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Meat production in developing countries

Margaret Gill

Natural Resources International Ltd, Chatham Maritime ME4 4TB, UK

Developing countries have very diverse food consumption patterns and agricultural production systems. The proportion of meat in national diets varies from negligible in some countries in central Africa to 30–40% in some countries in Latin America and Mongolia. However, the demand for meat in developing countries is increasing rapidly (5·3%/year from 1982 to 1993), as the result of population growth and the trend for people to move to the cities. Growth rates in consumption are greatest in Asia, with China dominating the statistics, in view of the size of its population. Theoretically, livestock production can be increased to meet this demand, but the multiple roles of livestock in developing countries must be recognized if this is to be achieved in a sustainable manner. Resource-poor farmers who keep livestock may value more highly their contribution to livelihoods and to crop production, through provision of draught power and improvements in soil fertility through the recycling of manure, than the production of more meat. Recognition of the goals of the farmer and the wishes of the consumer regarding meat quality need to be reflected in the way in which opportunities for increasing meat production are identified and communicated to farmers. The impact of the global economy on cereal prices, for example, will also influence which interventions will be economically viable. Interpretation of information in an integral manner, using geographical information systems, mathematical models and/or simple spreadsheet models will be an important ingredient in turning scientific knowledge into increased meat production in developing countries.

Developing countries: Meat: Livestock systems: Globalization

Meat consumption *per capita* in developing countries is considerably lower than that in the developed world. In the 1990s, average consumption for sub-Saharan Africa was 12 kg/head per year, for Asia 18 kg/head per year and for Latin America 45 kg/head per year (Food and Agriculture Organization statistics; http://www.fao.org 1998), compared with an average of 76 kg/head per year in developed countries (Delgado *et al.* 1998). However, in developing countries livestock are not only valued for their contribution to human food, they have additional roles to play through the provision of draught power and manure, and in contributing to the livelihoods of rural people.

Approximately four billion of the world's human population of 5·3 billion were estimated to live in the developing world in 1990, and this is predicted to rise to 6·6 billion of the predicted eight billion in the year 2020 (Rosegrant *et al.* 1995), with the population of China accounting for 13 % or 350 million of the predicted increase. Over 65 % of the world's cattle and small ruminants are found in the developing world, but the distribution between countries and regions varies (Fig. 1) according to cultural, climatic and economic factors.

The present paper will consider first the demand for different types of meat in different regions of the developing

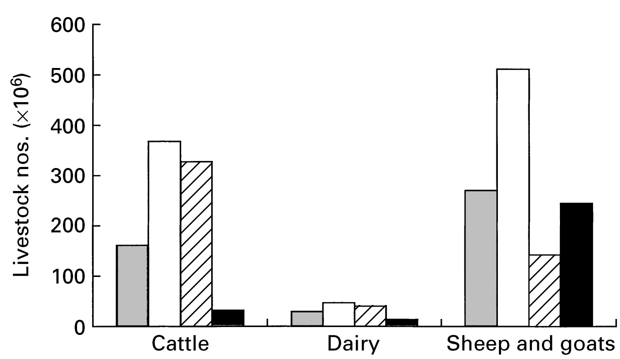

Fig. 1. Regional variation in livestock numbers. (▒), Sub-Saharan Africa; (▭), Asia; (▨), Central and South America; (■), West Asia and North Africa. (From Sere & Steinfeld, 1996.)

Corresponding author: Dr Margaret Gill, fax +44 (0)1634 883937, email e.m.gill@greenwich.ac.uk

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world, second it will consider different types of livestock system and their feed resources, third the role of livestock in terms of food production and contribution to livelihoods, fourth data on global trends in meat production in developing countries will be presented, and the final section will consider how the demand for meat might be met.

Meat consumption in developing countries

Meat, fish, milk and eggs provide an average of 13·5 % of daily energy intake on a global basis (Loftas, 1995). However, this global average conceals a wide variation, from a negligible contribution from livestock products in many African and South Asian countries up to 40 % in parts of Latin America and Mongolia. The demand for different types of meat also varies between regions: beef currently constitutes 50 % of total production in Latin America, 41 % in sub-Saharan Africa and only 5 % in China (Table 1; Delgado *et al*. 1998). Pork, in contrast, constitutes 59 % of total meat production in China and 0 % in West and North Africa. These variations reflect very different religions and cultures in different regions of the world, and there has been little change in the proportion of beef over the last decade, despite a doubling in total meat consumption in some developing regions (Table 1).

The rate of growth in meat consumption in the last decade has been much greater in parts of Asia than in other regions of the developing world or in the developed world (Table 2). These cultural variations in demand for meat, together with climatic factors, have led to the evolution of different types of production systems, and the next section analyses geographical variations in livestock production systems, together with gross statistics on the feed resources available in each system.

Table 1. Contribution (%) of beef to total meat production in a range of geographical locations in 1983 and 1993 (From Delgado *et al*. 1998)

	1983	1993
China	2	5
India	32	31
Latin America	54	50
West Asia and North Africa	23	21
Sub-Saharan Africa	48	41

Table 2. Trends in meat consumption (kg/head per year) (From Food and Agriculture Organization statistics; http://www.fao.org 1998)

	1983	1993
China	16	33
India	4	4
Other East Asia*	22	44
Other South Asia†	6	7
Southeast Asia	11	15
West Asia and North Africa	20	20
Sub-Saharan Africa	10	9
Latin America	40	46
Developed world	74	78

* Hong Kong, Macau, Mongolia, North Korea and South Korea.
† Afghanistan, Bangladesh, Bhutan, Maldives, Nepal, Pakistan and Sri Lanka.

Livestock systems and their feed resources

A recent study of interactions between livestock and the environment (de Haan *et al*. 1997) identified three main types of livestock system globally: grazing (entirely livestock systems, with stocking rates of <10 livestock units/ha and > 10 % of feed produced on the farm); mixed systems (> 10 % of feed from crop residues and by-products produced on the farm and > 10 % of the total value of production comes from non-livestock farming activities); industrial or 'landless' systems (< 10 % of feed farm-produced and annual stocking rates > 10 livestock units/ha agricultural land). For ruminants, mixed systems are the most important in Asia and Africa, with grazing systems most important in Latin America (see Fig. 2). For pigs and poultry, industrial systems predominate in Latin America, while mixed systems predominate in Asia (see Fig. 3).

Slightly less than half the world's usable surface is covered by grazing systems ($2{\cdot}2 \times 10^6$ km^2), which support 360 million cattle and 600 million sheep and goats (de Haan *et al*. 1997). However, grazing systems, even within developing countries, vary from the productive pastures of South America to the deserts in the arid regions of Africa and Asia. Vegetation is also varied, from highly-nutritious C_3 legumes to fibrous C_4 grasses (plants which use C_3 and C_4 pathways respectively for CO_2 fixation), woody trees and shrubs. Much is heard about the consequences of over-grazing, leading to soil degradation and erosion, but there is recent evidence that the extent of land degradation resulting from over-grazing in arid regions has been exaggerated (de Haan *et al*. 1997). An analysis of livestock production in five Sahelian countries over a 30-year period recorded a 93 % increase in meat production/ha and a 47 % increase in meat produced/head. Thus, although transhumance and the traditional movement of animals with the seasons may be in decline for largely political and demographic reasons, there is no doubt that grass will remain an important component of ruminant diets on a global basis. While the greatest benefits may well be obtained from research and development of policy and infrastructural issues, there is still a need for technology research, such as identifying nutritious fodder plants adapted to harsher environments and for feeding systems to make best use of local feed resources.

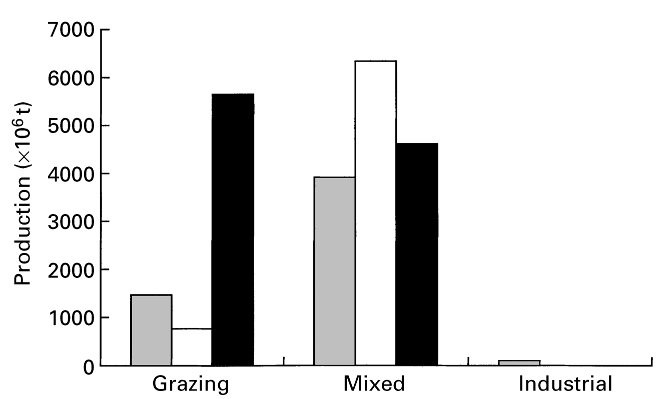

Fig. 2. Production of beef, mutton and goat meat ($\times 10^6$ t) in developing countries by production system. (▒), Africa; (▭), Asia; (■), Latin America. For details of production systems, see p. 372.

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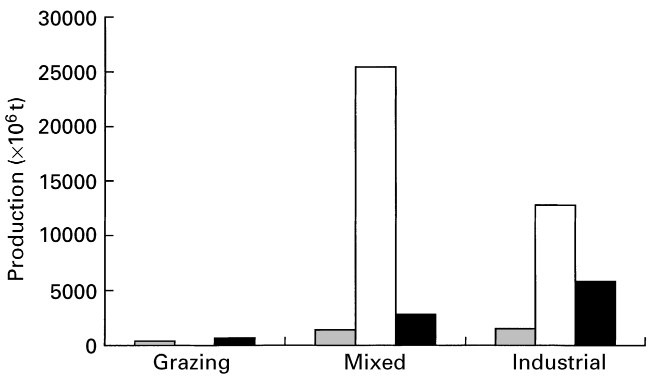

Fig. 3. Production of pig and poultry meat in developing countries by production system. (▒), Africa; (□), Asia; (■), Latin America. For details of production systems, see p. 372.

The majority of ruminants are kept in mixed systems in the developing world, where crop residues and by-products form an important part of ruminant diets. It is estimated (J. Fadel, personal communication) that 37 kg by-products suitable for animal feeds are produced from every 100 kg human food grown as plants. It is estimated that globally the residues from just four crops (wheat, maize, rice and barley) provide approximately 650×10^6 t DM for animal feed, with 25 % or 160×10^6 t being produced in China alone (Food and Agriculture Organization statistics; http://www.fao-org; accessed in 1997). Oilseed cakes and meals are one of the most important sources of by-products, followed by cereal brans and sugar-cane bagasse. Potential benefits could be achieved through the introduction of fodder trees and shrubs, improved quality of crop residues through breeding or chemical treatment, and increased knowledge of how to incorporate non-conventional feeds into diets.

Livestock produced under industrial or 'landless' systems provide the greatest competition for human-edible food. In developing countries, 31 % of cereals and 59 % of roots and tubers are used as animal feed, of which 74 % is used for pork and poultry production and a further 21 % for milk production (Hendy *et al*. 1995). It has frequently been suggested (for example, see Brown, 1997) that transferring the cereals currently utilized as animal feed into food for the human population would decrease global levels of malnutrition, but another paper presented at this meeting (Rosegrant *et al*. 1999) demonstrated that reduction in meat consumption in developed countries would be likely to have little impact on the nutritional status of poor people in developing countries. In developing countries themselves, livestock are often kept not just for meat production, but also as an integral part of livelihood strategies evolved by subsistence farmers and/or as important contributors to crop production. All three expectations of livestock systems are discussed in the following section.

The contribution of livestock to livelihoods and food

Livelihoods

In many arid and semi-arid regions of the world, crop failures are common and many farmers depend on livestock to survive. Worldwide, 29 % of cattle and 46 % of sheep and goats are found in arid and semi-arid regions. In Africa the percentage of ruminants found in arid and semi-arid regions rises to over 50 (see Jahnke, 1982). Data collected during the Livestock and Environment Study indicated that livestock provide the only source of income for twenty million pastoral families (de Haan *et al*. 1997). In addition, livestock provide a very significant source of income for mixed crop–livestock farmers in many countries of the world.

Table 3 presents data on the contribution of livestock to farm incomes in three continents. The data indicate a positive correlation between dependence on livestock and lower rainfall within Africa, i.e. a higher dependence in the lower-rainfall Sahelian countries on livestock compared with crops; the contribution of livestock being, for example, 24 % for lower-income farmers in the Sahelian zone of Senegal, compared with only 11 % for farmers with similar incomes in the Sudanian zone (Powell *et al*. 1998). Powell *et al*. (1998) also quoted evidence from Pakistan and the Philippines that livestock made a greater contribution to the income of lower-income rather than higher-income farmers, but the same trends were not apparent for either Niger or Burkina Faso.

The contribution of livestock to crop production

However, in Africa in particular, but also in Asia and some countries in Latin America, livestock also make a major contribution to food production indirectly, through increasing crop yields. It has been estimated (de Haan *et al*. 1997) that livestock provide sufficient power worldwide to cultivate $>320\times10^6$ ha, and that manure provides soil nutrients which in their inorganic form would cost £500×10^6/year.

The actual increase in crop yield in response to the application of manure is highly variable, depending among other factors on the basic nutritional status of the soil, the type of soil, and the way in which the manure is collected and applied. McIntire *et al*. (1992) reviewed the grain yields in response to the application of manure with fertilizer across a wide range of mixed farming systems in sub-Saharan Africa and reported an average 94 kg grain/t manure applied. A more detailed review of the benefits and limitations of using manure is given in Powell *et al*. (1998).

Livestock can also contribute to increased crop production through the provision of power. Tractors are unlikely to replace draught animals in significant numbers

Table 3. Household income shares by sector (%) (From von Braun & Pandya-Lorch, 1991)

		Crop	Livestock	Non-agricultural
Africa:	The Gambia	78	1	21
	Zambia	92	2	6
	Niger	45	8	47
	Senegal	43	13	44
Asia:	Pakistan	21	15	64
	Bangladesh	36	23	41
	The Philippines	42	17	41
Latin America:	Brazil	50	30	20

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in the immediate future, since the use of draught animals saves millions of dollars in foreign exchange. For example, Ramaswamy (1985) estimated that it would take 30 million tractors to replace the 300 million draught animals used on small farms in Asia. However, the comparison in many developing countries is still between draught animals and manual labour. Access to draught animals has been shown to increase the land area cultivated (Sumberg & Gilbert, 1992) as a result of the decreased time required for land preparation. For rice, the time spent in land preparation was decreased from 315 h/ha using manual labour to 94 h/ha using oxen, and from 65·5 to 28 h/ha for manual labour *v.* oxen for land preparation for maize (Lawrence *et al*. 1997). A manual on the increased feed requirements of draught animals related to different types of work is currently under preparation by PR Lawrence and co-workers at the Centre for Tropical Veterinary Medicine, Edinburgh, UK.

The contribution of livestock to meat production

During the decade 1983–93, meat production in developing countries increased from 51×10^6 t to 88×10^6 t. The biggest increase was in pork production in China, which increased from $14{\cdot}1\times10^6$ t to $29{\cdot}5\times10^6$ t over the 10-year period. The average increase in total meat consumption per year over the 10-year period was 8·3 %. Poultry production in Latin America doubled from $3{\cdot}5\times10^6$ t to $7{\cdot}4\times10^6$ t while the absolute increase in meat production in Africa was minimal, rising from $3{\cdot}1\times10^6$ t pork, poultry and beef in 1983 to $3{\cdot}6\times10^6$ t in 1993 (Delgado *et al*. 1998). The key questions for the present symposium are: if these trends continue, can supply continue to increase to meet the increased demand; if so, what are the consequences?

Global trends in meat production

In the early 1990s, the International Food Policy Research Institute (Washington, DC, USA) launched what was called its 2020 Vision Initiative, which 'seeks to develop an international consensus on how to meet future world food needs while reducing poverty and protecting the environment' (for details, for example, see Rosegrant *et al*. 1995). A key element of the initiative was the development of a model (the international model for policy analysis of agricultural commodities and trade) to generate projections of production, demand and trading quantities for the main supplies of human food, and consequently levels of malnutrition, under different economic and productivity scenarios. Some of the projections of this model form the basis of the predictions which follow.

The growth in demand for meat in developing countries is predicted to remain high, although over the 27-year period from 1993 to 2020, the percentage year-on-year increases for China are predicted to decrease to 3·1 %, similar to those for Southeast Asia, with India following at 2·7 %, slightly higher than the rest of South Asia (2·6 %) and the rest of East Asia (excluding China) at 2·5 %. Demand in Latin America and sub-Saharan Africa is predicted to grow at a lower rate of 2·1 %, giving an average projected annual increase in demand for meat in developing countries of 2·1 %, compared with the 5·2 % which was observed from Food and Agriculture Organization statistics over the 10-year period from 1983 to 1993 (Delgado *et al*. 1998). The trends in meat consumption in developing regions from 1983 to 2020 are shown in Fig. 4. Growth rates in consumption are projected to be greatest for beef in Asia (4·1 %), followed by poultry meat (3·9 %), sheep meat (3·6 %) and pork (3·5 %) on the international model for policy analysis of agricultural commodities and trade baseline scenario (Rosegrant *et al*. 1995).

How to meet demand?

There is no doubt that the theory of how to increase live-weight gains and hence meat production in the grazing and mixed farming systems in developing countries is known, and that theoretically production could be increased to meet demand simply by offering more or better-quality feed, or introducing more productive breeds. The quality of native grasses is generally low, and improvements could be made through introducing improved varieties, but the adoption of technologies for pasture improvement has been slow in many tropical regions, for reasons which are reviewed and discussed in Humphreys (1994). In mixed farming systems dependent on crop residues, live-weight gain can be increased both by treating fibrous crop resides with, for example, urea or by providing supplements (Table 4). However, with the exception of China, the adoption of chemical treatment of straw has been less than expected, largely due to lack of resources such as labour, water or the money to purchase the chemicals. Thus, given the importance of livestock to the livelihoods of poor people, care should be taken to ensure that technologies which appear to be the solution to increasing meat production are

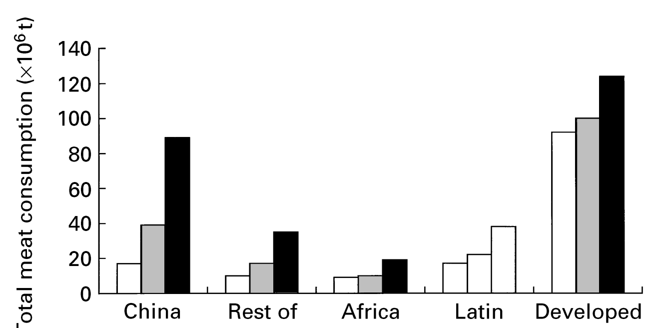

Fig. 4. Trends in total meat consumption between 1983 and 2020. (▭), 1983; (▨), 1993; (▬), 2020.

Table 4. Effect of urea treatment of straw with and without supplementation with 1 kg rice bran plus 0·25 kg coconut cake on live-weight gain (g/d) of growing bulls (From Schiere *et al*. 1988)

Control straw		Treated straw	
Without supplement	With supplement	Without supplement	With supplement
–26[a]	68[a,b]	146[b]	256[c]

[a,b,c] Values with different superscript letters were significantly different ($P<0{\cdot}05$).

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appropriate to the resources of the target farmer group and to meeting their multiple goals.

One example of how care needs to be taken in designing technologies appropriate to farmers' needs can be seen in the results of a study in Nepal (Thorne & Herrero, 1998). A comparison was made of the nutritive value of tree fodder as perceived by farmers, compared with the perceptions of nutrition 'experts', based on a series of laboratory indicators. Farmers refer to 'obano' fodder as feed which fills up their animals during times of feed scarcity, while 'posilo' fodder is referred to as feed which promotes milk yield. The data in Table 5 indicate that the nutrition 'experts' based their ranking primarily on values for neutral cellulase (*EC* 3.2.1.4) digestibility, with which the obanopan fodders were negatively correlated, while the posilopan fodders were correlated with an index of duodenal protein supply (for details, see Table 5). The results demonstrate that when feed is in short supply farmers prefer feeds which are slowly digested, and when they are interested in high milk yields the protein-yielding potential of the feed becomes important. These farmer preferences need to be taken into account when researching 'improved' feeding systems for Nepalese farmers.

The previously mentioned example also reminds us that technology needs to be transferred to the user in a form in which it can be understood. One of the characteristics of the last decade of the millennium is the 'explosion' in information technology, giving billions of people access to vast amounts of information, but how much is actually useful? There is clearly a demand for ways to analyse and interpret information in an integral manner, using geographical information systems, mathematical models or simple spreadsheet models. Such tools will enable the effects of trends in population and the impact of the global economy on cereal prices to be taken into account when developing strategies for increasing meat production.

Conclusions

Much work has been done to understand the objectives of consumers and producers in developing countries, and to predict future trends. A diversity of objectives exists, and while some factors are common across the world, others are location-specific. This makes the goal of matching supply with demand particularly challenging, but with access to modern technology predictions suggest that meeting the projected 60 % increase in demand for meat is feasible. In many countries the systems developed by livestock owners have evolved to minimize risk (e.g. local breeds have more immunity to tropical diseases, and local landraces of cereal may be more resistant to local conditions), and thus other methods of minimizing risk need to be in place before farmers will adopt new technologies. For example, a better infrastructure for transport and marketing, policies which prevent the 'dumping' of livestock products on markets in developing countries by countries which produce excesses, and efficient dissemination of information on weather forecasting would greatly help the process.

Table 5. Correlations of rankings of tree fodder by farmers in Nepal according to indigenous criteria with rankings based on chemical indicators and quality provided by a panel of 'expert' nutritionists (From Thorne & Herrero, 1998)

	Obanopan	Posilopan
Neutral cellulase (*EC* 3.2.1.4) digestibility	–0·84	0·34
Duodenal protein supply index*	–0·34	0·80
'Expert' rankings	–0·87	0·25

* $\frac{CP}{\text{mean [CP]}} + \frac{DMD_{70}}{\text{mean [}DMD_{70}\text{]}} + \frac{CT}{\text{mean [CT]}}$, where CP is the crude protein (N × 6·25) of the specific fodder, mean [CP] is the mean CP content of all the fodders, DMD_{70} is the DM digestibility of the specific fodder after 70 h incubation in an *in vitro* gas production system (Theodorou *et al.* 1994), mean [DMD_{70}] is the mean DMD_{70}, CT is the non-extractable condensed tannin content (Porter *et al.* 1986) and mean [CT] is the mean CT content.

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