Principles of Cattle Production

3rd Edition

Clive J.C. Phillips

CABI

Principles of Cattle Production, 3rd Edition

Principles of Cattle Production, 3rd Edition

Clive J.C. Phillips, BSc, MA, PhD
Foundation Chair of Animal Welfare
Centre for Animal Welfare and Ethics
School of Veterinary Science
University of Queensland
Gatton 4343
Queensland
Australia

CSIRO PUBLISHING

CABI

First published in 2018 by CABI, with ISBN 978 1 78639 270 1 HB, 978 1 78639 271 8 PB

CABI
Nosworthy Way
Wallingford
Oxfordshire OX10 8DE
UK

Tel: +44 (0)1491 832111
Fax: +44 (0)1491 833508
E-mail: info@cabi.org
Website: www.cabi.org

CABI
745 Atlantic Avenue
8th Floor
Boston, MA 02111
USA

Tel: +1 (617)682-9015
E-mail: cabi-nao@cabi.org

CABI is a trading name of CAB International

Published exclusively in Australia and New Zealand, with ISBN 978 1 48630 766 1, by:
CSIRO Publishing, Locked Bag 10, Clayton South VIC 3169, Australia

Telephone: +61 3 9545 8400
Email: publishing.sales@csiro.au
Website: www.publish.csiro.au

A catalogue record for this book is available from the National Library of Australia.

Commissioning editor: Caroline Makepeace
Editorial assistant: Alexandra Lainsbury
Production editor: James Bishop

Typeset by SPi, Pondicherry, India.
Printed and bound in India

Contents

Preface to the 3rd Edition

It is now approximately 20 years since the first edition of this book was written, and the cattle production industry is facing very different challenges and opportunities to the original ones I wrote about in the 1990s. The intensification and expansion of cattle production systems are still causing major concern on a number of counts but now there are alternatives to cattle products that are becoming popular. This new edition describes existing cattle production systems in detail, as before, but it also examines many of the concerns, the difficulties in changing existing systems and how they can become more sustainable.

Cattle production systems are being increasingly challenged, for their pollution of the atmosphere and environment, their inefficiency and wasteful use of resources, especially water and energy, the adverse effects of consuming cattle products on human health and the poor welfare of many cattle in intensive production systems. Governments, consumers and activist groups are all concerned about the impact that cattle production systems are having in the world today. I described many of these challenges in the second edition of this book, nearly 10 years ago. The difference now is that many alternatives to cattle products have become available – cheap poultry meat, fake (vegetable-based) meat and leather, and milks and milk products based on soya, almond, coconut and other non-animal alternatives. Next on the horizon are cultured meats (otherwise known as *in vitro* meat), already able to be grown under laboratory conditions but not yet produced on an industrial scale. The major investment in these alternatives, including by companies with strong interests in the cattle industries, and the rapid growth in consumption suggests that the cattle industry will have to adapt dramatically to maintain its market share.

Despite this rapidly changing market, new opportunities exist for cattle farmers, mainly relating to the fast-growing demand for cattle products in developing Asian regions. This stems from the growing affluence in these countries, their desire to emulate a Western diet and continued expansion of the population. However, consumers in these regions are also those who are more likely to change their diet in response to concerns about the cattle industries. Currently there is significant growth in the cattle production enterprises in the most prosperous regions of Asia, especially China, but we should not assume that this growth will continue indefinitely. Imports of live and deadstock are also increasing, the former leading to concerns about the welfare of cattle exported long distances. Demand for dairy cow products is also growing in India, which has the largest cow herd in the world, but expansion of the national herd is resulting in overcrowded cow shelters, as cattle slaughter is banned in most of the country. Africa has similar potential to Asia to grow its demand for cattle products but continued poverty is preventing the cattle production systems from modernizing and expanding in the way that they are in Asia.

The book has expanded in key areas of concern. There is a new chapter on cattle welfare, which provides important detail on the major welfare threats and challenges. Classroom exercises are included to aid discussion as a means to encourage readers to develop skills in resolving ethical dilemmas in the industry. Photographs are included to illustrate the cattle and systems of production in colour. New threats are considered in the chapter on diseases, especially the growing evidence for antibiotic resistance. New opportunities and requirements are described, such as better techniques for animal identification. The book addresses cattle production from a global perspective, with consideration of all cattle production systems from beef cattle on extensive rangeland to dairy cows that are permanently housed.

The cattle industry of the future will eventually be vastly different to what we have today, even though current production systems are growing at a rate that is demonstrably unsustainable. Cattle farmers are by nature conservative and reluctant to change their systems, but they will be faced with competition from within, as well as outside, the industry. Pressure on cattle farmers to produce more from fewer inputs is increasing continually, in response to

growing competition between supermarket chains and retail outlets. Resources will at the same time diminish as the human population continues to grow and unrenewable supplies become exhausted, such as phosphorus fertilizer and fossil fuels. At the same time consumers are awakening to the need to purchase products that are produced sustainably in an ethical manner. This is driving change in production systems in some of the most responsible sales markets. Eventually the cattle industries will change and this will be led by entrepreneurs, the young, highly educated visionaries who can see a future for sustainable, ethical production systems.

The final chapter takes a new and objective view of where the cattle industry is heading over the next 50 years or so. Although some of the changes anticipated are similar to those considered in previous editions – more emphasis on limiting environmental pollution, better welfare systems, healthier products for humans – the developments in the past 10 years in producing alternatives to cattle products raise an entirely new scenario that has to be carefully considered. The cattle production enterprises will face major competition that does not exist today, and which may relegate cattle products to a niche market in some areas. Competition for land may force production to be concentrated into areas that cannot be easily used for other more efficient forms of agricultural production, the hills and uplands in particular. This may seem strange at a time when demand is increasing but the scope for sudden change in a fickle market should not be underestimated. Consider the photograph developing industry, which was wiped out almost overnight by digital cameras; telephone switchboard and telegraph operators have suffered a similar fate, and before them rag-and-bone men, elevator operators and street sweepers. In the developed world cattle farmers may be relegated to the history books in future unless their systems of production are seen by consumers as relevant, necessary and responsible. Diet is also changing fast, becoming more international, and is likely to continue to develop as healthy foods are increasingly demanded to allow people to live to their potential age with the assistance of modern medicine.

In many developing countries cattle are still an essential part of the fabric of society, and the book emphasizes that there are environmental benefits to cattle farming: the use of cow dung for fuel and in buildings prevents deforestation; and traction and transport by cattle avoids the use of machinery that relies on fossil fuels and spare parts from developed countries. Although cattle production systems in developing countries are not without their share of problems – including overgrazing, or competition with crop growers – abrupt changes to combat climate change, for example, would be socially undesirable and economically unwise.

Establishing new systems for producing cattle takes time, skill and money, so cattle producers need to be planning now for the future. This new edition describes many ways in which farmers can improve their systems over time to meet new demands. Silvopastoral systems potentially provide better welfare for the cattle and improve the efficiency of production of trees and cattle, including water use, but they take time and skill to establish. Alternatives to antibiotic use when cows are dried off requires farmers to learn the skills of teat sealant injection and removal; improving biosecurity on the farm needs much careful consideration and testing of different strategies, and so on. This book will stimulate cattle producers and students of cattle production to reflect on the systems, how well they are meeting the challenges of today and whether they are prepared, or preparing, to meet the challenges of tomorrow.

Clive Phillips
2018

Acknowledgements

I acknowledge the following for supplying colour photographs: Andrew Robins (Fig. 11.3), Angus Australia (Fig. 7.1), Arvind Sharma (Fig. 2.3), Australian Ayrshires (Fig. 7.2), British Charolais Society (Fig. 7.4), British Simmental Society (Fig. 7.7), Meat and Livestock Australia (Fig. 2.8), UK Hereford Society (Fig. 7.5); all other photographs are the property of C.J.C. and A.P. Phillips. I acknowledge the One Welfare Portal (http://onewelfare.cve.edu.au/) for permission to reproduce Box 10.2. I am grateful to the CABI team for their support and patience during the preparation of the third edition.

1 The Development of the World's Cattle Production Systems

Prehistoric Development

The climate change that caused the extinction of the dinosaurs about 65 million years ago led to the replacement of gymnosperms (mostly conifers and ferns) by angiosperms, including grasses, herbs and broadleaved trees. Primeval ruminants first appeared in the Indian subcontinent about 40 million years ago, adapted to browse the trees of the tropical forests. About 25 million years ago the savannahs and grasslands of the world developed, and ruminants evolved with the necessary hypsodont teeth to consume grass and an enlarged forestomach, or rumen, to digest it with the aid of microorganisms.

About 2 million years ago the first members of the grazing *Bos* genus began to appear in northern India. They spread to other parts of Asia, northern Africa and Europe after the Ice Ages, between 250,000 and 750,000 years ago in the Pleistocene period. Three distinct subtypes of *Bos* cattle developed: the humped *Bos primigenius namadicus*, the forebear of the zebu cattle, which predominated in the Indian subcontinent and became commonly known as *Bos indicus*; *Bos primigenius primigenius*, which had no hump and gave rise to modern European cattle, commonly known as *Bos taurus* (or taurine cattle); and *Bos primigenius africanus*, which lived in the woodland and shrubland of North Africa. Related animals in the Bovini tribe that developed at this time include the bison (*Bison bison*) of North America, the European bison (*Bison bonasus*), the gaur (*Bos gaurus*), banteng (*Bos javanicus*) and kouprey (*Bos sauveli*) of South and East Asia, the yak (*Poephagus mutus*) of central Asia, the African buffalo (*Syncerus caffer*) and the wild water buffalo (*Bubalus arnee*) of South-east Asia and the Indian subcontinent, the likely ancestor of domesticated water buffalo (*Bubalus bubalis*).

Within the Bovini tribe, the wild cattle, or aurochs (*Bos primigenius*), were most closely related to the gaur (Fig. 1.1) and banteng cattle. They were large animals with big horns and powerful forequarters compared with today's domesticated cattle, and they inhabited both the temperate and subtropical zones, together with bison and yak, and the hotter regions, inhabited by buffalo. They were most prominent in central and western Europe, the Mediterranean coastal regions of North Africa, West Asia, the Indian subcontinent and central East Asia. The bulls were usually dark brown to black, and the cows, which were much smaller than the bulls, were red-brown.

As early as 38,000 years ago, prehistoric humans had a close association with cattle. Cave paintings in Europe show the aurochs both running wild on grassland and being preyed upon by men with arrows and spears. Their carcasses provided not only meat but also valuable hides for tents, boats and clothing and bones for fishhooks and spears. The extinction of the aurochs was largely due to human predation, since they were a popular target of hunting activities. Competition for feed with domesticated cattle and transmission of diseases between the two populations may also have contributed to their demise. This was the first documented anthropogenic extinction, and it began in England in about 1300 BC and ended when the last aurochs cow died in a hunting reserve in Poland in AD 1627.

Domestication

Cattle were first domesticated from wild *Bos primigenius* cattle in the Middle East about 8000–10,000 years ago. *Bos indicus* cattle were developed primarily in the Indian subcontinent from the diverse range of wild cattle that existed there, and a less diverse new breed type, the European taurine cattle, emerged from sequential limited migrations from west Asia. The resulting genetic diversity is at least as great as humans,

Fig. 1.1. A family group of gaur cattle (*Bos gaurus*) in Malaysia: (from left to right) calves, a cow and a bull.

and considerably greater than the dog. The domesticated cattle were earlier maturing, with smaller brains and less acute senses than the aurochs, but possessed larger udders. They were less sexually dimorphic, i.e. males and females were more similar in size, and they were more variable in coat colour and horn shape, as well as more likely to be polled (without horns), which was a disadvantage for aurochs but not for domesticated cattle. The aurochs were seasonal breeders, with offspring produced in late spring, whereas the breeding period for domesticated cattle shows little seasonality. The diet of aurochs and domesticated cattle was similar, mostly grasses but with tree foliage during winter. The aurochs lived in harmony with their varied environment: grasslands, forests and wetlands. Domesticated cattle survived in increasingly large numbers in deforested areas where the land had been converted to grassland.

The milking of cows for the production of human food was already well developed at the time of the first written records in Mesopotamia in 6000 BC; it is likely to have originated soon after the domestication of cattle, which had occurred at some time up to 2000 years beforehand. Studies of Neolithic cows and the human diet in Europe and Africa in approximately 4000–5000 BC have shown that dairying was commonplace at this time, and that calves were weaned early, at some time between 2 and 9 months of age. This may have been due to their lactation being shortened as a result of limited feed resources, but it may be that the herders separated cow and calf at this time because they wanted to extract milk for themselves as soon as the calf could feed on solid feed (Balasse and Tresset, 2002). In North Africa, climatic conditions were getting drier at this time, and the Neolithic herders began to replace cattle with sheep and goats that have lower nutritional requirements and cope with drought better.

Domesticated cattle were therefore probably used for the production of milk and meat and for draught power from the start of their symbiotic relationship with humans, but even as early as the Stone Age cattle also had a dominant role in religion. This mainly related to their power–fertility symbolism, which derives from their strength, aggression and the ability of bulls to serve large numbers of cows. The bull came to dominate the religions of the Middle East and North Africa in particular. The ancient Egyptians worshipped the bull god, Apis, which was embodied in bulls that were selected from local herds. These bulls were ritually slaughtered at the end of each year, after which they were embalmed and ceremoniously placed in a tomb in Saqqarah. The ancient Egyptians also worshipped cow goddesses, which represented fertility and nurture. Significantly, in Hebrew culture, as the people changed from being warriors to farmers, the image of the bull changed from aggression to virility.

Cattle Farming in Eurasia

The spread of cattle farming across Asia and Europe was caused as much by the invasions of nomadic herdsman from the Eurasian steppes as by the Middle Eastern influence. These invasions started as long ago as 4000 BC, when the European Neolithic farmers were conquered by the herdsmen on horseback who brought traditions of raising cattle on the steppes. These farmers had been settled agriculturists, growing cereals and keeping small numbers of livestock. Security was provided by investing in the land, returning nutrients to build up fertility and trading peacefully between small communities.

Cattle had a crucial role in both religion – principally for sacrifice – and as a tradable commodity. In many European countries the word for 'cattle' is synonymous with 'capital'. The resistance of the people of the southern part of the Italian peninsula to encroachment from Rome was fought under a banner of their cattle culture: the name Italia, originally referring to the south, is popularly suggested to have meant '(land of) young cattle'. When the people from the Asian steppes invaded Europe they brought few cultural advances but a new warrior-like attitude, in which security was valued as well as the ability to move fast (on horseback), with little allegiance to any particular place. Warriors were expected to expropriate cattle, often for sacrifice to appease the gods. The influence of these warriors was particularly pronounced in the west of Europe, where the Celtic descendants of the Eurasian herdsman developed a powerful cattle-based culture. Some historians believe this fuelled the colonizing tendencies of the Iberian and British peoples.

The warriors from the Asian steppes also migrated into India, where the cow acquired a unique significance in the Hindu religion. A ritualistic and sacrificial role of cattle was recognized in the Vedic literature as long ago as 1500 BC. At the time the human population density was low and large areas were forested before domesticated cattle were widely kept. As the population grew, an increase in crop production became inextricably linked with the use of cattle for tillage. It became impossible for everybody to consume beef, as the animals were required for draught purposes, and the cows were required to produce offspring to till the soil. The consumption of beef became restricted to the upper classes, in particular the Brahmin sect, and a strict class system evolved. When increased population further restricted the use of cattle for beef consumption, strict regulations were introduced that prevented beef consumption altogether. With the prohibition of cattle consumption, shelters, or *gaushalas*, were established to care for unwanted animals or those that had become unproductive. In the period of British occupation cow protection became a source of national pride for Indian people. The first major revolt against the British, in 1857, was due to a rumour that they were using beef tallow to grease cartridges used by Hindu soldiers. Cow protection movements evolved from this time onward, including by Mahatma Gandhi. Even today cattle protection remains a political issue, with most states banning cattle trading and slaughter. There are about 3000 *gaushalas* now, all around the country, looking after cattle that have mostly been abandoned. Conditions are sometimes poor and cows are often overcrowded (Fig. 1.2) and dependent on philanthropic donations, including of food for the cattle (Fig. 1.3).

Nowhere exemplifies the problems facing cattle production systems in developing countries better than India. With one of the highest cattle populations per capita in the world, this vast country has had to cope with increased human population pressure and the requirement to maintain inefficient cattle production systems for religious reasons. Nowadays, many of the abandoned cattle in India have assumed the role of scavengers and they compete only little with humans for food resources, as less than 20% of their feed is suitable for humans. Most is either a by-product of the

Fig. 1.2. A heavily stocked cow house in India, containing Gir (brown) and Kankrej (grey) breeds in a *gaushala* (cow sanctuary). The cows are kept in this yard for 19 hours per day.

Fig. 1.3. Cattle kept in an Indian *gaushala* after they have reached the end of their working life.

human food industry or is grown on land that cannot be used to produce human food. They have become an essential and valuable part of the agrarian economy, but two problems remain. Firstly, the inability to slaughter cows requires the maintenance of sick and ailing animals, although some are sold to Muslims, for whom slaughter is not against their religious beliefs. Large numbers of cattle are also smuggled across the borders to neighbouring countries for slaughter. Scavenging in the streets around communities with no refuse collection, many Indian cattle consume significant quantities of indigestible and potentially toxic materials, especially plastic, in their search for food residues. Secondly, the increased livestock population has led to overgrazing of many grassland areas, which were first created when India's extensive forests were felled. The cultivable land area has been declining by over 1%/year and, at the same time, the livestock population increased by more than 50% in the second half of the 20th century. Some of the grazing areas used for cattle could be used for the production of human food but, because of the high social status accorded to those with large herds, the increasingly affluent Indians are turning to grassland improvement to support their expanded herds. Water retention properties of the land are improved by contour ploughing and trenching. Nitrogen and phosphorus fertilizer are used in greater quantities. In some areas sustainable use of grassland resources is encouraged by the incorporation of legumes into the sward, which can contribute substantial quantities of nitrogen. Intercropping is often used to improve water and mineral resource use.

Over the course of history, the fencing of grazing land has been an important measure to control the movement and nutrition of cattle. Land enclosure began in England in the 12th century AD and accelerated in the 18th century due to the demands of an expanding population. Enclosing land is no guarantee against overgrazing and it does not create any extra land, but it is an effective management tool to allow farmers to use available feed resources most efficiently. The controlled burning of trees and weeds has been another management tool to allow productive grass species to be introduced. In mediaeval times, periodically leaving the land fallow to create fodder banks allowed soil reserves to accumulate and fodder supplies to match ruminant numbers. However, with increasing population this is now rare, and worldwide there has often been insufficient control over cattle numbers, with grazing resources overused and deterioration of grass production potential.

Colonial Expansion

In Spain the ideological significance of cattle is deeply rooted in the culture brought by the Celtic invasion initially and later by the Romans. The bullfight signifies the trial of strength between humans and one of nature's most fearsome beasts. The consumption of beef reared on the Spanish plains has always been popular but, for a long time, the warm climate meant that spices had to be added to meat because it spoiled rapidly. When Christopher Columbus set off to find a quick route to the East for spices, he found something of much greater significance for the cattle industry. The virgin territory of the New World provided cattle pastures of superior quality to the arid interior of Spain and paved the way for the colonization of most of the Americas. With no natural predators, the Spanish Longhorn cattle multiplied rapidly, and by 1870 there were over 13 million cattle on the Argentinian pampas alone. The principal South American exports at the time were salted beef and cattle hides. In the late 19th century refrigerated transport enabled carcasses to be sent to Europe to fulfil the rising demand for beef. Most of the production was, and in places still is, on large ranches or haciendas, so that the production system and the profits were in the control of a few families. This oligopoly of agricultural production in the Iberian Peninsula and in its colonies prompted regular revolts by the peasants that are typical of those that have occurred in Europe since the Middle Ages, and most recently in Portugal in the 1970s. The most recent South American revolution emanated at least in part from poverty of the farm workers, or *campesinos*, in Chile in the 1970s.

Another large-scale colonization with beef cattle, that of North America, began with the industrial revolution providing wealth for a new British middle class, who came to be able to afford to eat beef on a regular basis. The English aristocracy had in the Middle Ages gained a reputation for excessive feasting on a variety of meats, with beef being the most favoured. The nouveau riche of the 19th century required choice joints to feed their families, and English breeders selected smaller, better-formed cattle than the Spanish Longhorn that was by this time common in South America. Breeds such as the Hereford were developed, which could be fattened in two grazing seasons, whereas the larger animals might require up to 3 years. A key figure in the development of British breeds was Robert Bakewell,

who first selected cattle for meat production rather than for the dual purposes of meat and milk production.

In the late 19th century British and American pioneers began to search for new cattle pastures to provide for the growing demand for beef in Europe. The western ranges that covered much of the interior of the USA were home to about 4 million bison that had roamed free for about 15,000 years. In a 10-year period, from 1865 to 1875, the Americans and several European 'game hunters' systematically slaughtered the bison, mainly for their hides, which were more highly prized than cattle hides because of their greater elasticity. Coincidentally, perhaps, the slaughter of the bison greatly assisted in the subjugation of the indigenous Indians, who, deprived of their livelihood, became dependent on the colonizers. Many assisted in the bison slaughter and then turned to subsistence farming in the reservations. A rangeland management system that had been sustained by the Indians for several thousand years had been destroyed almost overnight.

The system that replaced it was funded by investment from abroad, especially from Britain, which supported the purchase of cattle, the expansion of the railways and later the development of refrigerated transport. The occupation of rangeland by cattle ranchers was facilitated by a simple invention, barbed wire, which could be used by the 'cowboys' to stake a claim to as much land as each felt able to manage. Publicly owned rangeland in the USA was, and still is, leased for a sum well below the market value. There was a similar spread of cattle over much of northern Australia, though this largely occurred during the 20th century, when farming methods for the tropics and subtropics had been developed and sheep had been found to be unviable in these areas. Decimated by disease and enforced subjugation, many aboriginal people found work on the large cattle stations. When the government forced station managers to pay the workers a wage in 1968, there was an exodus from the stations, which were unable or unwilling to pay for labour that had previously been provided in return for just the provision of food, clothing and accommodation.

The USA grew in stature as a world power as Britain declined, and with the increase in American affluence came the demand for well-fattened beef for home consumption. Then, instead of the cattle being finished on the range, they began to be transported for fattening on cereal-based diets in feedlots of the southern one-time Confederate states.

The Growth of Dairy Production Systems

For most of the second millennium AD, milk was produced for home consumption in villages, and cows were kept in the cities to produce milk for the urban populations. A rapid expansion of dairy farming in industrialized regions can be traced back to the advent of the railway. In Britain, for example, it meant that milk could be transported from the wet west of the country to the big cities, especially London, Bristol and the urban centres in the north. Nowadays, transporting milk and milk products is largely by road vehicles, but the centres of dairying remain in the west, where the rainfall is high and there is a plentiful supply of grass for much of the year.

In many developing countries such a ready supply of milk and milk products in the cities is not always available. With a continued migration from rural to urban areas, many rural migrants in the cities have inadequate access to high-quality dairy products because of their high cost. Often milk is diluted, or there is spoilage after being brought in from the countryside. Milk and dairy products provide an important source of minerals, particularly calcium, vitamins (especially vitamin A) and a highly digestible supply of energy and protein. In sub-Saharan Africa, rapid deterioration of milk and dairy products in the warm conditions prevailing necessitates the establishment of small urban and peri-urban farms, for which feed and other supplies have to be brought in from surrounding rural areas. Securing adequate forage resources can be difficult as the cities expand and distances to rural areas are often too long for the import of large quantities of fresh fodder. Conserved fodder may be scarce in supply, as well as being expensive and bulky to transport. In the rural areas there is sometimes conflict for land access between the settled agriculturists producing fodder and other crops and migrant pastoralists. Where land is limited in supply, the rural poor usually have to feed their cattle on waste products, including crop residues, or graze them on land that could not easily be used for other purposes. Rarely do they utilize grain, which can be used to feed humans. Of increasing interest is the use of by-products, such as paper and vegetable wastes, in the suburban dairy production systems. These non-conventional by-products are increasingly used with benefits to the environment and the efficiency of land use.

Cities are not just centres of human population but also of industrial development, and the continued growth of urban and peri-urban industry has left the problem of waste disposal. Some wastes, e.g. from the food and drink industry, can be used without modification for cattle production. They are characterized by variable nutritional value and poor hygienic quality and are more suited to feeding to ruminants than to monogastric animals because of their ability to ferment low-quality feeds. Brewers' and distillers' grains are particularly valued industrial by-products. Many other wastes do not have an established outlet and their safe disposal can be expensive; alternatively they may create a public health hazard if they are disposed of carelessly. Some can be utilized for cattle feed but others contain toxic agents, such as arsenicals in waste newspaper, or a variety of transmissible diseases. Zoonoses are of particular concern, especially since the transmission of a spongiform encephalopathy occurred from animal carcasses to cattle and thence to humans in the UK. Many feel that such recycling practices risk the emergence of novel pathogens, but it must be remembered that recycling predominates in nature and is in the interests of the development of an efficient industry. It is therefore not surprising that international bodies such as the Food and Agriculture Organization of the United Nations (FAO) and the World Bank have identified peri-urban dairying as showing the highest potential for meeting the growing nutrient need of urban consumers.

Cattle in the World Today

The world's cattle population is currently approximately 1.4 billion (Robinson *et al.*, 2014), or one for every five people, distributed across every continent except Antarctica (Fig. 1.4). Given that the biomass of cattle is almost ten times that of people, the biomass of cattle in the world is almost twice that of people and the largest of any animal on earth. It is increasingly recognized that the dominance of livestock systems in use of the world's land and water resources must be re-evaluated in the light of today's sustainability goals: poverty reduction, food and nutritional security, ecosystem protection, mitigation of greenhouse gases, and adaptation to climate change (Herrero *et al.*, 2013).

Just over a quarter of the cattle are dairy cows. Their density is determined by climate, topography, political considerations and religion (Fig 1.4). Nearly 30% reside in India, more than in any other country in the world. Here they are strongly connected with the country's religion, Hinduism. As sacred animals, they are not usually slaughtered for meat, but are used for production of milk, milk products and faeces. Elsewhere cattle are concentrated into parts of the world in which grass is more easily grown than crops: the savannah regions of Africa – both north and south of the equator – and Australia, the prairies of North America, the pampas of South America and the steppes of central and Eastern Europe. An exception is north-west Europe, where mixed farming systems integrate cattle and agricultural crop production.

Cattle production systems are often criticized for their environmental, welfare and nutritional impacts. In addition, protein production from beef cattle is one of the least efficient ways of producing protein for human consumption (Table 1.1), in part because of the high cost of maintaining cows to produce a relatively small number of calves. However, if it uses land that could not otherwise be used for human food production directly from crops it may augment the total food protein produced for human consumption. Protein in the milk of dairy cows is produced as efficiently as the non-ruminant protein sources – pigs, fish and poultry (see also Chapter 5 for discussion of processing efficiency).

Cattle are an integral part of the lives of many of the world's poorest people. In Africa, the savannah belt has many cattle farmers (Fig. 1.5), especially in Nigeria, Ethiopia, Uganda, Burundi, Rwanda and Malawi (FAO, 2002). In India, Pakistan and Bangladesh and much of South America, all of which are major cattle-rearing regions (Fig. 1.4), a high proportion of people earning less than US$2/day manage their cattle in mixed farming systems (compare Figs 1.4 and 1.6). Cattle make a significant contribution to wealth, and any attempts to restrict cattle numbers because of their environmental impact will need to take into account their widespread use by the world's poorest people. In many of the poorest parts of Africa, where only a small proportion of the population has access to electricity or clean cooking fuels, cattle dung is dried and used as a fuel for cooking. Sometimes it is mixed with straw. Its use in this way has been an important means of cooking food to improve its value for humans for thousands of years. Temperatures of several hundred degrees Celsius can be reached in a few minutes and sustained for a sufficient period of time for cooking. Using dung for fuel replaces the use of firewood (which has resulted in deforestation), but it prevents the dung being used as a valuable fertilizer on the land and may lead to increased use of artificial fertilizer.

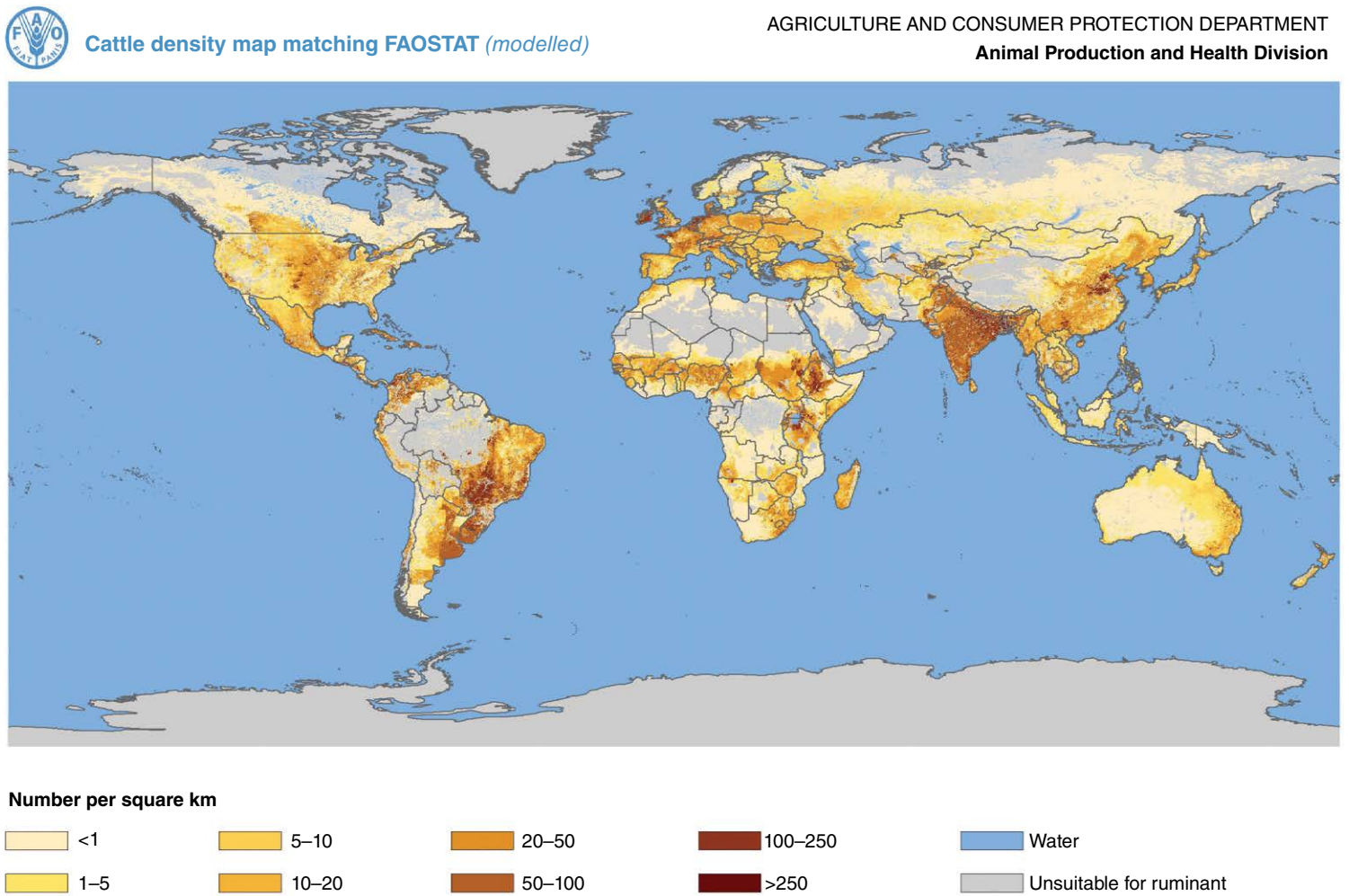

Fig. 1.4. World map of cattle density (from FAO, 2008a).

Table 1.1. Protein production efficiency of major animals used for human foods (adapted from Tilman and Clark, 2014).

Human food	Protein production efficiency (edible animal protein produced/feed protein used)
Beef	0.05
Mutton and goat	0.07
Pork	0.17
Poultry	0.20
Milk	0.25
Trout	0.25

Using dung directly for cooking pollutes the atmosphere and may cause respiratory problems in humans. Turning it into biogas, which is mainly methane (50%) and carbon dioxide (30%), requires some resources but it is a much more efficient and less polluting fuel for household use. Cattle dung is sometimes used for other purposes, for example in India where it is spread on the floor of houses because it has some sterilizing properties.

In the long term, cattle production systems cannot usually be justified only by their role in feeding and providing fuel for the rural poor, though this argument has been made to justify livestock exports from Australia to Asia and intensification of livestock production in countries, like South Africa, where there are rich and poor living in close contact. The reality is usually that the poor cannot afford to buy the cattle products as they are too expensive per unit of all of the major nutrients, and they have to be sold to generate income to buy staple foods. In the USA, even though cattle production has been intensified to reduce costs, meat products still cost over 40 cents per 100 kcal, and grains, beans, legumes, nuts and seeds only 10–20c/100 kcal (Drewnowski, 2010). Furthermore, the cost of meat is not the full cost, which should include the environmental pollution that animal farms cause, and the cost of their contribution to ill health, and eventually the cost of finding alternatives to the antibiotics that are being rendered ineffective because of their overuse in intensive livestock production. The high cost is principally due to the high level of resources that is required for cattle production. This includes large quantities of grain crops for intensive and semi-intensive feeding of cattle. The grain used for all animal feed, which accounts for 40% of all arable land worldwide, could feed 3.5 billion people (Niamir-Fuller, 2016).

Cattle Production Systems and Climate

Cattle are now kept in all the major climatic regions, which demonstrates the importance that they have assumed as the major species domesticated for the provision of food. Because of the large amount of heat produced by the microbial fermentation of coarse grasses, and their large size, they thrive better than most other domesticated animals in cold climates. The provision of a naturally ventilated shelter enables cattle to be kept for milk production in extreme cold, such as in Canada, even if ambient winter temperatures approach the lower end of their comfort zone. Feed intakes are increased to generate more internal heat but their survival is not threatened. Breeds of cattle that thrive under such conditions are usually of the more endomorphic type, such as the Hereford. At the opposite end of the climatic spectrum, cattle are able to survive in some of the hottest environments of the planet, especially if they are protected from the sun's radiant heat by provision of adequate shade. More crucial than the temperature in these environments is a regular supply of potable water.

Despite their successful integration into farming systems in extreme climates, cattle are best kept in moist, temperate environments with a regular rainfall that enables grass to grow for much of the year. In some parts of the southern hemisphere, such as New Zealand and southern Chile, and southern Ireland in the northern hemisphere, grass will grow for the entire year and grazing systems predominate. In more extreme latitudes colder conditions in winter mean that most cattle are housed for about 6 months of the year. Mediterranean climates are often too dry for cattle and the keeping of sheep and goats is traditional. Because of their low feed intake requirements sheep and goats survive on sparse vegetation more easily than cattle, and sheep in particular can survive with less water, producing a faecal pellet that is harder and drier. Mediterranean cattle production systems are therefore more likely to rely on forage crops such as maize rather than on grazing, as in the Po valley of Italy.

At high temperatures cattle reduce their production levels unless they are given shade, cooling and a highly concentrated diet to minimize the heat increment of digestion. Their morphology adapts to make their coat short-haired and shiny, to reflect the sun's rays, so that they absorb less heat and lose it more readily. Cattle have become well adapted to a hot

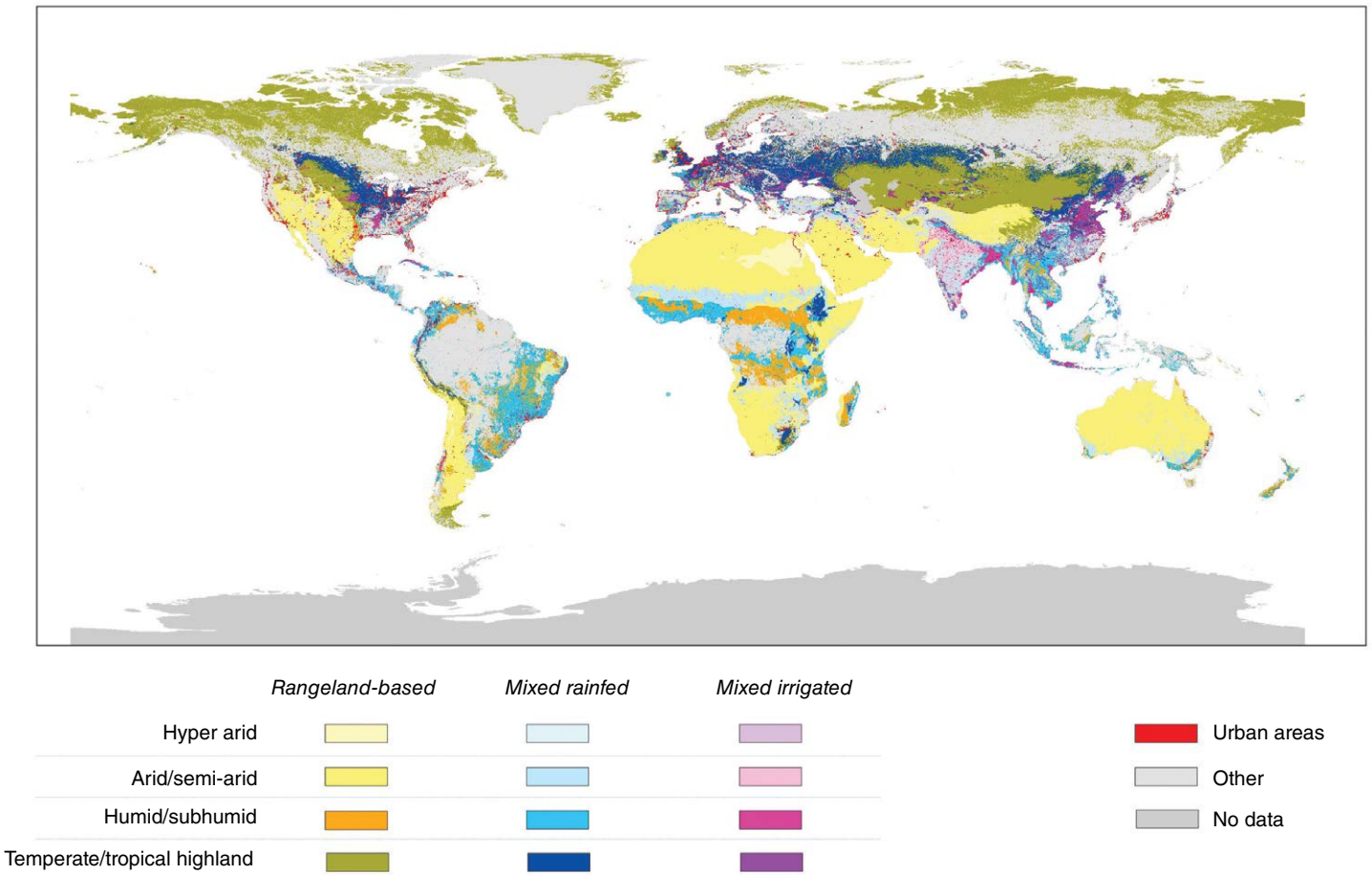

Fig. 1.5. Land utilization systems for livestock production in different climatic zones (from FAO, 2008b).