there are considerable opportunities to improve competitiveness through cost reduction. This can be achieved through increases in productivity or farm size. However, throughout Asia, smallholder farmers are often unable to improve efficiency without government support. They continue to run less productive local breeds using labour intensive technology.

17.2.1 General comments on Asian dairy industries

IFCN (2005) extended their surveys to 22 farms in six Asian dairy industries, namely India, Pakistan, Bangladesh, China, Vietnam and Thailand and have made several relevant observations:

- The lowest milk price was in Pakistan (14–18 US c/kg), followed by India (19–24), Vietnam (22), China (25), Bangladesh and Thailand (28 c/kg).
- The cost of milk production could be classified into two categories, namely <20 c/kg (Pakistan, large farms in India, north China) and >20 c/kg (small farms in India, Bangladesh, Thailand and Vietnam).

Table 17.2 Farm details and breakdown of farm costs and income for two case study farms in Vietnam and two in Thailand

Country	Vietnam		Thailand	
Farm	A	B	A	B
Farm descriptors				
Milking cows	2	4	14	117
Stocking rate (cows/ha)	4.0	9.3	6.7	39.0
Land productivity (kg ECM/ha/yr)	18	35	22	123
Labour units (% family)	1.9 (100%)	1.5 (100%)	2.3 (100%)	12.7 (18%)
Labour productivity (kg ECM/hr)	3	5	10	14
Milk yield (kg ECM/cow)	4083	3928	3342	3155
Farm milk production (t/yr)	8	16	47	369
Replacement rate (%)	25	22	21	20
Age at first calving (mo)	30	29	26	27
Farm equity (%)	91	81	100	100
Farm returns and costs (US cents/kg milk)				
Milk sales	19	19	28	28
Total farm return	26	29	37	38
Cost (means of production)	12	14	27	28
Labour	5	3	2	2
Capital	3	3	1	1
Land	4	2	1	0
Total costs	24	22	31	31
Entrepreneur's profit	2	8	6	4
Profit margin (%)	41	37	32	17

Abbreviations: ECM, energy corrected milk

- Full lactation milk yields per cow varied from more than 4000 kg on large farms in Thailand and India, and in Vietnam to less than 220 kg on a small Indian farm. The small Pakistani and Bangladeshi farms had between 500 and 2000 kg while medium Pakistani farms produced above 2000 kg.
- The highest return to labour was on a large farm in India (US\$2/hr), followed by China (<US\$1/hr), large Pakistani and small Vietnamese (<50 cents/hr), with the remainder having a return to labour of <20 cents/hr.
- Labour productivity varied from highs of 19 kg (Thailand) and 16 kg ECM/hr (large Indian farm) down to lows of 6 kg (Vietnam) and 4 kg (large Pakistani farm) with the majority of farms less than 3 kg milk/hr.
- The highest capital input per cow in Asia was in Vietnam (<US\$2000/cow), followed by Thailand, China and India (<\$1000/cow) with most small farms having a capital input of >\$1000/cow.

- In conclusion, most farms analysed had low costs and low returns to labour. Cost wise they were competitive as they were able to produce milk below 20 c/kg. This shows that Asian farms have the potential to compete internationally if milk quality improves and the dairy chain costs are reduced.

17.3 Comparing rural and peri-urban dairying

Many countries have peri-urban areas where smallholder dairying has flourished on the outskirts of large towns and cities. Such areas can have access to good supplies of feed, including:

- Green fodder: native and cultivated grasses and legume forages
- Crop residues: rice straw and maize stover
- Agro-industrial by-products and non-conventional feeds
- Concentrates.

Asian dairy systems can then be categorised into two types, rural farmers who own (or lease) land and peri-urban farmers who purchase all their feed requirements. In Table 17.3, IFCN (2004) compared the cost structure of the two types of farms in India and Pakistan using the same methodology as in Table 17.2. The ‘typical’ farms were:

- Peri-urban: located within a 5–10 km radius of city with no land, hence purchased all their green fodder and concentrates and they sell their milk direct to urban consumers.
- Rural: located more than 10 km from urban centres with land to grow fodder and they sell their milk through the informal markets via a milkman.

They concluded that milk can be produced in the rural areas 40–50% cheaper, but the investment in a peri-urban farm was much more profitable. Therefore, under the

Table 17.3 Comparing the cost structure of typical rural and peri-urban farms in India and Pakistan

Country	India		Pakistan	
	Rural	Peri-urban	Rural	Peri-urban
Milking cows	17	11	2	2
Milking buffaloes	5	26	8	8
Total assets (US\$/cow)	2800	550	1950	600
Milk price (c/kg)	19	27	16	26
Cost of production (c/kg)	11	19	7	21
Opportunity cost (c/kg milk)	2	2	3	1
Total cost (c/kg milk)	13	21	10	22
Total profit (c/kg milk)	6	6	6	4
Entrepreneur’s profit (c/kg milk)	5	6	5	4
Return on investment (%)	11	37	8	19

Abbreviations: COP, cost of production (calculate as [cost from profit and loss account] – non milk returns)

current conditions, peri-urban farms will continue to operate by sourcing their fodder supplies from rural areas. This could change if the competitive dairy chain generates higher farm gate milk prices in rural areas or environmental restrictions increase production costs in peri-urban areas.

These findings confirm an earlier study undertaken in South Vietnam by Cai *et al.* (2000). Detailed financial data from this study were presented in *Tropical dairy farming* (Moran 2005). Using milk income above feed cost (MIFC) as a measure of profits, rural farmers were 46% more profitable than were peri-urban farmers, whereas profit margins (taking into account all farm costs) were 96% higher for the rural farmers.

Planning and conducting workshops in Farm Business Management

This chapter summarises the programs and major findings from two workshops on Farm Business Management (FBM), the first one for dairy extension staff and farmers with little exposure to FBM, and the second one for economists and others with experience in FBM.

The main points in this chapter

- It is important to develop a clear set of workshop objectives to ensure all participants know why they are there.
- Distributing copies of all overheads, translated into their local language, prior to the workshop will improve comprehension of the material to be presented.
- Asking participants to complete an expectations form at the beginning and an evaluation form at the end of each workshop, in their local language, helps plan each day's program and provides valuable feedback.
- Conducting group presentations, where small groups prepare and report back on specific aspects of the program, encourages active participation.
- Input from the case study farmers will provide a 'reality check' for the participants on their recommendations for any practice changes.
- The chapter contains a theoretical case study to assess the impact of changes in farm practices on financial farm performance.

Chapter 1 outlines two structured Farm Business Management (FBM) training programs based on this book, firstly, a basic one for farmers and high school students, and secondly, an advanced one for more highly skilled farmers, advisers and university undergraduates. It is assumed that participants in the advanced program would be familiar with topics covered in the basic program; if not, they should be initially introduced as an abridged basic course.

This chapter outlines two workshops conducted in Thailand in 2007 entitled, 'Improving the business skills of smallholder dairy farmers in Thailand'. A 'train the

trainer' approach was considered the most cost-effective method to improve FBM skills among smallholder farmers because government, dairy cooperative and milk processing factory advisers can then pass these skills directly to smallholder dairy (SHD) farmers. There were 30 participants in the three-day Workshop 1, 24 livestock officers (government and cooperative advisers) and six government farm management specialists. The two farmers who agreed to have their farms used as case studies also attended for half a day during Workshop 1. The two-day Workshop 2 was planned specifically for eight government farm management specialists and senior government managers.

Workshop 1 was designed for livestock extension officers and other technical specialists with little exposure to the principles of FBM. Workshop 2 was developed for economists and other technical specialists with previous experience in FBM.

18.1 Workshop objectives

1. To highlight the importance of keeping accurate production and financial records.
2. To use these records to calculate cost of production (COP) on dairy farms of any herd size.
3. To quantify farm profit in terms of the three basic elements: cash, efficiency and wealth, these being the most relevant to long-term sustainability.
4. To prioritise farming practices to maximise sustainability and farm profit.
5. To better understand the technical practices (called the 'raw materials of FBM') behind successful dairy farming operations.
6. To provide a workshop environment conducive to farmer/farmer and farmer/adviser networking (this objective is more for farmer orientated programs).

18.2 Workshop preparation

Three modules (with the number of PowerPoint overheads) were developed as follows:

1. Introduction to Farm Business Management (29 overheads)
2. Economic performance of case study farm (24 overheads)
3. The raw materials of Farm Business Management (40 overheads).

Prior to the workshop, each participant received copies of all the PowerPoint overheads translated into the Thai language. This is important for ease of comprehension and to provide pages for writing down additional notes during the workshop. At the closing ceremony for each workshop, participants were each presented with a Certificate of Attendance.

During the workshops, participants were offered Australian souvenirs as rewards for individual oral presentations or as gifts for farmers who opened up their farm (and books) for participants to calculate their COP. Government workshop organisers also received similar gifts.

Expectation forms were completed by each participant at the beginning, and evaluation forms at the completion of each workshop, both translated into the Thai

language. Examples of these are presented in Appendix 7. These are very important, firstly, because workshop participants may not all be aware of the workshop's emphasis on FBM, and secondly, this helped plan the 'open session' on the last day to discuss specific issues on dairy production technology.

It is important to involve participants in the workshops in addition to them listening to, and discussing, course material. Conducting group presentations where small groups prepare and report back on specific aspects of FBM encourages active participation in the workshops. It also provides opportunities for public speaking which many may have not been asked to do previously. In addition, it gives a 'local flavour' to the workshop which is very valuable for the presenters as well as the participants. Examples of topics for several group presentations are given below.

18.3 Daily programs for each workshop

18.3.1 Workshop 1

The daily programs have been summarised in Tables 18.1, 18.2 and 18.3.

Table 18.1 Program for Day 1 of Workshop 1: 'Introduction to FBM'

Session	Content
Opening session	Official opening by senior government official Presenters introduce themselves Overheads on Australian dairy industry Overheads on aspects of smallholder dairying in South-East Asia Participants complete Expectation form
Smallholder Dairying (SHD)	Why SHD farmers need to formalise their business skills
What is profit?	Various elements of profit: cash, efficiency, wealth creation Various formulae to quantify profit
Record keeping	Physical and financial records to allow calculation of profit
What are farm costs?	Variable v overhead costs Cash v imputed costs Personal expenses v imputed labour Capital and financial costs Equity (or risk) Flow chart of farm costs on smallholder dairy farm
Categorising farm income	Cash income; sales of milk, stock, manure Imputed income; changes in livestock inventory, land value
Categorising farm costs	1. Herd and shed costs 2. Feed costs 3. Cash overhead costs 4. Imputed overhead costs
Components of total feed costs	Feeding decisions driving profit
Using profit to improve management	Optimum herd size Diagnosing poor farm profitability
Preparing for two farm visits	Participants form four groups to record the above annual costs

Table 18.2 Program for Day 2 of Workshop 1: 'Economic performance of case study farms'

Session	Content
Two farm visits	Groups interview farmers
Group Presentation 1: Feedback from farm visits	Groups prepare short report of calculated farm costs One person from each group presents 5–10 minute overhead presentation Participants discuss and calculate COP (in Bt/kg milk)
Group Presentation 2: Improving farm profitability	New groups formed to discuss following topics: 1. Increasing farm milk yields 2. Increasing milk unit returns 3. Reducing farm costs (cash and imputed) One person from each group presents 5–10 minute overhead presentation Participants discuss technical aspects of above topics
Group Presentation 3: Reporting back to farmers	Prioritise key findings from 'Improving farm profitability' session Groups present short report to farmers on calculated farm costs Groups present short report to farmers on how to improve their farm profit Farmers provide feedback to develop their on-farm action plans

Input from the case study farmers on Day 2 provides a 'reality check' for the participants on their recommendations for any practice changes arising from the farm visits.

Table 18.3 Program for Day 3 of Workshop 1: 'The raw materials of FBM'

Session	Content
Review	Participants share their most important learnings from Day 1 and 2
Group Presentation 4: Industry strategic planning	Same groups as for Presentation 2 discuss following topics: 1. Develop an extension program to demonstrate improved farm profitability as a result of reducing feed costs 2. Assess the opportunities for value adding to increase milk unit returns 3. What will the Thai dairy industry look like in 2017, in terms of farm and herd size, geographical location and level of farm profitability? One person from each group presents 5–10 minute overhead presentation
Open session	Discuss participants' specific queries on dairy production technology
Closing session	Concluding remarks from presenters Participants complete Evaluation form Presentation of workshop certificates by senior government official

18.3.2 Workshop 2

The daily programs have been summarised in Tables 18.4 and 18.5.

Table 18.4 Program for Day 1 of Workshop 2: ‘Economic performance and profits’

Session	Content
Review of breakdown in farm income and costs	Review sessions on Day 1 of Workshop 1
Key measures of FBM	Key performance indicators (KPI) of FBM, e.g. cash operating surplus, Milk income less feed costs, Economic farm profit and Return on assets, Return on equity and equity gain Sensitivity analysis
Dairy cow lactation cycle	Changes in milk yield, intake and live weight during a lactation cycle Effects on herd fertility
Farm case study	Description of theoretical case study farm Changes in peak milk yield and lactation persistency Feed inputs to effect such changes Changes in KPI of case study farm

Table 18.5 Program for Day 2 of Workshop 2: ‘Economic performance and profits’

Session	Content
Review of breakdown in farm income and costs	Participants share their most important learnings from Day 1
Diagnosing poor farm profitability	Ten KPI of farm profitability
Partial budgets	Partial budgets for farm case study Marginal responses to farm inputs
Risk	Examples of risk in smallholder dairy farming
Open session	Discuss participants’ specific queries on FBM
Concluding session	Key factors influencing the future of the Thai dairy industry

18.4 Group presentations from Workshop 1

The following two tables present some of the workshop participants’ original thoughts on FBM. Table 18.6 summarises their deliberations on ‘Improving farm profitability’ (Group Presentation 2 from Table 18.2). Table 18.7 summarises their reporting back on one of the case study farms they visited (Group Presentation 3 from Table 18.2), with both their specific suggestions and those agreed to by the farmer.

18.5 Theoretical farm case study in Workshop 2

The theoretical farm case study developed for the FBM specialists in Workshop 2 demonstrates the beneficial effects of improving milk production through better feeding management, on various KPIs of the farm business. The farm selected was the same 14-cow farm (Farm 2) used by Garcia *et al.* (2005) in their comparative analyses of herd size, already discussed in Table 17.1 (page 198). Farm input prices and output returns are the same 2003 values as used by Garcia *et al.* (2005).

Table 18.6 Workshop 1 summary of Group Presentation 2: 'Increasing farm profitability'

Technique	Details
Increasing farm milk yields	<ol style="list-style-type: none"> 1. Reproduction/breeding: group cows on milk yield and feed—high producers better, aim for 7:3 ratio of milking: dry cows, reduce services/conception to two (not three)] with better heat detection 2. Feeding: higher fertiliser rates on cut and carry forages and harvest at optimum stage of maturity, reduce concentrate: forage ratio, incorporate tree legumes into forage system 3. Management: 15% culling to reduce stocking capacity, dry off cows producing <4 kg/d, increase lactation length, aim for 25% replacement rate each year
Increasing milk unit returns	<p>Improve cleanliness of shed, equipment, cows and staff Reduce adulteration of milk, ensure no residual water in milk Improve milk composition with better feeding management Routinely test for mastitis and minimise antibiotic residues Avoid over milking, ensure colostrum doesn't contaminate raw milk</p>
Reducing farm costs	<ol style="list-style-type: none"> 1. Feed costs: concentrates: feed for a predetermined level of milk yield, formulate concentrates on-farm and bulk purchase ingredients 2. Feed costs: roughages: grow sufficient, plan for dry season feeding, use more fertilisers (e.g. urea), improve forage agronomy 3. Herd/shed costs: reduce length of dry period, reduce services/conception, farmer does AI following training, cull low producers, select heifers to grow out as replacement, milking machine maintenance, reduce use of veterinary drugs through greater use of natural medicines

Table 18.7 Specific recommendations for a case study farm to increase profitability and agreed farmer's decisions

Technique	Details
Increase farm milk yields	<p>Feed less concentrates and more roughages Feed better quality roughages Grow better quality roughages (tree legumes, fertiliser, forage maturity) Group and feed cows according to production (feed 1.5 kg conc: 1 kg milk)</p>
Increase milk unit returns	Farmer already has Grade 1 milk
Reduce farm costs	<p>Feed for target milk yields Grow more forage, especially for dry season feeding Forgo some cash crop area for forages Improve current irrigation system for dry season forages Cull stock to reduce herd size to optimise stocking capacity Aim for 25% replacement rate to allow culling of poor producers Improve milking machine maintenance</p>
Farmer decisions	<p>Reduce herd size Increase roughage supplies Address long calving interval Address low replacement rate Try to address problem of aging father with little involvement in day-to-day activities but still with strong influence on farm management decisions</p>

This farm had the following features:

- 14 crossbred cows producing 46.5 t milk/yr, all sold to local co-op
- Cows produce 3324 kg/lactation, averaging 11.1 kg/day
- Farmer uses AI, producing 12 calves/yr with 15% calf mortality, 7% cow mortality, and 7% cow culls
- Roughages are Napier grass, sweet corn stover, rice straw
- Feeds 1.9 t/cow of formulated concentrate (16–18% protein) or 0.5 kg/kg milk
- Four member household, no off-farm income, some farm income from poultry and mangos
- Labour is valued at 10.4 Bt/hr, averaging 480 hr/milking cow/yr
- No annual change in land or stock values
- Total farm assets are 2.5 M Bt, with 60% as land, 25% as cattle and 15% other
- Gross dairy enterprise income is 707 k Bt with COP 590 Bt/yr, hence 117 k Bt/yr profit.

This study compared three different scenarios for milk production as follows:

1. Current farm production, with 20 kg/d peak yield and 11% persistency (that is a 11% per month decline in milk yield from peak or 2.2 kg/d/month)
2. Improved persistency, with 20 kg/d peak and 8% persistency (or decline of 1.6 kg/d/month)
3. Improved peak and persistency, with 25 kg/d peak and 8% persistency (or 2.0 kg/d/month).

Scenario 2 produced an extra 645 kg milk/cow or a total farm yield of 55.5 t milk/yr, achieved by feeding 967 kg DM/cow more forages (milk response of 1 kg milk per 1.5 kg DM of extra forage) through purchasing additional Napier grass. This cost 0.8 Bt/kg fresh or 4.0 Bt/kg DM.

Scenario 3 produced an extra 1635 kg milk/cow or a total farm yield of 69.5 t milk/yr, achieved by feeding 600 kg DM/cow more concentrates and 1552 kg DM/cow more forage. Total extra concentrate purchases (with milk response of 1 kg milk/kg DM extra concentrate) were 456 kg of cassava (for 2.8 Bt/kg or 3.2 Bt/kg DM) plus 222 kg of cottonseed (for 5.2 Bt/kg or 5.8 Bt/kg DM). The purchased forage was Napier grass as in Scenario 2.

18.5.1 Calculation of financial measures

Table 18.8 presents COP and KPI measures for these three scenarios. Providing more feed at current feed and milk prices improved all measures of farm performance in Table 18.8, of cash and farm efficiency, with return on assets more than doubling from 4.6% to 6.6% to 10.2%.

Clearly then, more intensive production systems, even with current herd sizes and farm cost and return structures, are good investments in improving the profitability of smallholder dairying in countries such as Thailand.



Figure 18.1 Farm management economists calculating cost of production at the workshop in Thailand

Table 18.8 Breakdown of farm costs and income (Bt/kg milk produced) and KPIs of business performance for three scenarios on the theoretical farm case study

Scenario	1	2	3
Herd milk yield (t/yr)	46.5	55.5	69.5
Farm returns (Bt/kg)			
Milk sales	11.3	11.3	11.3
Stock sales	3.9	3.3	2.6
Total	15.2	14.6	13.9
Milk production costs (Bt/kg)			
Purchased feed	9.2	8.7	7.9
Other cash costs	1.6	1.3	1.0
Labour	1.3	1.1	0.9
Capital	0.4	0.3	0.3
Land	0.2	0.2	0.1
Total (COP)	12.7	11.6	10.2
Dairy enterprise profit (Bt/kg milk)	2.5	3.0	3.7
Cash operating surplus (k Bt/yr)	205	253	343
Economic farm surplus (k Bt/yr)	145	193	283
Dairy enterprise profit (k Bt/yr)	117	165	255
Profit (%)	17	20	26
Return on assets (%)	4.6	6.6	10.2

COP: cost of production (Bt/kg milk)

Dairy enterprise profit: gross income less total production costs (Bt/kg milk or k Bt/yr)

Cash operating surplus: gross cash income less cash costs

Economic farm surplus: gross income less cash costs plus labour

Profit percentage: dairy enterprise profit divided by gross income

Return on assets percentage: dairy enterprise profit divided by total farm assets.

18.5.2 Developing partial budgets

Table 15.1 in Chapter 15 presents a format to prepare a partial budget. As the Day 2 program in Workshop 2 includes partial budgets as one of the topics for discussion, the theoretical farm case study provided the ideal opportunity to develop them for Scenarios 2 (Table 18.9) and 3 (Table 18.10).

These partial budgets calculated positive net benefits for both scenarios and return on investments of 88% and 113% for Scenarios 2 and 3 respectively. This clearly indicates it was a good business decision to improve feeding practices in both cases.

The partial budgets only considered higher feed costs and improved milk returns. They did not take into account improved fertility (through better body condition) or higher unit milk price (through better milk composition). In addition, they did not take into account the higher costs of feeding out.

Partial budgets can quantify benefits in many farm practices, for example:

- Balancing diets for energy, protein and other nutrients
- Optimising farm stocking capacities to minimise fodder purchases
- Improving animal health and fertility
- Better young stock feeding and management
- Investing in housing, heat stress, effluent disposal and recycling
- Addressing problems in milking hygiene to improve milk quality.

Table 18.9 Annual partial budget for Scenario 2 (Improving milk persistency)

	K Bt/yr
Capital requirements	
Nil	–
Negative effects	
<i>Added costs</i>	
967 kg Napier grass @ 4.0 Bt/kg DM or 3868 Bt/cow/yr	54.1
<i>Reduced returns</i>	
Nil	–
Total	54.1
Positive effects	
<i>Added returns</i>	
645 kg milk @ 11.3 Bt/kg or 7288 Bt/cow/yr	102.0
<i>Reduced costs</i>	
Nil	–
Total	102.0
Net benefit	47.9
Return on marginal capital	88%
Additional non monetary factors	–

Table 18.10 Annual partial budget for Scenario 3 (Improving peak yield and persistency)

	K Bt/yr
Capital requirements	
Nil	–
Negative effects	
<i>Added costs</i>	
1552 kg Napier grass @ 4.0 Bt/kg DM or 6208 Bt/cow/yr	86.9
600 kg cassava/cottonseed meal @ 4.1 Bt/kg DM or 2460 Bt/cow/yr	34.5
<i>Reduced returns</i>	
Nil	–
Total	121.4
Positive effects	
<i>Added returns</i>	
Milk: 1635 kg @ 11.3 Bt/kg or 18 475 Bt/cow/yr	258.7
<i>Reduced costs</i>	
Nil	–
Total	258.7
Net benefit	137.3
Return on marginal capital	113%
Additional non-monetary factors	–

18.6 Conclusions from FBM workshops in Thailand

There are many constraints to smallholder dairy production in Thailand. Many of them are nutritional, generally a lack or imbalance of nutrients, which can be overcome with improved feeding in early lactation.

To improve the competitive strength of Thai dairy farmers and cooperatives:

- Reduce farm costs to at least maintain profit margins with lower milk returns
- Reduce variable costs, e.g. more local roughages, on-farm concentrate mixing
- Exploit economies of scale, more milk per cow and/or more cows per farm
- Exploit areas of specialisation to reduce costs, e.g., contract calf/heifer rearing
- Better monitoring of individual cow performance to cull poor stock
- Improve milking hygiene on-farm with cooperatives penalising poor milk quality
- Consolidate milk collection centres to reduce cooperative overhead costs
- Make better use of the full range of services that cooperatives can provide
- Undertake more on-farm applied research and extension into feeding, herd and financial management.

These workshops aim to provide a framework to allow COP comparisons to be made between different size and types of dairy farms in different countries. For example, IFCN

(2005) have published many surveys of costs and returns from smallholder dairy farming throughout Asia, although their methodology is slightly different to the one described above. The workshops provide an ideal learning tool for farmers and advisers to better understand the partitioning of costs and returns from smallholder dairy farming. In addition, it assists farmers with prioritising their farm management decisions to address the high cost components on their systems, such as on-farm production of forages and purchases of concentrates, either fully formulated or their ingredients.

A second series of workshops was developed for Vietnam in 2008, and as part of that training program a computer program was created to calculate COP and many of the key KPIs. This Excel spreadsheet, FARMPROFIT, is freely available from the author, at john.moran@dpi.vic.gov.au or jbm95@hotmail.com.

Analysis of farm financial performance data requires assumptions on farm unit costs and returns. When comparing farms with differing systems, herd sizes or geographical locations, such conclusions are dependent on these relative costs and returns, which can vary over time. Therefore generalisations about farm profits must specify their year of data collection.

The future for smallholder dairy industries in tropical Asia

This chapter focuses on three key aspects influencing the future of Asia's smallholder dairy industries, namely the role of 'high technology', issues of environmental sustainability and the balance between the public and private sectors in future development programs.

The main points in this chapter

- Dairy development in Asia and other tropical regions has not kept pace with 'the West' mainly because of unfavourable climates (for milking cows) and a range of socio-economic constraints.
- New technology must be appropriate to the needs of the user, which is not always the case when 'high technology' is directly transplanted from temperate to tropical dairy industries.
- Without proper focus on natural resource management, smallholder dairy farming can become a polluter, hence become socially unacceptable in close proximity to urban areas.
- The public and private sectors both have key roles to play in dairy development, but they should be complementary not competitive.
- Most smallholder farms have the potential to become technically, socially and ecologically sound. As they constitute the majority of milk production systems in Asia, it is not only economical but also ethical to give real attention and effective support to their sustainable development.

Over the last 20 years of dairy research, development and extension, many Western countries have produced sophisticated dairy production systems. 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 farmers can. Low population

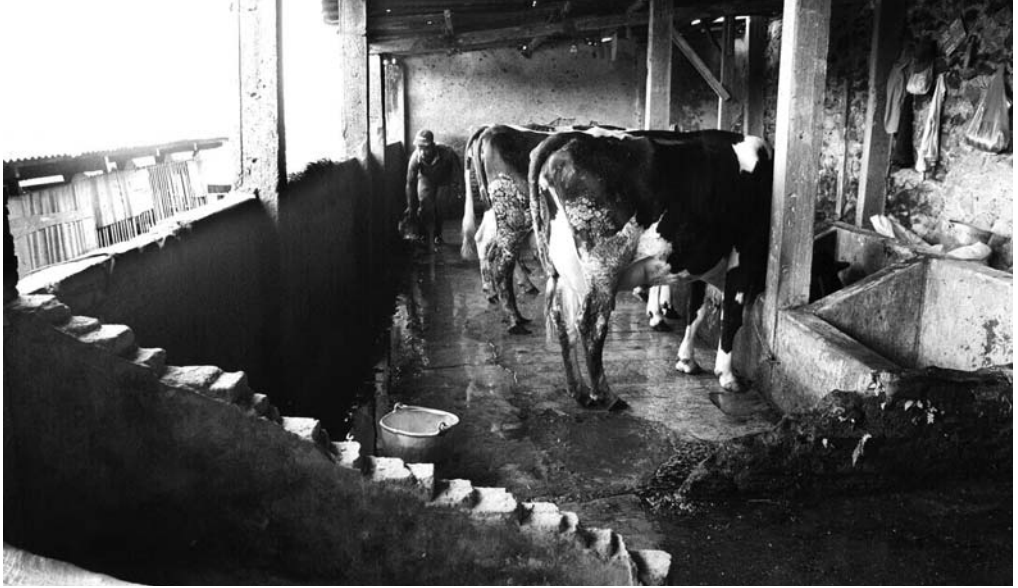


Figure 19.1 Many smallholder farmers are very poorly resourced (Indonesia)

pressures, hence relatively cheap land, have allowed farms in Western countries to expand in both size and cow numbers.

Unfortunately, this has not been the case for smallholder dairy farmers in most Asian countries. Being in the tropics, feed quality suffers from high temperatures and strongly seasonal rainfall patterns. Dairy cows are temperate animals with thermo neutral (comfort) zones closer to 10°C than to 30°C. Furthermore, high humidities reduce feed intakes which exaggerate the adverse effects of high fibre forages on appetite. In fact, a good measure of heat stress, the temperature humidity index, shows milking cows in the lowlands of the humid tropics to be in the ‘high stress’ and ‘reduced performance’ zones for much of most days throughout the year. Many dairy specialists argue that potentially high performance dairy breeds, such as Friesians, may not necessarily be the best cattle genotype for tropical regions, except in highland areas or those with low humidities.

There are many socio-economic reasons why the efficiency of smallholder dairy farming has not greatly improved over the last two decades. Granted, 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 dairy development initiatives. However, in terms of feed inputs per kg of milk produced, improvements have been slow.

Much of the technical progress in Western dairy countries has not been relevant to Asia, and in fact, some of it may have been unwisely transplanted. Commercial interests in selling ‘improved genetics’ often do not explain the need for the feeding and husbandry that go with the breeding. Granted, milking cows must get back in calf to



Figure 19.2 Dairy cows grazing under coconuts in Sri Lanka

keep producing milk, so good herd fertility is essential. However, poor early lactation feeding will not allow these ‘improved’ cows to express their potential for good fertility.

This chapter focuses on three key aspects influencing the future of Asia’s smallholder dairy industries, namely the role of ‘high technology’, issues of environmental sustainability and the balance between the public and private sectors in future development programs.

19.1 The relevance of ‘high technology’

Technological change plays a key role in agricultural development. The invention, innovation, diffusion chain involves many links. New technology may be transferred from overseas, where it was generated at international research centres or developed domestically by privately or publicly funded research. Private sector research is done by farmers and agribusiness, but since new knowledge is public good for the benefit of all peoples, public sector funding is also needed. Research prioritisation should be guided by the demands of producers, processors and consumers of new technology. The new social science of Farming System Research provides for assessment of producer objectives and constraints and for testing research results, but this is costly on-farm. Additional assessment is desirable as economic viability is a prerequisite, so it should involve cost-benefit analysis.

It has been my experience that with many developing tropical dairy industries, government policy makers all too often consider advanced technology and genetics as the panacea for their dairy industry. This approach is likely to yield disappointing results until some of the more basic dairy husbandry issues (feeding and herd management)

Table 19.1 The relevance of 'high technology' to developing tropical dairy industries

Links in the production supply chain	Very relevant in all-sized dairies	May be relevant in large dairy operations	Not relevant for next 5 to 10 years
1. Soils and fodder production	Effluent distribution systems	Some farm mechanisation	Genetically modified plants
	Macro nutrient fertilisers	Commercial silage additives	Organic production technology
	Micro nutrient fertilisers		Biodynamic production technology
	Latest generation pesticides		'Alternative' fertilisers
	Latest generation herbicides		
	Most farm mechanisation		
	Latest generation plant genetics		
2. Young stock	Electrolyte fluid replacers	Routine antibiotic therapy	Computerised (automatic) calf feeders
	Thermometers to monitor sick calves	Immunoglobulin monitoring equipment	Unnecessary overuse of antibiotic therapy
3. Nutrition and feeding	Macro mineral supplements	Computer software to monitor farm costs	Probiotics
	Access to computer software to formulate rations	Computerised animal identification systems	Micro mineral supplements
	Individual animal identification	Total mixed rations	Vitamin/micro mineral injections
			Computerised feed dispensers
4. Animal health	Latest generation drugs	Computer software to document animal health procedures	Routine blood profiles
	Latest generation vaccines	Access to some very sophisticated veterinary practices	Excessive use of antibiotics
	Access to most modern veterinary practices		
5. Reproduction	Artificial insemination technology	Oestrus synchronisation	Single sexed semen
	Aids for heat detection		
6. Breeding	High genetic merit semen	Exotic high genetic merit heifers	Embryo transfers
7. Environment	Effluent management systems	Village biogas systems	

Links in the production supply chain	Very relevant in all-sized dairies	May be relevant in large dairy operations	Not relevant for next 5 to 10 years
	Farm biogas systems	Climate controlled sheds	
	Advances in building designs		
	Latest generation heat stress alleviation systems		
8. Milk harvesting	Bucket milking machines	Automatic teat cup removers	Robotic milkers
	Herringbone dairies	Automatic cow exit	Rotary dairies
			Oxytocin for milk letdown
			Automatic laboratory milk assay equipment
			Rapid exit dairy systems
			Computers in the milking parlour for individual cow monitoring
9. Value adding	Farmer access to equipment to value add raw milk	Village access to equipment to value add raw milk	The latest advanced equipment to value add raw milk
	Processing, packaging and marketing at the dairy co-op level		
10. Miscellaneous		Computer (Information) technology	Growth hormone (Bovine somatotrophin or BST)

have been addressed at the grass roots level. Fortunately for many of these countries, there is considerable opportunity for improvement in basic farm management as many of the stakeholders in the dairy industry are relatively well educated, and a large network of government extension/animal health services can be mobilised.

The terms ‘high or new technology’ could be defined as the latest production technology in current or potential use by developed Western dairy industries. Dairy production technology can be broken down into nine key task areas (links) in a supply chain for any dairy farm, no matter its size or location. These were discussed in Chapter 2 and are listed in Table 19.1.

Much of this ‘high technology’ has been developed by advanced temperate countries with far more sophisticated and productive dairy industries than those likely to evolve in many South and East Asian countries for years (or even decades) to come. High technology has evolved through many routes, be they the end point of lateral thinking and human trial and error in the mind, the laboratory or on the farm. It can be questioned that some

of these evolutionary steps in dairy production technology may not, as yet or ever, be relevant to tropical smallholder dairy industries. Table 19.1 categorises these technologies into those currently very relevant in all-sized dairy operations in South and East Asia, those that may be relevant in large dairy operations and those not likely to be relevant to many of these dairy industries within the next 5–10 years.

The term ‘latest generation’ refers to the most recent stage of commercial evolution in particular farm production aids, such as pesticides, herbicides, plant genetics, veterinary drugs and vaccines. Plant and animal scientists are continually researching dairy production technology and as new discoveries are made and innovations evolve, they are upgraded from 1st to 2nd to 3rd generations and so forth, hence use of the term ‘latest generation’ in Table 19.1.

This table is rather subjective and may be incomplete. However, it should stimulate debate and become the basis of lengthy discussions between dairy production specialists into the future. Whatever their outcome, it is important to discriminate between **high technology** and **appropriate technology**.

19.1.1 The process of technological change

Driven by rapidly growing private investment in research and development (R&D), the knowledge divide between industrial and developing countries is widening. Including both public and private sources, developing countries invest only 11% of what industrial countries put into agriculture R&D as a share of agricultural R&D. Many international and national investments in R&D have paid off handsomely, with an average of 43% return on the investment dollar in 700 R&D projects evaluated in developing countries (World Bank 2007).

The process of technological change can be divided into three phases; invention, innovation and diffusion. Diffusion would be similar to extension, the third aspect of the acronym, R, D & E. However there are often other stages in the R, D & E chain leading to a usable invention, for example:

- Basic, applied and adaptive studies
- Development and testing
- Extension to the end users, namely producers, processors and consumers of farm products
- Technology has also been introduced from other countries, as part of the technology transfer.

Many agricultural innovations in the past were developed and spread through private enterprise, some by farmers themselves, while others such as machinery and fertilisers were developed and disseminated by industrial enterprises. Public sector involvement is relatively recent, but over the last few decades, the widespread drive for privatisation has been extended to R&D and it could be argued that publicly funded R&D must be maintained to achieve maximum benefit. Typical outcomes of private R&D include genetic material (including genetically modified organisms or GMO), nutritional additives, drugs, vaccines, farm machinery and equipment, which can be sold at a price that incorporates a share of the costs of research. Private R&D is usually

concentrated at the applied, near market end of the chain. It has been suggested that because public sector R&D can give high rates of return, it should receive continued funding and support in developing countries (Upton 2004). An important element of the prioritisation process must be the assessment of the demand for alternative types of innovation, as participatory approaches to identifying and executing research are vital.

There is a need to ensure that proposed new technologies are appropriate, that they accord with the producer's objectives and constraints, and match with consumer demands in accessible market outlets. Sustainability of livestock operations depends on availability of inputs, particularly fodder resources, but also on delivery systems for concentrate feeds, genetic material and disease control measures. The physical infrastructure of roads and appropriate institutional framework are also prerequisites.

A major challenge is to narrow income and productivity gaps between favoured and less favoured regions. Better technologies for soil, water and livestock management and more sustainable and resilient livestock systems, including varieties more tolerant of pests, disease and drought, are needed for these regions. Approaches that exploit biological and ecological processes can minimise the use of external inputs, especially agricultural chemical and unnecessary veterinary drugs. Examples include conservation tillage, improved tillage, green manure over crops, soil conservation and pest control that relies on biodiversity and biological control more than pesticides. Because most of these technologies are location specific, their development and adoption require more decentralised and participatory approaches, combined with collective action by farmers and communities.

Revolutionary advances in biotechnology do offer potentially large benefits to poor producers and poor consumers, so long as they are combined with other appropriate farm management practices. But today's investments in biotechnology, concentrated in the private sector and driven by commercial interests, have had limited impacts on smallholder productivity in the developing world, the exception being genetically modified cotton in China and India. Low public investment and slow progress in regulating possible environmental and food safety risks have restrained the development of GMOs that can help the poor. The World Bank (2007) argues that the potential benefits of these technologies will be missed unless the international development community sharply increases its support to interested developing countries.

Low spending is only part of the problem. Many public research organisations face serious leadership, management and financial constraints that require urgent attention. International research institutions, such as the International Livestock Research Institute in Kenya, also lack resources and personnel to deliver on their very broad mandate which includes encouraging the development of national agencies (Phelan, pers. comm.). However, higher value markets open new opportunities for the private sector to foster innovation along the value chain. Grasping them often requires partnerships among the public sector, private sector, farmers and civil society in financing developing and adapting innovation. With a wider range of institutional options now available, more evaluation is needed of what works well in what contexts.

Generally, improved technology will reduce costs and induce shifts towards more commercial systems. In most cases, farmers are already making use of most of the



Figure 19.3 Smallholder dairying is usually undertaken as part of mixed farming (West Java, Indonesia)

available technologies that meet their risk and return objectives and their market opportunities. The existence of other technologies locally, used by some commercial farmers, does not necessarily make them ‘available’ to traditional farmers, as the availability of technology depends partially on the capacity and objectives of the farmer. Productivity growth is likely to be driven mainly by increases in the opportunity cost of labour, which in turn drives the demand for a switch in use of available technology or even to the development of new technologies, not by availability of improved technologies. In fact, with low labour costs, there are few economies of scale in production due to limited incentive or means to invest in scale-dependent technology. Staal *et al.* (2008) report that in such diverse settings as Brazil and India, many small-scale dairy farmers have similar levels of unit profitability to larger-scale producers.

19.1.2 Technology and fertilisers

The 30 years from 1930–1960 saw a global population increase of 50% (Upton 2004). During this time the necessary world food supplies were largely obtained through the introduction of industrial manufactured farm inputs, such as machinery, fertilisers, herbicides and pesticides. For the industrialised countries, these new farm inputs were increasingly adopted but the developed countries largely found them expensive and often inappropriate.

For example, the rapid growth in the use of nitrogenous and other fertilisers was substituted for farmyard manure, including dairy shed effluent, in the maintenance of soil fertility, thus enabling Western farmers to abandon mixed crop-animal husbandry systems. The introduction of chemical herbicides and pesticides also reduced the need

for rotational cropping. By the late 1980s, nitrogenous fertilisers provided 50% of the total annual nitrogen flux in global cropland with animal wastes providing less than 9%. In developing countries relative prices made fertilisers less attractive. An estimated 70% of total fertiliser inputs in developing countries are still derived from animal manure. The structure of many tropical soils is poor and would benefit from application of such manure even when fertilisers are used. Inorganic fertilisers are a good investment on any tropical dairy farm, with cost:benefit ratios of at least 4:1 (Moran 2005).

19.1.3 Technology and animal health

One misuse of ‘high technology’ is in the area of animal health, not because farmers are accessing new technology, but because much of it is dated. Like human medicine, developments in the ‘latest generation’ veterinary drugs proceed at a very fast rate. All too often the veterinary drugs found on many smallholder dairy farms in South and East Asia are not the latest ‘generation’ but frequently those that were developed several years ago in the West. In all too many cases, drug companies are promoting, hence selling, the backlog of old products at discounted prices, or local veterinarians may not even be aware of the latest developments in drug therapy. Use of first generation vaccines, which have been stored appropriately and still within their ‘use by date’, may still be useful for smallholder dairy farmers.

The poor storage conditions on-farm of these drugs and their continued use well past their ‘use by date’, either through the veterinarian’s ignorance or, more commonly, that of the smallholder farmer, is a major problem. Appropriate drug storage facilities maintaining optimum conditions, including refrigeration if necessary, are a common feature on most Western farms but only on very few Asian dairy farms.

FAO estimate that 30% of livestock production in developing countries is lost through disease. In addition, routine disease control adds to the cost of production. Upton (2004) argues that technology is available for the control and treatment of many tropical livestock diseases but the delivery of veterinary service is beset with severe institutional problems. Due to increasing foreign debt and shortage of funds, many Asian governments face increasing pressure to reduce spending, to recover costs from users and to switch to private service providers wherever possible.

Well-trained veterinarians have a smorgasbord of drugs at their disposal and part of their training is to ensure that the most appropriate are prescribed for particular animal health situations. All too frequently farmers are prescribed antibiotics as the first drug to use, to treat the symptoms rather than the disease. For example, in young stock management, there is an overuse of antibiotics for calf scours. The majority of scouring calves die because of loss of essential minerals via the faeces, not because of excessive levels of infection in their gut.

Rather than detail treatment of calf scours in a book primarily on Farm Business Management, the reader is referred to my book on calf rearing (Moran 2002) and Chapter 10, where I wrote:

Many calf rearers have routinely used antibiotics to control potential pathogens, as well as to increase feed intake and utilisation. This is not necessary with ideal management and facilities, such as where colostrum intake is adequate, the rearing unit is clean and

well ventilated and not densely stocked and the operator is experienced. Because this ideal scenario is not common, antibiotics have been used as insurance against disease, particularly when rearing calves bought from often unknown sources. This could mask any disease outbreak for several days and also give a false sense of security, which often leads to an even poorer job in calf raising. Concern about the development of antibiotic resistant strains of bacteria has led to a marked reduction of this practice in certain countries.

There is no reason whatsoever why smallholder dairy farmers in the tropics should not have access to the latest drug technology, particularly since the tropics is a far from ideal environment for rearing and milking dairy cattle.

19.2 Making agriculture more sustainable

The environmental footprint of livestock farming has been large, but there are many opportunities for reducing it. Since the 1992 Earth Summit in Rio de Janeiro, it is generally accepted that the environmental agenda is inseparable from the broader agenda of smallholder agriculture for development. And the future of agriculture is intrinsically tied to better stewardship of the natural resource base on which it depends.

Both intensive and extensive agriculture face environmental problems, but of different kinds. Agricultural intensification has generated environmental problems from reduced biodiversity, mismanaged irrigation water, agrochemical pollution, and health costs and deaths from pesticide poisoning. The livestock revolution has its own cost, especially in densely populated and peri-urban areas, through animal waste and spread of animal diseases such as avian influenza. Many less favoured areas suffer from deforestation, soil erosion, desertification, and degradation of pastures and watersheds. For example, in the East African highlands, soil erosion results in productivity losses measured as high as 2–3% per year, in addition to creating offsite effects such as siltation of reservoirs.

The answer is not to slow down agricultural development, but to seek more sustainable production systems and enhance agriculture's provision of environment services. Many promising technological and institutional innovations can make agriculture more sustainable with minimal tradeoffs on growth and poverty reduction. Water management strategies in irrigated areas must improve water productivity, meeting demands of all users, including the environment, and reduce water pollution and the unsustainable mining of groundwater. These strategies depend on removing incentive for wasteful water usage, devolving water management to local user groups, investing in better technologies, and regulating externalities more effectively. Decentralising governance in irrigation management has a higher chance of success if legal frameworks clearly define the roles and rights of user groups and if the capacity of groups to manage irrigation collectively is increased.

Better technologies and better ways of managing modern farm inputs can also make rainfed farming more sustainable. One of agriculture's major success stories in the past two decades is conservation (or zero) tillage. This approach has worked in commercial

agriculture in Latin America, among smallholders in South Asia's rice-wheat (hence livestock) systems. As survey data from 20 countries show, women's engagement in community organisations improves the effectiveness of natural resource management (NRM) and the ability to resolve conflicts.

Getting incentives right is the first step towards sustainable resource management. Widespread adoption of more sustainable approaches is often hindered by inappropriate pricing and subsidy policies and the failure to manage externalities. Strengthening property rights and providing long-term incentives for NRM with off-farm benefits, such as matching grants for soil conservation, are necessary in both intensive and extensive farming areas. Inappropriate incentives that encourage the mining of our natural resources, such as subsidies to water intensive crops that cause groundwater over-pumping, must be reduced.

Such reforms are often politically difficult. Better water measurement through technology, such as remote sensing, better quality of irrigation systems and services, and greater accountability to water users can generate political support for otherwise stalled reforms.

There is a real urgency to deal with climate change throughout the tropics. Poor people who depend on livestock are most vulnerable to climate change. Increasing crop failures and livestock deaths are already imposing high economic losses and undermining food security in Sub Saharan Africa, and they will get far more severe as global warming continues. More frequent droughts and increasing water scarcity will devastate large parts of the tropics and undermine irrigation and drinking water in entire communities of already poor and vulnerable people. The international community must urgently scale up its support to climate proof the farming systems of the poor. Based on the 'polluter pays principle', it is the responsibility of the richer countries to compensate the poor for costs of adaptation. So far, global commitments to existing adaptation funds have been grossly inadequate (World Bank 2007).

Developing country agriculture and deforestation are also major sources of greenhouse gas emissions. They contribute 22–30% of the total emissions, more than half of which are from deforestation largely caused by agricultural encroachment (13 million ha of annual deforestation globally). Carbon trading schemes, especially if their coverage is extended to provide financing for avoiding deforestation and soil carbon sequestration (such as conservation tillage) offer significant untapped potential to reduce emissions from land use change in agriculture. Some improvements in land and livestock management practices are often win-win situations, in that after initial investments, they can lead to more productive and sustainable farming systems.

Biofuels provide another opportunity and challenge to smallholder dairy farming. Few of the current biofuel systems are economically viable and many pose social (rising food prices) and environmental (deforestation) risks. To date, production in industrial countries has developed behind high protective tariffs on biofuels and with large subsidies. Such policies hurt developing countries that are, or could become, efficient producers in profitable new export markets. Poor consumers also pay higher prices for food staples as grain prices rise in world markets due to the diversion of grain to biofuels or indirectly due to land conversion away from food production. With the dependence of

concentrates to intensify dairy production, ingredient costs for such high energy and protein supplements can also be influenced by similar economic pressures. Increased public and private investment in research is important to develop more efficient and sustainable production processes based on feeds other than human food staples. One promising area of work for smallholder dairy farmers is with tree legumes. Investors in Sri Lanka are currently assessing *Gliricidea* as a multi purpose crop for biofuel for generating electricity, supplying a valuable plant protein source for intensive livestock farming, and finally, timber for building.

19.2.1 Pollution and the public perception of dairy farming

There is little doubt that dairy farming, small- or large-scale, creates public concern about its impacts on human wellbeing and the environment. Moreover, due to expansion of urban areas, many farms that used to be located in rural areas are now peri-urban. Due to limitations of land and increases in family farms, the disposal of dairy waste can become a potential threat to community environment, particularly if their disposal is not well managed.

In a well-established dairying cooperative in Thailand, Chantlakhana and Skunmun (2002) evaluated the impacts of 47 smallholder dairy farms on local residents through personal interviews and samplings of the water, soil and air. On average, each farm had 20 milking cows, less than 0.3 ha for family and dairy housing and produced about half a ton of fresh manure each day, with some air dried and sold as fertiliser but much of it still being released into the surrounding areas. Three groups of people were surveyed, namely the dairy farmer households (Group 1), non-dairy households located 500 m from the nearest dairy barn (Group 2) and non-dairy households located more than 5 km from the nearest dairy barns (Group 3).

These groups were located in various areas around the dairy cooperative, namely:

- Location A: an area with irrigation canals and a high density of dairy farms
- Location B: a municipality area where public services such as roads, telephones and sewage systems were available
- Location C: a manufacturing area where factories exist among the dairy farms.

Nuisance from dairying to people. Only people in non-dairying households believed that dairying caused some nuisance to them (53%, 50% and 27% of those surveyed in locations A, B and C respectively). Specific nuisances ranked from high to low were as follows: smell of manure and urine, flies, bellowing noise and dust from dried manure. However, there were no real objections from non-dairy households in regions where dairying had been established for a long time.

People's perception of the effects of dairy waste on the environment. Interviewees had both positive and negative opinions on the water, soil and air environment. All dairy farmers (Group 1) appreciated the benefits of manure on improving soil fertility, while 7–14% of Group 2 indicated an adverse effect of soil manure on soil salinisation. Most non-dairy people (Groups 2 and 3) agreed that dairying created undesirable smells and water pollution to the community. All dairy farmers (Group 1) argued that dairy waste only created water pollution for a short period during the wet season, but this was much less than the pollution caused by wastewater from factories in Location C.

People's health. Results showed no significant differences in disease incidences over a 12-month period in all the three groups surveyed. Important diseases, ranked in decreasing order of occurrence were: respiratory diseases, skin diseases, diarrhoea and allergy. Interviewees agreed that it would be difficult to relate these diseases directly to dairy farming.

There is an urgent need to implement appropriate waste management systems for smallholder dairy farms. Liquid waste can contaminate water resources and public waterways, while piling and drying manure on bare land can lead to leaching and seeping of inorganic and organic matter into underground water. Cement drainage ditches should be constructed for waste water and liquid manure disposal and sewage tanks for holding liquid waste outside dairy barns. In addition, low cost cement floors should be constructed for drying manure. For the long term, central waste water treatment systems or biogas digesters should be considered, but only after careful planning and with active farmer participation in the decision-making process.

Future national dairy development programs should include elements of environmental protection with farmer training and regular monitoring of water, soil and air quality. In addition, dairy cooperatives should be provided with appropriate information regarding possible long-term effects of environmental pollution and sanitary measures to safeguard against risks to human health.

19.3 The role for Public Private Partnerships in dairy development

The recent price rises in dairy imports has led to a resurgence in dairy development throughout Asia. Rather than repeat the mistakes of the past, a concerted effort is being made to revisit the past to more fully understand why so many of the so-called integrated dairy programs and projects of the 1970s and 1980s failed and which of their characteristics succeeded. One major finding is that dairy development requires major inputs from the private as well as the public sector, in other words a Public Private Partnership (PPP).

With the help of international communities, many of the early government to government programs established hugely expensive, high capacity technologies and equipment. In some cases, local dairying was held back as the projects imported large quantities of subsidised skim milk powder and butter oil. Sometimes these countries were able to use these commodities to develop their own dairy industries, while at other times, they could not. In the latter cases, local milk prices were depressed, milk production dropped and the dairies became underutilised, partly because of the high price of imported replacement equipment and spare parts. There were many classic examples of inappropriate high technology, as discussed earlier in this chapter. Today, these countries are still highly dependent on imported milk.

In February 2008, a workshop on smallholder dairy development (APHCA 2008) was held at Chiang Mai in Thailand, attended by 50 participants from 18 countries and funded by three international aid agencies, namely Animal Production and Health Commission of Asia and the Pacific (APHCA), Food and Agriculture Organisation

(FAO) and the Common Fund for Commodities (CFC). By comparing the industries in nine different Asian countries, representing three broad categories of access to formal and informal milk markets, Dugdill and Morgan (2008) reviewed a variety of farmer models and of factors (both positive and negative) influencing smallholder participation in dairy food chains, that is the entire milk production, processing and marketing chain from the farm to the kitchen table. They identified six different ‘smallholder producer models’ with varying degrees of public and private involvement, ranging from dairy cooperatives to contract farming to community bank-funded livestock and dairy development and other collective/community dairy cow keeping models. In differentiating between the public and private sectors, their conclusions (with examples from various study countries) are summarised below.

19.3.1 The key roles for both public and private sectors

The public and private sectors both have key roles to play in dairy development, but they should be complementary not competitive. The public sector covers any stakeholder employed by a government agency, namely public servants generally paid a wage similar to other government employees in that country.

The private sector covers all other stakeholders, whose remuneration is more flexible and generally related to the performance of the dairy industry in their region. Such stakeholders include:

- Commercial farmers, both smallholder and large scale
- Rural traders, entrepreneurs, brokers and intermediaries
- Suppliers of farm inputs (feed, stock, veterinary drugs, machinery)
- Post farm gate stakeholders in the dairy value chain, such as transporters, cooperatives, milk processors, informal milk marketers
- Service providers (excluding government officers), such as veterinarians, inseminators, private consultants, contractors
- Financial institutions
- Non-government organisation and private aid agencies
- Administrators in dairy cooperatives and other farmer organisations including multinationals.

The key roles for the public sector should be to:

- Promote dairy development through policies, advocacies and strategies via tailored national institutions
- Provide technical support services and farmer training programs (although the private sector has an equally important role)
- Facilitate organisations of milk producers, legal framework and trade
- Promote milk consumption for improved nutrition.

Makeham and Malcolm (1986) expressed concern about public involvement in farming with rather strongly worded comments. There are numerous examples of economic disasters or near disasters which have occurred in such activities as federal, state, local government, tractor hiring services, marketing boards, distribution of inputs

and supply of foodstuffs to consumer and sometimes government-backed cooperatives. A build-up of bureaucracies with exceptionally low levels of productivity, and resistance to measures based on such criteria as profitability and sound resource use is all too common. Equally important, excess government participation in practical agriculture can create the situation whereby responsibility and accountability are not fostered. It's called the 'it's the government's money, so it doesn't matter' syndrome. It is often as though economic analysis of the use of government funds is something that cannot be done, and to be accountable to the providers of these funds would be too cumbersome an imposition upon the spenders.

Sometimes when the public sector 'overplays' its role, there is a reduced input from the private sector. This can become a vicious cycle because a lack of private sector participation can lead to further government intervention, hence continued reluctance of the private sector to participate. Reasons for limited private sector involvement can be many and varied, such as:

- Restrictions on private sector activities and other infrastructure constraints
- Barriers to establishment, registration and licencing of businesses, especially with small to medium enterprises
- State intervention in pricing (farm inputs as well as outputs)
- Shortage of technical and business skills
- Poorly developed financial sector
- Corruption and poor governance
- Perceived business risks
- Provision of free or subsidised services by government
- Poor (or poorly policed) regulations on food safety
- Availability of cheap imports and other examples of poor market protection
- Government support for cooperative models
- Existence of state owned enterprises.

Young (2008) concluded his review of PPPs by suggesting ways to encourage private sector involvement:

- Governments should not abandon their responsibilities.
- Focus on correcting market failures, if they can be corrected.
- Clearly delineate government and private sector responsibilities to dairy development.
- Investigate other successful models of free enterprise, such as poultry.
- Avoid 'crowding out' with too much competition and create a business friendly environment.
- Consider private delivery of public services.

19.3.2 Lessons learnt from the nine country study

From the APHCA study of nine different Asian dairy industries, Dugdill and Morgan (2008) summarised a range of 'lessons learnt', with examples from different countries. These were as follows:

How did the various smallholder producer models perform?

1. Centrally planned models, or those where government intervened in milk pricing, did not fare well in the long term (Pakistan, Vietnam).
2. Government-owned dairies, especially large-scale ones where civil servants managed the business did not fare well (Bangladesh, Pakistan, Vietnam), although there were exceptions such as recent centrally owned but market orientated Chinese companies.
3. Most of the successful models are private sector based, as they have more flexibility and are less constrained by regulations than other producer models, such as cooperatives.
4. There are concerns if the private sector wants to maximise profits and reduce risks by using cheap imported (subsidised) dairy commodities rather than setting up more difficult to manage, local milk procurement schemes.

The key lessons for the public sector were:

1. It must be careful about interventions such as pricing policies (Sri Lanka, Thailand) and dairy cow loan schemes (Bangladesh, Mongolia, Vietnam).
2. Government investment in large state-run processing does not work (Pakistan, Philippines). They should carefully target smallholder dairy development interventions (Bangladesh, India, Mongolia, Philippines, Vietnam).
3. It should encourage graduation from subsistence to commercial smallholder and/or larger-scale farming by adopting more appropriate policies and strategies (Bangladesh, India, Philippines, Thailand).

The key lessons for the private sector were:

1. It should become engaged sooner rather than later in the development process. Creative and carefully thought out linkages between smallholder groups and the private sector, such as technical assistance and financial support, will enable smallholders to move up the marketing chain more easily (Vietnam, Bangladesh, Mongolia, Philippines, Pakistan).
2. Milk quality and attractive product branding and presentation are prerequisites for persuading modern urban consumers to switch from imports to locally produced milk (China, India, Mongolia, Philippines).
3. Value adding activities can enhance returns to dairying. Selected smallholders close to formal and informal markets should produce high value added ready-to-drink indigenous and niche products (China, Mongolia, Philippines).

The key lessons applying across the entire dairy sector were:

1. Smallholders need accessible and affordable complete packages of technical support services (such as animal health and AI services) to produce milk competitively (Bangladesh, India, Mongolia). Not surprisingly, the key technical constraints are lack of feed and fodder, dairy breeding stock and training. Technical know-how and skills can be delivered through vocational and outreach training by industry institutions or smallholder dairy groups.
2. Pro-poor social programs, including school milk programs, need to be carefully targeted and are usually sustainable only if linked to remunerative markets

(Bangladesh, Mongolia). The important socio-economic-cultural-environmental benefits have been previously discussed in Chapters 2 and 3 of this book.

3. Lactose intolerance is basically a myth because many people seen as non-milk drinkers are increasing consumption of ready-to-drink processed and cultured milks (Philippines, Thailand, Vietnam). School milk programs help develop the milk drinking habit while promoting future demand, but should be based on locally produced rather than imported milk.

The five overarching principles of smallholder dairy development are:

1. Smallholder dairying is straightforward in concept but complex in execution.
2. Dairy farmers must be competitive to access markets, by producing top quality milk at affordable prices. Success requires adoption of a complete cow-to-consumer strategy and intervening at every stage of the dairy food chain to ensure profitable product integrity.
3. Strategies for and including smallholders require deliberate and creative development processes that are sensitive to the impact of policies, programs and activities of the farmers themselves.
4. The impact of such policies, programs and activities on the farmers depends on the local context and the people involved.
5. The private sector must be fully engaged with both government and farmers in developing regional strategies and also national action plans.

19.4 Ensuring a future for smallholder dairying

With growing political attention to narrowing current income disparities, there are many opportunities to better use dairying as an instrument for development.

When planning regional strategies, Young (2008) made some salient comments. These include:

- **Think globally but act locally.** As part of a global industry, smallholder dairying has to be competitive in a world of declining trade barriers. The ‘one size fits all’ approach does not work given the vastly different scenarios across Asia.
- **Focus on the long term.** It is too easy to be distracted by current issues and overlook the long-term requisites that are fundamental for their success.
- **Consider a wide range of possible scenarios.** There are many critical uncertainties, such as climate change and changes in consumer preferences and trade policies. These must be factored in when formulating strategies for them to remain relevant and flexible enough across the region.
- **Design for impact.** The regional strategy is about people, the millions of rural poor, and not about milk or cows. Policy makers must always remember who the intended beneficiaries are and how their lives will be affected by any proposed interventions.
- **Avoid overprescriptive blueprints.** By developing a range of options, individual countries and regions can select those most relevant to their needs and available resources.

- **Don't overlook financing needs.** Dairy development is capital intensive compared to other forms of livestock production. Finances should be mainly 'up-front' because ongoing donor support may not be sustainable.
- **Consider the enabling environment.** Although such strategies can be successful under a wide range of situations, they must take into account the key features of the region, such as its transport infrastructure, electricity and water supplies, financial services, telecommunications, current animal husbandry practices, technical support and market linkages.
- **Adopt a demand-led approach.** The engine of these strategies is growing consumer demand. However, as consumers are better informed, they become more discriminating in their tastes and more demanding of quality, product range and convenience. Without consistency of quality, smallholders may be sidelined for industrial-scale dairy operations or imported product. There may be market niches for smallholder products.
- **Establish preconditions.** Dairy development will not work without social stability, adequate governance and sound macro-economic policies. It must also meet the conditions of political feasibility, administrative capacity and financial affordability.

If the world is committed to reducing poverty and achieving sustainable growth, the future must include more sustainable livestock farming. As there are no magic bullets, this requires broad consultations at the country level to customise agendas and define implementation strategies. It also requires having livestock farming work in concert with other sectors at the local, national and global levels. It requires building the capacity of smallholders and their organisations, private agribusiness and the state. It requires institutions to help agriculture serve development and technologies for sustainable NRM. And it requires mobilising political support, skills and resources. However, it is difficult for developing countries to strive for sustainability when so many of their populations are faced with poverty and hunger. It is difficult to stop people from cutting and burning the forest, eroding the land or destroying the animals and fishes when they and their families are hungry. It is difficult to take an altruistic viewpoint on reducing global greenhouse gas production when there is such a discrepancy between the world's rich and the world's poor. In other words, it is not easy to be green when you are in the red! The need to strengthen moral and religious beliefs and the idea of sacrifice for the common good and survival of future generations are admirable philosophies which should be practised by every element of society as part of their everyday life, not just those who demonstrate such beliefs in closed communities.

Smallholder farms, though ecologically sustainable, are basically traditional systems which need further technical improvements to increase the farm outputs, hence profitability, to satisfy the food requirements of rising human population. However, research activities directly relevant to the development of small-scale production systems have received little attention from both scientists and policy makers of the developing countries. Chantalakhana and Skunmun (2002) argue that most scientists and high level administrators have been overly influenced by, and even overwhelmed with, the commercial production of commodities for export to earn foreign exchange, with insufficient emphasis on import replacement.

Since most smallholder dairy farms have the potential to be technically, socially and ecologically sound, and they constitute the majority of milk production systems in South and East Asia, it is not only economical but also ethical to give real attention and effective support to their sustainable development. Short-term gain and quick profit incentives must be seriously and carefully evaluated against any loss of natural resources and human survival in the long term. That is not to say that with appropriate management and sound government policies, large commercial dairy farms cannot contribute to the milk flow. However, even after 20 or 30 years of bitter experience, there are still far too many instances where large dairy operations have failed because not enough attention has been given to the basics (namely the nine links in the supply chain of a profitable dairy enterprise as described in Chapter 2).

Unlike crop science, most dairy production and health research is confined to the research station or laboratory. Such research can be criticised for not being relevant or practical enough to solve the ‘real farm problems’. Unfortunately, far too many dairy scientists are ‘compartmentalised’ in their scientific thinking rather than intuitively looking ‘at the big picture’ and employing a farming system or holistic approach to their work. Very few seem interested in, or have a real understanding of, the concept of sustainable farming, and there is little evidence of local farmer participation from the beginning to the very end of any project. Local farmers’ knowledge and problems must form the basis of their research. Changes in technical efficiencies can have carryover effects on socio-economics. Because village animal production involves the entire family, men, women, old and young including children, it must consider the needs and limitations of all these potential stakeholders in any one smallholder dairy farm.

In addition, research organisations in developing countries need to review their philosophies on science and technology and direct them more to the needs of farmers and local communities, not towards international publications or their own self-interest. As Chantalakhana and Skunmun (2002) express it so eloquently, ‘Animal scientists working on sustainable livestock production must be those with utmost interest in people, and not only money.’

Indonesian dairy smallholder pamphlet

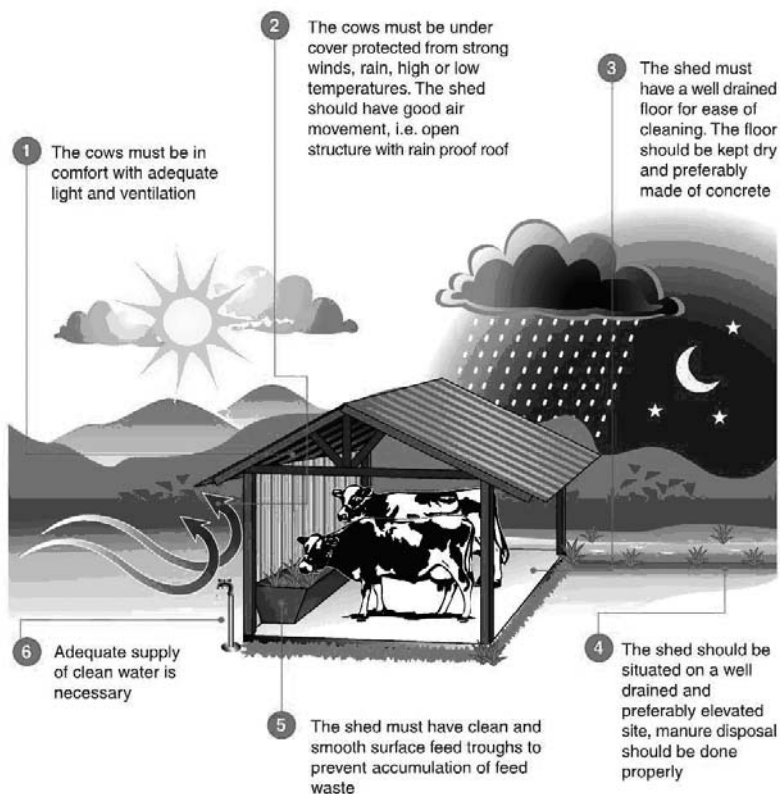
Tips For Proper Managing of Dairy Cows On Indonesian Smallholder Farms

(Edition 2)

All dairy cows have one thing in common, their milk production and quality are directly related to the way they are looked after, and the way they are milked. Caring and gentle treatment directly affects a cow's well-being, improving its milk production and general health.

A. Housing for Dairy Cows

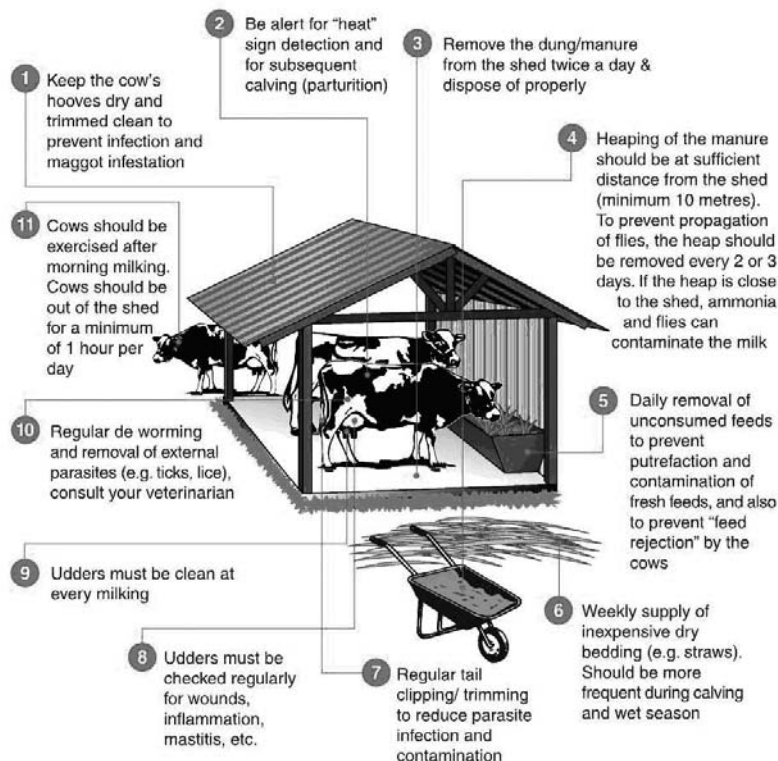
To ensure that the cows are in a proper environment resulting in higher milk production, the animals must be in proper shelters;



Tips For Proper Managing of Dairy Cows On Indonesian Smallholder Farms

B. Livestock Health and Hygiene

A good dairy farmer should be capable of detecting the early symptoms of ill-health in dairy cattle and to take steps to eliminate the sources of disease on the farm, e.g. contaminated water supply, infected buildings or roughages, etc. Other important factors are:

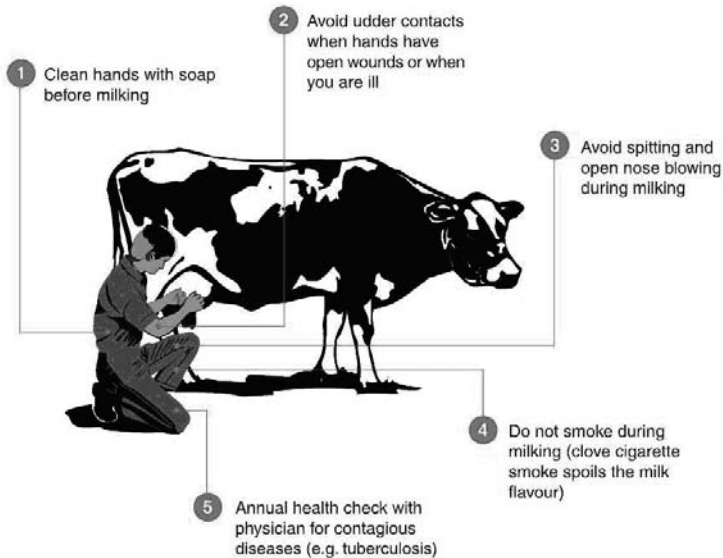


Tips For Proper Managing of Dairy Cows On Indonesian Smallholder Farms

C. Recommended Feeding

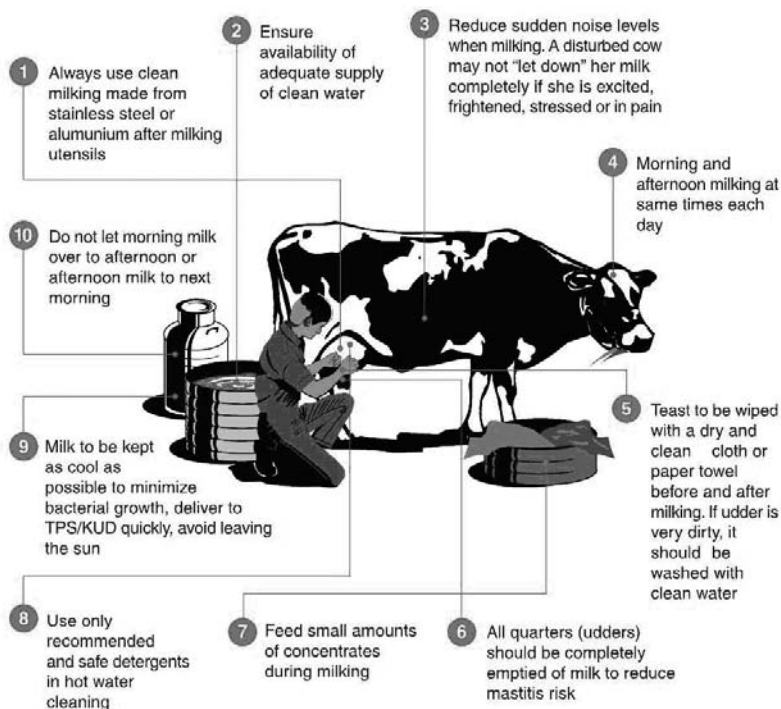
Follow the recommendations from the dairy training centre, i.e. a cow must eat the right quantity and the right quality of green roughage and concentrates, depending on the stage of development (calf, grower, heifer, pregnant, dry cow, bull) and milk production level (higher milk production needs more feeds) to maintain satisfactory milk production and ensure cow gets back in calf within 100 – 150 days of calving. Ideally milking cows should be fed 40 – 50 Kg fresh, high quality forage each day plus 1 kg quality formulated concentrate per 1 – 2 L milk. Wet or dry (ampas tahu, onggok, rice bran) by products can substitute for some of the concentrates so long as they.

D. Dairy Farmer Personal Hygiene



Tips For Proper Managing of Dairy Cows On Indonesian Smallholder Farms

E. Recommended Milking and Milk Handling



Important:

IF COWS SHOW SIGNS OF ILL-HEALTH, CONTACT IMMEDIATELY THE DAIRY CENTRE OR VETERINARIAN ON DUTY.

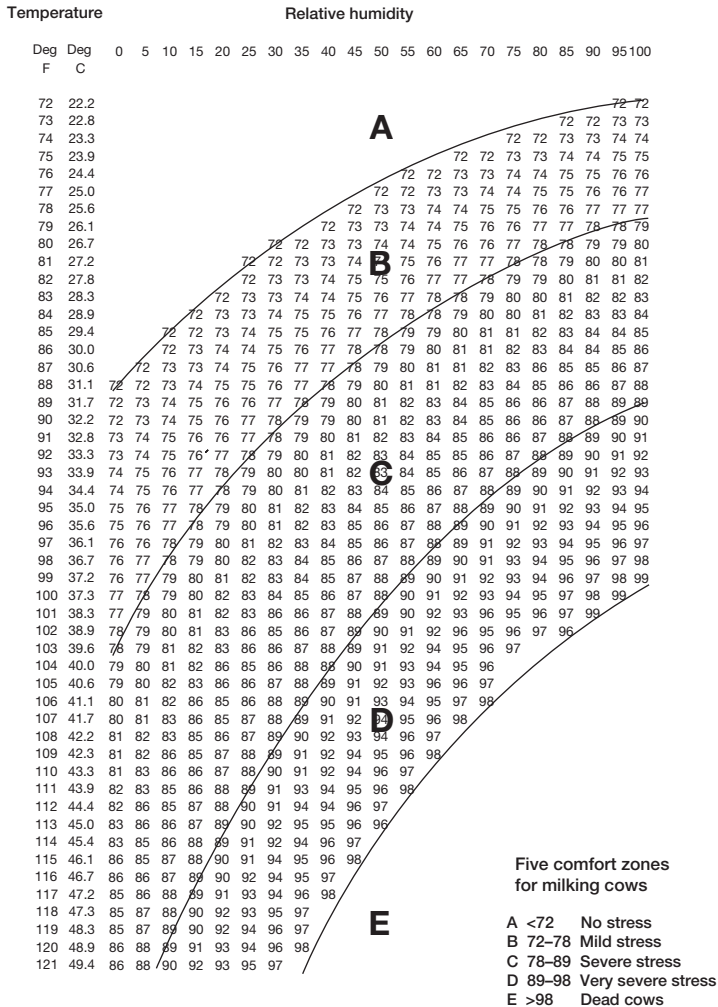
All these recommendations will ensure that the dairy cows will remain healthy, thus increase milk production and improve milk quality which result in higher income.



Appendix 1

Temperature Humidity Index

The following table presents the Temperature Humidity Index, calculated from temperature (in degrees fahrenheit or centigrade) and relative humidity (%), highlighting its effect on cow stress and hence performance



Appendix 2

Conversion of units of measurement

1 Abbreviations

mm	millimetre
cm	centimetre
m	metre
ml	millilitre
ppm	parts per million
k	kilo or thousands
M	mega or millions
MCal	megacalories
MJ	megajoule
MT	megatonnes
min	minute
hr	hour
d	day
mo	month
yr	year
mg	milligram
kg	kilogram
g	gram
J	joules
L	litre
lb	pound
ft	foot
hd	head
\$	dollar
c	cent
<	less than
>	greater than

2 Conversion of Imperial units to metric units

Length:	1 inch = 25.4 mm
	1 foot = 30.5 cm
	1 yard = 0.91 m
	1 mile = 1.61 km
Volume:	1 cu ft = 0.028 cu m
	1 pint = 0.57 L
	1 gallon = 4.54 L
	1 bushell = 36.4 L
Area:	1 acre foot = 1.23 Ml (megalitre)
	1 acre = 0.40 ha
Weight:	1 sq mile = 2.59 sq km
	1 ounce = 28.3 g
Energy	1 pound = 0.454 kg
	1 hundredweight = 50.8 kg
	1 long ton = 1017 kg (2240 lb)
Density:	1 calorie = 4.19 joules
Rate:	1 lb/ft ³ = 0.063 kg/m ³
Pressure:	1 gallon/acre = 11.23 l/ha
	1 pound/acre = 1.12 kg/ha
	1 gallon/ton = 4.17 l/tonne
Yield:	1 pound/sq in (psi) = 1.45 kPa (kilopascals)
Temperature:	1 lb/ac = 1.12 kg/ha
	$1^{\circ}\text{F} = ((9/5) * \text{C}) + 32$
	$1^{\circ}\text{F} = 0.56^{\circ}\text{C}$
	$50^{\circ}\text{F} = 10.0^{\circ}\text{C}$
	$60^{\circ}\text{F} = 15.6^{\circ}\text{C}$
	$70^{\circ}\text{F} = 21.1^{\circ}\text{C}$
	$80^{\circ}\text{F} = 26.7^{\circ}\text{C}$
	$90^{\circ}\text{F} = 32.2^{\circ}\text{C}$
$100^{\circ}\text{F} = 37.8^{\circ}\text{C}$	
	$110^{\circ}\text{F} = 43.3^{\circ}\text{C}$

3 Conversion of US units to metric units

Volume:	1 gallon = 3.79 L
	1 bushell = 35.2 L
Weight:	1 hundredweight = 45.4 kg
	1 short ton = 907 kg (2000 lb)
Milk prices:	\$10/hundredweight = 22.0 c/L
Forage maize yields @ 30% DM:	
	25 ton fresh weight/acre = 16.8 t DM/ha
Food energy:	1% unit TDN = 0.185 MJ/kg DM of metabolisable energy

30% TDN = 3.7 MJ/kg DM of ME
 40% TDN = 5.5 MJ/kg DM of ME
 50% TDN = 6.4 MJ/kg DM of ME
 60% TDN = 7.4 MJ/kg DM of ME
 70% TDN = 8.3 MJ/kg DM of ME
 80% TDN = 9.2 MJ/kg DM of ME
 1 MCal/lb = 9.22 MJ/kg
 1 MCal/kg = 4.19 MJ/kg

4 Conversion of other specific country units to metric units

Most countries now use the metric units of measurement, however, certain countries have their own historical units, which are still used by farmers and advisers.

China

Length: 1 chi = 33 cm
 1 li = 500 m
 Volume: 1 gongsheng = 1 L
 Weight: 1 jin = 500 g

Thailand

Length: 1 nui = 2.1 cm
 1 kheup = 25 cm
 1 sawk = 50 cm
 1 waa = 2 m
 1 sen = 40 cm
 1 yoht = 16 km
 Weight: 1 baht = 15 g
 1 tamleung = 60 g
 1 chang = 1.2 kg
 1 haap = 60 kg
 Area: 1 sq waa = 4 sq m
 1 ngaan = 400 sq m
 1 rai = 1.6 ha

Appendix 3

Currency converter for South and East Asia

Instead of expressing costs and returns in one currency (conventionally US dollars), this manual makes use of currencies from various South and East Asian countries. For the reader's benefit, rather than convert them all to a single currency in the text, the following currency converter can be used to compare their values in March 2009. More up-to-date conversions can be obtained via the internet from a currency converter located at www.xe.com/ucc/.

	AFN	AUD	BDT	CNY	INR	IDR	MYR	PKR	PHP	LKR	THB	USD	VND
AFN	x	32.4	0.690	6.90	0.94	3.93	12.9	0.585	0.976	0.412	1.32	47.1	2.69
AUD	0.03	x	0.021	0.213	0.029	0.012	0.399	0.018	0.030	0.013	0.041	1.456	0.083
BDT	1.45	46.9	x	9.99	1.36	5.69	18.7	0.846	1.41	0.597	1.911	68.20	3.901
CNY	0.144	4.69	0.100	x	0.135	0.057	1.871	0.085	0.141	0.060	0.191	6.826	0.390
INR	1.07	34.5	0.737	7.363	x	4.19	13.77	0.624	1.042	0.440	1.408	50.26	2.875
IDR	2.54	8.23	1.76	1.754	2.383	x	32.82	1.487	2.483	1.049	3.356	119.7	0.068
MYR	0.077	2.51	0.054	0.534	0.073	0.030	x	0.045	0.076	0.032	0.103	3.666	0.209
PKR	1.71	55.3	1.181	11.80	1.602	6.72	22.07	x	1.669	0.705	2.258	80.55	4.607
PHP	1.02	33.1	0.708	7.069	0.960	4.03	13.17	0.599	x	0.423	1.352	48.23	2.756
LKR	2.42	78.4	1.674	16.72	2.272	0.953	31.17	1.417	2.367	x	3.200	114.2	6.531
THB	0.758	24.5	0.523	5.227	0.710	0.297	9.733	0.443	0.740	0.312	x	35.54	2.041
USD	0.021	0.687	0.015	0.146	0.019	0.008	0.273	0.012	0.021	0.009	0.028	x	0.058
VND	0.371	12.01	0.256	2.560	0.347	0.146	4.790	0.217	0.362	0.153	0.490	17.48	x

AFN: Afghanistan afghanis; AUD: Australian dollar; BDT: Bangladesh taka; CNY: China yuan renminbi; INP: India rupee; IDR: Indonesian rupiah x 100; MYR: Malaysian ringgit; PKP: Pakistan rupee; PHP: Philippines peso; LKR: Sri Lanka rupee; THB: Thai baht; USD: US dollar; VND: Vietnam dong x 1000

Appendix 4

Tables of nutrient requirements

Information from these tables is required when completing Worksheet 1 on page 250.

Energy requirements for maintenance

Table A4.1 Energy requirements for maintenance (Ministry of Agriculture, Fisheries and Food 1984)

Live weight (kg)	Energy requirements	
	MJ ME/day	kg TDN/day
100	17	1.2
150	22	1.5
200	27	1.9
250	31	2.2
300	36	2.5
350	40	2.8
400	45	3.1
450	49	3.4
500	54	3.8
550	59	4.1
600	63	4.4

Energy requirements for pregnancy

Table A4.2 Average daily energy requirements in the last four months of pregnancy (Ministry of Agriculture, Fisheries and Food 1984)

Month of pregnancy	Additional energy required	
	MJ ME/day	kg TDN/day
Sixth	8	0.6
Seventh	10	0.7
Eighth	15	1.1
Ninth	20	1.4

Energy requirements for activity

An allowance for grazing activity has been factored into the maintenance requirements in Table A4.1. In flat terrain, 1 MJ ME (or 0.1 kg TDN) per kilometre should be added to provide the energy needed to walk to and from the dairy. In hilly country, this increases up to 5 MJ ME (or 0.4 kg TDN) per kilometre.

Energy requirements for milk production

For analyses of data comprising milk fat and milk solids-not-fat (SNF), milk protein can be calculated as follows:

$$\text{Milk protein (\%)} = \text{SNF\%} - 5.4$$

Table A4.3 Energy needed per kg of milk of varying composition, in MJ/kg of metabolisable energy (Ministry of Agriculture, Fisheries and Food 1984)

Fat (%)	Protein (%)									
	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4
3.0	4.5	4.5	4.6	4.7	4.8	4.8	4.9	5.0	5.0	5.1
3.2	4.6	4.7	4.7	4.8	4.9	5.0	5.0	5.1	5.2	5.2
3.4	4.7	4.8	4.9	4.9	5.0	5.1	5.2	5.2	5.3	5.4
3.6	4.9	4.9	5.0	5.1	5.1	5.2	5.3	5.4	5.4	5.5
3.8	5.0	5.1	5.1	5.2	5.3	5.3	5.4	5.5	5.6	5.6
4.0	5.1	5.2	5.3	5.3	5.4	5.5	5.5	5.6	5.7	5.8
4.2	5.3	5.3	5.4	5.5	5.5	5.6	5.7	5.7	5.8	5.9
4.4	5.4	5.5	5.5	5.6	5.7	5.7	5.8	5.9	6.0	6.0
4.6	5.5	5.6	5.7	5.7	5.8	5.9	5.9	6.0	6.1	6.2
4.8	5.6	5.7	5.8	5.9	5.9	6.0	6.1	6.1	6.2	6.3
5.0	5.8	5.8	5.9	6.0	6.1	6.1	6.2	6.3	6.3	6.4
5.2	5.9	6.0	6.0	6.1	6.2	6.3	6.3	6.4	6.5	6.5
5.4	6.0	6.1	6.2	6.3	6.3	6.4	6.5	6.5	6.6	6.7
5.6	6.2	6.2	6.3	6.4	6.5	6.5	6.6	6.7	6.7	6.8
5.8	6.3	6.4	6.4	6.5	6.6	6.7	6.7	6.8	6.9	6.9
6.0	6.4	6.5	6.6	6.6	6.7	6.8	6.9	6.9	7.0	7.1

Table A4.4 Energy needed per kg of milk of varying composition in kg/kg of total digestible nutrients (Ministry of Agriculture, Fisheries and Food 1984)

Fat (%)	Protein (%)									
	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4
3.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4
3.2	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
3.4	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
3.6	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
3.8	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4.6	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4.8	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
5.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5
5.2	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5
5.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
5.6	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5.8	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Energy requirements for changes in body condition

Table A4.5 The weight of one condition score on cows of different sizes (Target 10 1999)

Cow's approximate live weight (kg)	Additional weight to increase by one condition score (kg)
550	44
475	38
400	32

Table A4.6 The energy a kilogram of body weight or condition needs or releases expressed either in MJ of ME or kg of TDN (Target 10 1999)

Change in body condition	Energy needed to gain 1 kg of weight (MJ ME or kg TDN)	Energy available from 1 kg of weight loss (MJ ME or kg TDN)
Late lactation gain	44 (3.1)	–
Dry period gain	55 (3.9)	–
Weight loss	–	28 (2.0)

Protein requirements

Table A4.7 Crude protein needs of a cow at different stages of lactation (Target 10 1999)

Milk production	Crude protein requirements
Early lactation	16–18%
Mid-lactation	14–16%
Late lactation	12–14%
Dry	10–12%

Fibre requirements

Table A4.8 The absolute minimum percentage of fibre needed in a cow's diet for healthy rumen function, using three different measures of fibre (Target 10 1999)

Fibre measurement	Minimum amount of dietary fibre (% DM)
Neutral detergent fibre	30%
Acid detergent fibre	19%
Crude fibre	17%

Appetite limits

Table A4.9 Maximum daily intake of cows as affected by the NDF per cent of the diet (Linn and Martin 1989)

Live weight (kg)	NDF content (%)											
	25	30	35	40	45	50	55	60	65	70	75	80
100	4.8	4.0	3.4	3.0	2.7	2.4	2.2	2.0	1.8	1.7	1.6	1.5
150	7.2	6.0	5.1	4.5	4.0	3.6	3.3	3.0	2.8	2.6	2.4	2.3
200	9.6	8.0	6.9	6.0	5.3	4.8	4.4	4.0	3.7	3.4	3.2	3.0
250	12.0	10.0	8.6	7.5	6.7	6.0	5.5	5.0	4.6	4.3	4.0	3.8
300	14.4	12.0	10.3	9.0	8.0	7.2	6.5	6.0	5.5	5.1	4.8	4.5
350	16.8	14.0	12.0	10.5	9.3	8.4	7.6	7.0	6.5	6.0	5.6	5.3
400	19.2	16.0	13.7	12.0	10.7	9.6	8.7	8.0	7.4	6.9	6.4	6.0
450	21.6	18.0	15.4	13.5	12.0	10.8	9.8	9.0	8.3	7.7	7.2	6.8
500	24.0	20.0	17.1	15.0	13.3	12.0	10.9	10.0	9.2	8.6	8.0	7.5
550	26.4	22.0	18.9	16.5	14.7	13.2	12.0	11.0	10.2	9.4	8.8	8.3
600	28.8	24.0	20.6	18.0	16.0	14.4	13.1	12.0	11.1	10.3	9.6	9.0
650	31.2	26.0	22.3	19.5	17.3	15.6	14.2	13.0	12.0	11.1	10.4	9.8

Appendix 5

Worksheets for ration formulation

This appendix contains copies of the three worksheets discussed in Chapter 4. The table numbers referred to within the worksheets are from Appendix 4 (Tables of nutrient requirements). These three worksheets should be photocopied to use with future ration formulations. They have been electronically incorporated into a new computer program (FEEDPROFIT) as discussed on page 138.

Worksheet 1: To calculate the daily energy, protein and fibre needs of a cow

The cow	Her energy needs (MJ of ME)		Her protein needs	Her fibre needs
Cow live weight A <input type="text"/> Kg	For maintenance (Table A4.1) I <input type="text"/> MJ			
Daily activity level Terrain (1-5) B <input type="text"/> Kg/km	For activity <input type="text"/> × <input type="text"/> = <input type="text"/> MJ From B km	Early lactation 16-18% Mid-lactation 14-16% Late lactation 12-14% Dry 10-12%		
Month of pregnancy D <input type="text"/> th Month	For pregnancy (Table A4.2) L <input type="text"/> MJ			
Daily milk production Volume E <input type="text"/> Litres	For milk production (Table A4.3) <input type="text"/> × <input type="text"/> = <input type="text"/> MJ From E MJ/L			
Fat test F <input type="text"/> %				
Protein G <input type="text"/> %				
Daily change in body gain + <input type="text"/> Kg/cow loss - <input type="text"/> Kg/cow	For or from condition (Table A4.6) <input type="text"/> × <input type="text"/> = <input type="text"/> MJ From H MJ/kg			
<p>Total daily needs of this cow:</p> <p style="text-align: center;">Energy <input type="text"/> MJ I + J + L + M + N</p> <p style="text-align: center;">Crude <input type="text"/> % from above</p> <p style="text-align: center;">NDF or <input type="text"/> % from above</p>				

Worksheet 2: To calculate the energy, protein and fibre content of a diet

Dry matter	Energy (MJ)	Protein	Fibre
Forage: $\frac{\text{kg/cow/day}}{\text{kg/cow/day}} \times \frac{\text{dry matter \%}}{100} = \text{A}$ kg DM/cow/day	$\frac{\text{MJ/kg DM}}{\text{MJ/kg DM}} \times \frac{\text{MJ/cow/day}}{100} = \text{F}$ MJ/cow/day	$\frac{\text{Protein \%}}{\text{Protein \%}} \times \frac{\text{kg/cow/day}}{100} = \text{J}$ kg/cow/day	$\frac{\text{NDF/CF \%}}{\text{NDF/CF \%}} \times \frac{\text{kg/cow/day}}{100} = \text{O}$ kg/cow/day
Supplement 1: $\frac{\text{kg DM/cow/day}}{\text{kg DM/cow/day}} \times \frac{\text{dry matter \%}}{100} = \text{B}$ kg DM/cow/day	$\frac{\text{MJ/kg DM}}{\text{MJ/kg DM}} \times \frac{\text{MJ/cow/day}}{100} = \text{G}$ MJ/cow/day	$\frac{\text{Protein \%}}{\text{Protein \%}} \times \frac{\text{kg/cow/day}}{100} = \text{K}$ kg/cow/day	$\frac{\text{NDF/CF \%}}{\text{NDF/CF \%}} \times \frac{\text{kg/cow/day}}{100} = \text{P}$ kg/cow/day
Supplement 2: $\frac{\text{kg DM/cow/day}}{\text{kg DM/cow/day}} \times \frac{\text{dry matter \%}}{100} = \text{C}$ kg DM/cow/day	$\frac{\text{MJ/kg DM}}{\text{MJ/kg DM}} \times \frac{\text{MJ/cow/day}}{100} = \text{H}$ MJ/cow/day	$\frac{\text{Protein \%}}{\text{Protein \%}} \times \frac{\text{kg/cow/day}}{100} = \text{L}$ kg/cow/day	$\frac{\text{NDF/CF \%}}{\text{NDF/CF \%}} \times \frac{\text{kg/cow/day}}{100} = \text{Q}$ kg/cow/day
Supplement 3: $\frac{\text{kg DM/cow/day}}{\text{kg DM/cow/day}} \times \frac{\text{dry matter \%}}{100} = \text{D}$ kg DM/cow/day	$\frac{\text{MJ/kg DM}}{\text{MJ/kg DM}} \times \frac{\text{MJ/cow/day}}{100} = \text{I}$ MJ/cow/day	$\frac{\text{Protein \%}}{\text{Protein \%}} \times \frac{\text{kg/cow/day}}{100} = \text{M}$ kg/cow/day	$\frac{\text{NDF/CF \%}}{\text{NDF/CF \%}} \times \frac{\text{kg/cow/day}}{100} = \text{R}$ kg/cow/day
Total daily dry matter intake $\text{A} + \text{B} + \text{C} + \text{D}$ kg DM/cow	Total daily dry matter intake $\text{F} + \text{G} + \text{H} + \text{I}$ MJ/cow	Total daily protein intake $\text{J} + \text{K} + \text{L} + \text{M}$ kg/cow	Total daily fibre intake $\text{O} + \text{P} + \text{Q} + \text{R}$ kg/cow
Total daily DM intake limit Use T and Table A4.9, or the formula $(120 \div \text{T}) \div 100 \times \text{live weight}$ kg/cow	Protein % of ration $\text{N} \div \text{E} \times 100$	NDF/CF % of ration $\text{T} \div \text{S} \times 100$	
Cow requirements (from Worksheet 1)	Total daily energy kg	Crude protein requirement kg	Fibre requirement kg

Worksheet 3: The cost of nutrients in feeds (local currency units or LCU)

Feed 1	Feed 2
<p>Cost per kg DM</p> $\boxed{} \times \boxed{} \div 100 = \boxed{}^{\mathbf{A}}$ <p>kg bought DM% kg DM bought</p> $\boxed{} \div \boxed{} \times 100 = \boxed{}^{\mathbf{B}}$ <p>Cost (LCU) kg DM bought LCU/kg DM</p>	<p>Cost per kg DM</p> $\boxed{} \times \boxed{} \div 100 = \boxed{}^{\mathbf{A}}$ <p>kg bought DM% kg DM bought</p> $\boxed{} \div \boxed{} \times 100 = \boxed{}^{\mathbf{B}}$ <p>Cost (LCU) kg DM bought LCU/kg DM</p>
<p>Cost per MJ of ME</p> $\boxed{} \div \boxed{} = \boxed{}^{\mathbf{C}}$ <p>LCU/kg DM MJ/kg DM LCU/MJ of ME</p>	<p>Cost per MJ of ME</p> $\boxed{} \div \boxed{} = \boxed{}^{\mathbf{C}}$ <p>LCU/kg DM MJ/kg DM LCU/MJ of ME</p>
<p>Cost per kg of CP</p> $\boxed{} \div \boxed{} \times 100 = \boxed{}^{\mathbf{D}}$ <p>LCU/kg DM CP % LCU/kg CP</p>	<p>Cost per kg of CP</p> $\boxed{} \div \boxed{} \times 100 = \boxed{}^{\mathbf{D}}$ <p>LCU/kg DM CP % LCU/kg CP</p>

Appendix 6

Financial statements

The following tables were developed by the Target 10 (2004) team as part of a training package for Australian dairy farmers and advisers to assess changes in business performance of a dairy enterprise over a 12-month period. Most of the cost and income categories are relevant to Asian smallholder dairy farmers. The tables are based on Excel spreadsheets in which data are entered into the yellow (or light grey) cells with the spreadsheet automatically calculating data into the blue (or dark grey) shaded cells. Cells with no colour or shading are to be left empty. In the spreadsheet, the three tables are all incorporated into one spreadsheet, allowing automatic transfer of raw and derived data between the tables.

The three tables present the opening balance sheet followed by the closing balance sheet and finally, the combined cash flow and profit and loss statements. All these records are required to derive the financial KPIs needed to assess the business performance of the dairy enterprise. This program (FINSTATE) is available at no cost from the author, Dr John Moran, at john.moran@dpi.vic.gov.au or jbm95@hotmail.com.

1. Opening balance sheet

Table A6.1 is a stand-alone table as all the data automatically inputted into the dark grey cells originate from the corresponding data entered into the light grey cells. The following cells are calculated as:

Total assets = sum of all individual assets entered into the light grey cells

Total equity = sum of all individual equity values which are the same as those entered into the corresponding light grey cells

$$\text{Equity \%} = \frac{\text{Total equity}}{\text{Total assets}}$$

Table A6.1 The opening balance sheet summarising assets and liabilities at the beginning of the financial year (Target 10, 2004)

	Assets	Liabilities	Equity
Cows			
Heifers			
Yearlings			
Feed			
Machinery			
Land & Improvements			
Shares			
Cash			
Liabilities			
TOTAL			
		Equity %	

Light grey cells, for raw data; dark grey cells, for derived data; blank cells, to be left empty

Table A6.2 The closing balance sheet summarising assets and liabilities at the end of the financial year (Target 10, 2004)

	Assets	Liabilities	Equity
Cows			
Heifers			
Yearlings			
Feed			
Machinery			
Land & Improvements			
Shares			
Cash			
Adjustments			
Liabilities			
TOTAL			
		Change in equity	
		Equity %	

Dark grey cells, for derived data; blank cells, to be left empty

Table A6.3 The combined cash flow statement and profit and loss statement the financial year being assessed (Target 10, 2004)

CASH FLOW STATEMENT		PROFIT & LOSS STATEMENT		
INFLOWS	Receipts	Adjustments	Revenue	
Milk sales				
Feed sales				
Livestock sales				
Livestock profit/loss				
Machinery sales				
Land sales				
Land/improve appreciation				
Dividends				
Sundries				
Loan drawdowns				
TOTAL INFLOWS				
OUTFLOWS	Payments	Adjustments	Expenses	Interest/Tax
Pasture/feed				
Change in stored feed				
Purchased feed				
Herd & shed costs				
General O/H ex labour				
Actual labour				
Imputed labour				
Livestock purchases				
Machinery purchases				
Machinery depreciation				
Land/impr purchases				
Share deductions				
Principal repayment				
Principal interest				
Personal drawings				
Tax				
TOTAL OUTFLOWS				
				Net profit

Cash surplus/ deficit

EBIT

Net profit after tax
Retained profit

Light grey cells, for raw data; dark grey cells, for derived data; blank cells, to be left empty

2. Closing balance sheet

Table A6.2 is not a stand-alone sheet as the data automatically entered in the dark grey shaded cells are all derived from Tables A6.1 and A6.3. The actual calculations are lengthy and sometimes rather complex but are easily understood from the cell formulae in the software program. The following cells are calculated as:

$$\begin{aligned} \text{Adjustments} &= (\text{sum of most of the adjusted inflows}) \\ &\quad - (\text{sum of most of the adjusted outflows}) \text{ from Table A6.3} \end{aligned}$$

$$\text{Total assets} = \text{sum of all individual assets derived in the dark grey cells}$$

$$\begin{aligned} \text{Total equity} &= \text{sum of all individual equity values,} \\ &\quad \text{which are the same as those in the corresponding dark grey cells} \end{aligned}$$

$$\text{Change in equity} = (\text{Total equity at Closing}) - (\text{Total equity at Opening})$$

$$\text{Equity \%} = \frac{\text{Total equity}}{\text{Total assets}}$$

3. Combined cash flow and profit and loss statements

Table A6.3 combines both these statements to facilitate the calculations of adjustments and the business KPIs. Profit and loss statements are also known as income statements. The adjustments convert cash receipts to revenue and also convert cash payments to expenses. The data input and calculations used in deriving revenue and expenses, hence business KPIs, are explained as follows:

Inflows

- Milk sales: Revenue = (Cash receipts) – (Adjustment for any charges)
- Feed sales: Revenue = (Cash receipts) – (Adjustment for any charges)
- Dividends: Revenue = (Cash receipts) – (Cash payments, if dividend value decreases over 12 m)
- Sundries: Revenue = (Cash receipts) – (Adjustment for any cash payments)
- Loan drawdowns: This receipt is used when generating liabilities in the closing balance sheet.
- Livestock profit/loss and Land & improvement appreciation are imputed values, hence not entered as cash receipts.

Outflows

- Pasture feed: Expense = (Cash payment) – (Adjustment for any rebate)
- Change in stored feed: As well as an expense, this adjustment is used when generating the Feed asset in the closing balance sheet.
- Purchased feed: Expense = (Cash payment) – (Adjustment for any rebate)

- Herd & shed costs: Expense = (Cash payments) – (Adjustment for any rebates)
- General O/H (overhead costs) excluding labour: Expense = (Cash payments) – (Adjustment for any rebates)
- Actual labour: Expense = (Cash payment) – (Adjustment for any rebate)
- Imputed labour: It is entered as an adjustment to be automatically put in as an expense. It is also used in calculating retained profit.
- Share deductions: This payment is automatically entered in the shares cell as an asset in the closing balance sheet.
- Principal repayments: This payment is used to offset the opening balance sheet liability when generating liability in the closing balance sheet.
- Principal interest: When entered as an adjustment, it is automatically entered in the interest cell (hence used to calculate net profit).
- Personal drawings: This payment is used in calculating retained profit.
- Tax: When entered as a payment, it is automatically used in deriving the tax cell (which is used when calculating net profit after tax). When entered as an adjustment, not only is it used in deriving the tax cell, it is also used when calculating the total adjustments in the closing balance sheet.
- Changes in stored feed, imputed labour and machinery depreciation are all imputed values, hence not entered as cash payments.

Inflows/outflows

- Livestock transactions: All relevant transactions are automatically calculated and entered as revenue for livestock profit/loss. This is the sum of livestock sales and changes in livestock inventory value over the 12 months less livestock purchases.
- Machinery transactions: As machinery is a capital asset, machinery purchases and sales, when entered either as payments or receipts, are only used to derive cells in the closing balance sheet, which together with depreciation constitute change in total machinery asset value. Machinery depreciation is entered as an adjustment to be automatically put in as an expense.
- Land and improvement transactions: As land is a capital asset, land and improvement purchases or land sales, when entered either as payments or receipts, are only used to derive cells in the closing balance sheet, which together with land and improvement appreciation constitute change in total land and improvement asset value. Land and improvement appreciation is entered as an adjustment to be automatically put in as revenue.

The following financial measures are calculated as:

Total cash inflows = sum of all entered cash receipt items

Total cash outflows = sum of all entered cash payment items

Total revenue inflows = sum of all derived expense items

Total expenses outflows = sum of all derived expense items

$$\text{Cash surplus/deficit} = (\text{total inflows}) - (\text{total outflows})$$

$$\text{EBIT (earnings before interest and tax)} = (\text{total revenue}) - (\text{total expenses})$$

$$\text{Net profit} = (\text{EBIT}) - (\text{interest})$$

$$\text{Net profit after tax} = (\text{net profit}) - (\text{tax})$$

$$\text{Retained profit} = (\text{net profit after tax}) + (\text{imputed labour}) - (\text{personal drawings})$$

Appendix 7

Examples of expectation (7a) and evaluation (7b) forms for Farm Business Management workshops

(7a)

**Improving the business skills of smallholder dairy farmers in Thailand
Expectations from workshop**

1. Location:

2. Name:

3. Address:

4. Position held (Farmer, DLD Officer, MCC staff etc.)
.....

5. How many milking cows do you have?
.....

6. How many litres of milk each day do all your milking cows produce (on average)?
.....

7. What topics would you like to learn about in this workshop?

- a)
-
- b)
-
- c)
-

Please rank the following questions for their importance to you (1 to 5), where 1 is not important/little and 5 is extremely important/lot

	Score
8. How important do you rate business skills to Thai smallholder dairy farmers?	
9. How do farmers rate the importance of business skills?	
10. Do you think farmers have knowledge of business skills?	
11. What is your current knowledge of business skills?	
12. Would you like to improve your current knowledge of business skills?	
13. How well do you think farmers understand the cost of milk production (Bt/L)?	
14. How well do you understand the cost of milk production (Bt/L)?	

(7b)

**Improving the business skills of smallholder dairy farmers in Thailand
Evaluation of workshop**

1. Participant's name:.....

2. Expectations:

What were your expectations of the program? Please list:

3. Outcome:

What knowledge have you gained from this program?

4. Relevance of training:

Please describe how this training will be of use to your work.

5. Program delivery:

Please tick the appropriate space to indicate your views on the way the program has been delivered.

Please tick	Not enough	About right	Too much
Overall program			
Lectures and/or formal instruction			
Discussion			
Visits on site/fieldwork			
Reading matter provided			

6. Services:

How do you rate the services provided for you?

Please tick	Excellent	Good	Fair	Not good
Training/trainers				
Training location				
Other				

7. Other comments

.....

8. Overall

How do you rate this program?

Excellent Very good Good Not good (Please tick)

9. What are the weaknesses of the program?

10. What improvements can be made for future programs?

11. List the most important messages/information that you found most useful to you.

12. List the least useful messages/information that you found least useful to you.

Please rank the following questions for their importance to you (1 to 5), where 1 is low/not much and 5 is high/a lot

	Score
How do you rate: 13. Farm visit	
14. Visit to Milk Collection Centre	
15. Small groups & reporting back sessions	
16. Quantifying costs on Bt/L milk	
17. Overhead presentations	
18. How do you rate importance of business skills in your job?	
19. How much have you improved your knowledge of business skills?	
20. How well will you be able to apply knowledge to farmer situations?	
21. When should you do a refresher course? 1, in 3 mo; 2, in 12 mo; 3, in 2 yr; 4, never	

Thank you for your participation in this workshop.

Glossary and abbreviations

Terms in this glossary are defined in the context of their use in this book. Other abbreviations are listed in Appendix 2, Conversion of units of measurement.

A

A\$. Australian dollar(s).

accrued. An estimate of revenue, expense or liability that will occur but is not supported by a statement or invoice at the time the accounts were prepared.

acid detergent fibre (ADF). The less digestible or indigestible parts of the fibre, i.e. the cellulose and lignin only.

acidosis. An excessive increase in rumen acid caused by feeding too much grain or other starchy feeds or by introducing them into the diet too quickly.

adjustments. Adjustments are calculations made to derive management performance indicators from collected financial data. They account for those factors that affect farm earnings but are not reflected in cash transactions.

ad lib or ad libitum. Fed to appetite.

agistment. Grazing one's own stock on land controlled by another person, for payment of a fee in cash or in kind.

agribusiness. A business closely related to agricultural production activities.

AI. Artificial insemination.

amino acid. The building block of proteins; a cow requires 25 different amino acids for normal metabolic functioning.

analyse. Examine farm records to determine performance.

APHCA. Animal Production and Health Commission of Asia and the Pacific.

appropriate technology. A term developed to describe practical solutions to problems that could be readily accepted, hence undertaken by farmers, particularly traditional ones with minimal resources.

as-fed. Feed with its moisture still in it.

associative effects. Changes in utilisation of one feed type following supplementation with a second feed type, such as decreasing digestibility in forages with increasing

supplementation with concentrates. This means that assuming additive effects of supplements can overestimate milk responses.

asset. Anything controlled, owned or not, fixed or current, tangible or intangible that is of value to its possessor.

Australian Friesian Sahiwal (AFS). A tropically adapted dairy breed developed in Australia based on Friesian and Sahiwal.

Australian Milking Zebu (AMZ). A tropically adapted dairy breed developed in Australia based on Jersey and Red Sindhi.

B

balance sheets. Recorded assets and liabilities to determine net worth of the business. Usually created at the beginning of each financial year to assess growth in net worth, or wealth creation.

benchmark. Industry standard.

body condition. Energy stored in body reserves by cows, predominantly as fat.

Bt. Baht. Unit of Thai currency.

budget. A detailed statement of a future plan of action detailing the expected costs and benefits.

buffer. Body fluid (e.g. saliva) or feed additive that reduces the acidity in the rumen.

business. The money-making activities of a single enterprise farm or a collection of enterprises on a mixed farm.

business health. The state of, and prospects for, profit, financial viability and growth of a business.

bypass protein. See undegradable dietary protein.

C

°C. Degrees Celsius.

capital. Item that contributes to production over at least a medium-term period, such as 12 months. Examples are tractor, land, fertiliser, farm structures and equipment. Capital investment is using funds to acquire capital assets.

carbohydrates. The main source of energy in a cow's diet.

cash. An exact known amount you pay, or that is paid to you, in the form of currency, a cheque, transfer, credit card. It is not imputed, nor does it include depreciation of assets.

cash flow budget. A budget of the expected cash in (receipts) and cash out (payments) associated with a particular farm plan.

cash flow statement. A statement of cash inflows less cash outflows to indicate cash surplus or deficit.

cm. centimetre.

colony forming units (CFU). The measure of the level of bacterial contamination in raw milk when analysed for Total Plate Count (TPC).

comparative analysis. Comparing the performance of a particular farm with some 'standard' level of performance. The standard is usually the average performance of a group of broadly similar farmers. Also called benchmarking.

conception rate. The proportion of the total number of services or inseminations that result in pregnancy.

condition score. Objective visual assessment of a cow's body condition on a scale of 1 (emaciated) to 8 (obese).

cost. The price of something.

cost of production (COP). The summation of variable costs, cash overhead and imputed overhead costs for producing milk from the dairy enterprise.

cost price squeeze. The phenomenon of farmers' real costs for their inputs rising and prices they receive for their products being static, falling or rising at a slower rate than real costs are rising. It means that farmers have to increase their productivity to remain profitable.

COS. Cash operating surplus.

crude fibre (CF). A measure of fibre in the diet now considered unacceptable as it does not always take into account all of the constituents that make up the fibre component of a feed; it measures only the alkali-soluble lignin and the cellulose.

crude protein (CP). A rough measure of all the protein in the diet (NPN + RDP + UDP); it assumes (incorrectly) that all the nitrogen in a feed comes from protein.

current v fixed asset. Cash or other assets expected to be utilised within 12 months v having a useful life of more than 12 months.

current v fixed liability. Amounts owed to others that should be paid within 12 months v those requiring payment after 12 months.

D

d. day.

dairy. The dairy enterprise only.

demand. The amounts of a product or service that consumers wish to buy at a range of prices.

depreciation. The loss in value of capital items as they get used or become older.

developmental budget. A budget of cash flows used to assess expected profitability and financial feasibility when planning major farm system changes that will take some time to reach full capacity.

digestibility. The proportion of the dry matter in a feed that gets digested; it is the difference between what is eaten and what comes out as manure.

diminishing marginal returns. What occurs when increases in variable inputs added to fixed inputs in a production process lead to smaller and smaller increases in total output.

direct cost. See 'variable cost'.

discounting. The process of adjusting the value of a benefit or cost to be received in the future to their equivalent value at the present time.

discount rate. The rate at which the future sum is reduced to estimate the present value.

drawings. Amounts taken by owner for personal use. Also called personal expenses.

dry matter (DM). The proportion of any feed remaining after all the water has been taken out.

E

earnings before interest and tax (EBIT). See net farm income.

East Asia (E Asia). The countries in this region of Asia, namely Afghanistan, Bangladesh, India, Pakistan and Sri Lanka.

economic farm surplus (EFS). Same as operating profit.

economic efficiency. Measured by percentage return to all the capital invested in the business.

efficiency. The ratio of the quantity of output to the quantity of input. Can be technical or economic.

energy. The part of a feed that is used as 'fuel' in carrying out the cow's bodily functions.

energy corrected milk (ECM). Milk corrected to the same milk fat and protein contents.

energy-dense. Having a large amount of metabolisable energy per kilogram of dry matter.

enterprise. A farming activity or the production of a particular commodity or group of related commodities.

enzyme. A substance produced by the cow that helps digestion.

equity. The value of an asset after liabilities have been accounted for. Also called net worth. What the business owes the owners.

expense. Payment (in cash) plus imputed labour depreciation. Also called expenditure.

F

FAPRI. Food and Agriculture Policy Research Institute.

Farm benefit cost analysis. The budgeting process of evaluating the benefits and the costs and net benefits of an investment to change a farm system.

FBM. Farm business management.

finance budget. A budget showing the flows of cash in and out, in nominal dollars.

Identifies borrowings that are needed as well as interest and principal repayments.

financial efficiency. This assesses how efficiently the value of the assets is being used and is measured by asset turnover ratio (revenue divided by assets).

financial statement. An annual statement summarising a business's financial activities over the last 12 months.

fibre. The cell wall, or structural material, in a plant made up of (among other things) cellulose, hemicellulose, and lignin.

fixed capital. Land, buildings, irrigation equipment and other farm assets that cannot be easily moved.

fixed cost. See overhead cost.

Food and Agriculture Organization (FAO). The organisation within the United Nations structure that documents agricultural statistics and facilitates development in agriculture, particularly in the poorer countries of the world.

G

g. gram(s).

gearing. Ratio of debt to equity which can influence debt servicing ability and growth in equity. Also called leverage and solvency.

GFI. Gross farm income.

GMO. Genetically modified organism.

gross income. The total value of a farm activity during the production period (usually 12 months), whether the product is old, consumed or stored.

gross margin. Gross income minus variable cost. This can be whole-farm gross margin, as in whole-farm budget, or enterprise gross margin.

growth. Increase in net worth (wealth) over time. Measured as change in equity.

H

hemicellulose. The most digestible part of fibre; included in NDF analyses but not in ADF or CF analyses.

hr. hour.

I

imputed. Same as unpaid or book value.

income statement. This is the only financial record that actually measures profitability. Cash flow is converted to business earnings to calculate business performance. Also known as profit and loss statement.

incurred. An expense is 'incurred' when the goods or services have been received or consumed, which may be prior to the issue of an invoice or statement creating the liability for payment.

inflation. An increase in the supply of money in relation to the supply of goods and services available and, consequently, a decline in the purchasing power or value of currency.

input. Any resource used in production, such as land, labour, capital or purchased goods or services.

International Farm Comparison Network (IFCN). A worldwide network of farm economists who collect on-farm dairy production data, using the same methodology, hence allowing for country to country comparisons.

interest. A charge made for borrowing a sum of money or due on late payment of an account.

interest only loan. A loan where the borrowed capital is not intended to be repaid on a regular and gradual basis over the life of the loan and instead, annual interest is paid on the full amount of the borrowed capital for the life of the loan.

interpret. To compare farm performance against benchmarks.

internal rate of return. The discount rate at which the present value of future benefits from a project equals the present value of total costs of the project.

K

kg. kilogram(s).

kg DM. kilogram(s) of dry matter.

kg/d. kilogram(s) per day.

km. kilometre(s).

KPI. Key performance indicator.

Kt. Kilotonnes or million litres.

L

L. litre(s).

LCU. Local currency units.

L/d. litre(s) per day.

lease. Use of an asset not owned for a fixed period in return for payment by the lessee to the lessor.

leverage. This measures the extent to which equity has been multiplied by the use of debt, and is calculated as the ratio of debts to equity. It is also called financial structure.

liability. The amount of money borrowed from someone else. Also called borrowings and debt.

lignin. An indigestible part of plant fibre.

liquidity. Cash or near cash reserves. The ease with which assets can be converted into cash. The ability of a business to meet financial obligations (pay the bills) due within 12 months without having to sell fixed assets or increase borrowings.

livestock inventory. An estimate of the annual contribution to gross income of the trading of animals by sales and purchases, births and deaths, and changes in number and value of livestock on hand. This uses closing number and value less opening number and value. It captures the effects of depreciation and appreciation, as well as natural increases.

loss. A negative profit.

LWG. Live weight gain.

LWT. Live weight.

local currency units (LCU). Units of currency used in different countries (see Appendix 3).

M

maintenance requirement. The energy needed for essential body functions, such as blood circulation, breathing, keeping warm or cool, digestion, and tissue repair.

management. The process of setting and achieving (profitable) goals, using land, labour, management and capital.

marginal. The increase or decrease of one more unit of input or output.

marginal cost. The extra cost added to the total cost from using an extra unit of a variable input, or the extra cost incurred in producing an additional unit of product.

marginal returns (diminishing). The phenomenon that increases in variable inputs added to fixed inputs in a production process results in smaller and smaller increases in total input. The principle of diminishing returns indicates that variable input should be added to the production process only for as long as the extra return exceeds the extra cost. The maximum total profit is at the point where extra returns equals extra cost.

marginal revenue. The extra net income obtained from selling one additional unit of product.

marketing margin. The difference between the purchase price and resale price of a product between two levels in a marketing chain. Indicates the cost of adding services to products.

metabolisable energy (ME). The amount of energy provided by a feed after deducting energy lost to faeces, urine, heat, and gas production; it is the energy available to be used by the cow for her metabolic activities. *See also* digestible energy.

mg. milligram(s).

milk gross margin (MGM). Milk revenue less direct milk production expenses.

milk income less feed costs (MIFC). A measure of profitability calculated from the income from milk sales less the total cost of feed inputs.

MJ. megajoule(s), millions of joules.

MJ ME/kg DM. megajoules of metabolisable energy per kilogram of dry matter.

mm. millimetre.

MR. Malaysian ringgits.

N

N. Nitrogen.

net cash flow. The difference between the money received and the money spent in any one period.

net farm income (NFI). Gross income less variable and overhead costs. Also called operating profit or earnings before interest and tax (EBIT).

net present value (NPV). The difference between the present value of all benefits and the present value of all costs of an investment, with the present values of benefits and costs calculated using a particular discount rate.

net profit. Operating profit less finance costs.

net worth. The value of total assets owned by a farmer less his total liabilities. Also called equity.

neutral detergent fibre (NDF). A measure of all the fibre (hemicellulose, lignin, and cellulose) in a feed; it indicates how bulky the feed is.

NFI. Net farm income.

non-protein nitrogen (NPN). Not actually protein but simple nitrogen; however, microbes can make protein from simple nitrogen if enough energy (carbohydrates) is available in the rumen at the same time.

NRM. Natural resources management.

O

operating costs. Variable plus overhead costs.

operating profit. See 'net farm income'.

opportunity cost. Amount of net benefit that is given up by choosing one alternative action rather than some other action.

overhead cost. An expense that cannot be directly attributed to the production and/or harvesting of produce for sale. Also defined as a cost that remains the same when the level of input or output changes, or one that must be met and is not affected by the amount of produced in a year. Also called fixed cost.

output. The goods or products which come from a production process.

P

partial budget. A budget drawn up to estimate the effect on profit of a proposed change affecting only part of the farm. It is used to estimate the extra return on extra capital invested.

partitioning. The metabolic division of energy intake (above the maintenance requirement) between live weight gain and milk production.

payment in kind. Non-cash payment for a service received, such as labour.

per. In each or for each.

per cent. In or for each one hundred; for example, 5 per cent means 5 in (or for) each 100: if the interest rate on a loan is 5 per cent a year, you pay \$5 a year for each \$100 not yet repaid, or if the dry matter per kilogram is 5 per cent, then 50 grams in each kilogram (1000 grams) is dry matter.

percentage. The rate or proportion per hundred.

personal. Private, not applicable to the business.

peri-urban farms. Farms located on the outskirts of large towns and cities, benefiting from close proximity to consumers, hence markets, as well as being able to easily source forages in nearby rural areas and agro-industrial by-products from urban food processors.

pH. A measure of acidity or alkalinity on a scale from 1 (extremely acid) –14 (extremely alkaline).

PPP. Public private partnership(s).

principal. The amount of capital borrowed when a loan is taken out. Principal repayments are the amounts repaid to settle a debt.

principle of increasing risk. The more highly geared the business, the more rapidly equity grows when things go well, but equity declines at an even faster rate when things go badly.

profit. A general term indicating some kind of surplus from the year's farming operations.

profit and loss statement. See 'income statement'.

profitability. The ratio of the value of goods produced against the value of the resources used in their production. Profitability is different from profit. Profit is an amount of money; profitability is that amount compared to the resource used to produce that profit.

Pro-poor. Development programs specifically aimed at poorly resourced, subsistence farmers.

protein. The material that makes up most of the cow's body (muscles, skin, organs, blood); it is also part of milk.

Q

quality. In relation to feeds, it is an indication of the level of energy and digestibility. In relation to milk, it refers to the level of various contaminants in milk, such as bacteria, chemicals or any other adulterations that can be detected.

R

R, D & E. Research, development and extension.

real terms. Currency values or interest rates that have no inflation component.

receipts. Money received by the farmer for either farm or non-farm sources.

resource. A factor of production, commonly classified under labour, land, capital or raw materials.

return on assets (ROA). Profit before interest, as a percentage of the value of the total farm assets.

return on equity (ROE). Profit, after interest expenses, compared to equity.

return on extra (marginal) capital. The extra 'profit' resulting from investing extra capital in the farm, expressed as a percentage.

revenue. Receipts (cash) plus imputed gain in asset value.

risk. A situation with uncertain outcomes, but a case where some probabilities can be formed about the outcome. This is in contrast to uncertainty where no probabilities can be formed about uncertain events happening.

rumen degradable protein (RDP). The portion of protein in the diet that is digested and used by the microbes in the rumen to build themselves, if enough energy (carbohydrates) is available at the same time.

rumen modifier. A product that changes the rumen conditions and/or microbes and thereby changes the fermentation process and the products of fermentation.

rumen undegradable protein. See undegradable dietary protein.

S

sensitivity analysis. Checking the effects on a planned outcome of a change in one or more of the factors that affects that outcome.

SHD. Smallholder dairying.

short v medium v long term. Less than three months v 3–12 months v more than 12 months.

SMP. Skim milk powder.

specific gravity of milk is a measure of its weight relative to its volume, and this can vary from 1.024–1.032. When quantifying milk yields, Western dairy specialists tend to use volume (L/d) as this is measured by most milking machines. In contrast, Asian dairy specialists tend to use weight (kg/d) as this is measured by most hand milking operators. Interchanging the volume and weight of milk can then introduce an error of 2–3% in milk yields.

solids-not-fat (SNF). An alternative measure of milk composition to milk protein. SNF contains milk protein, lactose and minerals, allowing milk protein percentage to be calculated as (SNF% – 5.4).

solvent. A situation where assets exceed debts.

solvency. The ability to repay all borrowings when they are due, or if the business was sold. This indicates the borrowing capacity of the business and the financial risk the business is taking. Also referred to as gearing or leverage.

South-East Asia (SE Asia). The countries in this region of Asia, namely Cambodia, Indonesia, Laos, Malaysia, Myanmar (or Burma), Philippines, Thailand and Vietnam.

statement. Financial records recorded from the past.

strategic. Long term.

submission rate. The proportion of the herd inseminated at least once in a given period of time (e.g. the first 10, 21, 24 or 30 days of mating).

substitution. The extent to which a supplement replaces forage in the diet.

supplement. A feed or product added to the cow's diet to increase the intake of some dietary component, such as energy, protein, fibre, vitamins or minerals.

T

tactical. Short term.

Temperature humidity index (THI). A system for quantifying heat stress based on temperature and humidity. The higher the index, the greater the discomfort, and this occurs at lower temperatures for higher humidities.

term loan. A loan that is to be repaid in equal annual instalments of principal, with interest charged on the reducing outstanding balance of the loan.

total digestible nutrients (TDN). A system of describing dietary energy based on proximate analyses (ash, nitrogen, ether extract, and crude fibre). Formula uses crude protein, crude fibre, ether extract, and nitrogen-free extract.

total plate count (TPC). A measure of bacterial contamination of raw milk in millions of bacterial colony forming units per ml of milk.

total solids (TS or total dissolved solids, TDS). A measure of milk composition expressed in percentage of total milk solids (milk fat, milk protein, lactose and minerals).

U

UHT. Ultra high temperature treated milk.

uncertainty. A situation with uncertain outcomes where no probabilities can be formed about uncertain events happening. Chances are that the actual result will be different to the planned result. Volatility increases uncertainty, hence risk.

Undegradable dietary protein (UDP). Any protein in the diet that passes through the rumen without breaking down and is digested in the abomasum and small intestine. Also bypass protein.

US\$. United States dollar(s).

V

variable cost. Costs that change directly according to the amount of output of the activity. Also known as direct cost, e.g. fuel, seed, fodder.

VND. Vietnam dong (unit of currency).

W

Whole-farm approach. The farm management economic method, which involves understanding and analysing the farm system, namely the human, technical, economic, financial, risk, institutional elements, as a whole system.

Whole-farm profit budget. Budget showing expected outcomes of a farm plan, in terms of the entire farm's profitability for the coming year.

WMP. Whole milk powder.

working capital. Capital needed for the day-to-day operations of a farm, usually the amount current assets exceed current liabilities. Usually funded by relatively short-term borrowings related to the length of the production cycle, by bank overdraft facility or bank bills.

Y

yr. Year.

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