CHAPTER 5

Livestock production

5.1 Introduction

Livestock production is the world's largest user of land, either directly through grazing or indirectly through consumption of fodder and feedgrains. Globally, livestock production currently accounts for some 40 percent of the gross value of agricultural production. In industrial countries this share is more than half. In developing countries, where it accounts for one-third, its share is rising quickly; livestock production is increasing rapidly as a result of growth in population and incomes and changes in lifestyles and dietary habits.

Growth in the livestock sector has consistently exceeded that of the crop sector. The total demand for animal products in developing countries is expected to more than double by 2030. By contrast, demand for animal products in the industrial world has been growing at low rates, and livestock production in this group of countries is expected to grow only slowly over the projection period (see Table 5.1).

Satisfying increasing and changing demands for animal food products, while at the same time sustaining the natural resource base (soil, water, air and biodiversity), is one of the major challenges facing world agriculture today. Global agriculture as a whole will be increasingly driven by trends in the livestock subsector, many of which are already apparent:

- An increasing proportion of livestock production will originate in warm, humid and more disease-prone environments.
- There will be a change in livestock production practices, from a local multipurpose activity to a more intensive, market-oriented and increasingly integrated process.
- Pressure on, and competition for, common property resources such as grazing and water resources will increase.
- There will be more large-scale industrial production, located close to urban centres, with associated environmental and public health risks.
- Pigs and poultry will increase in importance compared with ruminants.
- There will be a substantial rise in the use of cereal-based feeds.

Meeting these challenges raises crucial global and national public policy issues that must be addressed. Broadly, these encompass equity and poverty alleviation, the environment and natural resource management, and public health and food safety.

The main purpose of this chapter is to discuss the factors and perspective issues underlying the

projections for livestock production as presented in Chapter 3. Developments in demand for livestock products will be briefly summarized in Section 5.2 and those for production of livestock commodities in Section 5.3. This latter section also discusses issues in increasing livestock productivity and expected changes in livestock production systems. Some selected livestock-related issues expected to take on greater importance over the projection period are dealt with in Section 5.4.

5.2 Consumption of livestock products

As incomes increase, demand for greater food variety grows. Demand for higher-value and quality foods such as meat, eggs and milk rises, compared with food of plant origin such as cereals. These changes in consumption, together with sizeable population growth, have led to large increases in the total demand for animal products in many developing countries, and this trend will continue.

The rising share of animal products in the diet is evident in developing countries. Even though calories derived from cereals have increased in absolute terms, as a share of total calories they continue to fall, from 60 percent in 1961/63 to an expected 50 percent in 2030. Similarly, the contribution of other traditional staples (potatoes, sweet potatoes, cassava, plantains and other roots) fell from second largest contributor to dietary calories (10 percent) in 1961/63 to lowest (6.2 percent) by 1997/99. By then, animal products had become the second major source of calories (10.6 percent) in developing countries.

In industrial countries, cereals contribute significantly less as a share of calories consumed – around 34 percent – while the contribution of animal products has remained stable at around 23 percent. In developing countries the per capita consumption of animal products is still less than a third of that in industrial countries, so there remains a significant potential to increase the contribution of animal products to the diet, both in absolute and percentage terms.

In industrial countries, the consumption of animal proteins increased in the 1960s and 1970s from 44 to 55 g/capita/day. After this, animal protein consumption remained fairly stable. In developing countries, however, although the level of consumption of animal proteins increased steadily from 9 g/capita/day in 1961/63 to 20 g/capita/day in 1997/99, there is still significant potential for increases.

Between 1997/99 and 2030, annual meat consumption in developing countries is projected to increase from 25.5 to 37 kg per person, compared with an increase from 88 to 100 kg in industrial countries. Consumption of milk and dairy products will rise from 45 kg/ person/p.a. to 66 kg in developing countries, and from 212 to 221 kg in industrial countries. For eggs, consumption will grow from 6.5 to 8.9 kg in developing countries and from 13.5 to 13.8 kg in industrial countries.

Wide regional and country differences are also evident in the quantity and type of animal products consumed, reflecting traditional preferences based on availability, relative prices and religious and taste preferences. Some of the more important aspects include the following:

- In *sub-Saharan Africa*, low consumption levels of animal products have changed little over the last 30 years. These contribute about 5 percent to per capita calorie consumption, about half the percentage of the developing countries as a whole and a fifth of that of the industrial countries. Milk contribution to total calories and protein per capita has remained constant in recent years, indicating an increase in total milk availability equivalent to population increases. Only minor increases in consumption are projected.
- In the *Near East and North Africa*, the contribution of animal products to the relatively high calorie consumption is small, just 8.7 percent in 1997/99. The contribution of animal products (primarily poultry meat and milk) to total calorie intake will increase to 11.4 percent by 2030.
- In *Latin America and the Caribbean* (excluding Brazil), consumption of animal products (meat) historically has been higher than in other developing country groups and is predicted to increase further. Currently, animal products provide 16.6 percent of the dietary energy, but meat consumption per capita is still only about 60 percent of that of industrial countries, implying that there is scope for further growth.
- *Brazil* is unusual in terms of its large and increasing dietary contribution of animal products (18.8 percent in 1997/99). The gap

between Brazil and the rest of Latin America is expected to widen. Meat consumption per capita, at present over three-quarters the level of industrial countries, is projected to reach the level of the latter by 2030. Per capita milk consumption, at present just over half the level of industrial countries, is projected to reach three-quarters of the industrial countries' consumption by 2030.

- In *South Asia* (excluding India), there has been a slow but steady growth in animal product consumption. This increase is mostly the result of an increase in the contribution of milk, already high at a per capita level 50 percent above the average for developing countries, together with an increase in the contribution of poultry meat. The contribution of eggs is well below the developing country average.
- In *India*, the relative contribution of animal products to diets is predicted to increase up to 2030 largely as a result of increases in the consumption of milk and milk products.
- In *East Asia* (excluding China) there is also a steady increase in the contribution of animal products to the diet. However, unlike South Asia, this increase is a result of the contribution of meat, predominantly pork.
- In *China*, the projected rapid rise in the contribution of animal products to dietary energy from 15 to 20 percent between 1997/99 and 2030 will be mainly on account of a substantial increase in the contribution of pork and poultry. Per capita consumption of milk is very low and projected to remain so (rising from 7 kg p.a. in 1997/99 to 14 kg in 2030). By contrast, egg consumption in China is very high – more than double the average for developing countries and even above the industrial country average – and will rise from 15 kg/ person/p.a. in 1997/99 to 20 kg in 2030.

5.3 Production

Chapter 3 details the production and trade projections for livestock commodities. This section will look more at the implications. The location of production and processing activities is increasingly determined by factors such as the availability, quality and cost of inputs and proximity to markets. With the expected expansion in demand for animal products, traditional mixed farming practices alone will no longer be capable of meeting requirements.

The supply of animal products can be increased by raising the number of animals, and by improving productivity and processing and marketing efficiency, and by adopting various combinations of these factors. In most regions, land availability limits the expansion of livestock numbers in extensive production systems, so the bulk of the production increase will come from increased productivity, through intensification and wider adoption of better production and marketing technologies.

The strongest structural trend in livestock production has been the growth of intensive, vertically integrated, intensive establishments close to large urban centres, particularly for pig and poultry meat production in East Asia and Latin America, and broiler production in South Asia. Similar trends are apparent in dairy and beef production, albeit to a lesser degree. In East Asia the growth in demand for feedgrains associated with these production systems has been met by increased imports, effectively substituting imports of livestock products by imports of feedgrains.

In framing public policies, governments and other stakeholders are confronted with important trade-offs. For example, many developing countries favour industrial livestock production in order to provide affordable animal protein to urban populations (nutritional and public health benefits). Yet this may occur at the expense of diminishing the market opportunities and competitiveness of small rural producers. Similarly, stricter food safety regulations to enhance public health constitute barriers that often prevent poor farmers from entering formal markets.

5.3.1 Livestock production and productivity

The projections of total demand for livestock products were reached by taking the projections of food demand for direct human consumption, and adding on other demand components, such as the use of livestock products for non-food industrial uses, milk consumed by offspring and eggs for hatching and wastage. Production projections for each country were arrived at by making a detailed analysis of past trade in livestock products, including trade in inputs such as cereals and oilseeds used for animal feed.

The overall results are presented in Table 5.1 (unlike Table 3.11 these are aggregated over all livestock products covered in this study, including meat, milk and eggs). The main feature is a gradual slowdown in the growth of global livestock production. This will be made up of slow growth in the industrial countries, a recovery in the transition countries and a pronounced slowdown from rapid to moderate growth rates in the developing countries. This latter trend is heavily dominated by the expected slowdown in two major countries that experienced fast growth in livestock production in the past, China and Brazil. Excluding these two countries, the slowdown is much more gradual. In individual countries, developments are much more varied, with accelerating livestock production growth in several countries.

Table 5.2 (a more detailed expansion of part of Table 3.11) gives details of the livestock production data and projections for the six livestock products covered in this study, underlying the overall results presented in Table 5.1. In developing countries there has been a continued increase in production. Annual growth rates for the six commodities ranged from 3.7 to 9.4 percent for the period 1989-99. By contrast, over the same period production in the transition countries actually fell, and grew only slightly in the industrial countries.

By 1997/99, the share of the developing countries in world meat production was 53 percent and in milk production 39 percent, compared with 40 and 28 percent only ten years earlier. This was in part a result of the collapse of production in the transition countries, but it is an ongoing trend even in the absence of this phenomenon. Annual growth of meat production in developing countries to 2030 is projected at 2.4 percent and of milk at 2.5 percent. This would raise developing countries' share in world meat production by 2030 to 66 percent (247 million tonnes) and in milk production to 55 percent (484 million tonnes).

The growth in white meat (pork and poultry) production in developing countries between 1989 to 1999 has been remarkable – more than double the growth of red meat (cattle, sheep and goats). There are, however, major regional differences. Growth in poultry production has been spectacular in East Asia (11.7 percent p.a.) and South Asia (7.2 percent p.a.) and reflects the rapid intensification of the poultry industry in these regions. Latin

Table 5.1 Annual growth rates of total livestock production

	1969-99	1979-99	1989-99	1997/99 -2015	2015 -2030	1997/99 -2030
				Percentage		
World	2.2	2.1	2.0	1.7	1.5	1.6
excl. China	1.7	1.3	0.8	1.6	1.5	1.5
Developing countries	4.6	5.0	5.5	2.6	2.1	2.4
excl. China	3.5	3.5	3.6	2.8	2.5	2.7
excl. China and Brazil	3.3	3.3	3.3	2.9	2.6	2.8
Sub-Saharan Africa	2.4	2.0	2.1	3.2	3.3	3.2
Latin America and the Caribbean	3.1	3.0	3.7	2.4	1.9	2.1
excl. Brazil	2.3	2.1	2.7	2.4	2.1	2.3
Near East/North Africa	3.4	3.4	3.4	2.9	2.6	2.7
South Asia	4.2	4.5	4.1	3.3	2.8	3.1
East Asia	7.2	8.0	8.2	2.3	1.6	2.0
excl. China	4.8	4.7	3.7	3.0	2.7	2.8
Industrial countries	1.2	1.0	1.2	0.7	0.4	0.6
Transition countries	-0.1	-1.8	-5.7	0.5	0.6	0.5

Note: Total livestock production was derived by aggregating four meats, milk and eggs at 1989/91 international commodity prices used to construct the FAO indices of agricultural production.

Table 5.2 Livestock production by commodity: past and projected

	1967/69	1987/89	1997/99	2015	2030	1969 -1999	1989 -1999	1995/97 -2015	2015 -2030
	Million tonnes					% p.a.			
Total meat									
World	92	166	218	300	376	2.9	2.7	1.9	1.5
excl. China	84	142	162	218	277	2.1	1.3	1.8	1.6
Developing countries	28	66	116	181	247	5.2	5.9	2.7	2.1
excl. China	21	41	60	98	147	3.8	3.9	3.0	2.7
excl. China and Brazil	18	34	47	79	123	3.5	3.3	3.1	2.9
Sub-Saharan Africa	3	4	5	9	16	2.3	2.2	3.3	3.5
Latin America and the Caribbean	10	19	28	43	58	3.5	4.5	2.6	2.1
excl. Brazil	7	11	15	24	33	2.5	3.1	2.7	2.3
Near East/North Africa	2	5	7	13	19	4.4	3.8	3.5	2.9
South Asia	3	5	7	13	23	3.7	2.8	3.6	3.9
East Asia	10	33	69	103	131	7.1	7.6	2.4	1.6
excl. China	3	8	13	21	32	5.1	4.1	3.0	2.8
Industrial countries	46	71	85	99	107	1.9	1.8	0.9	0.5
Transition countries	17	29	17	20	22	0.0	-6.4	0.8	0.8
Bovine meat									
World	38.0	53.7	58.7	74.0	88.4	1.4	0.8	1.4	1.2
Developing countries	11.8	19.3	28.0	41.2	55.0	3.0	3.8	2.3	2.0
excl. China	11.7	18.4	23.2	33.5	44.1	2.5	2.2	2.2	1.8
excl. China and Brazil	10.0	14.4	17.3	25.2	34.1	2.0	1.5	2.3	2.0
Sub-Saharan Africa	1.6	2.2	2.6	4.3	6.7	1.5	1.7	3.0	3.0
Latin America and the Caribbean	6.8	10.4	13.1	18.2	22.5	2.5	2.1	1.9	1.4
excl. Brazil	5.1	6.5	7.2	9.9	12.5	1.4	0.4	1.9	1.6
Near East/North Africa	0.7	1.3	1.8	2.8	4.1	3.2	3.4	2.4	2.6
South Asia	1.7	3.1	4.0	5.7	7.4	3.1	2.3	2.1	1.7
East Asia	1.0	2.3	6.4	10.1	14.4	6.4	11.5	2.7	2.4
excl. China	0.8	1.4	1.6	2.5	3.5	2.1	2.3	2.6	2.2
Industrial countries	19.1	23.8	25.0	26.6	26.5	0.6	0.6	0.4	0.0
Transition countries	7.0	10.6	5.7	6.3	6.9	-0.3	-7.5	0.5	0.6
Ovine meat									
World	6.6	9.1	10.8	15.3	20.1	1.9	1.4	2.1	1.8
Developing countries	3.0	5.0	7.4	11.2	15.4	3.4	3.7	2.5	2.1
Sub-Saharan Africa	0.6	0.9	1.3	2.2	3.4	2.8	3.5	3.1	3.0
Near East/North Africa	0.9	1.5	1.8	2.6	3.5	2.3	1.9	2.2	2.0
South Asia	0.6	1.1	1.3	2.1	3.1	3.5	1.4	2.6	2.6
East Asia	0.4	1.1	2.5	3.8	4.8	7.0	8.1	2.6	1.5
Industrial countries	2.4	2.8	2.7	3.1	3.5	0.6	-0.8	0.9	0.8
Transition countries	1.3	1.3	0.8	0.9	1.1	-1.0	-6.4	1.3	1.1

Table 5.2 *cont.* Livestock production by commodity: past and projected

Pig meat									
World	34.1	66.3	86.5	110.2	124.5	3.2	2.7	1.4	0.8
excl. China	28.1	46.2	48.1	57.9	66.2	1.7	0.4	1.1	0.9
Developing countries	9.7	28.0	49.3	69.5	82.8	6.1	5.7	2.0	1.2
excl. China	3.8	7.9	10.9	17.2	24.5	3.7	3.4	2.7	2.4
Latin America and the Caribbean	1.8	3.0	3.9	6.0	7.8	2.1	3.9	2.5	1.8
excl. Brazil	1.1	1.9	2.3	3.4	4.4	1.7	2.8	2.3	1.8
East Asia	7.6	24.2	44.3	61.6	71.9	6.8	6.0	2.0	1.0
excl. China	1.6	4.0	5.9	9.3	13.6	5.1	3.3	2.8	2.5
Industrial countries	16.6	26.0	29.3	32.3	33.1	1.8	1.4	0.6	0.2
Transition countries	7.7	12.3	7.9	8.4	8.6	-0.1	-5.3	0.4	0.1
Poultry meat									
World	12.9	37.2	61.8	100.6	143.3	5.2	5.4	2.9	2.4
excl. China	12.1	34.6	51.2	81.4	117.5	4.8	4.1	2.8	2.5
Developing countries	3.3	13.2	31.3	59.1	93.5	7.9	9.4	3.8	3.1
excl. China	2.5	10.6	20.7	39.9	67.7	7.4	7.2	4.0	3.6
excl. China and Brazil	2.2	8.6	15.6	31.9	56.4	6.9	6.4	4.3	3.9
Sub-Saharan Africa	0.3	0.7	0.9	1.9	4.1	3.8	2.6	4.3	5.1
Latin America and the Caribbean	1.0	4.7	10.5	18.2	27.3	7.8	9.0	3.3	2.7
excl. Brazil	0.7	2.7	5.4	10.2	16.0	6.7	8.4	3.8	3.0
Near East/North Africa	0.4	2.1	3.2	7.1	11.6	7.7	5.2	4.7	3.3
South Asia	0.2	0.5	1.1	3.9	10.6	7.7	7.2	7.9	6.9
East Asia	1.5	5.3	15.5	27.9	39.9	8.5	11.7	3.5	2.4
excl. China	0.7	2.6	4.9	8.7	14.1	7.3	6.1	3.4	3.2
Industrial countries	8.1	18.8	27.7	37.5	44.1	4.0	3.9	1.8	1.1
Transition countries	1.5	5.2	2.9	4.1	5.7	1.6	-6.7	2.0	2.3
Milk (whole milk eq.)									
World	387	528	562	715	874	1.3	0.6	1.4	1.3
Developing countries	78	149	219	346	484	3.6	4.1	2.7	2.3
excl. China and Brazil	69	128	189	301	425	3.5	4.1	2.8	2.3
Sub-Saharan Africa	8	13	16	26	39	2.7	1.9	3.0	2.8
Latin America and the Caribbean	24	40	57	81	105	2.6	3.9	2.1	1.8
excl. Brazil	17	26	36	52	69	2.2	4.0	2.1	1.9
Near East/North Africa	14	21	28	41	56	2.3	3.1	2.2	2.1
South Asia	30	65	104	174	250	4.5	4.9	3.1	2.4
East Asia	3	10	15	25	34	6.9	4.5	2.9	2.2
excl. China	1	4	5	8	12	7.3	3.2	3.0	2.4
Industrial countries	199	236	246	269	286	0.7	0.5	0.5	0.4
Transition countries	110	144	97	100	104	-0.3	-4.6	0.2	0.2
Eggs									
World	18.7	35.6	51.7	70.4	89.9	3.4	4.2	1.8	1.6
Developing countries	4.9	16.2	33.7	50.7	69.0	7.0	8.0	2.4	2.1
excl. China	3.2	9.5	13.5	24.6	37.8	5.0	3.4	3.6	2.9
Sub-Saharan Africa	0.3	0.7	0.9	1.8	3.4	3.7	2.6	4.0	4.1
Latin America and the Caribbean	1.2	3.6	4.6	7.3	10.4	4.5	2.5	2.8	2.3
Near East/North Africa	0.4	1.5	2.2	3.6	5.3	6.0	4.1	3.0	2.6
South Asia	0.3	1.4	2.2	5.7	9.9	6.3	4.7	5.8	3.7
East Asia	2.6	9.1	23.8	32.1	40.0	8.3	10.7	1.8	1.5
excl. China	0.9	2.4	3.6	6.0	8.8	5.0	3.5	3.0	2.6
Industrial countries	10.7	12.8	13.7	14.8	15.5	0.6	0.9	0.5	0.3
Transition countries	3.1	6.5	4.3	5.0	5.5	0.7	-4.7	0.8	0.7

America saw annual growth rates of 9 percent. Yet in sub-Saharan Africa the annual growth rate was only 2.6 percent. Red meat accounted for almost 37 percent of total meat production in the developing countries in the late 1980s, but declined to 31 percent in 1997/99 and this proportion is expected to decline further.

Egg production increased in developing countries during the last ten years (1989-99) with similar regional differences. Annual growth rates for East Asia, South Asia and sub-Saharan Africa were 10.7, 4.7 and 2.6 percent, respectively. Latin America saw a growth rate of 2.5 percent p.a. and the industrialized countries 0.9 percent p.a., while in the transition countries production fell by 4.7 percent p.a. Milk production in developing countries grew at 4.1 percent p.a. over the same period, with the highest annual growth found in South Asia (4.9 percent) and the lowest in sub-Saharan Africa (1.9 percent). Milk production in industrial and transition countries followed the same trend as egg production.

Productivity can be measured by the amount of meat or milk produced per animal per year. More sophisticated productivity analyses – based on unit of output per unit of biomass or feed input or based on financial flows – are much more difficult to undertake. For example, in high-income countries there is a growing demand for free-range meat at premium prices, and this might still allow farmers to make higher net returns despite lower carcass weight and lower offtake rates.

Increased production can be achieved by a combination of expansion in animal numbers and increased productivity. Higher productivity is a compound of higher offtake rates (shorter production cycles by, for example, faster fattening), and higher carcass weight or milk or egg yields. The projections show that the increase in livestock numbers will remain significant, but less so than in the past. Higher carcass weights will play a more important role in beef production, while higher offtake rates (shorter production cycles) will be more important in pig and poultry meat production.

There are problems in getting reliable data for offtake rates and carcass weights. To circumvent these, meat production can be compared directly with herd sizes. For example, over the last decade (1989-99), beef production in developing countries increased by 3.8 percent p.a., while cattle numbers increased by only 1.3 percent (Table 5.3), implying an annual productivity improvement of 2.5 percent. Small ruminant production increased by 3.7 percent p.a. while flock size increased by only 1.5 percent, suggesting a 1.2 percent annual productivity improvement.

There are substantial differences between regions and countries, however. In sub-Saharan Africa the increase in cattle numbers was greater than the growth in production, indicating a decline in meat productivity. In Asia, where land is scarce, growth in herd size for cattle and buffaloes was much lower than the growth in output, indicating that intensification and increased productivity were relatively more important. Increases in productivity were also responsible for the increases in white meat and egg production.

Meat or milk output per animal remains higher in industrial countries than in developing ones. For example, in 1997/99 the yield of beef per animal (carcass weight) in developing countries was 163 kg compared with 284 kg in industrial countries, while average milk yields were 1.1 and 5.9 tonnes p.a., respectively. Pork and poultry productivity levels are more similar across regions, reflecting the greater ease of transfer and adoption of production techniques.

5.3.2 Production systems

The changes in global demand for animal products and the increasing pressures on resources have important implications for the principal production systems found in developing countries.

Grazing systems. A quarter of the world's land is used for grazing, and extensive pasture provides 30 percent of total beef production and 23 percent for mutton (FAO, 1996e). In developing countries, extensive grazing systems have typically increased production by herd expansion rather than by substantial increases in productivity. However, globally the market share from these extensive systems is declining relative to other production systems. The availability of rangelands is decreasing, through arable land encroachment, land degradation, conflict and so on. Hence the scope for further increasing herd numbers in these systems remains limited.

Crop-livestock production systems. In developing countries, most ruminant livestock are found in

TABLE 5.3 Meat production: number of animals and carcass weight

	Number of animals (millions)				Number of animals (% p.a.)			Carcass weight (kg/animal)		
	1967/69	1987/89	1997/99	2030	1969 -1999	1989 -1999	1997/99 -2030	1967/ 69	1997/ 99	2030
World										
Cattle and buffaloes	1 189	1 418	1 497	1 858	0.8	0.5	0.7	174	198	211
Sheep and goats	1 444	1 708	1 749	2 309	0.9	-0.1	0.9	14	14	17
Pigs	566	838	873	1 062	1.4	0.3	0.6	65	78	84
Poultry	5 585	10 731	15 067	24 804	3.8	3.4	1.6	1.3	1.6	1.8
Developing countries										
Cattle and buffaloes	799	1 013	1 156	1 522	1.3	1.3	0.9	150	163	188
Sheep and goats	862	1 121	1 323	1 856	1.6	1.5	1.1	13	13	16
Pigs	297	493	581	761	2.2	1.6	0.8	49	73	82
Poultry	2 512	6 168	10 544	19 193	5.6	5.5	1.9	1.2	1.4	1.8
Sub-Saharan Africa										
Cattle and buffaloes	130	159	200	285	1.5	2.4	1.1	137	130	157
Sheep and goats	182	269	346	501	2.4	2.6	1.2	12	12	17
Pigs	6	13	18	27	4.5	2.3	1.4	45	47	63
Poultry	313	555	720	1 459	3.1	2.4	2.2	0.9	1.0	1.4
Latin America and the Caribbean										
Cattle and buffaloes	219	317	350	483	1.6	0.9	1.0	191	211	230
Sheep and goats	152	145	119	145	-0.5	-2.5	0.6	15	13	16
Pigs	63	74	76	108	0.6	0.1	1.1	65	72	83
Poultry	558	1 248	2 075	3 815	4.5	5.7	1.9	1.2	1.5	1.9
Near East/North Africa										
Cattle and buffaloes	37	37	39	62	0.0	0.7	1.5	107	158	194
Sheep and goats	205	241	256	350	0.9	0.5	1.0	14	16	20
Poultry	215	722	1 101	2 135	6.3	4.9	2.1	1.1	1.1	1.6
South Asia										
Cattle and buffaloes	293	348	384	424	1.0	1.0	0.3	95	121	151
Sheep and goats	148	241	289	405	2.5	1.7	1.1	11	12	15
Pigs	6	12	17	23	3.4	3.6	1.0	35	35	55
Poultry	232	472	717	2 256	4.4	4.7	3.6	0.9	0.9	1.6
East Asia										
Cattle and buffaloes	121	153	183	268	1.8	2.0	1.2	147	144	176
Sheep and goats	174	226	312	455	2.0	3.1	1.2	12	13	15
Pigs	221	393	470	602	2.4	1.7	0.8	47	75	83
Poultry	1 195	3 171	5 930	9 529	6.5	6.1	1.5	1.3	1.6	1.8
Industrial countries										
Cattle and buffaloes	263	253	254	243	-0.5	0.2	-0.1	212	284	308
Sheep and goats	397	394	341	358	-0.1	-2.2	0.2	16	17	20
Pigs	172	206	210	220	0.7	0.4	0.1	75	85	89
Poultry	2 167	2 941	3 612	4 325	1.8	2.2	0.6	1.4	1.8	2.1
Transition countries										
Cattle and buffaloes	127	152	87	94	-1.0	-6.4	0.2	144	155	170
Sheep and goats	185	193	85	95	-1.9	-9.3	0.3	14	15	18
Pigs	97	139	81	82	-0.5	-6.2	0.0	77	82	84
Poultry	906	1622	920	1 287	0.4	-6.9	1.1	1.3	1.4	1.6

mixed farming systems. These are estimated to provide over 65 percent of beef, 69 percent of mutton and 92 percent of cow milk (FAO, 1996e). The complementarity between crop and livestock production is well known. Crops and crop residues provide feed, while livestock provide animal traction, manure, food, a form of savings or collateral, income diversification and risk reduction. Although short-cycle species, such as chickens and pigs, are often very important for household food security and immediate cash needs, only ruminants can convert highly fibrous material and forages with little or no alternative use into valuable products. An estimated 250 million work animals provide draft power for cultivation of about half the total cropland in developing countries.

Intensive industrial livestock production systems. The trend towards intensification is most pronounced in Asia, where there is a shortage of land but an abundance of relatively cheap labour. This has encouraged small-scale intensive systems such as "cut and carry" and stall feeding, which have higher labour but lower land requirements. Increasing access to capital has allowed for investment in machinery, housing and inputs such as improved breeds, concentrate feeds and veterinary drugs. This has resulted in improved productivity and has accounted for faster growth in production of monogastric animals such as pigs and chickens than of ruminants. The consequence has been a reduction in the value of livestock's alternative uses, as the value of its food products becomes relatively more important.

In sub-Saharan Africa, semi-intensive and intensive dairying has developed close to urban centres and, where agro-ecological conditions permit, on the basis of cultivated fodder and agro-industrial by-products. In Latin America, intensive poultry production and, to some extent, dairying have developed partly in response to the high level of urbanization and a resumption of economic growth in the 1990s.

Large-scale and vertically integrated intensive industrial poultry and pig production systems have increased significantly in the developing world, particularly in East Asia. They make use of improved genetic material and sophisticated feeding systems, and require highly skilled technical and business management. They are also dependent on inputs of high-energy and protein-rich feeds and animal health prophylactics, and consume considerable amounts of fossil fuel, both directly and indirectly. The wholesale transfer of these types of production systems has been facilitated by the relative ease and speed with which the required infrastructure and equipment can be operationalized in so called "turnkey" operations. In recent years, industrial livestock production grew at twice the annual rate of the more traditional, mixed farming systems (4.3 against 2.2 percent), and at more than six times the annual growth rate of production based on grazing (0.7 percent; FAO, 1996e). The major expansion in industrial systems has been in the production of pigs and poultry since they have short reproductive cycles and are more efficient than ruminants in converting feed concentrates (cereals) into meat. Industrial enterprises now account for 74 of the world's total poultry production, 40 percent of pig meat and 68 percent of eggs (FAO, 1996e).

5.4 Major perspective issues and possible policy responses

In this section a number of selected livestock-related issues that are expected to increase in importance over the projection period will be discussed.

5.4.1 Livestock, economic development and poverty alleviation

As discussed in Chapter 8, a key challenge for development and poverty alleviation is the identification and promotion of broad-based income opportunities that may lead to significant pro-poor growth. The livestock sector appears to present a major opportunity to enhance the livelihoods of a large portion of the world's poor.

Livestock ownership currently supports and sustains the livelihoods of an estimated 675 million rural poor (Livestock in Development [LID], 1999). These people depend on livestock fully or partially for income and subsistence. Livestock can provide a steady stream of food and income, and help to raise whole-farm productivity. They are often the only livelihood option available to the landless, as they allow the exploitation of common property resources for private gain. In addition,

livestock are often the only means of asset accumulation and risk diversification that can prevent the rural poor in marginal areas from sliding into poverty. Recent statistics show that an estimated 70 percent of the poor are women, for whom livestock represent one of the most important assets and sources of income (DFID, 2000a). Livestock ownership also tends to increase consumption of animal products and create employment opportunities.

In spite of the trend towards increasing scales of production and vertical integration, the greater part of the food consumed in developing countries is still produced by semi-subsistence farmers. The projected growth in the demand for animal products therefore offers opportunities for the rural poor since they already have a significant stake in livestock production. Unfortunately, until now the large majority of the rural poor have not been able to take advantage of these opportunities. Thus far, the main beneficiaries have been processors and traders, middle-class urban consumers, and a relatively small number of large producers in high-potential areas with good access to markets.

A number of handicaps prevent the poor from taking advantage of the available development potential. These are summarized below.

Financial and technical barriers. Financial barriers prevent small farmers from intensifying their production. The investment required often exceeds their capital wealth. Policies and institutions must facilitate forms of targeted small- to medium-scale credit, based among others on the strengthening of property rights, to ensure the poor's future involvement in increasing livestock production and processing. Technical barriers prevent small producers from supplying a safe and relatively uniform product to the market. The lack of appropriate infrastructure to preserve perishable products affects the negotiating power of small production units, particularly if they are distant from consumption centres. Technical barriers exist in the form of sanitary requirements (including animal welfare) as a prerequisite to trade. Perceived or real livestock disease incidence may exclude groups of farmers or whole countries from international, regional and local markets. Policies and institutions must facilitate access to technologies, goods and services, and encourage the establishment of product standards and safety norms that do not exclude smaller producers, yet do not compromise public health.

A combination of higher production and higher transaction costs can make small producers *uncompetitive* and limit their access to markets. They do not benefit from the economies of scale available to large-scale units, so their production costs are usually higher, outweighing any cost advantages from the discounted value of family labour. Hidden and overt subsidies to facilitate the supply of cheap animal products to the cities may impact on small-scale producers, public health and the environment, but there is a lack of objective data to assess this.

Transaction costs can be prohibitively high for small-scale producers because of the small quantities of marketable product and the absence of adequate physical and market infrastructures in remote areas. Transaction costs are also increased where producers lack negotiating power or access to market information, and remain dependent on intermediaries. Public policies are needed to develop market infrastructures, including appropriate information systems enabling small-scale producers to make informed marketing decisions. Producers' associations or cooperatives enable producers to benefit from economies of scale by reducing transaction costs.

Reducing *risks* and mitigating their effect on poor livestock-dependent people are prerequisites for a sustainable reduction in poverty. Small-scale production is associated with both market and production risks. Market risks include price fluctuations of both inputs and products and are often associated with a weak negotiating position. While subsistence farming often has sound risk-coping mechanisms, many small-scale producers lack the assets or strategies to sustain full exposure to market risks. If the poor are to participate fully in the market, safety nets are needed to cope with the economic shocks invariably present in free markets.

Production risks arise from resource degradation, extreme weather events such as droughts and floods, and disease outbreaks. Both small-scale and intensive livestock production systems are at risk from the ravages of epidemic diseases and droughts, but the poor are particularly vulnerable to these types of shocks because of their limited assets and the lack of insurance schemes. Public and private services in disaster-prone poor countries almost invariably lack the capacity to plan for

such risks, or to respond in a timely manner. Building up such response capacity of communities and institutions is important, and drought and disease preparedness strategies need to be an integral part of public policy.

Development interventions in the livestock sector generally have not been very successful. Many livestock development projects have not succeeded because of inappropriate technologies and failure to deliver services to poor farmers. However, even in cases where the technologies were appropriately targeted and the focus was distinctly pro-poor, many technical projects have failed to improve the livelihoods of the poor substantially. Clearly, an enabling institutional and political environment is indispensable if interventions and strategies are to focus on the poor in a sustainable way (LID, 1999; IFAD, 2001).

5.4.2 Livestock health, welfare and nutrition

Animal health. Infectious and parasitic diseases of livestock remain important constraints to more productive and profitable livestock production in many developing regions. Diseases reduce farm incomes directly and indirectly: directly, by causing considerable losses in production and stock as well as forcing farmers to spend money and labour on their control; and indirectly by the consequent restrictions on exports.

Infectious diseases such as rinderpest, foot-and-mouth disease, contagious bovine pleuropneunomia, classical and African swine fever and peste des petits ruminants are still major threats to livestock production in developing countries. Through increased movements of livestock, livestock products and people, they also threaten production in industrial countries.

The global eradication of rinderpest by 2010 remains an achievable goal. However, the other epizootic diseases can be brought under control only gradually through intensive, internationally coordinated animal health programmes. There has been a major shift away from countrywide eradication programmes towards more flexible control strategies, where interventions are focused on areas offering the highest returns. Risk analysis and animal health economics help determine where disease control investment will have the greatest impact and benefit. Because of the large externalities of outbreaks of these diseases, management of their control remains a public sector responsibility. However, many developing countries do not have effective veterinary institutions capable of the task and public funding for disease control has been on the decline over the last decades.

Among the parasitic diseases, trypanosomosis (sleeping sickness) poses an enormous constraint to cattle production in most of the humid and subhumid zones of Africa. Flexible combinations of aerial spraying, adhesive pyrethroid insecticides, impregnated screens and traps and sterile insect techniques (SIT), supported by use of trypanocidal drugs, hold the promise of gradually recovering infested areas for mixed farming. These strategies will provide much greater benefits than the increased livestock output alone. They will raise crop output, allow the introduction of mixed farming, and improve human welfare by preventing sleeping sickness, providing higher and more stable incomes, and improving nutrition.

From a production viewpoint, helminthosis and tick-borne diseases are particularly important. Helminths (worms), while rarely fatal, can seriously affect productivity and profitability. Although helminths can be effectively controlled, parasite resistance to drugs through the inappropriate use of antihelmintics is a growing problem. Ticks have the capacity to transmit diseases, notably East Coast fever in eastern and southern African countries. But the cost of traditional dipping with acaracides for tick control is becoming prohibitive, and raises environmental concerns about disposal of the waste chemical. As production systems become more intensive, diseases affecting reproductive performance, and nutritional imbalances will also assume greater importance.

Intensification of livestock production is thus going to face growing constraints both from epidemic and endemic disease agents. In many parts of China, for example, high pig and poultry densities close to high concentrations of human population are breeding grounds for existing and emerging diseases, such as avian influenza and nipah virus in pigs. Foot-and-mouth and other diseases are endemic in India, with its very high cattle density. In the Near East, diseases such as bluetongue and Rift Valley fever occur in the large populations of sheep. Some livestock diseases (zoonoses) also cross from animals to humans,

directly or through an intermediate host (e.g. new influenza strains through mosquitoes).

In industrial countries, centuries of systematic eradication efforts have eliminated some livestock diseases and drastically reduced the incidence of others. The maintenance of this situation is becoming more and more difficult with the ever-increasing intensity of international travel and the growing long-distance trade in animals and livestock products. Veterinary barriers are part of the response, such as the screwworm control programme that started in the United States and Mexico, and is now protecting almost all of Central America as well, or the foot-and-mouth disease control programme that is protecting Australia and Indonesia.

Biotechnology offers the promise of solving some of the technical constraints through improved prevention, diagnosis and treatment of animal disease. Genomics, for example, may well contribute to the development of new generations of vaccines using recombinant antigens to pathological agents. A far wider range of effective, economic vaccines that are easy to use and do not require a cold chain can be expected in the future. The development of cost-effective, robust pen-side diagnostics will enhance the veterinary services offered in developing countries. However, technological advances must be matched by enhanced epidemiological and logistical capacities, and by greatly improved coordination of all institutions involved in animal disease control from local up to international level.

Animal welfare. Unregulated intensification of livestock production is associated with animal management practices, such as space, light and movement limitations, which do not allow the animals to express their natural behaviour. Such practices are increasingly disliked in more affluent societies. Similar reservations are also expressed about animal transportation over large distances, and about certain feeding and medication practices. Genetic selection for increased weight in broilers has also been linked to animal health problems: skeletal and circulatory systems taxed by the rate of muscle formation, leading to increased rates of heart failure and broken limbs. Particularly in the industrial world, such concerns are likely to have an increasing influence on production systems over the projected period. This trend is already reflected in EU regulations regarding the minimum cage sizes for battery hens.

Feed quantity and quality. A large majority of the world's livestock, particularly ruminants in the pastoral and low-input mixed farming systems, suffer from either permanent or seasonal nutritional stress. Finding better ways to use fibrous plant material is a high priority. A better understanding of how the rumen functions has led to proven techniques for treating crop residues and other low-quality roughage, and further developments can be expected. Improving the capacity of the rumen to digest high-fibre diets could dramatically improve the prospects of ruminant production in areas with easy access to roughage with low feed quality.

Critical dry season feed shortages can be alleviated by techniques for cultivating, collecting, storing and conserving fodder, forage and residues. There is considerable potential for incorporating a wide range of high-quality products (e.g. leguminous feeds) into animal rations. Strategic feeding and supplementation with key ingredients, such as minerals or nitrogen, can improve the overall utilization of low-quality diets. The feed industry has introduced a range of enzyme additives to enhance the nutritive value and quality of feeds. For example, silage additives containing cellulase and hemi-cellulase enzymes and bacterial inoculates have been shown to increase digestibility and improve preservation.

Plant genomics and phytochemistry have identified antinutritional factors (ANFs) in plants, such as phytic acid in maize. The transfer of a detoxifying (dehalogenase) gene from the soil bacterium Morexella to rumen bacteria has been successful under experimental conditions, opening the possibility of enriching the ruminant ecosystems with microbes with improved ability to detoxify ANFs. Microbial and ionophoric feed additives have been shown to increase feed conversion efficiency by up to 7.5 percent, although the results remain variable and the precise mechanisms and complex interaction of breed, micro-organism and animal are yet to be fully understood.

For pigs and poultry, improving feed conversion efficiency will be crucial to profitability. It will also reduce dependency on feedgrains where

appropriate. Over the past decade, feed conversion rates for pigs and poultry have improved by 30 to 50 percent, in part through breeding and in part through the addition of enzymes to feeds. Still, in monogastrics only 25 to 35 percent of the nutrients consumed are captured in the final products. Further understanding of digestive physiology and biochemistry can be expected to improve feed utilization.

5.4.3 Livestock and trade

Expanding demand for livestock products, particularly in developing countries, has translated into rapid growth in trade in meat products over the past decade (see Chapter 3). This dynamic growth has been facilitated by a changing policy environment that has reduced market barriers to trade. It has also been favoured by technical factors, such as increasing specialization of production and processing operations as well as advances in transportation and cold-chain technology. The growing complexity of global meat markets, driven by heightened consumer-related demands about product type, quality and safety will increasingly dictate the patterns of trade. The competitiveness of meat exporters will increasingly hinge on their ability to respond to rapidly changing consumer preferences, and to the myriad of international regulations related to food safety and animal health standards.

One of the factors shaping future developments in the global meat trade is the continuing specialization of production and processing. Increasing production specialization, driven by consumer preferences for specific types and cuts of meat, will result in countries trading different types of meat cuts. For example, the United States imports manufacturing-grade beef and exports high-quality grain-fed beef to China. China in turn imports chicken feet and wings and exports higher-value processed cuts to Japan, in some cases using cheaper imported cuts from other countries as an input. Increasing product differentiation in response to varying preferences in different markets will accelerate in the future as consumers become more sophisticated and demanding, leading to a more complex and diverse meat economy.

The complexity of the global trading system for meat products is expected to increase further in response to consumers' preoccupation about the ways in which meat is produced and sold. Another factor pushing towards increasing complexity is the increased risk of international spread of animal diseases, zoonoses and food-borne infections associated with increased trade in livestock and livestock products. With greater scrutiny of meat production systems and the "hoof to plate" approach to food safety and quality, there is a risk of proliferation of divergent food standards, sanitary assurances and certification procedures. This would disadvantage meat-exporting developing countries, which would face higher costs in adhering to these changing requirements.

In response to food safety and animal disease concerns, countries have encouraged initiatives towards the establishment of science-based food safety regulations in terms of the sanitary and phytosanitary standards (SPS) under the Uruguay Round global trade agreements. The Agreement on SPS aims to eliminate the use of unjustified, unscientific regulations to restrict trade. Under the new rules, countries maintain the right to set their desired level of protection or "acceptable risk" of food safety and animal and plant health, but are obliged to adhere either to international standards or, when setting their own standards, to provide scientific backing for the latter. This right has been used and put to the test mostly by industrial countries. However, national standards, and some international standards, may be the subject of difficult and contentious trade disputes in the future. They will also exert increasing pressure towards improved delivery of veterinary and public health services in both industrial and developing countries.

The SPS notification process should provide a mechanism for introducing increased transparency into the system of notification, consultation and resolution of trade disputes, as also will moves to harmonize measures based on international standards of the Codex Alimentarius Commission and the International Office of Epizootics (OIE). Perhaps the success of the SPS Committee can be measured by the fact that to date, only one livestock/meat case has involved the formal dispute settlement body. In 1999, the World Trade Organization Hormone Case resolved a long-standing dispute between the EU and the United States, supported by Canada. Since 1989, the EU had banned imports of red meat from animals treated with six different growth promotants.

WTO arbitrators determined that the United States and Canada were entitled to suspend tariff concessions for certain EU products, in compensation for the EU not opening its market to beef treated with hormones.

Trade in livestock products has also been facilitated by the spread of cold-chain facilities and by lower costs for constructing, operating and maintaining this equipment. This has made transportation of fresh livestock products technically feasible and accessible to a much larger group of countries and greatly reduced the costs of transportation. Previously, such developments may have provided an incentive for agribusinesses to move their production to countries where labour, environmental and public health regulations are less stringent. However, consumer concerns and international regulations are no longer conducive to such shifts. Stricter food sanitation regulations and labelling and certification requirements demand controls and investment in infrastructure to a level that may be difficult to achieve in most developing countries in the near future. Additional factors are the costs and risks related to the transport of animal feed versus transport of livestock products. Shipment of animal feeds, in livestock product equivalent units, is still significantly cheaper than the shipment of livestock products. In addition, livestock feeds are far less perishable and thus run less risk during transport than fresh livestock products.

Technical advances in packaging, transportation and information will continue to be among the key determinants in meat trading patterns. They will allow meat shippers to deliver frozen, fresh and chilled meat products to buyers thousands of kilometres away, with no substantial loss in quality. Loading and unloading have always accounted for a relatively large share of total transportation costs. The use of containers, however, has radically reduced these front- and back-end costs. Shorter delivery times, improvements in pre- and post-shipment handling activities, and advances in technologies extending shelf-life, including packaging, will continue to reduce the transaction costs of trade.

Improvements in transportation systems inside developing countries will influence their consumption and trading patterns. As infrastructure improves, advances in intermodalism – moving goods by linking together two or more modes of transportation – will make it easier to move imported perishable meat products within the country. This will be accompanied by advances in controlled atmosphere (CA) technologies, added refinements and cold-chain facilities that extend the shelf-life of meat, thus expanding the types of meat that can be shipped in refrigerated containers without spoilage.

Continuing liberalization of meat markets as well as closer regional integration (in particular the accession of Eastern European countries to the EU) will focus attention on individual countries' comparative advantage and international competitiveness. The cost of capital and labour as well as industries' ability to respond to consumer requirements in meat processing will increasingly dictate the patterns of meat trade. The rapid pace in technology transfer, along with cross-border investments in meat production and processing, may accelerate trading changes together with increased product diversity.

Pressures on the competitiveness of traditional developed country meat exporters have stemmed from the increasing stringency of environmental regulations targeting animal feeding operations and waste management. In the Netherlands, it is estimated that strict regulations on phosphate quotas, regulations on waste treatments, restrictions on storage and field applications and, more recently, direct output controls are costing up to US$4.05/hog (Metcalfe, 2001). In the United States, it has been estimated that waste management costs vary from US$0.40 to US$3.20 per hog, or 1 to 8 percent of total hog production costs. Application of these regulations results in higher producer costs and a loss of competitiveness for specific industries, particularly those in the EU.

Social, health and environmental issues related to animal production are being raised more explicitly in WTO negotiations. The competitive playing field for animal industries will change if these issues are formally incorporated as "trade issues," and related international regulations are harmonized (as has happened with animal diseases, zoonoses and food safety). In addition, decisions on how to incorporate animal welfare concerns, traceability and meat labelling will affect exporter competitiveness. Specifically, it will disadvantage developing country exporters who, by the nature of their smaller-scale export operations, will have higher compliance costs.

5.4.4 Intensification: public health risks and consumer choices

Food safety and emerging zoonoses. Access to safe and healthy food products is an important public good. Animal products, especially animal fat, are linked with human health risks, but some of these risks are associated only with overconsumption. At low to moderate intakes, meat, milk and egg products are beneficial and provide essential amino acids, minerals and vitamins. Indeed, an increase in consumption of animal products in developing countries will help to combat some forms of undernutrition.

Growing densities of livestock, particularly in peri-urban and urban areas, import of feedstuffs from distant areas, and shifts in dietary habits have raised concerns about diseases, microbial contamination of food and general food safety.

Changes in production systems, changing feeding practices and the safety of animal feed may increase the risk and change the pattern of disease transmission. The recent upsurge of human cysticercosis in eastern and southern Africa following the expansion in pork production is an example of how a zoonotic disease may become a significant risk when production systems change without accompanying changes in veterinary regulations and enforcement.

Certain livestock diseases (zoonoses) can also affect humans, e.g. brucellosis and tuberculosis, and new zoonoses may originate from livestock populations (e.g. nipah and avian flu). The potential dangers are clearly demonstrated by the emergence of BSE (bovine spongiform encephalopathy) in cattle and its ramifications for human health (variant Creutzfeld-Jakob disease) and the livestock industry. It is estimated that new diseases have been detected at the rate of one a year over the last 30 years.

Meat, milk and eggs are perishable products and susceptible to contamination by microbes. Some of these, such as salmonella and *Escherichia coli*, reside in the intestinal tract of livestock. Thus inappropriate handling, slaughter hygiene, processing or preservation throughout the food chain can result in contamination and propagation of microbes and create serious health risks for consumers. Although many microbial contaminants are of little or no effect if products are prepared appropriately, contamination is the leading reason for ever-increasing sanitary standards imposed on livestock processing and transport. Stricter regulations – combined with a growing number of affluent consumers prepared to pay a premium for organic or free-range livestock products – are likely to have a lasting effect on production methods, particularly in the industrial countries. Changes will include the application of pre-harvest food safety programmes through the Hazard Analysis Critical Control Point (HACCP) concept at farm level, from breeding to the slaughterhouse, and pathogen reduction or elimination programmes along the production chain, such as the elimination of *Salmonella enteritidis* from breeder flocks.

Food safety also concerns biological and chemical contaminants. Aflatoxins, for example, are of major importance in humid and warm environments, and drug residues are another major category of contaminants.

In order to improve food safety from feed production to the supermarket shelf, basic food quality control systems are evolving into quality assurance systems, and these in turn are moving towards total quality management (TQM) systems. The costs of compliance with these systems are high and will lead to further concentration and integration of the food chain.

Antimicrobials and hormones. Antimicrobials are widely employed in the livestock sector, and not just for therapeutic purposes. It is common practice, in modern farming systems with high animal density, to supplement feed with subtherapeutic doses of antimicrobials so as to enhance growth rates. Constant exposure to antimicrobials, however, promotes the development of resistant microbes. Resistance to antimicrobials in farm animal pathogens can be passed on to bacteria of humans through the exchange of genetic material between micro-organisms. This can increase public health costs by necessitating the use of more expensive drugs for treatment, and longer hospital stays. The problem of antibiotic resistance is compounded by the fact that no truly novel antibiotics have been developed over the last decade. Most antimicrobial resistance in human pathogens stems from inappropriate use of these drugs in human medicine, but the use of antimicrobials in the livestock sector plays a contributing role.

The World Health Organization (WHO) has recently called for a ban on the practice of giving healthy animals low doses of antibiotics to improve their productivity, and the EU has implemented a partial ban on six antibiotics that are also used in the treatment of humans. Although such moves are strongly opposed by livestock producers, they are likely to gain momentum, particularly in the light of consumer demands. In 1998, the Danish poultry industry decided voluntarily to discontinue the use of all antimicrobial growth promoters, despite concerns that this would result in decreased productivity and increased mortality. Contrary to expectations, mortality was not affected and the feed-conversion ratio increased only marginally. Similar steps have been taken by the United Kingdom's largest poultry producer.

Hormones that increase feed conversion efficiency are used in many parts of the world, particularly in the beef and pig industry. No negative impacts on human health as a result of their correct application have been scientifically proven. However, the EU, partly in response to consumer pressure, has taken a strict stand on the use of hormones in livestock production. This has led to major trade disputes with the United States. These examples show that consumer concerns will increasingly influence not only the quality of the end product, but also the ways in which it is produced.

Livestock biotechnology. As defined by the Convention on Biological Diversity (CBD), biotechnology is "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use". Much of the debate to date has been about biotechnology applications to crops, but many aspects, including intellectual property rights and biodiversity, are also relevant for animals.

Biotechnology with respect to animals may be classified into two groups: reproductive interventions, including artificial insemination (AI), embryo transfer (ET), *in vitro* maturation, fertilization and sexing, and cloning; and DNA-based genetic interventions, including marker-assisted selection, DNA vaccines, GM marker vaccines, recombinant vaccines and the development of GM livestock.

AI is an established technology particularly in the commercial dairy sector in all industrial countries. In future, widespread use of AI is likely to occur in the more favoured production environments of developing countries, where the demand for milk provides an economic incentive for its introduction. ET allows cows of high genetic potential to produce a much larger number of calves than with normal reproduction. But this technology is currently limited to only a small part of commercial herds and breed improvement programmes in some industrial countries. This and other advanced reproductive technologies are unlikely to spread widely in developing countries within the foreseeable future.

Recent advances in cloning of mammalian cells could potentially have a very large impact, particularly for dairy cattle in industrial countries. There is, however, the danger of further narrowing the genetic base and decreasing disease resilience. Cloning is a wasteful process (only 2 to 5 percent of attempts to clone animals currently succeed) and cloned animals often develop serious health problems. Cloning is thus an area where a number of complex ethical and scientific issues still have to be resolved.

The rapid increase in the understanding of the genetic make-up of animals is likely to have a major impact on animal breeding. Genetic improvement could be accelerated by direct identification of genes affecting important traits for economic performance or disease resistance, together with the use of neutral markers. This technology is being developed for a large range of traits, and could provide a short cut to genetic development in developing countries, not only for productive traits but also for adaptation to adverse environmental conditions such as climate and diseases.

Existing technologies – including even the more basic biotechnologies available as listed above – are underutilized in many developing countries. This is a result of a number of factors, including underinvestment in education, health, financial, communication and transport infrastructure that would reduce the costs and risks of input supply and product marketing (Thompson, 1997). These limitations are likely to hold back even more the application of the new sophisticated technologies, so that the technology gap between industrial and developing countries may grow rather than shrink.

Over 80 percent of research activities in biotechnology are conducted by large private

companies for commercial exploitation to meet the requirements of developed markets and large-scale commercial producers (Persley and Lantin, 2000). They are thus unlikely to be very suitable for the conditions of small-scale farmers in tropical regions and this may lead to increasing inequality of income and wealth within countries. In addition, legal registration requirements can act as barriers to commercial product introduction, giving relative advantage to large, mostly international corporations that have sufficient institutional infrastructure and financial resources to meet intensive registration requirements.

GM livestock and feeds. Estimates of the current number of GM animals being produced are difficult to establish. The vast majority have been used for biomedical research, and have been engineered to produce different products such as human proteins in their milk. Researchers are currently planning to modify chickens to express certain products in their eggs that may have medicinal use.

GM cattle, sheep, pigs and chickens are also being produced for eventual direct human consumption, although this is still largely in the experimental phase. For example, genes are being transferred to livestock with the aim of increasing the endogenous production of growth hormones to speed up growth rates. So far, however, this process has had negative impacts on animal welfare.

The main risks to animal and human health and the environment from GM livestock arise from pleiotropy, i.e. unexpected changes in form and function resulting from gene insertion, especially when these take place without sufficient testing before widespread release.

GM animals and their products themselves are not at present used for human consumption. But products are on the market from livestock fed with GM crops (e.g. corn and soybean feeds used in poultry meat and egg production and cottonseed cake in dairy production). In 2001, the Indian Government commissioned field trials of transgenic cotton in various agroclimatic regions of the country to assess its environmental safety. Parallel nutritional studies were carried out in buffaloes and cows to determine whether transgenic cottonseed and oil have any effect on animal health, milk production and quality with regard to human health and toxicity.

Little impact of GM food and feed has been seen so far in international markets, but some biotechnology-related changes in international trade are expected. Currently, importers wanting to obtain GM-free food to satisfy strong consumer demand have had the choice between importing feed from GM-free regions, or importing segregated non-GM products from GM-producing regions. Market segmentation in food products is taking place, in the EU and Japan particularly, where GM-free soya food products are receiving price premiums above products made from mixed GM-free and GM soya products. So far this market development is reported to have had little impact on the pattern of global trade in foods, as GM-free products can be obtained without significant extra cost. However, consumers are only now beginning to demand products from animals fed on GM-free diets, and this trend may have a significant impact on international bulk-based feed handling and commodity trade flows.

5.4.5 Livestock, environment and animal genetic diversity

There can be substantial environmental benefits from keeping livestock in mixed farming systems. Historically, mixed crop-livestock systems have formed the basis for agricultural intensification. In these systems, livestock not only accelerate nutrient turnover, but also provide a mechanism to import and concentrate nutrients, which is key to intensification. Livestock can also perform important functions in landscape and ecosystem maintenance.

However, many contentious issues remain to be addressed. Widespread poverty-led land degradation, and associated biodiversity losses, are occurring in semi-arid and humid environments because of increased population pressure, ill-defined access to land and other resources, and poor access to markets and financial services. Degradation reinforces poverty by reducing the productivity of shared resources and by increasing vulnerability.

Pollution of land, water and air from intensive livestock production and processing in both industrial and developing countries has raised awareness of the associated environmental problems. This pollution can directly damage the environment, and it can also become a major vehicle for disease transmission. Animals are also associated with

global warming. Directly and indirectly, domesticated livestock produce greenhouse gases: carbon dioxide (CO_2) and methane (CH_4) together with small quantities of ozone (O_3) and nitrous oxide (N_2O). These issues are covered in detail in Chapter 12. Examples of other livestock-related environmental impacts are summarized below.

Land degradation is the result of a complex interaction involving livestock movement and density, land tenure, crop encroachment and fuelwood collection. It is particularly evident in the semi-arid lands of Africa and the Indian subcontinent. Changing land tenure, conflicts, and settlement and incentive policies have undermined traditional land use practices and exacerbated the situation in many cases. Earlier reports of widespread irreversible degradation may have exaggerated the extent of the problem, but there is no reason for complacency and concerted action is needed.

Deforestation. Commercial ranching has been responsible for the destruction of vast areas of rain forest, with a serious loss of biodiversity. The problem arose from policies that promoted inappropriate ranching and was largely, but not exclusively, confined to Central and South America.

Animal genetic diversity. Intensification is associated with the risk of losing farm animal genetic diversity through a reduction of the gene pool. Almost 5 000 identified breeds and strains of farm animals have been identified. Currently some 600 breeds are in danger of extinction, and further erosion of many traditional and locally adapted breeds is expected.

Over the past decades, several new breeds of farm animal species have been successfully developed. Such animals produce more meat, milk or eggs, as long as they receive ample quantities of high-quality feed and are protected from harsh weather, pests, diseases and other kinds of environmental stress. But the consequence has been an increasing dependency on a narrowing genetic resource base, facilitated by biotechnologies such as AI, which allows easy transfer of genetic material across international borders.

The wholesale transfer of breeds suited to high-input production systems from industrial to developing countries is one of the greatest threats to domestic animal diversity. Development policies favour such introductions, which generally work against the survival of local breeds. It is estimated, for example, that while 4000 of the world's remaining breeds are still popular with farmers, only about 400 are the subject of genetic improvement programmes, almost all of them in industrial countries.

Maintaining animal genetic diversity allows farmers to select stock or develop breeds in response to environmental change, disease threats, consumer demands and changing market and societal needs. Genetic diversity thus represents a storehouse of largely untested potential. Breeds that utilize low-value feeds, survive in harsh environments or have tolerance to or resistance against specific diseases may offer large future benefits. Wild relatives of common breeds, in particular, may contain valuable but as yet unknown qualities that could be useful now or in the future (FAO, 1999d). The characterization, conservation and use of tropical animal breeds are vital if livestock production is to respond to changing production environments worldwide. Adapted livestock are more resistant to disease and environmental challenges, and can remain productive without the need for high-value inputs, and thus increase farm income and contribute to poverty alleviation.

Considerable potential exists for the within-breed improvement of locally adapted breeds, given that most indigenous populations have not been subject to heavy selection pressure for particular traits. Such programmes promise significant returns, but are necessarily long-term in nature and require substantial commitment and investment.

5.5 Concluding remarks

Increasing population, urbanization and disposable incomes in developing countries are fuelling a strong growth in demand for animal food products. This will have a major impact on the location and organization of livestock production. Changes in the latter will in turn strongly impinge on animal and human health, the livelihoods of the poor and the environment. The following consequences of these trends are expected:

- a major increase in the share of the developing countries in world livestock production and consumption;

- a gradual substitution of cereals and other basic foods by meat and milk in the diets of developing countries;
- a change, varying in speed between regions, from multiple production objectives to more specialized intensive meat, milk and egg production within an integrated global food and feed market;
- rapid technological change and a shift to more industrial production and processing;
- a rapid rise in the use of cereal-based animal feeds;
- greater pressures on fragile extensive pastoral areas and on land with very high population densities and close to urban centres; and
- increasing livestock disease hazards, with public health consequences, particularly in areas with high livestock densities near human population centres.

The future holds both opportunities and serious pitfalls for animal production in developing countries. There is a danger that livestock production and processing will become dominated by integrated large-scale commercial operations, displacing small-scale livestock farmers and thus exacerbating rural poverty and malnutrition. Uncontrolled expansion of highly intensive animal production could have major environmental consequences. On the other hand, if correctly managed, a dynamic livestock sector could prove catalytic in stimulating rural economies. However, if it is to take on this role, it will require proactive policies from the private and public sector, such as:

- the removal of policy distortions that artificially increase economies of scale and disadvantage small-scale producers;
- building of institutional and infrastructural capacities to allow small-scale rural producers to compete and integrate successfully within the developing livestock industry;
- a conducive environment, through public sector investment where necessary, to allow producers to increase production through improved efficiency and productivity; and
- effective reduction of environmental, animal and human health threats.

Without such proactive development policies, the impact of increased demand for livestock products on food security and safety, environmental protection and poverty reduction will be far less favourable.